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KANGAMIUT-1

Micropalaeontology of the upper part of the Kangâmiut-1 well, offshore southern West Greenland

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Contents

Abstract

The present biostratigraphic study of microfossils (mainly foraminifera and diatoms) from the 500-1730 m interval of the Kangâmiut-1 well offshore West Greenland, is based on 120 ditch cutting samples. The samples were sieved and separated at the Geological Survey of Greenland (now part of GEUS) in the early 1980's. 81 of the samples were picked again in the 125-500 μm fraction for the present study. In addition, 12 sidewall cores were analysed for their nannofossil content. Despite the low microfossil content, the present study has added new biostratigraphical information to the previous biozonation of Toxwenius (1986), most notably in the 500-900 m and 1480-1730 m intervals. The investigated interval has been separated into 7 new biozones spanning the Middle-?Late Eocene (Zone KM7) to Pleistocene (Zone KM1) period.

Introduction

This report describes the biostratigraphical results from a new micropalaeontological study of 120 microfossil samples (DCS) and 12 nannofossil samples (SWC) through the 500 m -1730 m interval of the Kangâmiut-1 well, covering the Pleistocene to upper Middle Eocene section of well. The Kangâmiut-1 well is situated in the Davis Strait region of the West Greenland Basin at 66° 09' 01" N and 56° 11' 24" W

During 1976 and 1977 five exploration wells (Hellefisk-1, Ikermiut-1, Kangâmiut-1, Nukik-1 and Nukik-2) were drilled through Cenozoic and Upper Cretaceous sediments offshore central West Greenland between 65° N and 68° N (Fig. 1). Rolle (1985) described the lithostratigraphy, sedimentary evolution and petroleum potential of the five wells. The ages of Rolle's (1985) lithostratigraphic formations were based on palynological datings by Croxton (1981a, b, c, d & e) and Costa (1982). Later, Toxwenius (1986) compiled the Upper Cretaceous–Cenozoic biostratigraphical data and correlated the five wells. Recently, Nøhr-Hansen (1998) studied the dinoflagellate cysts from the Cretaceous and Paleogene parts of the wells and added important new biostratigraphical data, which in many cases have changed the previously dated ages considerably.

Samples and methods

The majority of the microfossil samples were prepared by B. B. Toxwenius at the Geological Survey of Greenland (GGU, now part of GEUS) during the early 1980's, whereas the nannofossil smear-slides were recently prepared by Birthe Hammerstrøm (GEUS).

The material is housed at the Geological Survey of Denmark and Greenland (GEUS). The present work included a study of 120 previously processed microfossil samples and 12 nannofossil samples processed in the spring 1999 (Appendix 1). 78 of the 132 analysed samples contained micro- or nannofossils.

All depths quoted are measured metres from the rotary table unless otherwise marked. The distance from the rotary table to the sediment surface was 192 m.

Enclosure 1 illustrates the ranges of the recorded species in the Kangâmiut-1 well. The chart is organised from the first down-hole occurrence of the species. Stratigraphically important events are shown to the right.

Microfossils were recorded from the sieved, separated and partly picked sediment fractions. Additional microfossil picking was carried out in the intervals where no microfossil slides were available. Twelve nannofossil smear-slides were prepared from sidewall cores through the 500-1730 m interval. Specimen counting was carried out on those out of 132 samples that contained microfossils (75 of 120 microfossil samples and 3 of 12 nannofossil samples). The preservation of the microfossils were good to poor (in average intermediate), and abundance was low (only rarely more than ten specimens per sample).

Micropaleontology

Samples analysed

500 m - 1730 m : 120 DCS samples mainly at 10 m spacing

Nannopaleontology

Samples analysed

500 m - 1730 m : 12 SWC samples at c. 100 m spacing

Micropalaeontological results

The objective of the present analysis was to monitor the biostratigraphic age of the sediments from 500 m (the uppermost available sample) to 1700 m.

Although it was possible to correlate parts of the faunal succession of the Kangâmiut-1 with the available zonations for the North Atlantic and Arctic regions, it was not possible to use the established zonations directly due to the partly different microfaunal composition of the 500 m - 1730 m interval of the Kangâmiut-1 well. For instance, the Kangâmiut-1 samples contain remarkably less agglutinated foraminifera in the Neogene portion of the well than reported from several of the ODP and DSDP wells in the western part of the North Atlantic. Nevertheless, the age determinations presented here have benefitted greatly from previous work along the eastern North American margin by e.g. Feyling-Hanssen (1985, 1986), Gradstein *et al.* (1994), Miller *et al.* (1982), Katz & Miller (1987), Miller & Katz (1987), Aksu & Kaminski (1989), Kaminski *et al.* (1989a, b), Knüttel *et al.* (1989) and from other North Atlantic sites (Thomas 1987, King 1989, Gradstein & Bäckström 1996) as well as the Beaufort Basin (McNeill 1989).

Seven provisional biozones have been proposed for the upper part of the Kangâmiut-1 well (zone KM1-KM7, where KM are abbreviations of Kangâmiut and Microfossil), but because of the relatively poor fossil yield, it is expected that the zonation will be improved when additional data become available from the neighbouring Hellefisk-1, Ikermiut-1, Nukik-1 and Nukik-2 wells. The provisional zonation scheme (Fig. 1 and Enclosure 1) is defined and described below. Only three out of twelve nannofossil samples contained determinable nannofossils. A similar meagre nannofossil yield was reported from the Neogene strata of the ODP 645 Site, further north in the Baffin Bay (Knüttel *et al.* 1989).

