JURASSIC AMMONITES FROM THE NORTHERN NORTH SEA

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A deep well drilled by Shell/Esso some 100 km NE of the Shetlands was partly cored and yielded identifiable ammonites of two age-groups: Upper Oxfordian and Bathonian. The former consist of *Amoeboceras* as found both in Britain and the Arctic. The latter include *Cranocephalites, Arcticoceras* and *Kepplerites* identical in form, facies and sequence with those from East Greenland, constituting the most southerly record so far of the Boreal Middle Jurassic faunas so widespread in the Arctic but unknown in Britain and the rest of epicontinental Jurassic Europe.

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One of the many wells drilled in recent years in the search for hydrocarbons in the North Sea is Shell/Esso's well 211/21–1 which lies at 61°11′11″N, 01°05′54″E, some 100 km NE of the Shetlands (Fig. 1). Drilling commenced at a water-depth of 163 m (535 ft.) and penetrated a complete Tertiary sequence, followed by Cretaceous, Jurassic and what lithological criteria and some scattered palynological evidence indicate to be Triassic.

In the Jurassic parts of an interval of 45 m (149 ft.) were cored, and macrofossils obtained from four cores as shown in Fig. 2. The positions in these cores of the 16 samples of ammonites, labelled consecutively, are also shown.

The ammonite faunas

The ammonites were identified as follows. Sample-numbers in brackets are those used in the records of Shell U.K. Exploration and Production Ltd., in whose collections the material is kept. Levels refer to depths in feet below an arbitrary zero at the top of the cores.

Cores 1 and 2

A. (1½ ft.) (1) (Fig. 3A, B) *Amoeboceras* (*Amoeboceras*) cf. *alternans* (v. Buch)

B. (5 ft.) (3) (Fig. 3E) *Amoeboceras* (*Amoeboceras*) cf. *ovale* (Quenstedt)

C. (6 ft.) (2) *Amoeboceras* (*Prionodoceras*) cf. *marstonense* Spath, fragment.

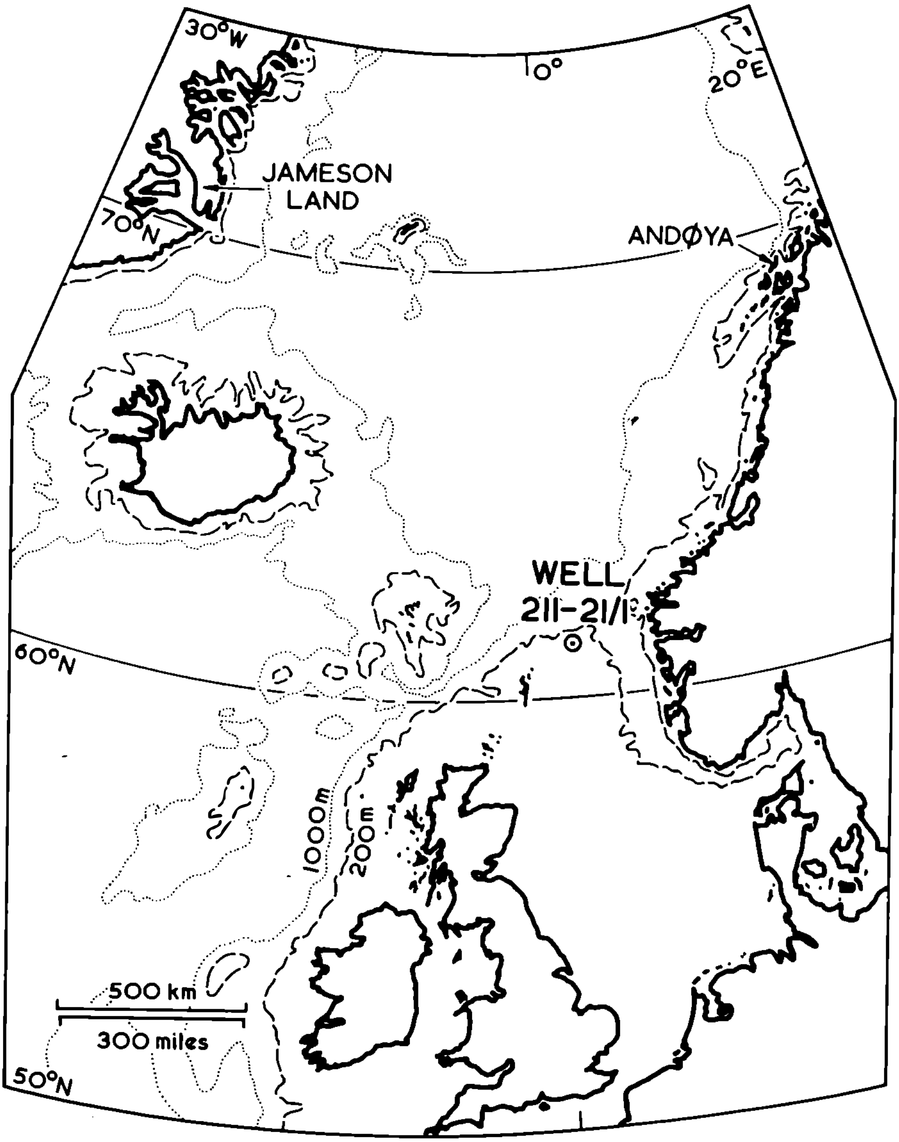

Fig. 1. Location of the well in the northern North Sea.

