Palynological evidence of Lower Triassic rocks subcropping offshore mid-Norway

JORUNN OS VIGRAN & GUNN MANGERUD

Vigran, J. O. & Mangerud, G.: Palynological evidence of Lower Triassic rocks subcropping offshore mid-Norway. *Norsk Geologisk Tidsskrift*, Vol. 71, pp. 29–35. Oslo 1991. ISSN 0029-196X.

An early Triassic palynomorph assemblage has been recorded in a shallow core representing the deposits of a narrow seismic unit subcropping between the Caledonian basement and the Jurassic sediments of the continental shelf off Helgeland, mid-Norway. The palynomorph assemblage is completely dominated by cavate, trilete spores assigned mostly to *Densoisporites*, *Kraeuselisporites* and *Lundbladispora*. Sporadic foraminifera test-linings suggest occasional periods of marine influence during deposition of these rocks. An additional *Lunatisporites* assemblage with marine acritarchs is recorded in one subcrop sample, while another sample contains *Vittatina* spp., reflecting Permian evidence, and indicates that Permian to lowermost Griesbachian rocks are present in the seismic unit. The material accordingly supports the idea that the oldest Triassic of the mid-Norwegian Continental Shelf was deposited under conditions similar to those occurring in East Greenland at the same time.

J. O. Vigran & G. Mangerud, Continental Shelf and Petroleum Technology Research Institute (IKU), N-7034 Trondheim, Norway.

This paper presents some of the palynological results obtained during a mapping project which involved the collection of about 90 subcrop samples and the drilling of 14 shallow boreholes on the continental shelf off Helgeland during 1981 and 1982. Prior to this, IKU carried out extensive seismic surveys in the area, resulting in a subcrop map for eleven seismic units of early Triassic to Tertiary age (Bugge et al. 1984). Detailed biostratigraphy of the mid-Norwegian shelf has so far only been published for the Cretaceous and Jurassic (Van der Zwan 1990; Århus et al. 1986, 1989). The Triassic rocks of seismic unit II (Fig. 1) (Bugge et al. 1984) outcrop in a narrow zone off north Helgeland between the Caledonian basement of the mainland and Jurassic seismic unit III with a characteristically layered seismic signature.

Since exploration drilling started on the mid-Norwegian shelf in 1980, only a small number of wells have been drilled through rocks attributed a Lower Triassic age. Only one well has penetrated Paleozoic rocks (Cohen & Dunn 1987). The pre-Triassic stratigraphy of the area is therefore poorly known, and a standard lithostratigraphic nomenclature has yet to be established for Triassic and older sediments on the mid-Norwegian shelf.

Rocks of Middle and Late Triassic age from the continental shelf off Helgeland have been discussed by Fagerland (1990) and Hagevang & Rønnevik (1986). Jacobsen & van Veen (1984) compared these rocks with the development of the Mesozoic succession in East Greenland. This resemblance is discussed by other authors for Late Permian prospects in East Greenland and their implications for the mid-Norwegian shelf (e.g. Surlyk et al. 1986). With the exception of two halite layers that are thought to reflect a mid-Triassic marine transgression on the mid-Norwegian shelf, it is not clear whether more marine Triassic deposits occur to the east of the Atlantic rift (Bukovics & Ziegler 1985). The purpose of this paper is therefore to: (1) describe the recognized Early Triassic palynological assemblages from the continental shelf off Helgeland, and discuss their ages, (2) correlate with the better known deposits from East Greenland and the Barents Sea area, (3) discuss the depositional environment with regard to marine influence.

Material

Core IKU82-2 penetrated the middle part of seismic unit II (Fig. 1), the exact drilling position being 65° 59′ 16″N/ 11° 23′ 41.6″E. The bedrock at this location has a thin (4.1 m) Quaternary cover. The core extended 23.64 m below the seabed and sampled a succession of homogeneous, well-consolidated grey to greenish claystone with thin siltstone and sandstone laminae. The sediment shows no evidence of bioturbation and apparently contains no macrofossils. The similar mineralogies of the cored bedrock and the overlying Quaternary clays suggest local reworking of the bedrock into the glacial sediment (Bugge et al. 1984).

