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Research paper

A magnetostratigraphic calibration of Middle Miocene through Pliocene dinoflagellate cyst and acritarch events in the Iceland Sea (Ocean Drilling Program Hole 907A)

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ABSTRACT

A detailed dinoflagellate cyst investigation of the almost continuous Middle Miocene through Pliocene of Ocean Drilling Program Hole 907A in the Iceland Sea has been conducted at 100-kyr resolution. The investigated section is well constrained by magnetostratigraphy, providing for the first time an independent temporal control on a succession of northern high-latitude dinoflagellate cyst bioevents.

Based on the highest/lowest occurrences (HO/LO) and highest common occurrence (HCO) of 20 dinoflagellate cyst taxa and one acritarch species, 26 bioevents have been defined and compared with those recorded at selected DSDP, ODP, and IODP sites from the North Atlantic and contiguous seas, and in outcrops and boreholes from the onshore and offshore eastern U.S.A., and the North Sea and Mediterranean basins.

Comparisons reveal near-synchronous HOs of the dinoflagellate cysts *Batiacasphaera micropapillata* (3.8–3.4 Ma, mid-Pliocene) and *Reticulatosphaera actinocoronata* (4.8–4.2 Ma, Lower Pliocene) across the Nordic Seas and North Atlantic, highlighting their value on a supraregional scale. This probably applies also to *Hystrichosphaeropsis obscura* (upper Tortonian), when excluding ODP Hole 907A where its sporadic upper stratigraphic range presumably relates to cooling in the early Tortonian. Over a broader time span within the upper Tortonian, the HO of *Operculodinium piaseckii* likely also permits correlation across the Nordic Seas and North Atlantic, and the HO of *Labyrinthodinium truncatum* appears useful in the Labrador and Nordic Seas. Biostratigraphic markers useful for regional rather than supraregional correlation are the HOs of *Batiacasphaera hirsuta* (c. 8.4 Ma, upper Tortonian) and *Unipontidinium aquaeductus* (c. 13.6–13.9 Ma, upper Langhian), the HCO of the acritarch *Decahedrella martinheadii* (c. 6.7–6.3 Ma, Messinian), and possibly the LO of *Cerebrocysta irregulare* sp. nov. (c. 13.8 Ma, uppermost Langhian) across the Nordic Seas. Since *Habibacysta tectata*, *B. micropapillata*, *R. actinocoronata* and *D. martinheadii* have been observed in the Arctic Ocean, they are potentially useful for high latitude correlations in the polar domain.

The LOs of *Habibacysta tectata* and *Unipontidinium aquaeductus* suggest a mid- to late Langhian age (15.1–13.7 Ma) for deposits at the base of Hole 907A, thus providing new constraints on the age of basalts at the base of ODP Hole 907A.

The stratigraphically important dinoflagellate cysts *Cerebrocysta irregulare* sp. nov., and *Impagidinium elongatum* sp. nov. are formally described.

1. Introduction

Following the first published Neogene dinoflagellate cyst (dinocyst) biozonation by Williams (1975) on drill holes from offshore eastern Canada, assemblages of Miocene through Pliocene age have been reported frequently from the Northern Hemisphere, and our knowledge of their (paleo)ecology and stratigraphy has improved significantly (e.g. Williams and Bujak, 1985; Stover et al., 1996). It soon became evident that dinocysts are the only microfossil group with a continuous Neogene record in the high northern latitudes, and their relatively high diversity predisposes them to detailed and reliable biostratigraphic correlations in a region critical for understanding the development of Northern Hemisphere climate (De Schepper and Head, 2008). Despite their biostratigraphic potential, and although Miocene and Pliocene sequences have been drilled successfully in the subpolar/polar North Atlantic and Arctic Ocean (Deep Sea Drilling Project [DSDP] Leg 38, Ocean Drilling Program [ODP] Legs 104, 105, 151, 162, and Integrated Ocean Drilling Program [IODP] Expedition 302), a consistent dinocyst biozonation for the Neogene is still not available.