D. (7½ ft.) (6) (Fig. 3D) *Amoeboceras* (*Prionodoceras*) cf. *freboldi* Spath
E. (8½ ft.) (5) (Fig. 3F) *Amoeboceras (Amoeboceras) ovale* (Quenstedt)
F. (11½ ft.) (4) *Amoeboceras* sp. aff. *rosenkrantzi* Spath
G. (12½ ft.) (7) (Fig. 3C) *Amoeboceras* (*Amoeboceras*) cf. *ovale* (Quenstedt) (3 specimens)
H. (16 ft.) (8) *Amoeboceras* sp. indet.

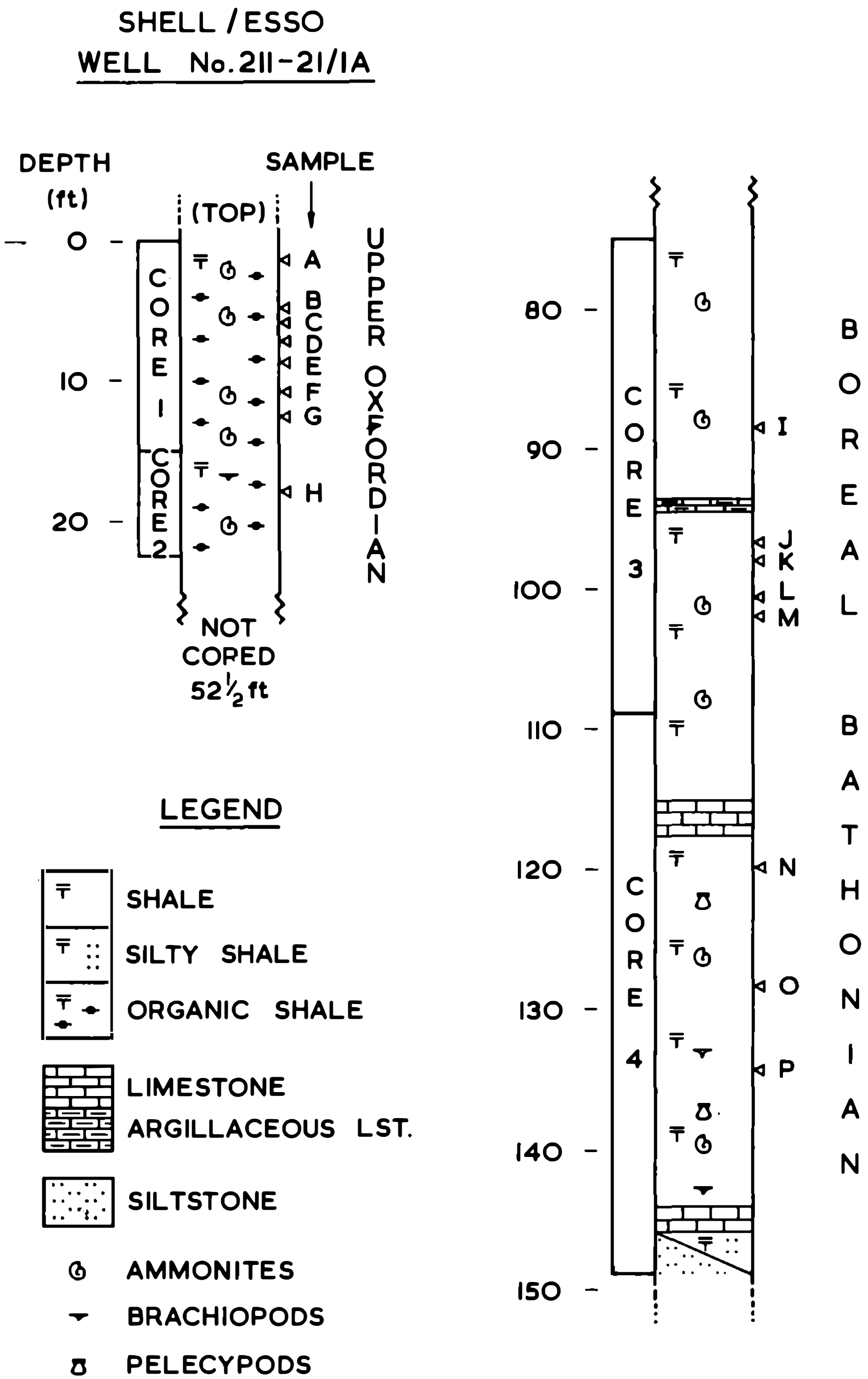

Fig. 2. Diagram showing the cores and their contents.