Biostratigraphic summary, Kangâmiut-1

Depth (MD)	Age	Formation	Zone	Event
530 m	Pleistocene	Manîtsoq Fm.	KM1	*Planulina ariminensis*
560 m	Pleistocene	Manîtsoq Fm.	KM1	*I. islandica*
580 m	Pleistocene	Manîtsoq Fm.	KM1	*G. inflata*, *Buccella frigida*
610 m	Pleistocene	Manîtsoq Fm.	KM2	*C. teretis*, *O. universa* *Coscinodiscus* sp. 33
650 m	Pliocene	Manîtsoq Fm.	KM3	*C. grossa*
660 m	Pliocene	Manîtsoq Fm.	KM3	*Coscinodiscus* sp. 44
840m	E. Pliocene? to M. Miocene	Manîtsoq Fm.	KM4	*C. pachyderma*
1068.50 m	E. Pliocene? to M. Miocene	Manîtsoq Fm.	KM4	*R. pseudoumbilicus*
1070 m	Pliocene? to E. Miocene	Manîtsoq Fm.	KM4	*C. dutemplei*
1120 m	M. Miocene to Oligocene	Manîtsoq Fm.	KM4	*C. perlucida*
1480 m	L. Miocene to E. Oligocene	Manîtsoq Fm.	KM6	*P. vaughani*
1483.50 m	late E Oligocene to E. Eocene	Manîtsoq Fm.	KM6	*R. callida*
1680 m	L?-M. Eocene	Kangâmiut Fm.	KM7	*B. trinitatensis*, *R. nodulosus*, *K. grzybowski*
1686 m	L?-M. Eocene	Kangâmiut Fm.	KM7	*K. conversa*, *T. robertsi*
1725 m	L?-M. Eocene	Kangâmiut Fm.	KM7	*U. eocaena*, *G. s. mamillata*, *C. eocaenus*, *G. octocamerata*
1730 m	M. Eocene	Kangâmiut Fm.	KM7	*C. solitus*, *R. callida*, *C. pelagicus*

Technical data

Kangâmiut-1 was drilled in 1976 by Total Grønland Olie A/S. The position of the well is 66° 09' 01" N and 56° 11' 24" W. The water depth was 180 m (590 ft). The rotary table was 12 m (41 ft) above sea leavel, and the total depth was 3874 m (12710 ft) below rotary table when the well reached Precambrian basement (Rolle, 1985). All sample depths given in this paper are measured in metres from the rotary table datum.

Description of biozones

KM1 Zone

Definition. The strata between the LAD (last appearance datum) of *Planulina ariminensis* and the LAD of *Cibicides grossus* (Enclosure 1).

Interval. 530 m to 590 m BRT (below rotary table).

Age. Pleistocene.

Characteristic fauna and flora. The KM1 Zone is characterised by the LAD of the planktic foraminifera (PF) *Globorotalia inflata*, and the benthic foraminiferas (BF) *Buccella frigida, Islandiella islandica, Cibicides scaldisiensis* and *Elphidium* spp..

Discussion. According to Poore & Berggren (1974) and Aksu & Kaminski (1989), *G. inflata* indicates a Pleistocene or Late Pliocene age. However, the absence of *Cassidulina teretis* favours an Early Pleistocene rather than Late Pliocene age for the zone (Feyling-Hanssen (1985, 1986).

Previous dating. Toxwenius (1986) correlated the 500 m - 600 m interval with the Pleistocene (to Late Pliocene).

Correlation. The KM1 Zone correlates with the *I. islandica* Zone of Feyling-Hanssen (1985, 1986) of Baffin Island, Canada, and the NSR13 biozone of Gradstein & Bäckström (1996) of the northern North Sea. McNeil (1989) proposed twelve interval zones and seven assemblage zones for the Cenozoic strata of the Beaufort-Mackenzie Basin, north of Yukon/North West Territories, Canada. The KM1 and KM2 zones correlate with McNeil's *Cribroelphidium ustulatum* Interval Zone (Fig. 1).

KM2 Zone

Definition. The strata between the LAD of *Cassidulina teretis* and the LAD of *Cibicides grossus*.

Interval. 610 m to 640 m BRT.