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The independent age calibration of dinocyst events is hampered partly by an incomplete chronostratigraphic framework of DSDP/ODP sites, as few holes have robust age control. First-order absolute age determinations using magnetic polarity reversals are often fragmentary due to incomplete core recovery and drilling disturbances caused by the technical difficulties of drilling at high latitudes. Where available, magnetostratigraphy is primarily supported by calcareous microfossil datums, but the paucity of biogenic carbonate in the high northern latitudes restricts their use and has relegated stable oxygen and carbon isotope stratigraphy to a subordinate role (Fronval and Jansen, 1996; Matthiessen et al., 2009a). In addition, the low evolutionary turnover of these calcareous microfossil groups at high latitudes reduces the number of bioevents, which themselves are not necessarily synchronous between high and low latitudes (Backman et al., 1984). These deficiencies are compounded by the susceptibility of foraminiferal tests and calcareous placoliths to dissolution in the colder waters of high northern latitude sites (e.g. Spiegler and Jansen, 1989).

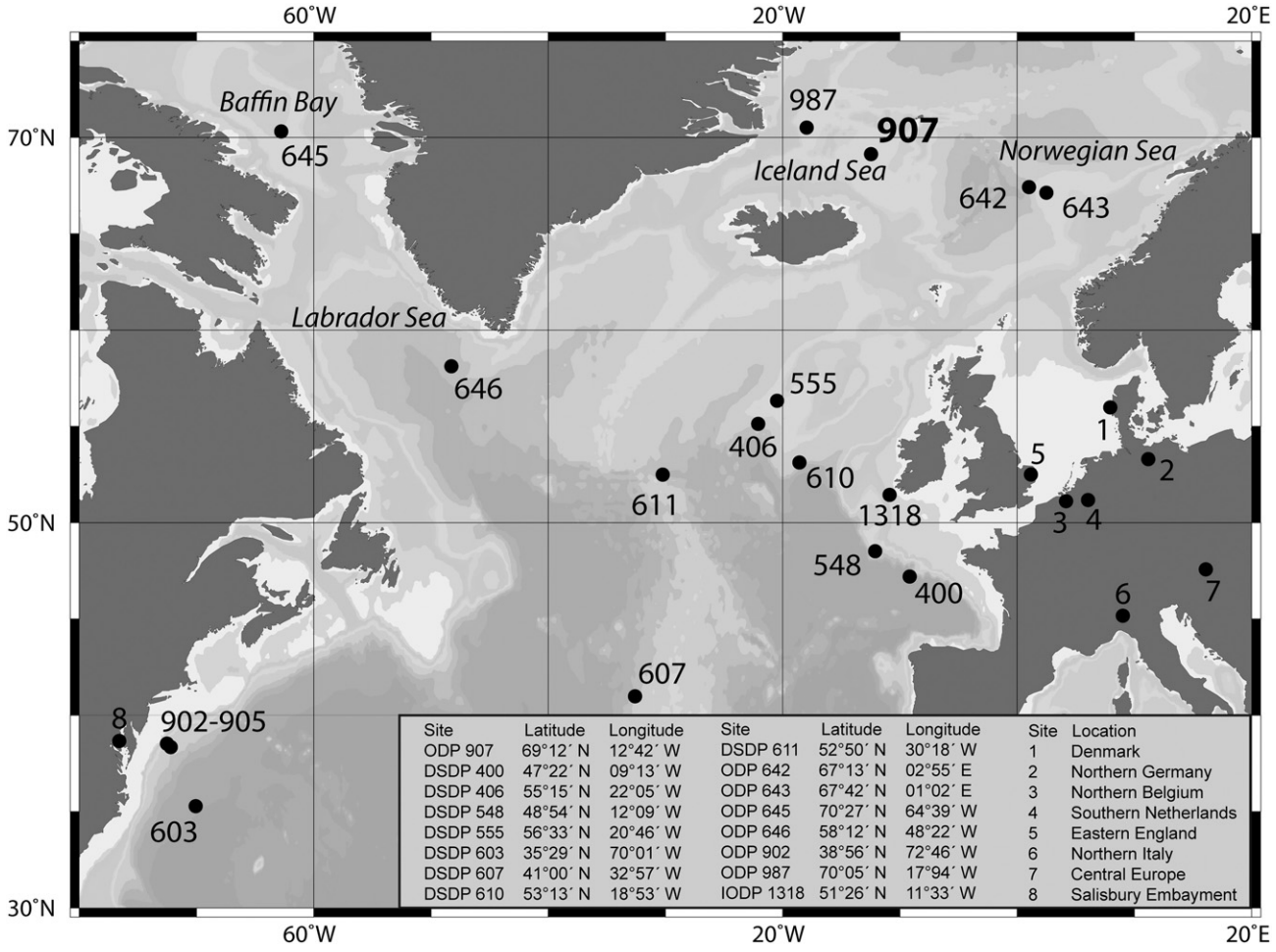
Dinocysts are therefore crucial for high-latitude biostratigraphy, but to further enhance their utility it is necessary to study those sites with robust chronostratigraphy as a means of independently calibrating the dinocyst datums (De Schepper and Head, 2008). ODP Hole 907A in the Iceland Sea (Fig. 1) is at one of few high northern latitude sites featuring a comparatively well-constrained magnetic polarity stratigraphy for the Middle and Upper Miocene (Channell et al., 1999a), in this case supported independently by silicoflagellate biostratigraphy (Amigo, 1999). Located today under the influence of cold water-masses exported from the Arctic Ocean, Hole 907A serves as a reference section for biostratigraphic correlation in the polar environments.

