Palynological age constraints on the base of the Helvetiafjellet Formation (Barremian) on Spitsbergen

KARI GRØSFJELD

Grøsfjeld, K. 1991: Palynological age constraints on the base of the Helvetiafjellet Formation (Barremian) on Spitsbergen. *Polar Research 11(1)*, 11–19.

The age of the uppermost part of the Rurikfjellet Member, Janusfjellet Formation, underlying the Helvetiafjellet Formation, is discussed on the basis of the occurrence of dinoflagellate cysts. Samples collected from thirteen localities in western and central Spitsbergen were examined. Forty-eight dinoflagellate cyst species were recorded during the study, but only a few provide good time resolution. They show that the youngest beds of the Rurikfjellet Member, previously regarded to be of Hauterivian age, belong to the Barremian. The presence of Barremian sediments below the base of the Helvetiafjellet Formation at several widely separated localities constrains the diachronism of the Rurikfjellet Member – Helvetiafjellet Formation transition.

Kari Grøsfjeld, Norges geologiske undersøkelse, P.O. Box 3006, N-7002 Trondheim, Norway.

Introduction

The purpose of the present study was to obtain detailed information about the age of the youngest beds of the Rurikjfellet Member, Janusfjellet Formation, in Spitsbergen. In order to understand the differing development of the transition between the Rurikjfellet Member and the Helvetiafjellet Formation in western and central Spitsbergen as compared to that in the eastern and southern Spitsbergen, dating of the sediments across the boundary becomes essential. In western and central Spitsbergen, marine shales of the Rurikfjellet Member are sharply overlain by deltaic distributary channel sand of the Helvetiafjellet Formation, whereas in southeastern and southern Spitsbergen the transition between the two units is gradual with prodelta deposits underlying delta front deposits (Nemec et al. 1988; Edwards 1976; Mørk 1978).

The most recent interpretation of the relationship between the Rurikfjellet Member and the Helvetiafjellet Formation (Steel & Worsley 1984; Nemec et al. 1988) proposes a significant relative sea-level fall at the transition between the two units, defining a stratigraphic sequence boundary. If the sea-level fall was caused partly by uplift of northwestern Spitsbergen, the Rurikfjellet Member would be expected to be more deeply eroded in this direction.

The present study contributes to the discussion of this model by offering dating of the sediments that were possibly affected by erosion in different parts of the basin during this transition.

Material and methods

Thirteen localities along the assumed progradation direction of the Helvetiafjellet Formation fan delta from the NNW to the SSE were sampled (Fig. 1). Well-exposed sections are only present in four localities: Bohemanneset SE (16.7 m), Janusfjellet (87.3 m), Forkastningsfjellet (27.5 m), and Helvetiafjellet SE (62.2 m). From the other localities, only spot samples were collected. Wherever possible, samples were taken at 2 m intervals. All sample positions are given as metres below the base of Helvetiafjellet Formation (m b.b.).

Samples for the present study were collected in 1984 during fieldwork organised by Norsk Hydro a.s.

Standard palynological preparation procedures were applied (Barss & Williams 1973). Oxidation was carried out to remove commonly occurring pyrite. Slides were prepared from both oxidised and unoxidised residues.

Palynological preservation is highly variable in the material. Generally it becomes poorer towards the top of the unit.

Stratigraphy and regional geological setting

The Janusfjellet Formation is separated into two members by an unconformity, the lower Agardhfjellet Member (?Bathonian/Callovian – Lower Volgian) and the upper Rurikfjellet Mem-