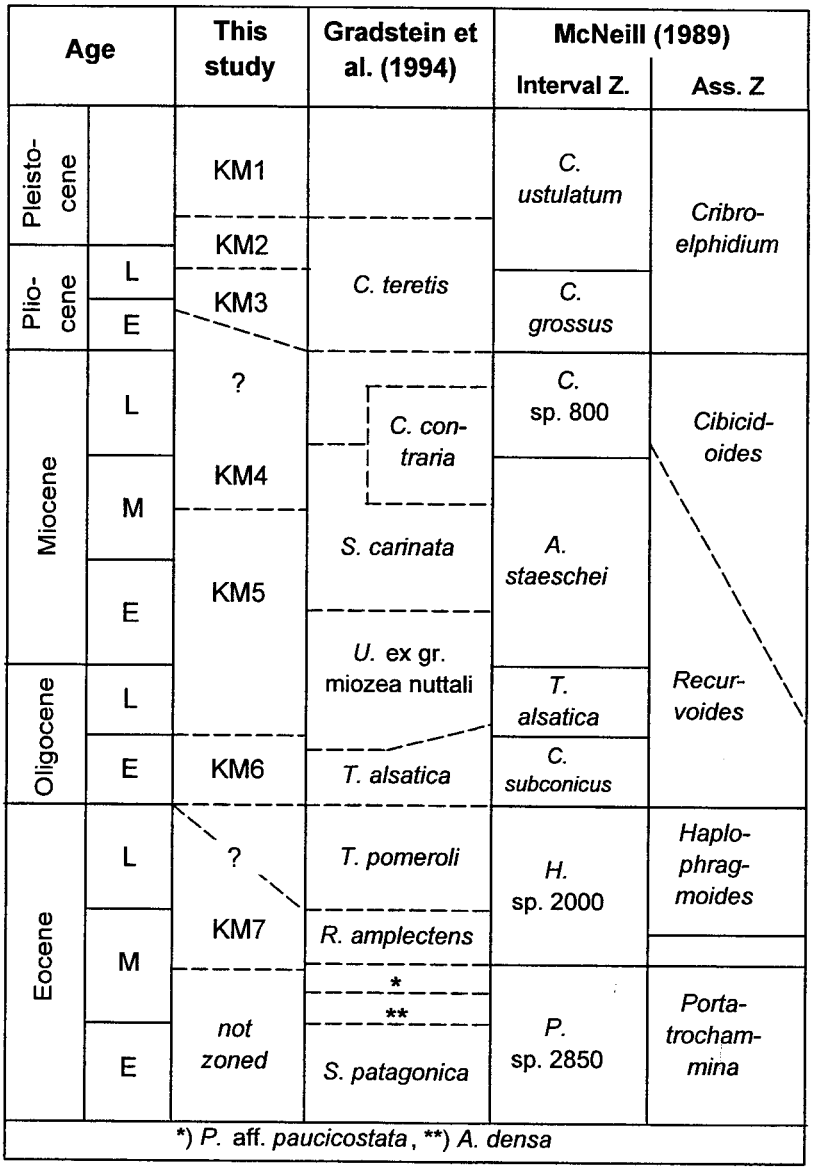

Fig. 1. Biozonation for the upper part of the Kangâmiut-1 well correlated with zonations of the Labrador Shelf / Grand Banks area (Gradstein et al. 1994) and the Beaufort Basin (McNeill 1989).

Age. Early Pleistocene - Late Pliocene.

Characteristic fauna and flora. The KM2 Zone is characterised by the uppermost occurences of *Cassidulina teretis* (BF). Also *Nodosaria* sp. A (BF), *Orbulina universa* (PF), and the diatom *Coscinodiscus* sp. 33 (GEUS in-house name) have their last apperance within this zone.

Discussion. Feyling-Hanssen (1986) placed the Pleistocene-Pliocene boundary between the LAD of *C. teretis* and the LAD of *Cibicides grossus* in the Arctic region, while King (1989) placed the boundary somewhere between the first and last appearence of *C. grossus* in the North Sea, more precisely at the last dominant occurrence of dextral coiling *Neogloboquadrina pachyderma*. Seidenkrantz (1992), who studied the foraminifera from the Gullfaks Field in the northernmost North Sea, placed the Pleistocene - Pliocene boundary at the level where *Cibicides grossus* has its last apperance.

Previous dating. Toxwenius (1986) dated the 600 m - 760 m interval as Early Pliocene.

Correlation. The KM2 (and KM1) Zone correlates with the *Cribroelphidium ustulatum* Interval Zone of McNeill (1989) (Beaufort Basin), which was dated as Pleistocene to Latest Pliocene, and the *C. teretis* (LGR11) Zone of Gradstein *et al.* (1994) (Labrador/Grand Banks) that ranges through the Pliocene. However, according to Feyling-Hanssen (1985, 1986), the presence of *Cassidulina teretis* and absence of *C. grossus* favours correlation with the earliest Pleistocene to latest Pliocene *Cassidulina teretis* Zone of from Baffin Island. This corresponds to the Pleistocene NSR13 Zone of Gradstein & Bäckström (1996) of the northern North Sea, and the Pleistocene NSB16 Zone of King (1989) from the North Sea. The present author follows the interpretation of Feyling-Hanssen (1985, 1986) and place the Pleistocene - Pliocene boundary between the LAD's of *C. teretis* and *C. grossus*, in this case arbitrary at 630 m.

KM3 Zone

Definition. The strata between the LAD of *Cibicides grossus* and the LAD of *Cibicidoides pachyderma.*

Interval. 650 m to 830 m BRT.

Age. Pliocene.

Characteristic fauna and flora. The KM3 Zone is characterised by the highest occurrences of the benthic foraminifera *Cibicides grossus* and the pyritised diatoms *Coscinodiscus* sp. 44, *C.* sp. 1, *C.* sp. 7, and *C.* sp. 11 (GEUS in-house names). Other characteristic species include *Buccella hannai* (BF), *Islandiella helenae* (BF) and *Orbulina universa* (PF) and *Globocassidulina* cf. *subglubosa* (BF). Single specimens of the benthic foraminifera species *Uvigerina pergrina*, *Quinqueloculina lamarckina* and *Planulina wuellerstorfi* were also observed.