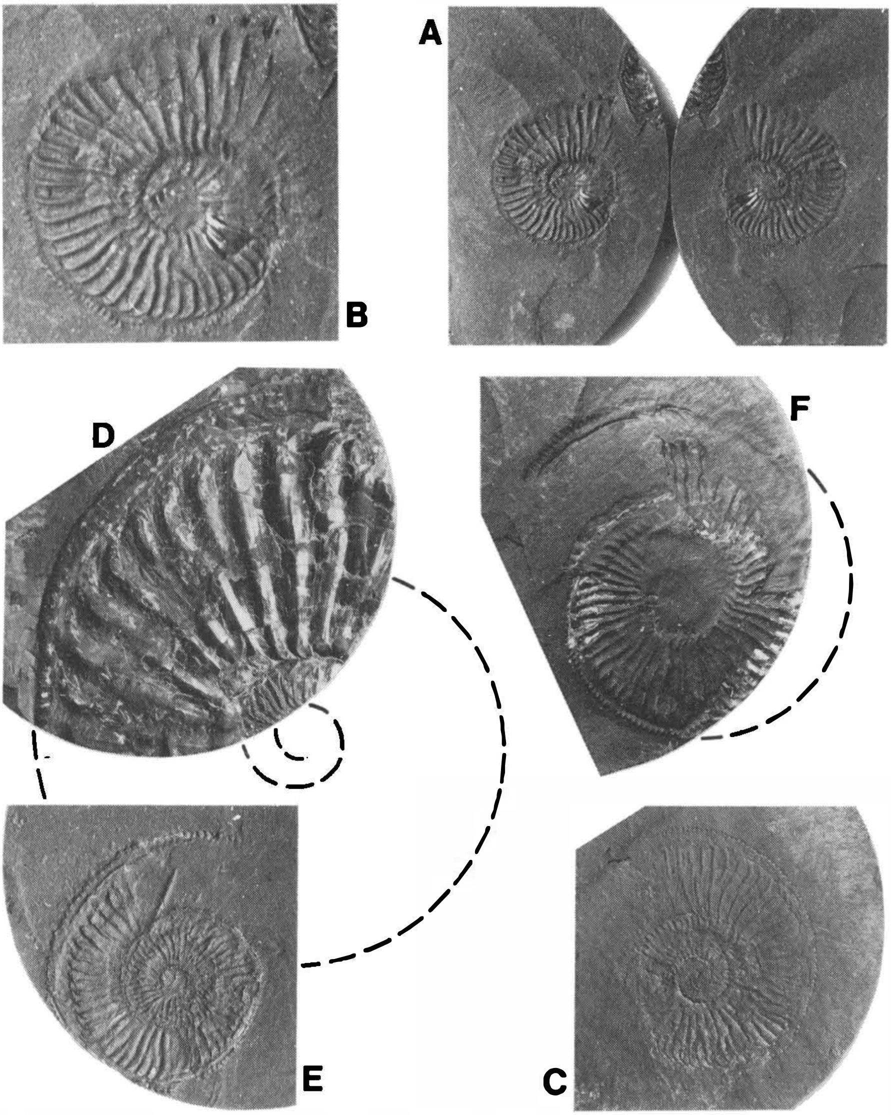

Fig. 3. A. *A.* (*Amoeboceras*) cf. *alternans* (v. Buch) (1½ ft.), positive (left) and negative (right) moulds. B. The same, × 2. C. *A.* (*Amoeboceras*) cf. *ovale* (Quenstedt) (12½ ft.). D. *A.* (*Prionodoceras*) cf. *freboldi* Spath (7½ ft.). E. *A.* (*Amoeboceras*) cf. *ovale* (Quenstedt) (5 ft.). F. *A.* (*Amoeboceras*) *ovale* (Quenstedt) (8½ ft.). All Upper Oxfordian, reduced × 0.82 except 3B (= A × 2).

Break: Cores 3 and 4

I. (88½ ft.) (9) (i, Fig. 4A) *Kepplerites stephanoides* sp.nov. MS (ii, Fig. 4F) *Arcticoceras cranocephaloides* sp.nov. MS

J. (96½ ft.) (10) (Fig. 4C) *Arcticoceras* cf. or aff. *ishmae* (Keyserling)

K. (98 ft.) (12) *Arcticoceras* sp. indet.

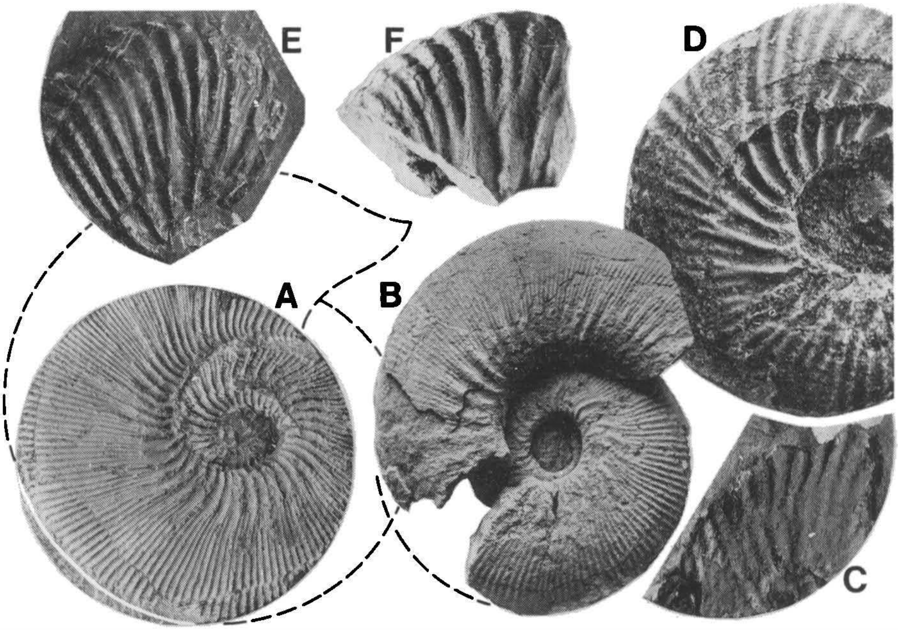

Fig. 4. A. *Kepplerites stephanoides* sp.nov. MS (88½ ft.), positive mould, crushed. B. *Kepp. stephanoides* sp.nov. MS, Vardekløft Formation, Hurry Inlet, Jameson Land, E. Greenland (Spath 1932, pl. xxvi, fig. 6). C. *Arcticoceras* cf. *ishmae* (Keyserling) (96½ ft.). D. *Arcticoceras cranocephaloides* sp.nov. MS, bodychamber of a complete adult, Vardekløft Formation, S. of Olympen, Jameson Land (No. GGU 102309, coll. RGB 1969). E. *A.* cf. *cranocephaloides* (88½ ft.), a crushed bodychamber fragment. F. The same, for comparison, from the same area as D, E. Greenland (No. JHC-TB 3093, coll. 1970). – Boreal Bathonian, reduced × 0.57.

