

The transition from deposition of condensed carbonates to dark claystones in the Lower Cretaceous succession of the southwestern Barents Sea

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Four shallow coreholes in the area 72°45'–74°30'N and 21°–31°E penetrate 3 to about 15 m thick Boreal Berriasian to Lower Barremian marls, claystones of different colours and carbonates. The Berriasian seems to be missing in the two southernmost holes. Lithostratigraphical units are in general problematic to correlate although light grey fossiliferous packstone of Valanginian age are widely distributed (also known from Kong Karls Land). An abrupt facies change from condensed carbonates to dark clay deposition took place at slightly different times within the Early Barremian. In 7425/9-U-1 and 7430/10-U-1 the upper part of the carbonates is very dark and rich in *Inoceramus* debris. The upper part of these can be assigned to the middle part of the Barremian, *H. rude-fissicostatum* ammonite Zone, whereas in 7320/3-U-1 the top of the limestones may be Hauterivian in age. In 7231/1-U-1 in the Nordkapp Basin the age at the top of the limestone is close to the Hauterivian/Barremian boundary. The Lower Barremian including the *H. rude-fissicostatum* Zone may be represented by a 0.3 m thick calcareous transitional bed with clay clasts in its upper part. Normal clay sedimentation was initiated in post *H. rude-fissicostatum* Zone equivalent time, in contrast to in the three other cores and in a section on Kongsøya, Kong Karls Land.

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In the period 1985–88 four shallow boreholes were drilled through Lower Cretaceous sections in the Barents Sea as part of IKU's shallow drilling program. Information from the two westernmost of these boreholes was published by Århus et al. (1990), but otherwise no data on the in situ Cretaceous bedrock in the area are available. The incomplete and condensed Lower Cretaceous (Boreal Berriasian–Lower Barremian) sections of the boreholes are difficult or impossible to distinguish on the seismics. Until the Jurassic–Cretaceous Boundary Working Group (IGCP) makes precise correlation between the regions, the term Boreal Berriasian (rather than Ryazanian) is recommended.

The purpose of this paper is to relate the four cores to each other, with emphasis on the transition from condensed to non-condensed facies. Some comments on equivalent strata in the surroundings will also be given.

Lithology

The locations of the examined coreholes are shown in Fig. 1 and simplified lithological columns are presented in Fig. 2. For more details on cores 7425/9-U-1 and 7320-3-U-1, see Århus et al. (1990).

The upper part of 7430/10-U-1 comprises Boreal Berriasian black shales with a few mm thick fine-grained sandstone and siltstone laminae up to level 43.9 m. A 20 cm thick mudpebble conglomerate with pebbles of various grey colours occurs at 47.8 m and a 60 cm thick, very fine-grained, glauconitic, calcite cemented sand-

stone bed around 45 m. From 43.9 m the lithology, over an interval of 0.8 m with reworked Oxfordian dinoflagellate cysts, grades into grey marls. Around 39 m there is a new gradual transition, this time into nodular limestones (wackestones) with abundant bivalve fragments. At 36 m an abrupt change from greyish, nodular limestone to mottled dark grey and reddish brown, strongly bioturbated, clayey limestone (wackestone) dominated by *Inoceramus* debris takes place. Around 34 m this rock grades into dark grey, moderately bioturbated claystones with some dolomite concretions.

In core 7231/1-U-1 dark Volgian shales are abruptly overlain at 64.4 m by a 4.5 m thick condensed calcareous unit dominated by green claystone with small bivalve fragments in the lower 2 m. The calcite content increases upwards and the next metre is mainly a light grey to white nodular and bioturbated limestone (wackestone and some packstone). Towards the top of the condensed unit the carbonate content decreases so that the uppermost 30 cm are again dominated by green claystone in a rock of intermingling claystone and wackestone. At 59.9 m a dark grey, variably bioturbated claystone appears. Clasts of the underlying unit occurs at this lithological boundary, and siderite beds or nodules are present around 58 and 53 m.