Previous dating. Toxwenius (1986) dated the 600 m - 760 m interval as Early Pliocene, and the 760 m - 1300 m interval as Middle - (Late) Miocene.

Correlation. The upper part of the KM3 Zone correlates with Late Pliocene *C. grossus* Zone of Feyling-Hanssen (1985, 1986) from Baffin Island, the Late Pliocene NSR13 Zone of Gradstein & Bäckström (1996) of the northern North Sea, and the Early Pleistocene NSB15b Zone of King (1989) of the North Sea. It is more difficult to correlate the lower part of zone KM3, but it is striking that Kaminski *et al.* (1989a) described pyritised diatoms from the earliest Pleistocene and Pliocene of ODP Site 645 further north in the Baffin Bay. This may suggest that the entire KM3 Zone is of Pliocene age. The *C. grossus* Interval Zone of McNeill (1989) of the Beaufort Basin was dated as Pliocene, which is in accordance with this interpretation.

KM4 Zone

Definition. The strata between the LAD of *Cibicidoides pachyderma* and the LAD of *Cibicides perlucida.*

Interval. 840 m to 1110 m BRT.

Age. Early Pliocene? - Middle Miocene.

Characteristic fauna and flora. The KM4 Zone is characterised by the highest occurrence of *Cibicidoides pachyderma* (BF) in the top of the zone, while the nannofossil *Reticulofenestra pseudoumbilicus* and *Cibicidoides dutemplei* (BF) occur in the lower part of the zone. Scattered pyritised diatoms were observed within the upper 60 m of the KM4 Zone. Other characteristic species include *Buccella hannai* (BF), *Islandiella helenae* (BF) and *Orbulina universa* (PF) and *Globocassidulina* cf. *subglubosa* (BF). Single specimens of the benthic foraminifera *Uvigerina pergrina*, *Quinqueloculina lamarckina* and *Planulina wuellerstorfi* were also observed.

Discussion. A foraminiferal assemblage including *Cibicidoides pachyderma* was reported from lower Middle Miocene to Lower Miocene strata from the ODP Site 645 in the Baffin Bay by Kaminski *et al.* (1989). To the south, offshore New Jersey, Katz & Miller (1987) observed *C. pachyderma* in lowermost Pliocene to Upper Miocene strata of the DSDP 612 well.

The LAD of *C. pachyderma* is in considerably younger further east, in the North Sea, where *C. pachyderma* was reported to range from the Pleistocene-Pliocene boundary to the base of Middle Miocene (King 1989, Gradstein & Bäckström 1996). Thomas (1987) reported *Uvigerina peregrina* from the DSDP Sites 608 and 610 northeast of the Azores and in the Rockall trough, respectively. In these sites, *U. peregrina* was ranging from the Quaternary to the Early Miocene, and was most common in the Quaternary - Late Miocene time interval.

Previous dating. Toxwenius (1986) dated the 760 m - 1300 m interval as Middle - (Late) Miocene.

Correlation. If the vertical range of *C. pachyderma* in the Kangâmiut-1 well agree stratigraphically with its range at the DSDP Site 612 (Katz & Miller 1987), it is likely that the KM4 Zone spans the period from earliest Pliocene to Middle Miocene. Alternatively, if the range of *C. pachyderma* corresponds to its range at the more closely situated ODP Site 645 (Kaminski *et al.* 1989a), the KM4 Zone of is of Middle Miocene to Early Miocene age.

The nannofossil *Reticulofenestra pseudoumbilicus* that appears in lower part of the KM4 Zone (1068.5 m, SWC), was reported from Lower Pliocene to Middle Miocene strata in ODP Site 645 (Knüttel *et al.* 1989). Together, these data indicate that the KM4 Zone is of Early Pliocene? to Middle Miocene age.

The Miocene - Oligocene *Cibicidoides* Assemblage Zone of McNeill (1989) (Beaufort Basin) contained e.g. *Cibicidoides* spp., *Cibicides perlucida*, *Pullenia bulloides* and *Globocassidulina* sp., which indicate correlation with the KM4 and KM5 Zones of the present study.

KM5 Zone

Definition. The strata between the LAD of *Cibicides perlucida* and the LAD of *Plectfrondicularia vaughani.*

Interval. 1120 m to 1460 m BRT.

Age. Middle Miocene - Oligocene.

Characteristic fauna and flora. The KM5 Zone is generally very poor in microfossils and several samples in this zone were barren. No nannofossils were observed. *Cibicides perlucida* (BF) occurs in two samples in the upper part of the zone. *Globocassidulina subglobosa* (BF) was observed in the lower part of the zone.

Discussion. The present author is not aware of any previus reports of *C. perlucida* in the Labrador Sea or Baffin Bay. However, *Cibicides perlucida* was reported by Thomas (1987) from lower Middle Miocene to Oligocene strata in the northeastern North Atlantic (DSDP Site 608), northeast of the Azores. This range is similar to its range reported from the Beaufort Basin by McNeill (1989), who observed it within the Miocene - Oligocene *Cibicidoides* Assemblage Zone.

Previous dating. Toxwenius (1986) dated the 760 m - 1300 m interval as Middle - (Late) Miocene and the 1300 m - 1670 m interval as Early Miocene.

Correlation. The KM5 Zone is difficult to correlate with other sites because of the extremely poor fossil content. The occurrence of *Cicbicides perlucida*, however, may indicate an early Middle Miocene to Oligocene age of KM5 when it is correlated with the DSDP Site 608 (Thomas 1987).