L. (100½ ft.) (11) (Fig. 5A) *Arcticoceras michaelis* Spath (= *A. ishmae* (Keyserling) [m]) in highly glauconitic shale with pyritic *Chondrites*

M. (102 ft.) (13) *Arcticoceras* sp. indet.

N. (120 ft.) (14) (Figs. 5C, D, F, G) *Arctocephalites arcticus* (Newton–Whitfield) [m]

O. (128½ ft.) (16) *Cranocephalites* sp. indet. cf. *pompeckji* (Madsen), fragment

P. (134½ ft.) (15) (Figs. 6A, B) *Cranocephalites* cf. *carlsbergensis* sp.nov. MS

Notes on the ammonites and their ages

([M], [m] designate macro- and microconch dimorphs)

Cores 1 and 2: samples A–H: Upper Oxfordian

Amoeboceras (*Amoeboceras*) *alternans* (v. Buch) [m]

Fig. 3A, B

□ *Ammonites alternans* v. Buch, 1831: pl. VII, fig. 4 (2 figures) □ *Cardioceras alternans* (v. Buch), Salfeld, 1915: 163, pl. XVI, figs. 3, 4 (2 syntypes) □ *Cardioceras alternans* (v. Buch), Dorn, 1931: 81, pl. XIX(XXXV), figs. 3–5.

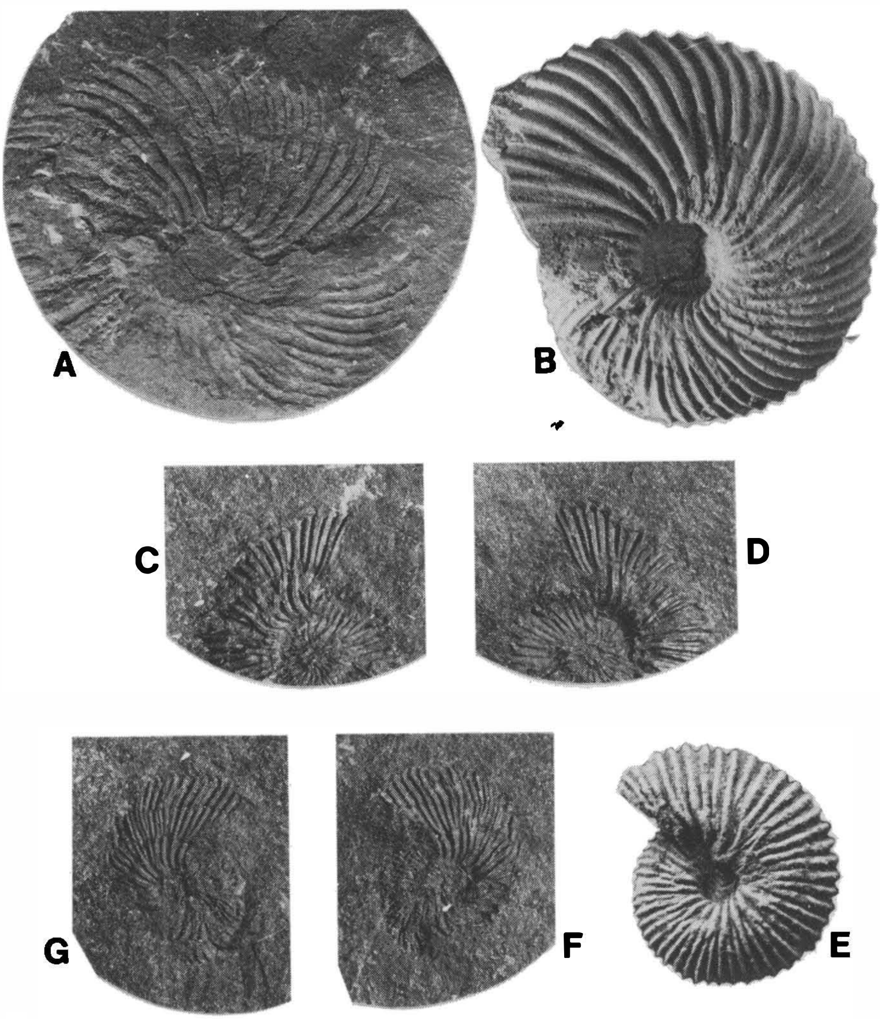

Fig. 5. A. *Arcticoceras michaelis* Spath (= *A. ishmae* (Keys.) [m]) (100½ ft.), positive mould. B. *A. ishmae* (Keyserling), an immature nucleus with a ¼-whorl of body-chamber, for comparison with A; Vardekløft Formation, Olympen, Jameson Land (No. JHC-TB 3008, coll. 1970). C and D, G and F. *Arctocephalites arcticus* (Newton-Whitfield) [m] (120 ft.), negative and positive moulds of two complete adults. E. *A. arcticus* (Newton-Whitfield) [m], a complete adult, Vardekløft Formation, near Hjørnefjeldet, Jameson Land, for comparison (No. JHC-TB 4230, coll. 1971). – Boreal Bathonian, reduced × 0.83.