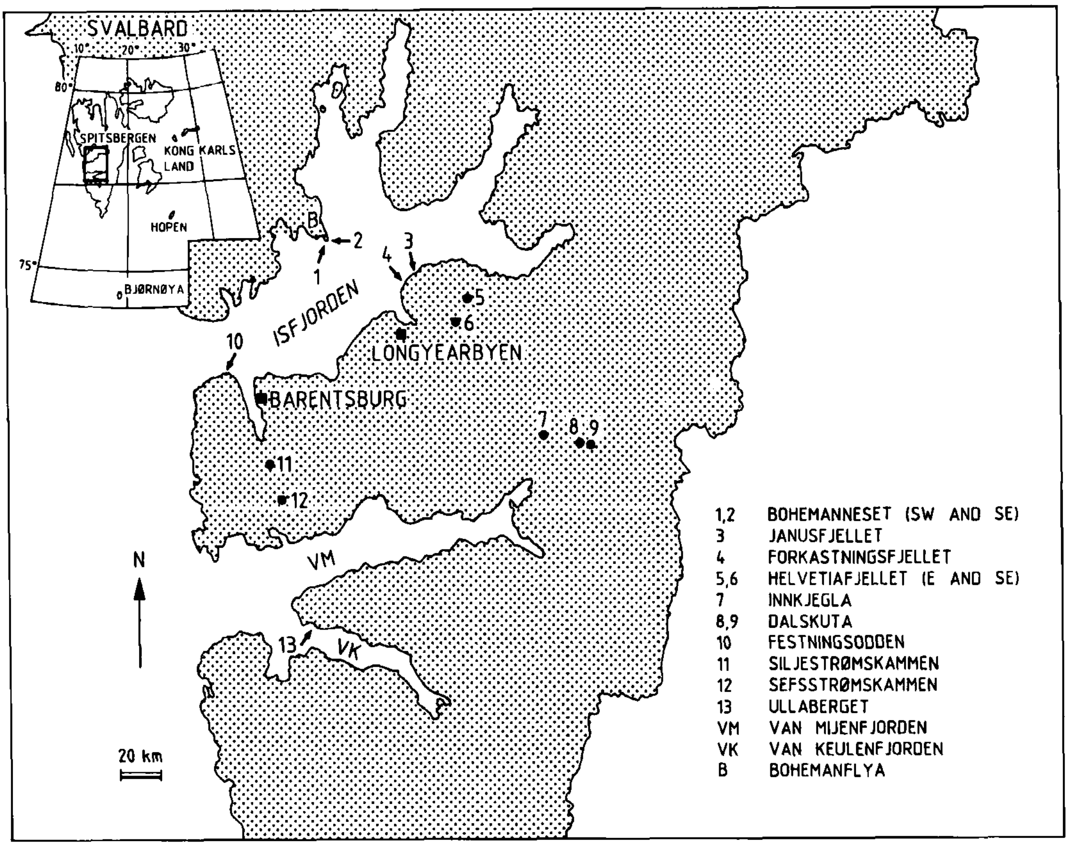


Fig. 1. Central Spitsbergen, position of localities.

ber (Lower Cretacous) (Fig. 2) (Parker 1966, 1967). The Rurikfjellet Member is exposed along the margins of the Tertiary Trough. It dips steeply eastwards along the western margin, lies nearly horizontal in the central part, and dips slightly southwest and west in the eastern areas. In the west it reaches a thickness of 300–400 m, decreasing to 160–180 m in the central part (Parker 1966; Dypvik 1985).

The Rurikjfellet Member consists mainly of heavily bioturbated mudstones. In many places it shows an irregular coarsening upwards development towards the Helvetiafjellet Formation. The top of the member is marked by the first distributary channel sands of the Helvetiafjellet Formation. For a detailed description of the sedimentology of the Rurikfjellet Member in central Spitsbergen, the reader is referred to Øxnevad (1987).

Previous dating

The age of the Rurikfjellet Member (Lower Cretaceous) was based on ammonites and bivalves (Pchelina 1965a, b; Parker 1967). A Lower Cretaceous dinoflagellate assemblage was reported for the first time from the Helvetiafjellet Member at Agardhfjellet by Bjærke & Thusu (1976). A comprehensive study of the Lower Cretaceous dinoflagellate assemblages from three surface sections through the Rurikfjellet Member was published by Bjærke (1978). He divided the Rurikfjellet Member into two assemblage zones of Valanginian and Valanginian–Hauterivian age. He concluded that, in general, the dinoflagellate assemblages from the Rurikfjellet Member are similar to those recorded from the Berriasian, Valanginian and Hauterivian deposits of NW Europe and Arctic Canada.