Subcrop samples (B82-107/3 and B82-131/2) were collected from seismic unit II to the north of core IKU82-2 (Fig. 1) with the use of a gravity corer and grab. The samples consist of clasts of laminated claystone within an over-consolidated basal till. The till is only a few metres thick and shows evidences of derivation from local bedrock. Based on a very good agreement between the seismic interpretation and the dating, lithology, etc., of the 90 seabed samples and the 14 shallow drillings, the

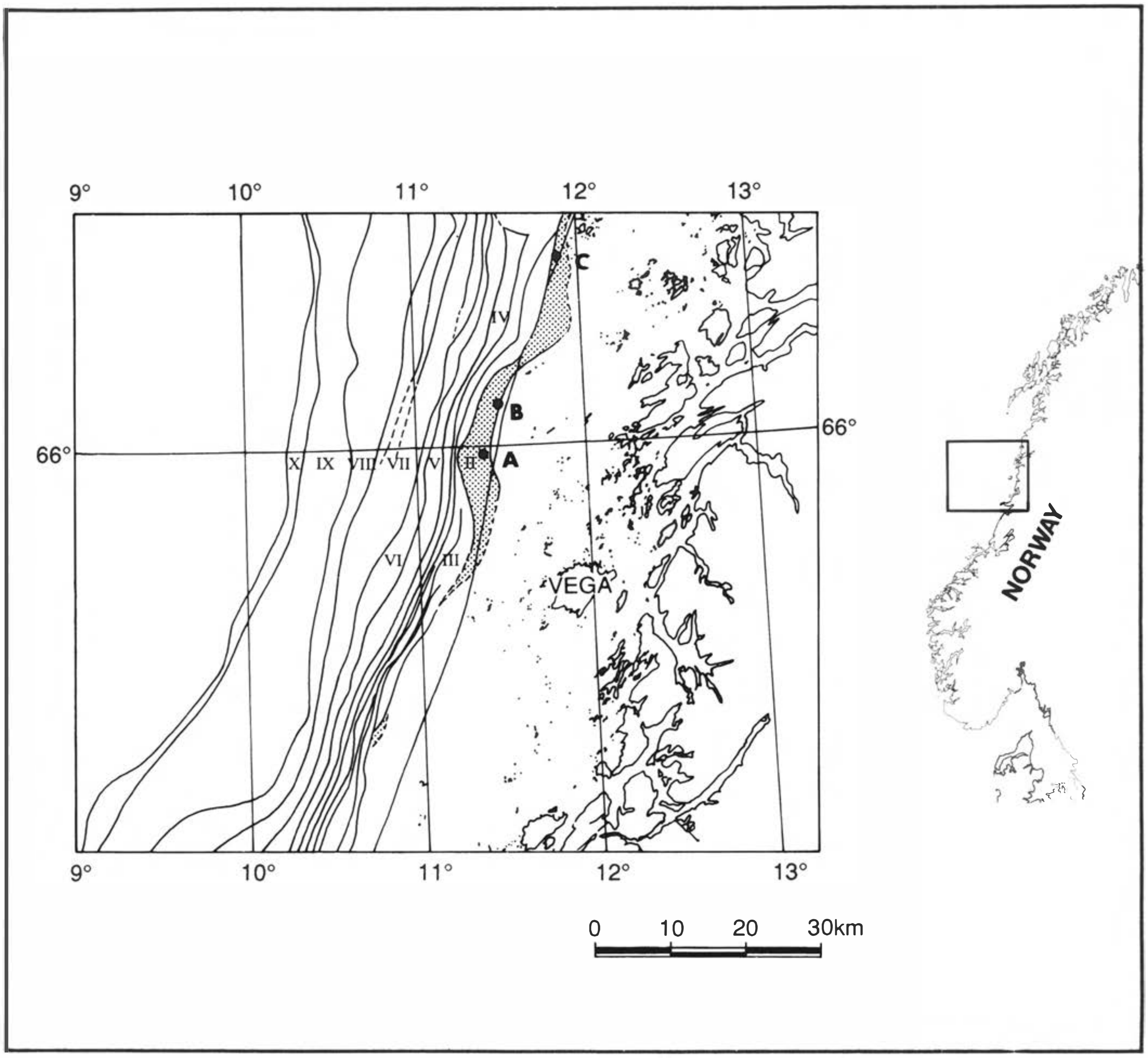

Fig. 1. Bedrock map showing the seismic units subcropping below the Quaternary cover off the coast of Helgeland, mid-Norway. The location of core IKU82-2 and the two seabed samples B82-107/3 and B82-131/2 are marked as A, B, C respectively. Roman numerals indicate seismic units – X: Pliocene, IX: Oligocene, VIII: Eocene, VII: Paleocene/Eocene, VI: Paleocene, V: Cretaceous, IV: Late Jurassic/Early Cretaceous, III: Jurassic, II: Triassic.

classification of the seabed samples has proven reliable. From similar evaluation of the two samples presently analysed, the clasts are interpreted to represent the local bedrock. Knowing that the glaciers generally moved northwestwards in this area (Andersen et al. 1982) and that the seismic unit II extends up to 5 km farther to the east, we feel confident that the clasts were derived from the bedrock of seismic unit II.