For these reasons the Middle Miocene to Pliocene interval of Hole 907A has been selected for a detailed palynostratigraphic study. We present a suite of biostratigraphically useful dinocyst and acritarch bioevents that are correlated for the first time in the Nordic Seas to the astronomically-tuned Neogene time scale (ATNTS 2004, Lourens et al., 2005), by using a revised magnetostratigraphy for Hole 907A (Channell et al., 1999a).

To identify those bioevents in Hole 907A that potentially extend biostratigraphic correlation into the high northern latitudes, we have compared the timing of our events with the published records of lower-latitude sites having independent age control. The most important of these sites are in the North Atlantic region, but we also compare our data with records from the North Sea and Mediterranean Sea basins and the on- and offshore eastern U.S.A. to evaluate possible ecologically- or climatically-induced asynchronies.

2. Materials and methods

ODP Leg 151 Hole 907A was drilled in the southwestern part of the Norwegian–Greenland Sea, on the eastern Iceland Plateau (69°14.989′ N, 12°41.894′ W; 2035.7 m water depth; Fig. 1), which is a flat-topped platform defined by the 1800-m contour. The drill hole penetrated a horizontal, undisturbed, pelagic sequence and reached a total depth of 224.1 meters below sea floor (mbsf). The lithology consists of 216.3 m of sediment (recovery 102.6%) underlain by 8.7 m of basalts (recovery 60.2%) at the base of the hole. The sediments mainly comprise unlithified silty clays and clayey silts, dark grayish brown in the upper half of the hole (0–56.3 mbsf) and olive gray, greenish gray, and grayish green in the lower half (56.3–216.3 mbsf; Shipboard Scientific Party,



Site	Latitude	Longitude	Site	Latitude	Longitude	Site	Location
ODP 907	69°12′ N	12°42′ W	DSDP 611	52°50′ N	30°18′ W	1	Denmark
DSDP 400	47°22′ N	09°13′ W	ODP 642	67°13′ N	02°55′ E	2	Northern Germany
DSDP 406	55°15′ N	22°05′ W	ODP 643	67°42′ N	01°02′ E	3	Northern Belgium
DSDP 548	48°54′ N	12°09′ W	ODP 645	70°27′ N	64°39′ W	4	Southern Netherlands
DSDP 555	56°33′ N	20°46′ W	ODP 646	58°12′ N	48°22′ W	5	Eastern England
DSDP 603	35°29′ N	70°01′ W	ODP 902	38°56′ N	72°46′ W	6	Northern Italy
DSDP 607	41°00′ N	32°57′ W	ODP 987	70°05′ N	17°94′ W	7	Central Europe
DSDP 610	53°13′ N	18°53′ W	IODP 1318	51°26′ N	11°33′ W	8	Salisbury Embayment

Fig. 1. North Atlantic and adjacent basins, showing the location of ODP Site 907 in the Iceland Sea and other sites discussed in the text.