Berriasian

Indubitable Boreal Berriasian strata have been penetrated in the two northernmost holes 7425/9-U-1 and

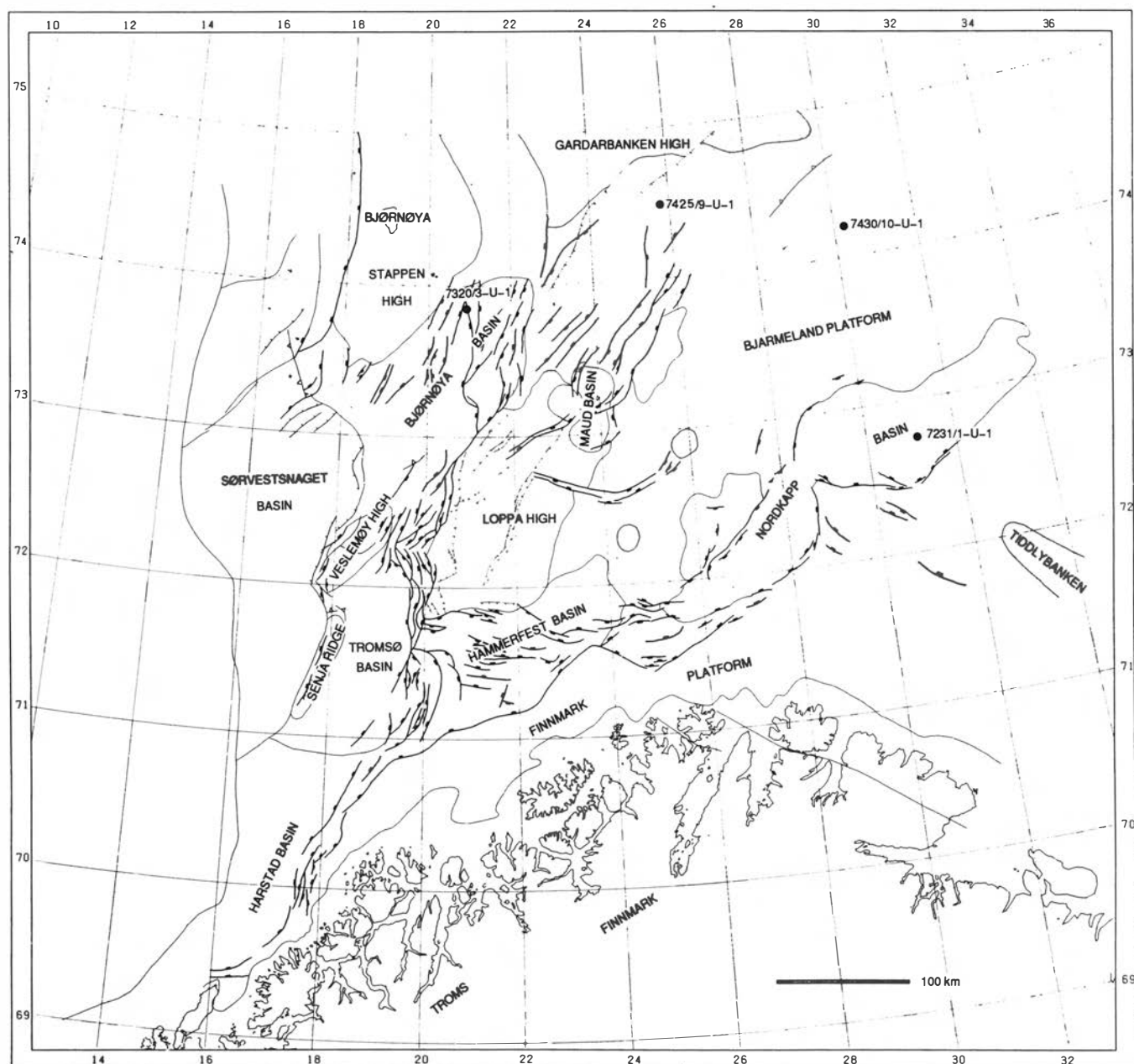


Fig. 1. Locations of the four studied shallow coreholes (7320/3-U-1 at 205500.8E 735115.2N, 7425/9-U-1 at 254619.3E 742925.3N, 7430/10-U-1 at 301444.2E 741247.8N and 7231/1-U-1 at 310730.2E 724512.5N). Map modified after Gabrielsen et al. (1990).