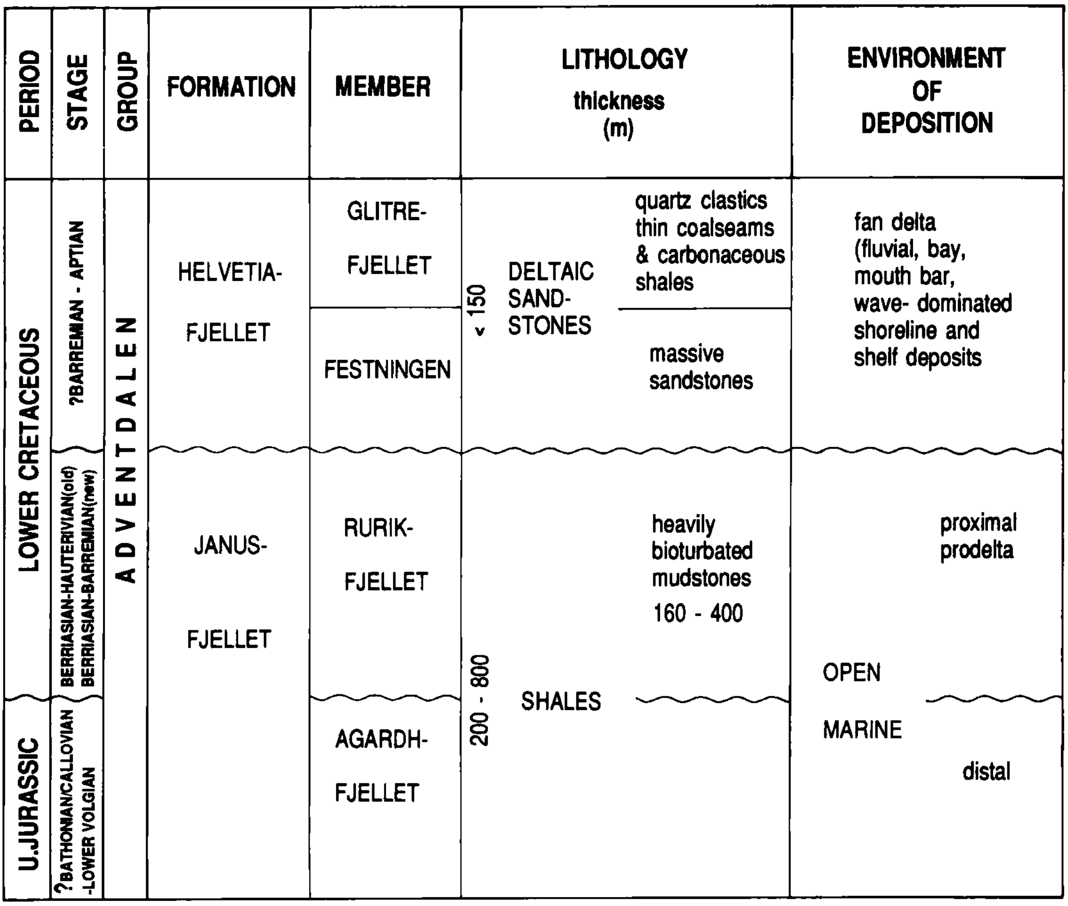


Fig. 2. Stratigraphy of the Janusfjellet and Helvetiafjellet formations.

Due to the absence of marine fossils, an accurate dating of the continental Helvetiafjellet Formation has not been possible. Plant macrofossils collected by Pchelina (1965a) are closely similar to assemblages from Siberia which are assigned a Late Valanginian–Barremian age. A Barremian age is also suggested indirectly, the unit being younger than the Late Hauterivian Rurikfjellet Member below and older than the Aptian Carolinefjellet Formation above.

Discussion

A total of sixty-two samples were examined palynologically. Forty-eight dinoflagellate cyst and three acritarch taxa were recorded (Table 1). The nomenclature follows Lentin & Williams (1989).

Most of the species recorded have long stratigraphic ranges and only a few species proved useful for dating in the uppermost part of the Rurikfjellet Member (Fig. 3). The selected marker species are *Gardodinium ordinale* (Fig. 4, A–C), *Nelchinopsis kostromiensis* (Fig 4, G), ?*Nyktericysta pannosa* (Fig. 5, E–H) and *Pseudoceratium polymorphum* (Fig. 5, A–D). Some other characteristic species recorded are also illustrated in Fig. 4.

Gardodinium ordinale (Fig. 4, A–C) has previously been recorded from Middle to Late Barremian of the Speeton Clay, England (Davey 1974). The previous record of *Nelchinopsis kostromiensis* is from Lower and Upper Valanginian in the District of Mackenzie, Northern Canada (McIntyre & Brideaux 1980) and from Middle and Upper Valanginian in the Sverdrup Basin (Davies 1983). The previous record of ?*Nyktericysta pannosa* (Fig. 5, E–H) is from Middle to

Table 1. List of species.