It is likely that most of the few other species recorded in the zone were caved from higher levels in the well (e.g. *Cibicides grossus* and *Cassidulina teretis*).

KM6 Zone

Definition. The strata between the LAD of *Plectofrondicularia vaughani* and the LAD of *Bulimina trinitatensis* (BF) together with the LAD of the agglutinated foraminifera *Kalamopsis grzybowskii* and *Reophax nodulosus.*

Interval. 1480 m to 1674 m BRT.

Age. Early Oligocene.

Characteristic fauna and flora. The KM6 Zone is very poor in microfossil content, especially in the upper part. The benthic foraminifera *Plectofrondicularia vaughani* was observed at 1480 m just above a sidewall core at 1483 m with the LAD of the nannofossil *Reticulofenestra callida. Gyroidina* sp. 1 is restricted to three levels in the lower part of the zone. A single specimen of *Asterigerina guerichi guerichi* was found at 1659 m but was possibly caved from Upper Oligocene strata.

Previous dating. Toxwenius (1986) dated the 1300 m - 1670 m interval as Early Miocene, and the 1670 m - 1960 m interval as Early Oligocene.

Correlation. *Plectofrondicularia vaughani* ranges from the Late Miocene to the Early Oligocene (van Morkhoven *et al.* 1986) and *Reiculofenestra callida* from late Early Oligocene to Early Eocene (NP23-NP13) (Gallagher 1989). This indicates an Early Oligocene age for the KM6 Zone, because the underlying KM7 Zone is characterised by the LAD of several Eocene species.

KM7 Zone

Definition. The interval from the LAD of *Bulimina trinitatensis* (BF) together with LAD's of the agglutinated foraminifera *Kalamopsis grzybowskii* and *Reophax nodulosus* to the LAD of the nannofossil *Chiasmolithus solitus* (from the lowermost sample encountered in this work).

Interval. 1680 m to 1730 m BRT.

Age. Late? - Middle Eocene.

Characteristic fauna and flora. The upper part of the zone is characterised by the first downhole appearance of common agglutinated foraminifera (*Reophax nodulosus*, *Kalamopsis grzybowski* and *Karreriella conversa*) together with the calcareous benthic foraminifera *Bulimina trinitatensis*, *Lagena* sp. A and *Turrilina robertsi* (*T. brevispira* of some authors). The lower part of the zone is characterised by the benthic foraminifera *Uvigerina eocaena*, *Cibicidoides eocaenus* and *Gyroidinoides octocamerata* together with the nannofossils *Chiasmolithus solitus*, *Coccolithus pelagicus* and *Reticulofenestra callida*.

Previous dating. Toxwenius (1986) dated the 1670 m - 1960 m interval as Early Oligocene, while Nøhr-Hansen (1998) dated the 1556 m - 1638 m interval as earliest Oligocene - latest Middle Eocene and the 1725 m - 1818 m interval as late Middle Eocene.

Correlation. The LAD of the agglutinating foraminifera *R. nodulosus*, *K. grzybowski* and *K. conversa* indicate a Late? - Early Eocene age for the KM7 Zone when it is correlated with the North Sea assemblages (Charnock & Jones 1990, King 1989). *K. conversa*, however, is restricted to the lowermost Upper Eocene and Middle Eocene strata in the ODP Site 647A well, offshore South Greenland (Kaminski *et al.* 1989b).

Bulimina trinitatensis and *Turrilina robertsi* were reported from Upper to Lower Eocene strata of the DSDP Site 612 offshore New Jersey by Miller & Katz (1987). This range corresponds to the dating presented here based on the agglutinating foraminifera. The nannofossils *C. solitus* (LAD) and *R. callida* were observed at 1730 m. *C. solitus* was also documented from Middle - Early Eocene strata in the ODP Site 647A strata, by Firth (1989). In summary, the age of the KM7 Zone is most likely Late? - Middle Eocene based on micro- and nannofossils.

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Appendix 1. Microfossils recorded in the upper part of the Kangâmiut-1 well

All samples are microfossil ditch-cutting samples unless otherwise stated.

500 m
Barren

510 m
Barren

512.5 m (nannofossil smearslide, sidewall core)
No identifiable nannofossils were observed.
Diatom fragments are common.

520 m
Barren

530 m

Planulina ariminensis d'Orbigny	1

540 m

Nonion spp.	1

550 m

Cibicides scaldisiensis Ten Dam & Reinhold.	1

560 m

Nonion spp.	1
Buccella spp.	1
Islandiella islandica (Nørvang)	1
Elphidium spp.	1

570 m
No sample

580 m

Islandiella islandica (Nørvang)	1
Cibicides scaldisiensis Ten Dam & Reinhold.	1
Buccella frigida (Cushman)	1
Nonion spp.	1
Globorotalia inflata (d'Orbigny)	1

590 m

Islandiella islandica (Nørvang)	2
Elphidium incertum clavatum Cushman	2

Nonionella sp.	1
Elphidium asklundi Brotzen	1
Elphidium spp.	1
Nonion? sp.	1
Indet . benthic calc.	2

600 m
No sample

610 m

Nonion spp.	1
Buccella frigida (Cushman)	2
Orbulina universa d'Orbigny	1
Cassidulina teretis Tappan	1
Indet. calc. benthic	2
Coscinodiscus sp. 33	1

620 m

Nodosaria sp. A	2

630 m

Buccella frigida (Cushman)	1
Sphaeroidinella? spp.	1

640 m

Nonion spp.	1
Nodosaria sp. A	2
Coscinodiscus sp. 33	1

650 m

Buccella frigida (Cushman)	1
Elphidium spp.	1
Cibicides grossus Ten Dam & Reinhold	1
Indet calc. benthic	2

660 m

Cassidulina spp.	1
Indet calc. benthic (badly preserved)	1
Coscinodiscus sp. **44**	1

662 m (nannofossil smearslide, sidewall core)
No identifiable nannofossils were observed.
Diatom fragments are common.