Palynological assemblages

Cavate, mostly trilete, spores completely dominate the samples of core IKU82-2. The assemblage (Fig. 3, A–L, Fig. 4, J–L) is also confirmed from several subcrop samples in the same area which are not discussed in this paper. The organic content is low, but despite this preservation is fairly good. The *Densoisporites* group, comprised mainly of *D. playfordii* (Balme) Dettmann 1963, accounts for 60–80% of the total assemblage (at the 19.48 m and 23.63 m levels). The associated forms of the assemblage include *Kraeuselisporites hystrix* Visscher 1966, *K. apiculatus* Jansonius 1962, *K. cuspidus* Balme 1970, *Lundbladispora obsoleta* Balme 1970, *Lapposisporites* sp., *Pechorosporites* sp. cf. *P. intermedius* Yaroshenko & Golubeva 1989, *Perotrilites* sp., *Verrucosisporites* sp., *Dictyotriletes* sp., *Deltoidospora* spp. and *Calamospora* sp. Monolete, cavate spores including *Aratrisporites tenuispinosus* Playford 1965 and *A. scabratus* Klaus 1964 are also fairly common. Some alete

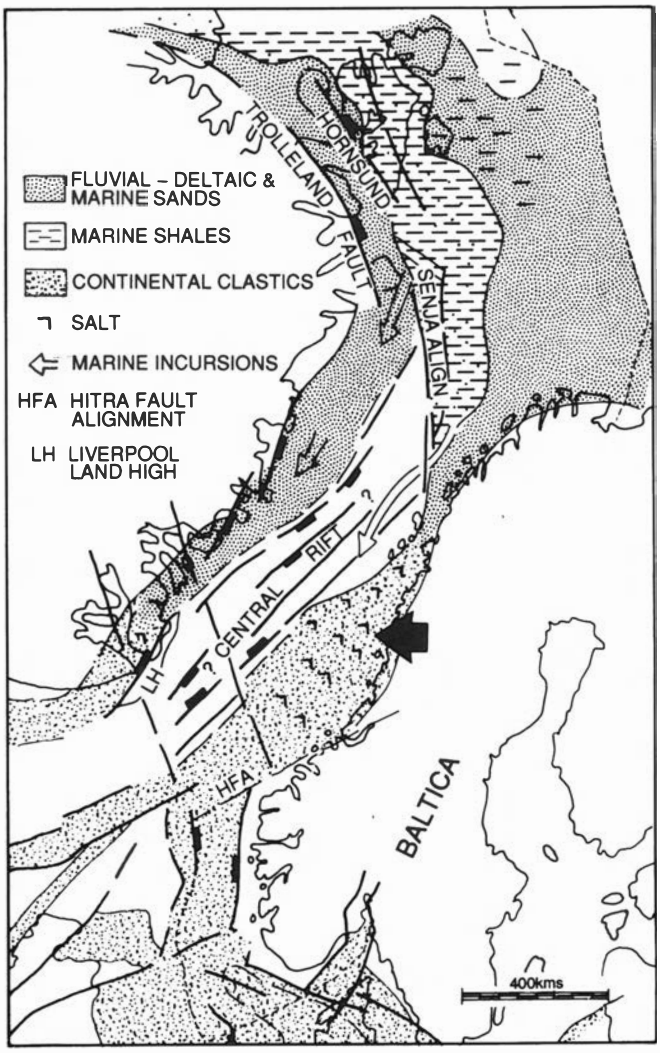

Fig. 2. Reconstruction of the Early/Late Triassic palaeogeography (from Gage & Doré 1986), with arrow indicating study area.

bisaccate pollen assigned to *Alisporites* spp. and a few taeniate pollen (*Lunatisporites noviaulensis* (Leschik) Scheuring 1970, *L. pellucidus* (Goubin) Balme 1970) are present, together with a few foraminifera test-linings. In general, terrestrial plant material, including spores, a few cuticles and rare tracheids, dominates the organic matter in the samples from this core. In addition, common structureless sheets are present and probably represent blue green algae.

The assemblage of sample B82-131/2 (20–0 cm) contains dominantly pollen assigned to *Lunatisporites* spp., *L. acutus* (Leschik) Scheuring 1970, *L. noviaulensis*, and *L. pellucidus* (Fig. 4, A–E, G). The spores include *Acanthotriletes* sp., *Kraeuselisporites* sp., *Pechorosporites intermedius* and cf. *Proprisporites* sp. Most specimens are too poorly preserved for confident identification to species level. The association is comparable to that reported by Balme (1980) and Piasecki (1984) from East Greenland.