Apteodinium spongiosum
Apteodinium sp. A of Bjærke (1978)
Avellodinium falsificum
Batioladinium longicornutum
Batioladinium radiculatum
Canninginopsis colliveri
Cassiculosphaeridia magna
Chlamydophorella largissima
Chlamydophorella sp.
Circulodinium distinctum
Cleistosphaeridium polytrichum
Cleistosphaeridium sp.
Cometodinium whitei
Cribroperidinium edwardsii
Cribroperidinium orthoceras
cf. Dioxya armata
Gardodinium ordinale
Gardodinium trabeculosum
Gochteodinia villosa
Gonyaulacysta fastigiata
Gonyaulacysta perforobtusa
Gonyaulacysta sp.
Heslertonia heslertonensis
Hystrichodinium voigtii
Hystrichosphaeridium tubiferum subsp. *brevispinum*
Hystrichosphaerina schindewolfii
Kleithriasphaeridium eoinodes
Meiourogonyaulax stoveri
Muderongia macwhaei
Muderongia simplex
Muderongia staurota
Muderongia tetracantha
Nelchinopsis kostromiensis
?Nyktericysta pannosa
Oligosphaeridium asterigerum
Oligosphaeridium complex
Pareodinia ceratophora
Pseudoceratium pelliferum
Pseudoceratium polymorphum
Rhynchodiniopsis cladophora of Bjærke (1978)
Sentusidinium verrucosum
Spiniferites ramosus
Surculosphaeridium longifurcatum
Tanyosphaeridium isocalamus
Tanyosphaeridium magneticum
Tenua hystrix
Tubotuberella rhombiformis
Organism sp. indet of Bjærke (1978, pl. 6, fig. 7)
Pterospermopsis sp.
Veryhaccium reductum
Veryhaccium sp.

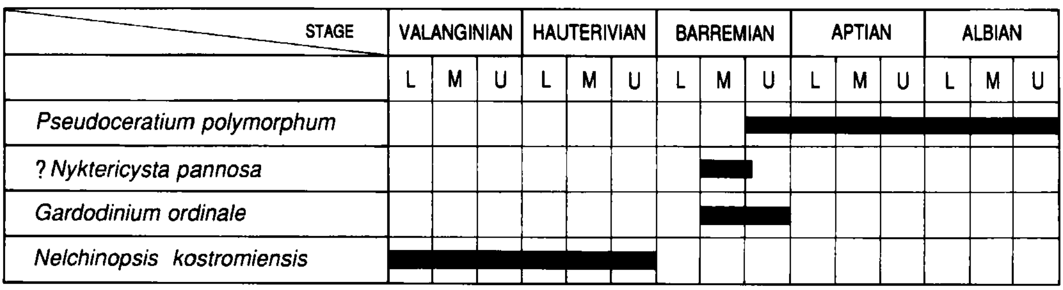
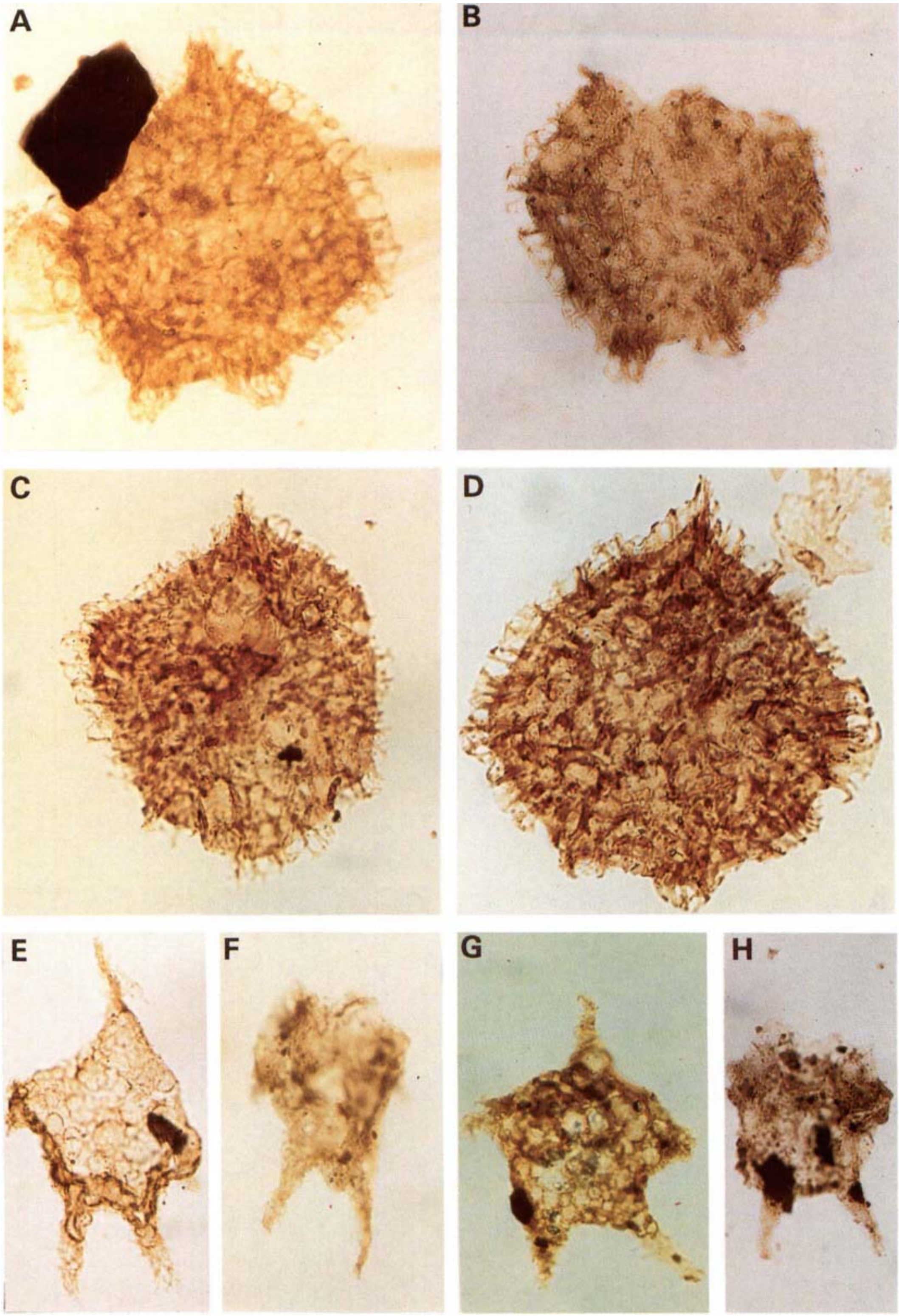