670 m

Islandiella islandica (Nørvang)	2
Lenticulina sp. indet.	1
Buccella hannai (Phleger & Parker)	1
Cibicides grossus Ten Dam & Reinhold	2

680 m

Cibicides grossus Ten Dam & Reinhold	1
Islandiella islandica (Nørvang)	1

690 m

Islandiella islandica (Nørvang)	1
Cassidulina teretis Tappan	2
Cassidulina reniforme Nørvang (?)	1
Quinqueloculina lamarckina d'Orbigny	1
Cassidulina spp.	1
Cibicides grossus Ten Dam & Reinhold	1
Indet calc. benthic (badly preserved)	1

700 m

Uvigerina peregrina Cushman	1
Cassidulina teretis Tappan	2
Islandiella islandica (Nørvang)	1
Buccella spp.	1
Cibicides scaldisiensis Ten Dam & Reinhold.	1
Buccella hannai (Phleger & Parker)	1
Planktic forams (indet.)	2
Indet. calc. benthics	4
Coscinodiscus sp. 1	1
Coscinodiscus sp. 7	1

710 m

Cibicides grossus Ten Dam & Reinhold	1
Lenticulina spp. (badly preserved)	2
Indet calc. benthic	3
Elphidium sp.	1
Cibicides spp.	1
Coscinodiscus sp. 7	1

720 m

Islandiella islandica (Nørvang)	2
Islandiella helenae Feyling-Hanssen & Buzas	2
Buccella frigida (Cushman)	1

Nonion spp.	1
Indet calc. benthic	1
Coscinodiscus sp. 44	3
Coscinodiscus sp. 7	2

730 m

Islandiella islandica (Nørvang)	2
Islandiella helenae Feyling-Hanssen & Buzas	5
Cassidulina sp. indet.	1
Nonion erucopsis Todd	1
Nonionella spp.	1
Cibicides grossus Ten Dam & Reinhold	1
Globocassidulina cf. *subglobosa* Brady	1
Indet calc. benthic	1
Coscinodiscus sp.44	1
Coscinodiscus sp. 7	5
Coscinodiscus sp. 33	6
Coscinodiscus sp. indet.	1

sponge spicules
Pyritised tubes

740 m
Barren

743.5 m (nannofossil smearslide, sidewall core)
Thoracosphaera spp. (?) are very rare.
No identifiable nannofossils were observed.
Diatom fragments are rare.

750 m

Globocassidulina cf. *subglobosa* Brady	5
Melonis barleeanum (Williamson)	1
Orbulina universa d'Orbigny	15
Elphidium subarcticum Cushman	1
Buccella frigida (Cushman)	1
Elphidium sp. indet.	2
Islandiella helenae Feyling-Hanssen & Buzas	2
Orbulina universa d'Orbigny	2
Planulina wuellerstorfi (Schwager)	1
Cassidulina sp. indet.	1
Nonion erucopsis Todd	1
Cibicides grossus Ten Dam & Reinhold	1
Indet calc. benthic	2

sponge spicules

760 m

Cassidulina teretis Tappan	1
Islandiella sp. indet. (badly preserved)	1
Nonionella sp. indet.	1
Indet calc. benthic	1

770 m

Cibicides grossus Ten Dam & Reinhold	1
Islandiella helenae Feyling-Hanssen & Buzas	1

780 m

Globocassidulina cf. *subglobosa* Brady	2
Islandiella sp. indet. (badly preserved)	1
Buccella frigida (Cushman)	1
Nonion orbiculare (Brady)	1
Elphidium excavatum (Terquem)	1
Indet calc. benthic	1

790 m

Cassidulina teretis Tappan	3
Cibicides grossus Ten Dam & Reinhold	3
Buccella frigida (Cushman)	2
Cibicides scaldisiensis Ten Dam & Reinhold	1
Elphidium incertum (Williamson)	5
Elphidium spp.	1
Eponides spp.	1
Melonis spp.	1
Globigerina sp. indet. (aff. *G. woodi* Jenkins)	1
planktic foram., indet	1
Indet calc. benthic	1

800 m

Barren

810 m

Buccella frigida (Cushman)	1
Elphidium sp. indet.	1

820 m

Cibicides grossus Ten Dam & Reinhold	1
agglut. benthic indet.	1

830 m

Cassidulina sp. indet.	1

Coscinodiscus sp. 11 1

840 m
Cibicidoides pachyderma (Rzehak) 1

842.5 m (nannofossil smearslide, sidewall core)
No identifiable nannofossils were observed.
Diatom fragments are abundant.