Poorly preserved terrestrial debris dominates the organic matter from sample B82-107/3 (113–103 cm). A few specimens of pollen are present which can be assigned to *Vittatina* spp., *V. striata* (Luber) Jansonius 1962, *V. subsaccata* Samoilovich 1953, *Lunatisporites* sp. and *Protohaploxypinus* sp. (Fig. 4, F, H–I). Both the association and its preservation differ from the assemblages of core IKU82-2 and sample B82-131/2.

Discussion

The palynological assemblages from the continental shelf off Helgeland are dominated by cavate spores, and similar associations have been well described from Lower Triassic rocks occurring in various parts of the world (Balme 1963, 1970, 1980; Visscher 1971; Balme & Helby 1973; Dolby & Balme 1976; Piasecki 1984; Pavlov et al. 1985). Trilete, cavate spores have a botanical affinity particularly with the *Pleuromeia* group of the Lycopodiales (Balme 1970). This indicates that the palynological assemblage from core IKU82-2 is part of a globally well-developed vegetation.

The abundance of *Densoisporites playfordii*, a species which becomes extinct at the end of the Smithian in the Barents Sea area (Hochuli et al. 1989), is taken as evidence of a Smithian or older age for the sediments penetrated by core IKU82-2. The common occurrence

Fig. 3. Magnification ×500. Each figured palynomorph is located by IKU sample and references, followed by slide coordinates according to an England Finder. The slides are curated by the Palaeontological Museum, University of Oslo, PMO 121.511–121.514. A. *Densoisporites playfordii:* IKU82-02. 23.63 m x, PMO 121.511, P26/2. B. *Lundbladispora obsoleta:* IKU82-02, 19.48 m x_2, PMO 121.512, T28. C. *Perotrilites* sp.: IKU82-02, 19.48 m x_2, PMO 121.512, E13. D. *Deltoidospora* sp.: IKU82-02, 19.48 m x_2, PMO 121.512, H18/1. E. *Lundbladispora* cf. *obsoleta*: IKU82-02, 19.48 m x_2, PMO 121.512, S22/2. F. *Densoisporites nejburgii*: IKU82-02, 19.48 m x_2, PMO 121.512, L24/1. G. *Pechorosporites* sp. cf. *P. intermedius*: IKU82-02, 19.48 m x_2, PMO 121.512, F31/1. H. *Pechorosporites* sp. cf. *P. intermedius*: IKU82-02, 23.63 m x, PMO 121.511, Y32/1. I. *Densoisporites playfordii*: IKU82-02, 23.63 m x, PMO 121.511, T32/3. J. *Kraeuselisporites cuspidus*: IKU82-02, 23.63 m x, PMO 121.511, H30/4. K. *Aratrisporites tenuispinosus*: IKU82-02, 19.48 m x_2, PMO 121.512, H16/1. L. *Densoisporites playfordii*: IKU82-02, 19.48 m x_2, PMO 121.512, S20/2.

Fig. 4. Magnification ×500. Each figured palynomorph is located by the IKU sample and references, followed by slide coordinates according to an England Finder. The slides are curated by the Palaeontological Museum, University of Oslo, PMO 121.511–121.514. A. *Lunatisporites noviaulensis* and foraminifera test-lining: B82-131/2A, 20-0 cm x, PMO 121.513, X23/2. B. *Proprisporites* spp.: B82-131/2A, 20-0 cm x, PMO 121.513, Y22. C. *Endosporites papillatus*: B82-131/2A, 20-0 cm x, PMO 121.513, G35/1. D. *Lunatisporites* sp. cf. *L. acutus*: B82-131/2A, 20-0 cm x, PMO 121.513, X24/2. E. *Converrucosisporites* sp.: B82-131/2A, 20-0 cm x, PMO 121.513, Z31/4. F. *Vittatina striata*: B82-107/3A, 113–103 cm x_2, PMO 121.514, H18. G. *Lunatisporites* sp. cf. *L. acutus* (detached bladders): B82-131/2A, 20-0 cm x, PMO 121.513, V23. H. *Vittatina* sp.: B82-107/3A, 113–103 cm x_2, PMO 121.514, E31. I. *Vittatina* sp.: B82-107/3A, 113–103 cm x_2, PMO 121.514, E30/3. J. Unidentified ?pollen: IKU82-02, 23.63 m x, PMO 121.511, X13/4. K. *Veryhachium* sp. and unidentified ?Algal/Faunal remain: IKU82-02, 23.63 m x, PMO 121.511, O32/4. L. Foraminifera test-lining IKU82-02, 23.63 m x, PMO 121.511, U39/2.