Fig. 3. Total ranges for selected age-diagnostic dinoflagellate cysts recorded from the Rurikfjellet Member. Information on ranges from Singh 1971, Pocock 1976, Bujak & Williams 1978, Eisenack 1958, Cookson & Eisenack 1960, Duxbury 1980, Davey 1974, McIntyre & Brideaux 1980, Davies 1983, and Williams & Bujak 1985.

Figs. 4 and 5. Illustrations of selected species. Standard bright field microphotographs. Magnifications × 580. Species names followed by locality-sample number (as cm below base of Helvetiafjellet Formation), slide number and England Finder coordinates. FOR = Forkastningsfjellet; BOH = Bohemanflya; JAN = Janusfjellet. Slides are housed at the Geological Survey of Norway, Trondheim.

Fig. 4. A–C. *Gardodinium ordinale*, FOR-65, FOR 2B (V50/4), dorsal view: A. high focus, showing paratabulation; B. low focus, showing ectophragm supported by distally bifurcated processes; C. low focus, showing alignment of processes just inside paraplate boundaries on precingular paraplates. D–F. *Apteodinium* sp. A of Bjærke (1978): D. JAN-4605, JAN 21A (L50/4); E, F: JAN-6180, JAN 29 (M29/3), right ventral view. E. low focus. F. high focus. G. *Nelchinopsis kostromiensis*. JAN-6180, JAN 1006 (M29/3).