7430/10-U-1 only. Black Boreal Berriasian shales are found in the middle part of the stage in 7430/10-U-1, which contains *Buchia* cf. *volgensis* (Lahusen) (46.90–46.45 m), *Buchia unschensis* (Pavlov) (47.82–46.45 m) and *Subcraspedites* (*Borealites*) sp. (44.10 m) according to Zakharov (pers. comm. 1988). Poorly preserved bivalves determined in open nomenclature by Zakharov as *Buchia* cf. *okensis* (Pavlov) and *Buchia* cf. *jasikovi* (Pavlov) occur in the interval 42.70–40.20 m and appear approximately where the more calcareous sedimentation starts. Two markers for the Berriasian, the foraminifera *Lenticulina sosipatrovae* Gerke & Ivanova and the dinoflagellate cyst *Systematophora palmula* Davey occur from 42.95 and at 42.65 m, respectively. *L. sosipatrovae*

ranges up to 40.30 m. According to Shulgina & Chirva (1986) a foraminifera assemblage with *Ammobaculites praegoodlandensis* Bulynnikova and *L. sosipatrovae* ranges up into the uppermost Berriasian *B. mesezhnikovi* ammonite Zone along the river Izhma in the Pechora Basin. Basov (pers. comm. 1989) also found *L. sosipatrovae* to disappear at the Berriasian/Valanginian boundary in a section along the river Boyarka, North Siberia, but reports the species to be most characteristic for the lower part of the Berriasian (*Hectoroceras kochi* ammonite Zone). On Agardhfjellet, eastern Spitsbergen *L. sosipatrovae* occurs in high numbers 228 and 230 m above the base of the Brentskardhaugen Bed in a section studied by Nagy et al. (1990). They also revised the