850 m
Cibicidoides sp. indet. (badly preserved, with steep sides) 1

Coscinodiscus sp. 44 1

860 m
Cibicidoides refulgens de Montfort 1
Cal. benthic indet. 1

870 m
Barren

880 m
Buccella frigida (Cushman) 1
Bulimina? sp. indet. 1

890 m
No sample

900 m
Melonis barleeanum (Williamson) 2
Globigerina sp. indet. 1
Nonion spp. 3
Cibicides sp. 1
Cibicides grossus Ten Dam & Reinhold 1
Calc. benthics indet. 11

Coscinodiscus sp. 7 2

sponge spicules

910 m
Lenticulina sp. indet. 1
?*Melonis* sp. 1
Calc. benthics indet. 2

920 m

Buccella frigida (Cushman) 1

930 m
Melonis barleeanum (Williamson) 1
Lenticulina sp. indet. 1
Elphidium cf. *hughesi* (white preservation) 1

Fish teeth

940 m
Elphidium cf. *hughesi* (white preservation) 1

943 m (nannofossil smearslide, sidewall core)
Thoracosphaera spp. ?
No identifiable nannofossils were observed.
Diatom fragments are rare.

950 m
Barren

960 m
Coscinodiscus sp. indet. 1

970 m
Cassidulina sp. indet. 2
Elphidium cf. *hughesi* (white preservation) 1
Elphidium subarcticum Cushman 1

980 m
Cibicides grossus Ten Dam & Reinhold 1
Cassidulina teretis Tappan 1
Calc. benthic indet. 1

990 m
Cassidulina sp. indet. 1
Elphidium subarcticum Cushman 1

1000 m All specimens are badly preserved
Melonis sp. indet. 1
Elphidium spp. 3
Cassidulina teretis Tappan 1
Cassidulina laevigata d'Orbigny 1
Bulimina gibba Fornasini 1
Orbulina universa d'Orbigny 1
Calc. benthic indet. 4

1010 m

Cassidulina teretis Tappan	2
Melonis barleeanum (Williamson)	1
Melonis sp. indet.	1
Elphidium sp. indet.	1
Buccella hannai (Phleger & Parker)	2
Ammonia? spp.	1
Calc. benthic indet.	3

1020 m

Cibicidoides pachyderma (Rzehak)	1
Cibicides scaldisiensis Ten Dam & Reinhold.	1
Buccella frigida (Cushman)	1
Cassidulina sp. indet. (badly preserved)	5
Cassidulina teretis Tappan	2
Elphidium cf. *hughesi* (white preservation)	1
Calc. benthic indet.	3

1030 m

Elphidium sp. indet.	1

1040 m

Fish teeth

1050 m

Barren

1060 m

Barren

1068.5 m (nannofossil smearslide, sidewall core)

Reticulofenestra pseudoumbilicus	1

1070 m

Elphidium sp. indet.	1
Cibicidoides dutemplei (ten Dam & Reinhold)	1

1080 m

Pullenia bulloides d'Orbigny	1
Cassidulina teretis Tappan	1
Cassidulina sp. indet. (?*C. pliocarinata*)	1
Elphidium bartletti Cushman	1

1090 m

Cibicides grossus Ten Dam & Reinhold	1
Cassidulina pliocarinata van Voorthuysen	1
Calc. benthic indet.	1

1100 m

Pullenia quinqueloba (Reuss)	1
Buccella frigida (Cushman)	1
Cassidulina teretis Tappan	2
Quinqueloculina spp.	1
Cibicidoides spp.	2
Cibicidoides pachyderma (Rzehak)	1
Elphidium sp. indet.	1
Calc. benthic indet.	3

Sponge spicules

1110 m

Cassidulina teretis Tappan	1
Elphidium spp.	1

1120 m

Cibicides perlucida Nuttall	1
Melonis spp.	1
Lenticulina sp.	1

1130 m

Barren

1140 m

Cassidulina teretis Tappan	1

1150 m

Cassidulina teretis Tappan	1

1160 m

Cassidulina spp.	1
Elphidium spp.	1

1160 m (nannofossil smearslide, sidewall core)
No identifiable nannofossils were observed.
Diatom fragments are rare.

1170 m

Barren

1180 m

Barren

1190 m

Oridorsalis sp. indet.	1
Melonis barleeanum (Williamson)	1

Cibicides perlucida Nuttall 1
Calc. benthic indet. 1

1200 m
Calc. benthic indet., possibly *Elphidium* sp. 1

1210 m
Calc. benthic indet, possibly *Neoeponides?* sp. indet. 1

1220 m
Barren

1230 m
Barren

1237.5 m (nannofossil smearslide, sidewall core)
Thoracosphaera sp. very rare.

1240 m
Barren

1250 m
Barren

1260 m
Barren

1270 m
Barren

1280 m
Calc. planktic indet. 1

1290 m
Barren

1300 m
Cibicides grossus Ten Dam & Reinhold 1
Cicicidoides bradyi (Trauth) 1

Sponge spicules

1310 m
Calc. benthic indet 1

1320 m
Barren

1330 m
Barren

1340 m
Barren

1350 m
Barren

1356.5 m (nannofossil smearslide, sidewall core)
No identifiable nannofossils were observed.