Fig. 5. A–D. *Pseudoceratium polymorphum*: A. FOR-0, FOR 1A (G46/2); B. FOR-640, FOR 7B (N49/1); C. FOR-0, FOR 1B (F42/3); D. FOR-640, FOR 7A (F33/2). E–H, *?Nyktericysta pannosa*: E: FOR-203, FOR 3A (Y50/1); F. BOH/SW-304, BOH 105C (P53); G. BOH/SE-175, BOH/SE 3 (X15/3); H. BOH/SW-350, BOH 105C (H46/1).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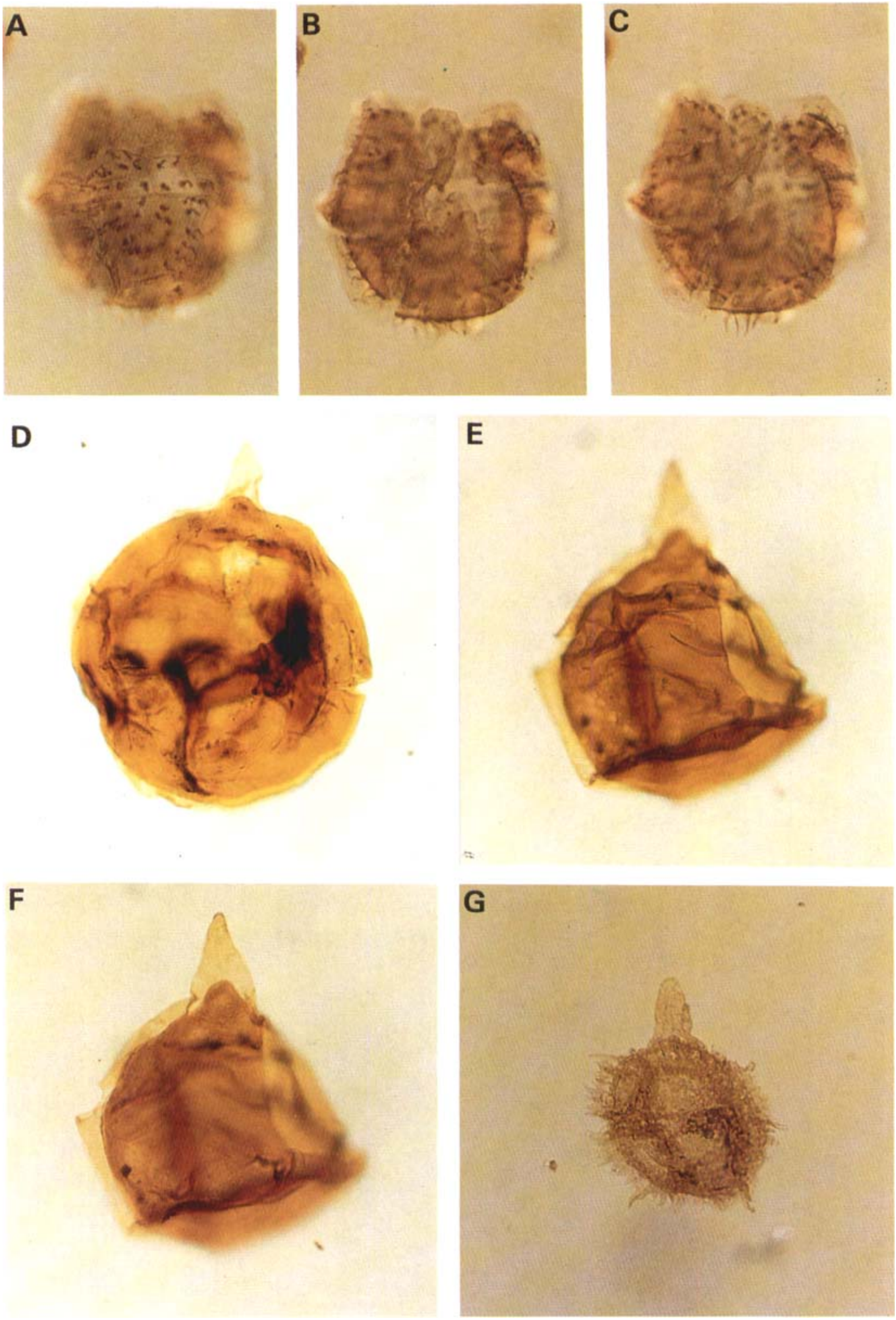
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lower Upper Barremian of the Speeton Clay, Yorkshire (Duxbury 1980). *Pseudoceratium polymorphum* (Fig. 5, A–D) has previously been recorded from Middle to Upper Albian in the Western Canadian mainland (Singh 1971); from Upper Barremian to Lower Albian in the Canadian Arctic (Pocock 1976); from Barremian to Albian in southeast of Canada (Bujak & Williams 1978); from Late Albian in North Germany (Eisenack 1958) and from Albian in Australia (Cooksom & Eisenack 1960).

At Bohemanneset SW and SE, ?*N. pannosa* and *P. polymorphum* were recorded from samples close to the base of the Helvetiafjellet Formation. A Barremian age is therefore suggested for the Upper Rurikfjellet Member at the localities in this area.