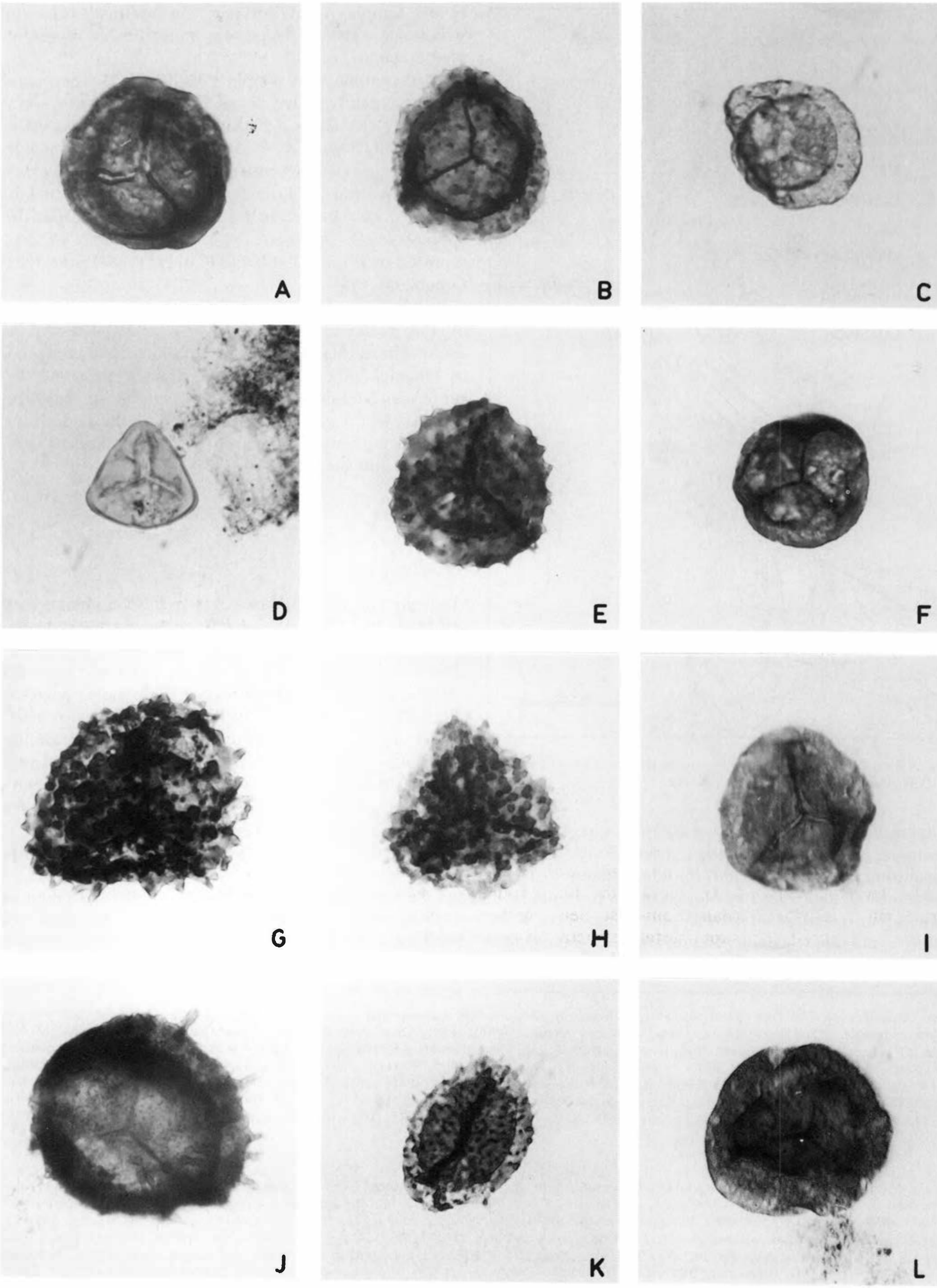

Fig. 3.