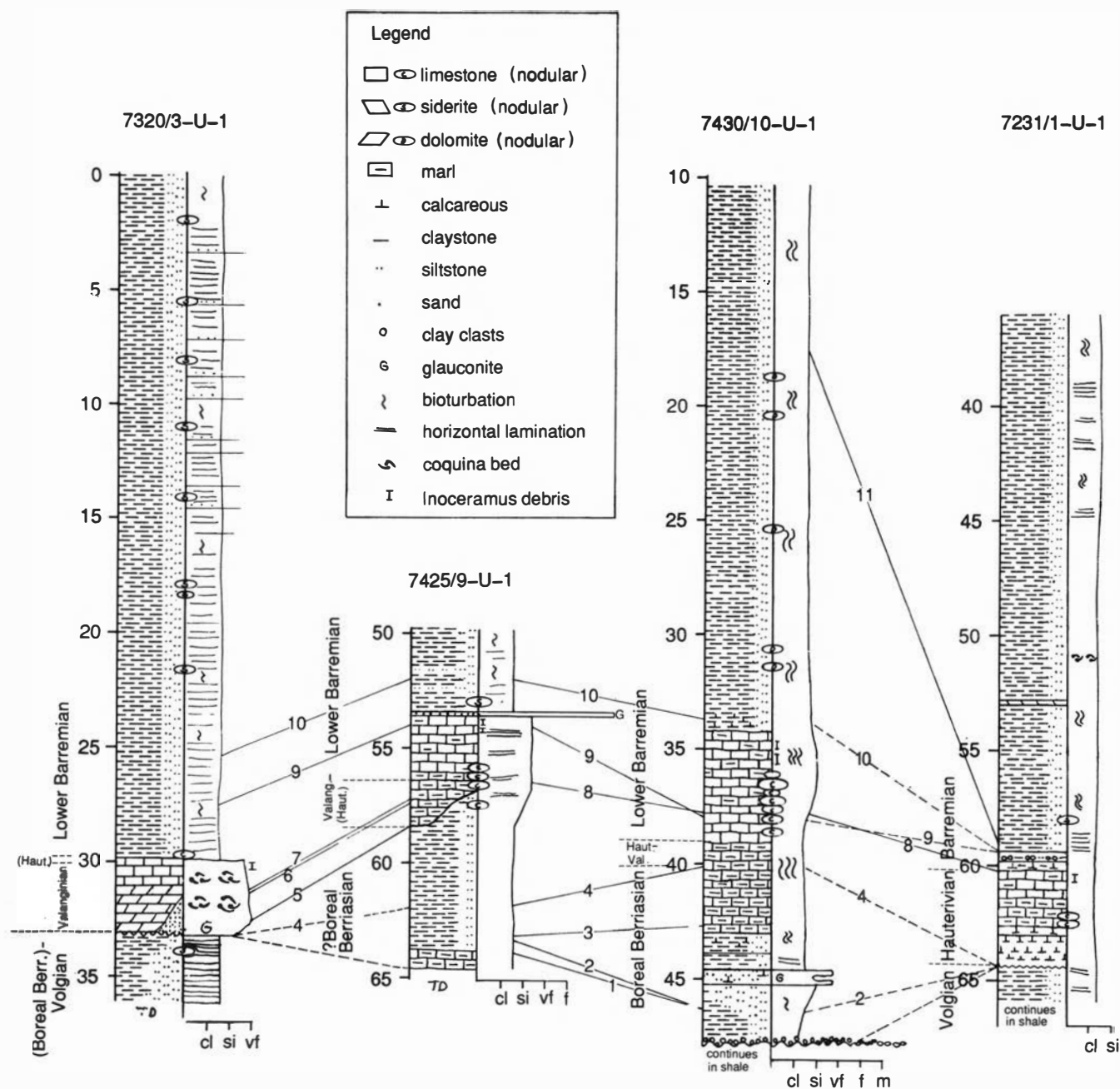


Fig. 2. Simplified lithological columns of the studied cores with correlation lines for some first and last occurrences of bivalves, foraminifera and dinoflagellate cysts. 1 – top *Buchia unshensis*, 2 – top *Buchia* cf. *volgensis*, 3 – base *Buchia okensis*, 4 – top *B. cf. okensis*, 5 – base *Buchia keyserlingi*, 6 – top *B. keyserlingi*, 7 – base *Buchia sublaevis*, 8 – base *Gavelinella barremiana*, 9 – base *Pseudoceratium anaphrissum*, 10 – base *Pseudoceratium nudum*, 11 – base *Hystrichosphaerina schindewolfii*. Dashed lines represent correlations based on fossil evidence only in one of the connected sections, or (when no number is indicated) on indirect evidence. Age interpretations are also indicated. Vertical scales indicate depths in metres below sea bottom.

elevations of the profile. Numerous *Apteodinium apiatum* McIntyre & Brideaux appear at 230 m in the same section, and in the Isfjorden area, Spitsbergen high numbers of this species appear in a ferruginous clay close to the Berriasian/Valanginian boundary 5 m above a bed with middle Berriasian ammonites identified by Burdykina (pers. comm. 1989) as *Subcraspedites* (*Borealites*) sp.

In 7425/9-U-1 the probable Boreal Berriasian dating for the lower part of the core is based on recovery of representatives of the bivalve genus *Buchia* (see Århus

et al. 1990). The ammonite, dinocyst and foraminifera stratigraphic marker taxa from 7430/10-U-1 have not been observed, but records of the foraminifera *Spirillina minima* Schacko from 64.56 m and of *Marssonella kummi* Zedler from 62.50 m may conflict the Berriasian dating as these species appear at the same level as *L. sosipatrovae* disappears in 7430/10-U-1. *S. minima* and *M. kummi* belong to the same assemblage as the one with *Lenticulina macrodisca* Reuss and *Trocholina* spp. in the eastern part of the Barents shelf according to Basov (pers. comm. 1990, see also Verba et al. 1988) and may be correlative

with the *Lenticulina eichenbergi* complex of Kolguyev and the Pechora Basin. The age of the interval containing the *L. eichenbergi* complex is late Valanginian to Hauterivian according to Basov although he cannot exclude that its lowermost part may belong to the lower Valanginian.

Valanginian–Hauterivian

Valanginian, Hauterivian or undivided Valanginian–Hauterivian marls and carbonates are recognized in all the four examined cores, although poorly documented in 7430/10-U-1. *Buchia keyserlingi* (Trautschold) occurs from 32.70–31.37 m in the dolomite interval in the nodular lower part of the limestone (wackestone) unit in 7320/3-U-1. This species is most common in the Lower Valanginian, but ranges up into the Lower Hauterivian. In 7425/9-U-1 *B. keyserlingi* is also observed, from 58.41–57.37 m, in the lower part of the limestone (wackestone) interval. If we accept the opinion of Hart et al. (1989) that the foraminifera *Tritaxia pyramidata* Reuss appears in the Hauterivian, strata of this age have been reached at 40.30 m in 7430/10-U-1 and at 63.79 m in 7231/1-U-1. The uppermost records of *Trocholina infragranulata* Noth at 39.45 and 63.79 m in 7430/10-U-1 and 7231/1-U-1, respectively, point to a pre-Barremian age (King et al. 1989).

Buchia sublaevis (Keyserling) is present from 31.12–30.20 m in the limestone (wackestone with some packstone interbeds) in the upper part of the carbonate unit in 7320/3-U-1. This species is most characteristic for the Late Valanginian, although it ranges from Early Valanginian to earliest Hauterivian. *B. cf. sublaevis* has also been found at 57.10, 55.95 and 54.34 m in 7425/9-U-1. The records at 55.95 and 54.34 m conflict foraminiferal evidence for dating.