v. Buch's two figures were based on two syntypes which were refigured by Salfeld and are now lost. The three specimens illustrated by Dorn cover the range of variability found, his fig. 5a, b being probably the most typical. Specimens other than nuclei are rare in Franconian material, and hence a precise interpretation of the species will always be difficult. The present specimen is not as coarsely-ribbed and evolute as the most typical

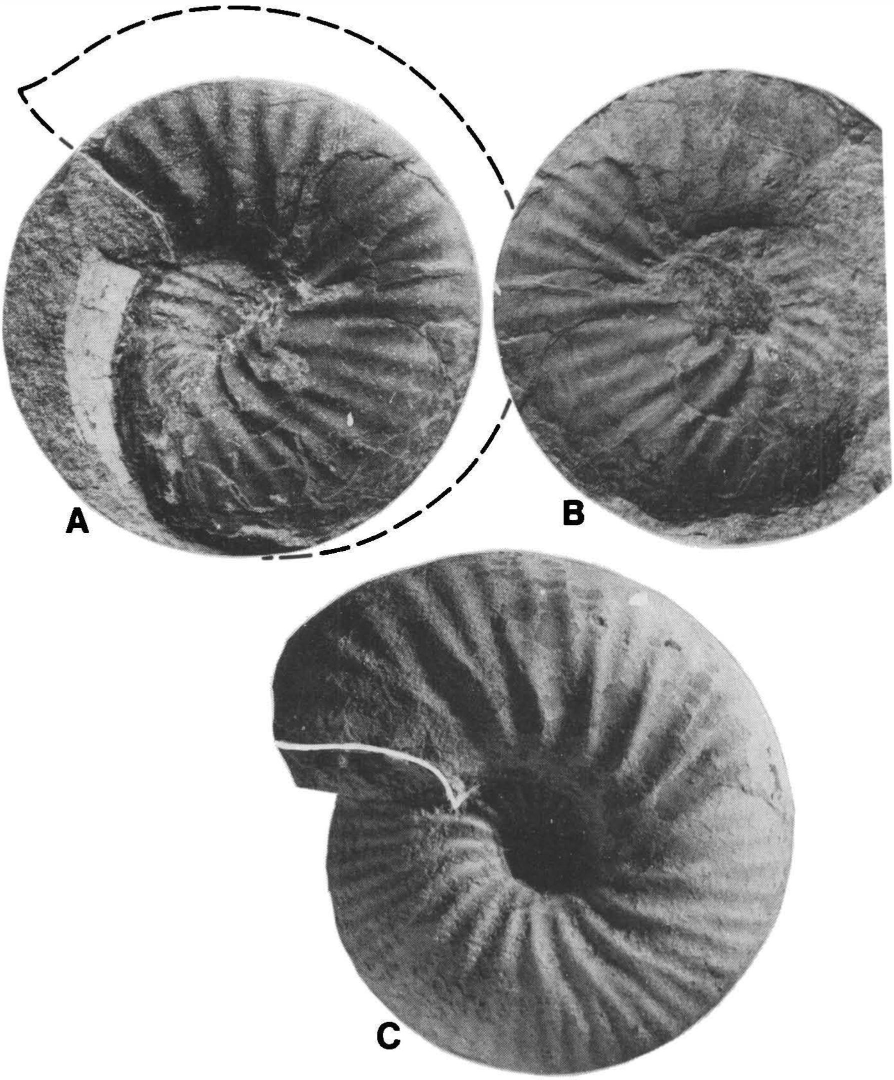

Fig. 6. A, B. *Cranocephalites* cf. *carlsbergensis* sp.nov. MS (134½ ft.), positive and negative moulds. C. *C. carlsbergensis* sp.nov. MS, a specimen from the Vardekløft Formation, Carlsberg fjord, E. Greenland, for comparison (No. JHC 1751, coll. 1958). – Boreal Bathonian, reduced × 0.83.

form but matches Dorn's other figures well as far as it goes: it may be transitional to *A. ovale*, from which it differs mainly in having more biblicate ribs. Russian representatives include *A. schuravskii* (Sokolov 1912) *pars* (Sokolov 1912, pl. II, fig. 6), from the Petchora. In Franconia, Swabia and the Jura the typical *A. alternans* occurs in the Upper Oxfordian, Bifurcatus Zone, but some variants range higher and occur together with *A. ovale*.

Amoeboceras (*Amoeboceras*) *ovale* (Quenstedt) [m]

Fig. 3C, E, F
□ *Ammonites alternans ovalis* Quenstedt, 1849: pl. 5, fig. 8a–c □ *Cardioceras ovale* (Quenst.), Salfeld, 1915: 166, pl. XVI, figs. 1, 2, 5, 8–10, and synonymy *partim* □ *Cardioceras ovale* (Quenstedt), Dorn, 1931: 80, pl. XVIII(XXXIV), figs. 25–27.

The specimen shown here in Fig. 3F matches Dorn's fig. 26 in all respects. The German forms occur in the Hypselum Subzone of the Bimammatum Zone which correlates roughly with the Decipiens Zone or perhaps lower Pseudocordata Zone of the British Upper Oxfordian (Enay 1971).