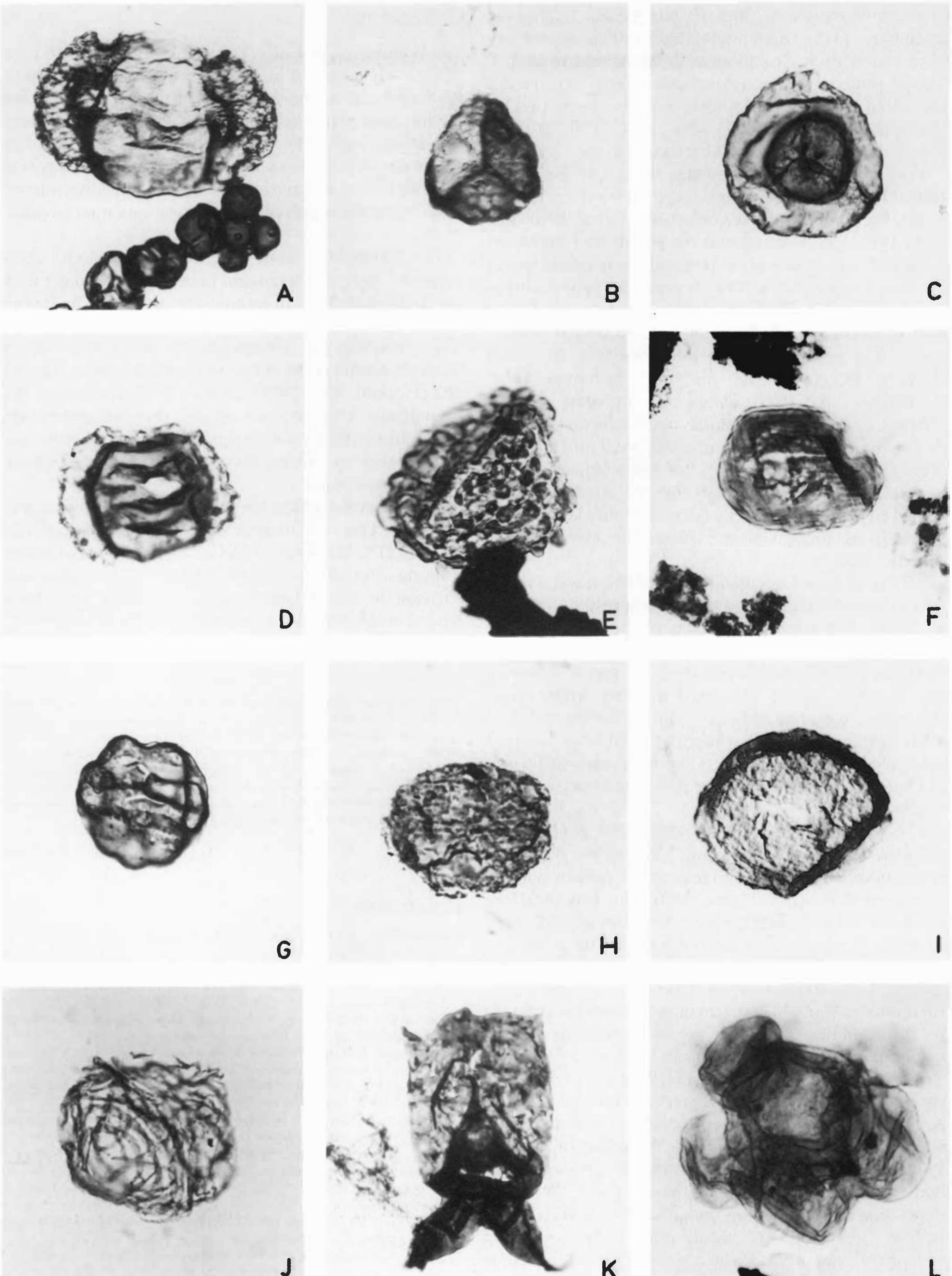

Fig. 4.

of *Pechorosporites* sp. and *P. intermedius* relates the assemblage to the ammonoid-dated Smithian assemblage from the Barents Sea (Vigran & Mangerud in prep.). The presence of common *Aratrisporites* spp., a genus not recovered from the Griesbachian assemblages of East Greenland (Balme 1980; Piasecki 1984, 1990), is interpreted as indicating a post-Griesbachian age.

The *Lunatisporites* assemblage in sample B82-131/2 resembles the Griesbachian association from the Wordie Creek Formation in East Greenland (Balme 1980; Piasecki 1984). Taeniate, bisaccate pollen and acritarchs dominate parts of this formation and trilete cavate spores are rare (Balme 1980). Very few marine palynomorphs were recorded by Piasecki (1984, 1990) in equivalent Early Griesbachian beds despite the presence of macrofossils. The presence of sparse foraminifera test-linings in core IKU82-2, and the rare acritarchs (*Micrhystridium* sp., *Veryhachium* sp.) in some subcrop samples, indicate that sporadic marine incursions must also have occurred on the continental shelf off Helgeland (Fig. 2). To date, no macro- nor microfauna has been recorded from Triassic beds in this area, although reworked Triassic ostracods (pers. comm., 1983 Magne Løfaldli) are present in the Quaternary clay overlying core IKU82-2.