Barremian

Dodekapodorhabdus noelae Perch-Nielsen at 60.44 and 60.19 m in the uppermost part of the limestone (wackestone) in 7231/1-U-1 is restricted to the Hauterivian/Barremian boundary beds (*S. marginatus* and *S. variabilis* ammonite Zones) according to Taylor (1982) and Jakubowski (1986). A similar nannoflora dominated by *Ellipsagelosphaera britannica* (Stradner) and including *D. noelae* (35.57 and 34.52 m) and *Corollithion achylosum* (Stover) (34.52 m) occurs in the uppermost part of the limestone in 7430/10-U-1. Taylor (1982) reported an earliest occurrence of *C. achylosum* in the earliest Barremian *S. variabilis* ammonite Zone.

King et al. (1989) claimed that *Gavelinella barremiana* Bettenstaedt appears in the middle part of the Barremian. In 7425/9-U-1, 7430/10-U-1 and 7231/1-U-1 the first records have been noted at 56.62, 37.75 and 60.19 m, respectively; in the upper part of the limestones. This evidence is in good agreement with the first specimens

of the late Early Barremian dinocyst *Pseudoceratium anaphrissum* (Sarjeant) at 53.94 and 38.00 m, respectively, in 7425/9-U-1 and 7430/10-U-1. *P. anaphrissum* seems to be the most significant species for dating the transition from condensed carbonates to dark claystones in the area. The already mentioned records of this species from 7425/9-U-1 and 7430/10-U-1 are from the limestones, although it is very rare in this facies in 7430/10-U-1. But it also occurs throughout the dark claystones of these two holes (in high numbers at 21.01 m in 7430/10-U-1) showing that the facies transition here took place in the middle Barremian *H. rude-fissicostatum* Zone. The acme at 53.94 m somewhat below the transition in 7425/9-U-1 suggests that the initiation of clay deposition took place somewhat earlier in 7430/10-U-1 than in 7425/9-U-1, although the distribution of *P. anaphrissum* is naturally also influenced by environmental factors (see Mutterlose & Harding 1987).

In 7320/3-U-1 there is a few metres thick claystone interval below the first record of *P. anaphrissum*, which in this hole is common at 27.44 and 23.45 m. One sample from the interval barren of *P. anaphrissum* contains common *Muderongia australis* Helby. This acme may be of biostratigraphic significance. Nøhr-Hansen (pers. comm. 1989) has observed a similar relative distribution of numerous *M. australis* and *P. anaphrissum*, although the two species are also co-occurring in his material from East Greenland.

P. anaphrissum has not been recorded in 7231/1-U-1, and the presence of *Hystriosphera schindewolfii* Alberti from 59.29 to 44.22 m and *Subtilisphaera terrula* (Davey) from 44.22 m and upwards suggests that the claystone in this core is slightly younger than in the other cores.

Comments on neighbouring areas

Section 76-S12 on Tordenskjoldberget, Kongsøya, Kong Karls Land measured by Marc Edwards, IKU in 1976 comprises dark Volgian shales overlain by 7 metres of Valanginian–Hauterivian strata (5 m of sandy marl with *Muderongia tetracantha* (Gocht) and *Nelchinopsis kostromiensis* (Vozzhennikova) and 2 m of packstone). This is followed by about 32 m of a fining upward, silty claystone. *P. anaphrissum* appears 10–15 m above the top of the limestone with numerous specimens 10–15 m above this again. Thus the stratigraphy is most similar to core 7320/3-U-1, but the section is rich in palynomorphs reworked mainly from the Oxfordian. According to Smith et al. (1976) there are rapid lateral variations in the Lower Cretaceous of western Kongsøya. Nevertheless the successions on Kongsøya resemble the core-hole successions considered here whereas the sections along Izhma river in the Pechora Basin, in Novaya Zemlya (according to evidence from residual nodules) and particularly in Spitsbergen are thicker and dominated by claystones in the Valanginian and Hauterivian. During

these stages and in the lower Barremian big areas in the southwestern part of the present Barents Sea formed one or more carbonate platforms, surrounded by seas with higher input of fine-grained terrigenous matter. Elverhøi et al. (1988) reported a possible time equivalent short limestone core from Storbanken at about 77°N 34°E. A similar Valanginian–Hauterivian condensed platform succession has been recorded in a shallow corehole offshore Helgeland, Norway, but are there overlain by Barremian red claystones (Århus, Verdenius & Birkelund 1986).

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