Amoeboceras (Prionodoceras) freboldi Spath [M]

Fig. 3D
□ *Cardioceras* cf. *nathorsti* (Lundgren), Frebold, 1930: 75, pl. XXVI, fig. 4 (holotype) □ *Amoeboceras* (*Prionodoceras*) *freboldi* nom.nov. Spath, 1935: 25 □ *Amoeboceras* (*Prionodoceras*) *freboldi* Spath, Mesezhnikov, 1967: 121, pl. II, figs. 1, 2.

These are probably the macroconchs of *A. ovale.* Frebold's specimen from Spitsbergen and Mesezhnikov's from northern Siberia differ from the one shown here only in having even more angularly twisted and tangentially projected secondary ribs on the ventrolateral shoulders.

Amoeboceras (*Prionodoceras*) *marstonense* and *rosenkrantzi* Spath

□ *Amoeboceras* (*Prionodoceras*) *marstonense* Spath, 1935: 20, pl. 4, fig. 5 □ *Amoeboceras* (*Prionodoceras*) *rosenkrantzi* Spath, 1935: 25, pl. 12, fig. 4, pl. 13, fig. 5.

Close to *A. freboldi,* but more involute. The former species is dated in Britain as Pseudocordata Zone, Upper Oxfordian.

Cores 3 and 4: Boreal Bathonian

The affinities of the ammonites described below lie entirely with the Arctic and not with NW Europe. The ammonite succession in East Greenland has been worked out in great detail in recent years as the result of extensive mapping (Surlyk et al. 1971, Surlyk & Birkelund 1972) and collecting in Jameson Land, and a full description of the zonation is in preparation (by J. H. Callomon and T. Birkelund). An account of the lithostratigraphy has been published (Surlyk et al. 1973) and contains a summary of the scheme of ammonite zones which has been set up: the relevant part is reproduced here in Fig. 7. It is a modification of an earlier version (Callomon 1959).

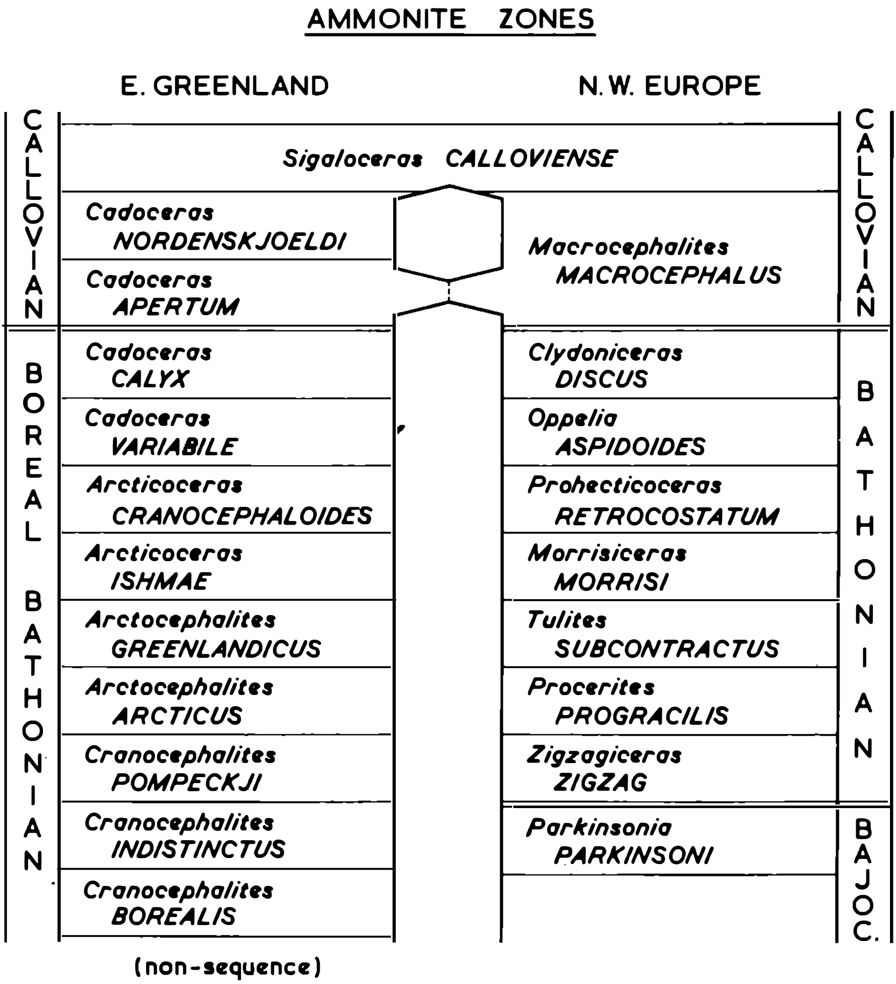

Fig. 7. The standard ammonite zones of the Bathonian in the Boreal and European realms. Note that equal spacings do not imply equal time-intervals, and that units appearing opposite each other in the two columns do not imply correlations, which remain problematical between the two realms.

Kepplerites stephanoides sp.nov. MS

Figs. 4A, B

□ *Kepplerites* (*Seymourites*) *tychonis* var. *fasciculata* Spath, 1932: 86, pl. XXVI, fig. 6.