At Janusfjellet the lowermost sample is at 87.3 m b.b (below base of Helvetiafjellet Fm.). Samples cover the section between 64.8 and 10.7 m b.b. From 10.7 to 1.5 m the section is not exposed. Samples were also taken in the uppermost 1.5 m b.b. *Nelchinopsis kostromiensis* was recorded from the interval 64.8–40 m b.b. Bjærke (1978) recorded *N. kostromiensis* in the Rurikfjellet Member up to 16 m b.b. at Wimanfjellet, Knorringfjellet and Agardhfjellet. Its absence in the uppermost part of the member has been confirmed by the present study (Fig. 6). ?*Nyktericysta pannosa* and *Pseudoceratium polymorphum* are present only in the uppermost 1.5 m of the section. *N. kostromiensis* has not been recorded from sediments younger than the Hauterivian, while ?*N. pannosa* is restricted to the Barremian, and the stratigraphic range of *P. polymorphum* is Barremian-Albian (Fig. 3). This suggests that the youngest beds of the Rurikfjellet Member on Janusfjellet are of Barremian age, and that the Hauterivian/Barremian stage boundary lies somewhere between 1 and 40 m b.b.

At Forkastningsfjellet the presence of *Gardodinium ordinale* in association with ?*N. pannosa* and *P. polymorphum*, recorded in the uppermost 9 and 14.7 m b.b., respectively, confirms a Barremian age (Figs. 3 and 6).

At Helvetiafjellet SE samples from 62.2 m b.b., 16.7 to 15 m b.b. and from the upper 1 m b.b. were studied (Fig. 6). *N. kostromiensis* was recorded at 62.2 m b. b., but it is absent from the higher samples. ?*N. pannosa* and *P. polymorphum* are both present in the uppermost metre of the section. This suggests that the upper interval is Barremian and that the Hauterivian/Barremain boundary is situated between 1 and 62.2 m b.b. (Fig. 3).

None of the four indicator species are recorded from the other eight localities, where only spot samples were collected (Fig. 1), except for *P. polymorphum* which was recorded from the sediments at Innkjegla, Dalskuta and Ullaberget. The assemblages are dominated by terrestrial palynomorphs which is a characteristic feature of the upper part of the Rurikfjellet Member. Stratigraphic data from these localities can be found in Grøsfjeld (1987).

The morphologically distinct species *Apteodinium* sp. A of Bjærke (1978)* was recorded frequently during the present study. It occurs at Bohemanneset SE (13.45–11.55 m b.b.), Janusfjellet (64.8–22.5 m b.b.), Forkastningsfjellet (27.54–22.98 m b.b.), and at Helvetiafjellet SE (62.2 m b.b.) (Fig. 6). Except for single specimens recorded from two samples at Bohemanneset SE, *Apteodinium* sp. A of Bjærke (1978) was not recorded in association with species diagnostic for the Barremian. Assuming that this species is reworked at Bohemanneset SE, it may prove to be a useful marker for the Hauterivian in Spitsbergen.

In the Janusfjellet section (Fig. 6) ?*Apteodinium* sp. A has a longer range than *N. kostromiensis* (LO in Hauterivian). Therefore the LO on Spitsbergen for ?*Apteodinium* sp. A could alternatively be Barremian.

Conclusions

Based on the new evidence, the youngest beds of the Rurikfjellet Member, Janusfjellet Formation, which have previously been regarded to be of Hauterivian age, are now referred to the Barremian.

There is apparently no major time gap between the Rurikfjellet Member and the Helvetiafjellet Formation at the studied localities.

Further there is no evidence for a deeper erosion within the Rurikfjellet Member in northwest Spitsbergen compared to southeast Spitsbergen, as has been predicted by the most recent stratigraphic model. The basal surface of the Helvetiafjellet Formation represents, an important

* ?*Apteodinium* sp. A has a double wall (Fig. 5, D–F). The genus *Apteodinium* (Eisenack 1958) does not accommodate species with a double wall. A transfer of this species to another genus is therefore recommended.