Rifting in East Greenland during the earliest Triassic led to fault-bounded basins being transgressed (Surlyk et al. 1986). The resulting deposits of the Wordie Creek Formation contain a boreal ammonoid fauna (Grasmück & Trümpy 1969) which forms the basis for an ammonite zonation that can be correlated to other Arctic areas. Our palynological assemblages from the continental shelf off Helgeland suggest that brackish conditions occurred sporadically over limited areas during the earliest Triassic and supplied the deposits with microplankton, including foraminifera.

The assemblage recorded in sample B82-107/3, which includes specimens of the genus *Vittatina* generally represent Permian evidence and resembles Permian material from East Greenland (Balme 1980). This may therefore represent palynological evidence of Permian rocks subcropping in areas within seismic unit II. The genus *Vittatina* is also sometimes present in basal Triassic beds (Balme 1980; Piasecki 1984; Hochuli et al. 1989) and therefore an Early Griesbachian age cannot be excluded for the assemblage. We interpret the sparse palynological evidence outlined above to indicate Later Permian–Early Triassic deposition in fault-bounded small basins on the continental shelf off Helgeland as suggested by Hagevang & Rønnevik (1986). The episode of crustal extension which led to the transgression of Arctic seas in the Late Permian, as suggested by Bukovics & Ziegler (1985) and Surlyk et al. (1986), may have resulted in similar depositional conditions on the mid-Norwegian shelf and in East Greenland. This would result in the deposition of Upper Permian rocks which later became more deeply buried on the mid-Norwegian shelf, but with the same character as those in East Greenland.

Conclusion

The dominance of Early Triassic cavate spores in core IKU82-2 is regarded as evidence of close proximity to vegetation during the deposition of the sediments within the southern part of seismic unit II. The few foraminifera test-linings, acritarchs and abundant (? blue green) algal sheets are, in relation to negative parameters such as lack of bioturbation and macrofossils, interpreted as evidence of occasional brackish conditions in an estuarine environment.

The assemblage from core IKU82-2 includes *Aratrisporites* spp., and is thought to be slightly younger than the Early Griesbachian assemblages described by Balme (1980) and Piasecki (1984, 1990) from East Greenland. The presence of *Densoisporites playfordii*, which becomes extinct at the end of the Smithian in the Barents Sea (Hochuli et al. 1989), defines minimum age for the assemblage. Therefore we suggest that the assemblage may range from Late Griesbachian to Smithian in age, the younger age being favoured in view of common *Aratrisporites* spp.

The palynomorphs in the two subcrop samples suggest that older Triassic (Griesbachian) beds occur within seismic unit II to the north of IKU82-2. The *Vittatina* pollen from claystone clasts of sample IKU82-107/3 suggest that Permian or oldest Griesbachian sediments have been eroded in this part of the continental shelf off Helgeland, Norway.

Acknowledgements. – We acknowledge funding from twenty oil companies regarding the initial sampling and drilling projects in Helgeland. The previous seismic surveys were funded by IKU and NTNF. We are also indebted to the IKU staff for their assistance during the preparation of this paper. We are in particular grateful to Tom Bugge and Jan Einar Ringås for discussions of the manuscript, and to our referees Stefan Piasecki and David Renshaw for their comments and suggestions for improvements. Leslie Leith kindly improved the final manuscript. Finally we thank IKU for financial support of the publication.

Manuscript received November 1990

References

Andersen, B. G., Bøen, F., Rasmussen, A., Rokoengen, K. & Vallevik, P. N. 1982: The Tjøtta glacial event in southern Nordland, North Norway. *Norsk Geologisk Tidsskrift 62*, 39–49.

Balme, B. E. 1963: Plant microfossils from the Lower Triassic of Western Australia. *Palaeontology 6(1)*, 12–40.

Balme, B. E. 1970: Palynology of Permian and Triassic strata in the Salt Range and Surghar Range, West Pakistan. *In* Kummel, B. & Teichert, C. (eds.): Stratigraphic Boundary Problems: Permian and Triassic of West Pakistan. *University of Kansas Department of Geology Special Publication 4*, 305–453.

Balme, B. E. 1980: Palynology of Permian–Triassic Boundary beds at Kap Stosch, East Greenland. *Meddelelser om Grønland 200(6)*, 1–37.

Balme, B. E. & Helby, R. J. 1973: Floral modifications at the Permian–Triassic boundary in Australia. *Canadian Petroleum Geology Bulletin 21*, 433–444.

Bugge, T., Knarud, R. & Mørk, A. 1984: Bedrock geology on the mid-Norwegian continental shelf. *In* Spencer, A. M. et al. (eds.): *Petroleum Geology of the North European Margin*, 271–282. Norwegian Petroleum Society. Graham & Trotman, London.

Bukovics, C. & Ziegler, P. A. 1985: Tectonic development of the Mid-Norway continental margin. *Marine Petroleum Geology 2*, 1–22.