The genus *Kepplerites* first appears in NW Europe as *K. keppleri* in the Macrocephalus Zone and Subzone of the basal Callovian by definition. It is now known to have a long pre-Callovian history in E. Greenland, the first forms appearing suddenly in the lower part of the Cranocephaloides Zone (see Fig. 7). They will be described fully elsewhere but include the specimen quoted above from Jameson Land described by Spath which is reproduced here as Fig. 4B. There can be little doubt that the specimen from the core shown in Fig. 4A is conspecific for agreement between the figures is almost perfect when allowance is made for the apparent difference in involuteness which is due to crushing. In Greenland the Cranocephaloides Zone is divisible on the basis of the Keppleritids into two subzones, the lower of which is the Stephanoides Subzone. *K. keppleri* is also found there, but much higher, in the Apertum Zone.

Arcticoceras cranocephaloides sp.nov. MS [M]

Figs. 4D–F

This is another Greenland group which will be described in detail elsewhere. It marks the last stage of evolution of the Arctocephalitinae before changing into the Cadoceratinae by acquiring the characteristic sharp umbilical edge of *Cadoceras,* and these late forms of Arcticoceras bear a strong resemblance to their distant ancestors, *Cranocephalites.* A complete topotype of *A. cranocephaloides* from Jameson Land is shown in Fig. 4D, and a piece for comparison with the specimen from the core in Fig. 4F. Although so fragmentary and crushed, the core specimen is identified with confidence. The association of *A. cranocephaloides* with *Kepp. stephanoides* leaves the dating in no doubt.

Arcticoceras michaelis Spath [m]

Fig. 5A

☐ *Arcticoceras michaelis* Spath, 1932: 56, pl. XIII, figs. 3a, b ☐ *Arcticoceras kochi* var. *pseudolamberti* Spath, 1932: 55, pl. XIV, figs. 2, 3, pl. XV, fig. 6.

This is the microconch of *A. ishmae* (see below) from whose inner whorls it is barely distinguishable, and with which it is found together in Greenland. A specimen of *A. ishmae* from Jameson Land (Fig. 5B) is shown here for comparison.

Arcticoceras ishmae (Keyserling) [M]

Figs. 4C, 5B

☐ *Ammonites ishmae* Keyserling, 1846: 331, pl. XX, figs. 8–10 ☐ *Arcticoceras ishmae* (Keyserling) Spath, 1932: 50, pl. XV, fig. 7a, b ☐ *Arcticoceras kochi* Spath, 1932: 53, pl. XV, fig. 1.

Extensive new collections in Jameson Land have shown that the old Kochi Zone is divisible into several subzones, and that Spath's *A. kochi,* based originally on scanty crushed material, is in fact indistinguishable from the true *A. ishmae.* The Kochi Zone thus becomes the Ishmae Zone, and the material from the borehole can be placed in the Ishmae Subzone.

Arctocephalites arcticus (Newton–Whitfield) [m]

Fig. 5C–G
□ *Ammonites ishmae* var. *arcticus* Newton, 1897: 500, pl. XL, figs. 1, 1a □ *Amm.* (*Cadoceras*) *arcticus* Whitfield, 1906: 132, pl. XVIII, fig. 2 only □ *Arctocephalites nudus* Spath, 1932: 35, pl. IX, fig. 3, pl. XI, figs. 1, 7, pl. XII, fig. 4 [M]; pl. XV, fig. 2 [m].

The microconchs of this group are relatively rare and seem never to have been properly described. They strongly resemble the much younger *Pseudocadoceras*, but by comparison with a complete succession now known from E. Greenland, the borehole specimens (Figs. 5C, D, F, G) resemble most closely those from the Arcticus Zone and Subzone, one of which is shown for comparison (Fig. 5E). The new collections from Greenland have also shown that *A. nudus* is only a variant of *A. arcticus*, and hence the former Nudus Zone becomes the Arcticus Zone of Fig. 7.

Cranocephalites carlsbergensis sp.nov. MS

Figs. 6A–C

The *Cranocephalites*-faunas are among the most widespread in the Arctic, a wide selection from E. Greenland having been described by Spath (1932). These were thought to be all more or less contemporaneous and placed in a Vulgaris Zone. New collections have shown that they include forms of slightly different ages; that even so, by no means the whole range of faunas had been sampled; and that the species taken as zonal index, *C. vulgaris* Spath, is in fact synonymous with *C. pompeckji* (Madsen 1904). The Vulgaris Zone thus becomes the Pompeckji Zone, which is divisible into a number of subzones. One of these is based on a fauna first discovered at Carlsbergfjord (71°20′N, 22°40′W) and it is this which the specimen from the borehole most strongly resembles. The new species will also be described more fully elsewhere, but a topotype is shown for comparison (Fig. 6C). It shows the characteristic strong but subdued biplicate ribbing.

Comparative stratigraphy

The nearest successions on land that can serve as standards for comparison with the borehole are in Jameson Land, E. Greenland, to-day 1500 km to the NW; and NE Scotland near Brora and in the Moray Firth, or the Inner Hebrides at Skye, 400 km and 550 km to the SW respectively. If we restore Greenland to its Jurassic position as computed by Bullard (1965: fig. 8), the distance from Jameson Land also becomes 400 km, almost due N. (Alternative fits of the continents that have been proposed make little difference to the present discussion.)