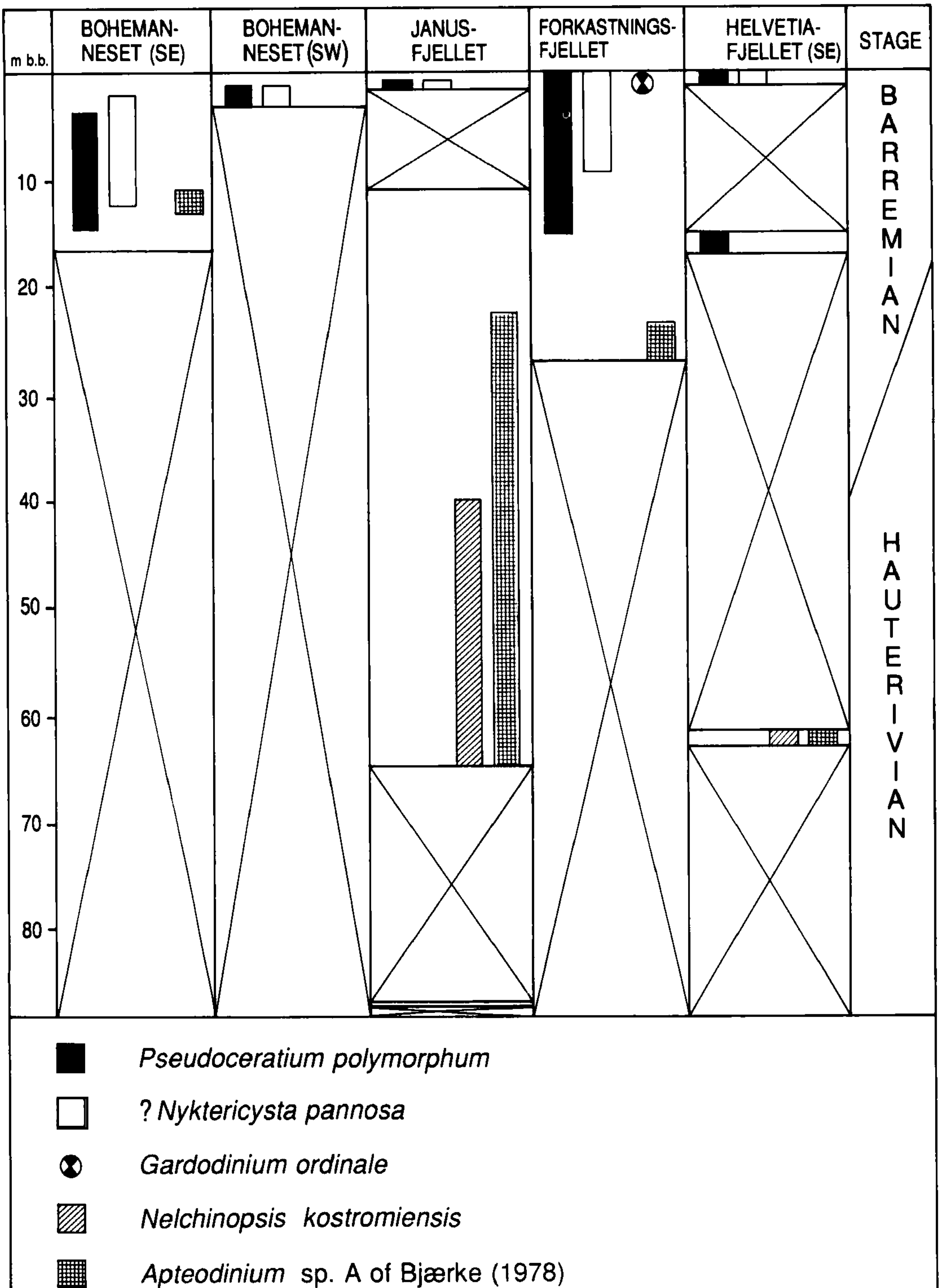

Fig. 6. Occurrences and ages of age-diagnostic dinoflagellate cysts in sections at five localities.

erosional surface as seen from sedimentological description, but no major discordance.

The regional relative sea-level fall and the postulated uplift of northwest Spitsbergen occurred at the beginning of the Barremian. Diachronism at the base of the Helvetiafjellet Formation is of only limited scale in the studied area as Barremian sediments are present in the upper part of the underlying Rurikfjellet Member.

Acknowledgements. – I am grateful to T. Bjærke, S. B. Manum and R. Steel for their helpful comments. I thank Statoil Norge A/S for providing helicopter transport during fieldwork in 1984 and Store Norske Spitsbergen Kullkompani A/S for accommodation in Longyearbyen; and I wish to thank Norsk Hydro a.s for financial assistance for a field trip to Svalbard in 1984. I am also grateful to the Geological Survey of Norway (NGU) for allowing me time to work with this paper.

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