Cohen, M. J. & Dunn, M. E. 1987: The hydrocarbon habitat of the Haltenbank–Trænabank area offshore Mid-Norway. *In* Brooks, J. & Glennie, K. (eds.): *Petroleum Geology of North West Europe*, 1091–1104. Graham & Trotman, London.

Dalland, A., Worsley, D. & Ofstad, K. (eds.) 1988: A lithostratigraphic scheme for the Mesozoic and Cenozoic succession offshore mid- and northern Norway. *NPD-bulletin 4*, 65 pp. ISBN 82-7257-304-0.

Dolby, H. J. & Balme, B. E. 1976: Triassic palynology of the Carnarvon Basin, Western Australia. *Review of Palaeobotany and Palynology 22*, 105–168.

Fagerland, N. 1990: Mid-Norway shelf – hydrocarbon habitat in relation to tectonic elements. *Norsk Geologisk Tidsskrift 70*, 65–79.

Gage, M. S. & Doré, A. G. 1986: A regional geological perspective of the Norwegian offshore exploration provinces. *In* Spencer, A. M. et al. (eds.): *Habitat of Hydrocarbons on the Norwegian Continental Shelf*, 21–38. Norwegian Petroleum Society, Graham & Trotman, London.

Grasmück, K. & Trümpy, R. 1969: Triassic stratigraphy and general geology of the country around Flemming Fjord (East Greenland). *Meddelelser om Grønland 168(2)*, 5–71.

Hagevang, H. & Rønnevik, H. 1986: Basin development and hydrocarbon occurrence offshore mid-Norway. *In* Halbouty, M. T. (ed.): Future petroleum provinces of the world. *American Association of Petroleum Geologists Memoir 40,* 599–613.

Hochuli, P. A., Colin, J. P. & Vigran, J. O. 1989: Triassic biostratigraphy of the Barents Sea area. *In* Collinson, J. D. (ed.): *Correlation in Hydrocarbon Exploration*, 131–153. Norwegian Petroleum Society, Graham & Trotman, London.

Jacobsen, V. W. & van Veen, P. 1984: The Triassic offshore Norway north of 62°N. *In* Spencer, A. M. et al. (eds.): *Petroleum Geology of the North European Margin*, 317–327. Norwegian Petroleum Society, Graham & Trotman, London.

Pavlov, V. V., Fefilova, L. A. & Lodkina, L. B. 1985: Palynological characterization of the Mesozoic deposits of the Southern Barents Sea Shelf. *In* Vasilevskaya (ed.): Stratigrafiya Mesozoyskikh osadochnykh basseynov severa SSSR, 88–103. PGO Sevmorgeologiya, Leningrad (transl. R. Sorkina 1989).

Piasecki S. 1984: Preliminary palynostratigraphy of the Permian-Lower Triassic sediments in Jameson Land and Scoresby Land, East Greenland. *Geological Society of Denmark Bulletin 32*, 139–144.

Piasecki, S. 1990: Biostratigraphy the 'grey' interval from the Permian to the Triassic in East Greenland. In: *International Symposium to Celebrate 25 Years of Palynology in the North Sea Basin*. British Geological Survey, Nottingham, England 1990 (Abstract).

Surlyk, F., Hurst, J. M., Piasecki, S., Rolle, F., Scholle, P. A., Stemmerik, L. & Thomsen, E. 1986: The Permian of the western margin of the Greenland Sea – A future exploration target. *American Association of Petroleum Geologists Memoir 40*, 629–659.

Van der Zwan, C. J. 1990: Palynostratigraphy and palynofacies reconstruction of the Upper Jurassic to Lowermost Cretaceous of the Draugen Field, offshore Mid Norway. *Review of Palaeobotany and Palynology 62*, 157–186.

Vigran, J. O. & Mangerud, G.: Palynostratigraphy of Lower and Middle Triassic deposits near the Svalis Dome, Central Barents Sea. In prep.

Visscher, H. 1971: The Permian and Triassic of the Kingscourt Outlier, Ireland. A palynological investigation related to regional stratigraphical problems in the Permian and Triassic of Western Europe. *Geological Survey of Ireland, Special paper 1*, 114 pp.

Århus, N., Birkelund, T. & Smelror, M. 1989: Biostratigraphy of some Callovian and Oxfordian cores off Vega, Helgeland, Norway. *Norsk Geologisk Tidsskrift 69,* 39–56.

Århus, N., Verdenius, J. G. & Birkelund, T. 1986: Biostratigraphy of a Lower Cretaceous section from Sklinnabanken, Norway, with some comments on the Andøya exposure. *Norsk Geologisk Tidsskrift 66*, 17–43.