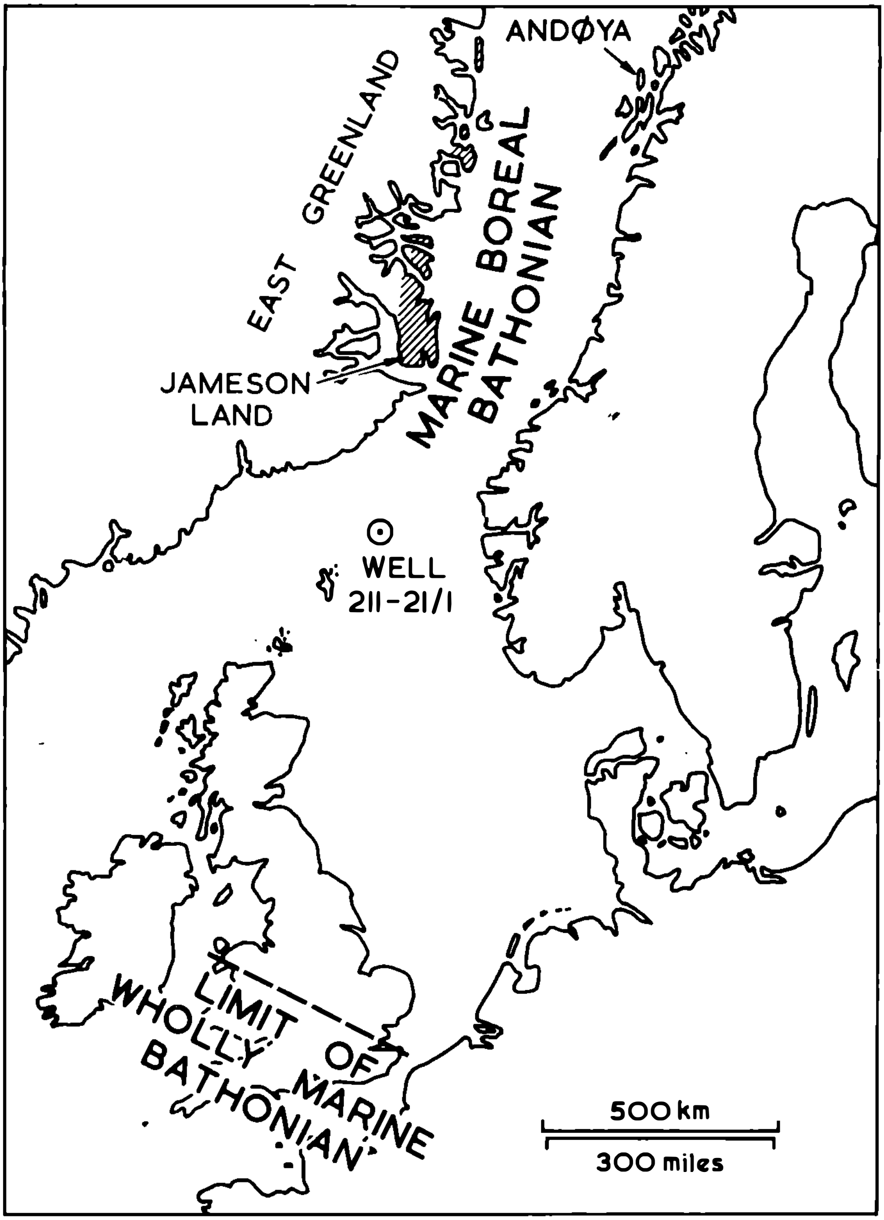

Fig. 8. The north Atlantic in Jurassic times after the reconstruction by Bullard et al. 1965. Bathonian on-shore deposits in Britain north of the line across southern England are in partially or wholly non-marine facies, as are those on Andøya.

Correlation of the Upper Oxfordian presents few problems. The ammonites from the borehole resemble closely forms found in the Hareelv Formation of Jameson Land (Surlyk et al. 1973) and the Ampthill Clay or its equivalents in Scotland and eastern England. The facies of 'black shales' are very similar except that they become highly micaceous, silty and almost non-argillaceous in Greenland.

The facies of the Boreal Bathonian are closely comparable to those of Jameson Land. Of particular interest is the presence of at least one highly glauconitic silt, exactly as found at numerous horizons in Jameson Land. The thicknesses are, however, rather less: when silty, the Pompeckji–Cranocephaloides Zones extend typically over some 50 m in Hurry Inlet (see Surlyk et al. 1973: fig. 14), expanding greatly when some of the locally developed and rapidly-accumulated sandstone members are present (fig. 17), compared with the 20 m or so in the borehole. Similarly, the interval between the Pompeckji Zone and the Hareelv Formation tends to span at least 100 m, compared with ?40 m in the borehole.

Detailed correlation of the Boreal Bathonian with the classical European succession remains wholly problematical. There is little new to add to the previous discussion (Callomon 1959), except that indirect correlations based on evidence in N. America tend increasingly to support the suggestion that the lowest ammonite zone, the Borealis Zone, may still be in the Upper Bajocian and that the Pompeckji Zone is no younger than Lower Bathonian. The new discoveries in the borehole reduce the geographical gap between the known points of closest approach of marine Boreal Bathonian and classical wholly marine Bathonian to its narrowest yet, 1000 km, the most northerly outcrops of the latter being in about Oxfordshire. As is well known, the intervening deposits are in largely or wholly non-marine facies ('Estuarine Series', the Hebridean representatives described for example by Hudson 1963, 1964), which extends at least as far as Skåne in S. Sweden. The traditional picture then used to project the Bathonian as non-marine or even wholly non-represented due to emersion indefinitely northwards; but the area of non-marine deposition can now be seen to be closely circumscribed, in the region of the North Sea alone (see map in Sellwood & Hallam 1974), thereby losing much of the special significance attached to it in the past in support of the idea of a world-wide Bathonian regression.

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