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The First Appearance Datum (FAD) of *Heterosphaeridium difficile* (Manum & Cookson), dinoflagellata, in clastic deposits offshore Norway

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INTRODUCTION

Thick sequences of clastic deposits of Late Cretaceous age (1000–1500 m) are present offshore mid and north Norway. Dinoflagellate assemblages from these deposits have arctic affinities and are dominated by species of *Chatangiella*, *Trithyrodinium* and *Isabelidinium*. The First Appearance Datum (FAD) of *Heterosphaeridium difficile* is an important correlation point within this sequence and is equated with a Turonian age in most current zonal schemes. Our observations on the relative ranges of *H. difficile*, members of the *Endoceratium dettmanniae–E. ludbrookiae* plexus and other key index species in well materials offshore mid and north Norway are not consistent with ranges documented from European stratotypes and suggest a Cenomanian age for the correlation point. This note is intended as a basis for discussion pending a more detailed account of these deposits.

OBSERVATIONS

Three released offshore wells with good control from sidewall and core samples were selected for study. All of the well sections produced rich typical middle Cretaceous dinocyst assemblages with common *H. difficile*. At some levels typical forms of *H. difficile* with discrete processes intergrade with morphotypes having shorter, wider, coalescing processes, probably related to species in the *Cyclonephelium membraniphorum* complex. As recognized here, *H. difficile* is restricted to forms similar to the holotype, with discrete processes. Species of *Endoceratium* are present consistently in the lower part of the *H. difficile* range zone. There is gradation between forms close to *E. dettmanniae* and *E. ludbrookiae* to reticulate forms similar to *E. turneri*.

Well 35/3-5 is located about 190 km NNW of Bergen in the North Sea. *H. difficile* occurs in sidewall cores down to 2896 m and is associated with *E. dettmanniae* and *E.* cf *turneri* in sidewall cores between 2733 and 2896 m. Well 7119/7-1 is located 200 km N of Tromsø in the Barents Sea. *E. dettmanniae* occurs from 2529.5 m and co-occurs with *H. difficile* in sidewalls between 2529.5 m and 2654.0 m. The lower part of the *H. difficile* range zone in this well is also associated with *Batioladinium jaegeri*. *Cauca parva* occurs at 2654 m. Well 6507/7-1 is in the mid-Norway exploration area about 275 km NW of Trondheim. A thick Cenomanian–Turonian sequence is present. *H. difficile* occurs in sidewall and core samples down to 3506 m; *E. dettmanniae* and *B. jaegeri* occur in samples downhole from 3131 m and 3239 m, respectively. The planktonic foraminifera *Hedbergella delrioensis* is present from 3419 m and is common at 3464 m. *Hedbergella planispira* is present at 3479 m. These foraminifera are typically, but not exclusively associated with Cenomanian deposits.

DISCUSSION

Costa & Davey (1992) in a critical review of (mainly British) Cretaceous dinoflagellate data indicate mutually exclusive ranges for *H. difficile* and *E. dettmanniae*. The FAD of *H. difficile* is given as Early Turonian and the Last Occurrence Datum (LOD) of *E. dettmanniae* within the Late Cenomanian. The widespread occurrence of the *H. difficile–E. dettmanniae* assemblage in these and other wells on the Norwegian shelf is taken to imply that the assemblage is *in situ* and the records documented above are not therefore consistent with the accepted ranges of these species. A consideration of the actual data on the occurrence of *H. difficile* in English and French Turonian deposits, as documented by Tocher & Jarvis (1987), (1995), Jarvis *et al.* (1988), Foucher (1981) and others shows the distribution to be erratic and it is not a consistent marker for the Turonian of these areas. In Norwegian arctic deposits *H. difficile* is common and regular throughout its range. These differences are thought to be due, at least in part, to dinoflagellate provincialism though other factors may also be involved.

Outside of Western Europe, Chlonova (1996), commenting on provincialism in Late Cretaceous assemblages from Western Siberia, notes that they differ markedly from Western Europe and that there are variations in species abundance and apparent range from area to area, though no details are given. In Western Greenland (Nøhr-Hansen, 1996, & pers. comm., 1996) the oldest relevant deposits investigated are of Coniacian or possibly Late Turonian age and the FAD of *H. difficile* has not been located. Norvick & Burger (1976) documented assemblages from two Cenomanian sections from Bathurst Island, Northern Territory, Australia. These sections include *H. difficile*, *Endoceratium* spp., *B. jaegeri* and *Litosphaeridium siphoniphorum*. The chronostratigraphy is well documented. Kennedy (1970) indicated a mid-Cenomanian age for ammonites from an adjacent cliff section and Burger (pers. comm. 1996) notes that an ammonite from the same fauna was recovered from the sample containing the lowermost record of *H. difficile*. Planktonic foraminifera indicate an Early to mid-Cenomanian age for the lower part of the cored sections (Norvick & Burger, 1976, p.5).

CONCLUSIONS

A concurrent range zone defined by the FAD of *H. difficile* and the LOD of *E. dettmanniae* is widely recognizable in wells from the Norwegian shelf. Evidence from the Australian stratotype suggests that this zone is of Early to mid-Cenomanian age and that the FAD of *H. difficile* in a continuous section should probably be considered as close to the Early to mid-Cenomanian boundary. This may be of some significance to the regional model as potential hydrocarbon reservoir horizons are present around the *H. difficile* FAD level.

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