1360 m
Barren

1370 m
Barren

1380 m

Cassidulina sp. indet. (badly preserved)	1

1390 m
Barren

1420 m
Barren

1430 m

Globocassidulina subglobosa Brady	1

1440 m
Barren

1450 m
Barren

1460 m

Calc. benthic indet. (very badly preserved)	1

1470 m
Barren

1480 m

Plectofrondicularia vaughani Cushman	1
Elphidium incertum (Williamson)	1
Cassidulina sp. indet. (badly preserved)	1

Globigerina sp. indet. 1
Calc. planktic indet. 1

1483 m (nannofossil smearslide, sidewall core)
Reticulofenestra callida (Perch-Nielsen) 1
Thoracosphaera spp. 2
Unidentifiable nannofossils 3

1490 m
Fish teeth

1500 m
Calc. planktic indet. 1

1509 m
Barren

1518 m
Barren

1556 m (nannofossil smearslide, sidewall core)
Thoracosphaera spp. very rare.
No identifiable nannofossils were observed.

1572 m
Fish teeth

1581 m
Fish teeth

1590 m
Fish teeth

1599 m
Melonis barleeanum (Williamson) 1
Fish teeth

1608 m
Indet. tube

1620 m
Barren

1626 m
Fish teeth

1632 m

Fish teeth

1638 m
Fish teeth

1644 m
Calc. benthic indet. (white, very badly preserved) 1

Fish teeth

1650 m
Gyroidina sp. 1 1
Siphonina sp. indet. 1
Calc. benthic indet. (badly preserved) 1
Agglut, badly preserved 1

1659 m
Asterigerina guerichi guerichi (Franke) 1
Gyroidina sp. 1 1
Calc. benthic indet. (badly preserved) 1

1668 m
Sphaeroidina bulloides d'Orbigny 1
Quadrimorphina spp. 1
Calc. benthic indet. (badly preserved) 1

1674 m
Gyroidina sp. 1 1

1680 m
Bulimina trinitatensis Cushman & Jarvis 1
Uvigerina spp. 1
Lagena sp. A 1
Reophax nodulosus Brady 1
Kalamopsis grzybowskii (Dylazanka) 2
agglut. indet. 1
Calc. benthic indet. 3

1686 m
Karreriella conversa (Grzybowski) 1
Turrilina robertsi (= *T. brevispira* of some authors) 1
Calc. planktic indet. 1

1713 m
Lenticulina spp. 1

1719 m

Calc. benthic indet.	1

1725 m

Uvigerina eocaena Gümbel	3
Gyroidina soldanii mamillata (Andreae)	1
Siphonina spp.	2
Cibicidoides eocaenus (Gümbel)	1
Gyroidinoides octocamerata (Cushman & Hannah)	1

1730 m (nannofossil smearslide, sidewall core)

Chiasmolithus solitus	1
Coccolithus pelagicus	1
Transversopontis rectipons	1
Reticulofenestra callida (Perch-Nielsen)	1
Uidentifiable nannofossils	5
Thoracosphaera spp.	2

Enclosure 1. Ranges of micro- and nannofossils from the 500 m - 1730 m interval

GEUS
Report File no.
16142
Enclosure 1(1)

ENCLOSURE 1 | SHEET: 1 | SCALE: 1:2000 | Groups: All | Complete spp. set

GEUS

Kangamiut (500 - 1730m)

DEPTH | FORMATION | SYSTEM | STAGE | MICRO. ZONES | SAMPLES

MANITSOQ FM. | CENOZOIC | PLEISTOCENE | PLIOCENE | KM1 | KM2 | KM3 | M.MIOCENE-?E.PLIO. | KM4 | OLIGOCENE-M.MIOC. | KM5 | E. OLIGOCENE | KM6 | MIDDLE EOCENE | LATE?-MIDDLE EOC. | KM7 | KANGAMIUT FM.

DEPTH: 500.00 — 530.00 — 540.00 — 550.00 — 560.00 — 580.00 — 590.00 — 610.00 — 620.00 — 630.00 — 640.00 — 650.00 — 660.00 — 670.00 — 680.00 — 690.00 — 700.00 — 710.00 — 720.00 — 730.00 — 750.00 — 760.00 — 770.00 — 780.00 — 790.00 — 810.00 — 820.00 — 830.00 — 840.00 — 850.00 — 860.00 — 880.00 — 900.00 — 910.00 — 920.00 — 930.00 — 940.00 — 960.00 — 970.00 — 980.00 — 990.00 — 1000.00 — 1010.00 — 1020.00 — 1030.00 — 1068.50 ≈ 1070.00 — 1080.00 — 1090.00 — 1100.00 — 1110.00 — 1120.00 — 1140.00 — 1150.00 — 1160.00 — 1190.00 — 1200.00 — 1210.00 — 1280.00 — 1300.00 — 1310.00 — 1380.00 — 1430.00 — 1460.00 — 1480.00 ≈ 1483.50 — 1500.00 — 1599.00 — 1644.00 — 1650.00 — 1659.00 — 1668.00 — 1674.00 — 1680.00 — 1686.00 — 1713.00 — 1719.00 — 1725.00 — 1730.00

SAMPLES:
1 Planulina ariminensis
2 Nonion spp.
3 Cibicides scaldisiensis
4 Buccella spp.
5 Islandiella islandica
6 Elphidium spp.
7 Globorotalia inflata
8 Buccella frigida
9 Elphidium asklundi
10 ?Nonion spp.
11 Nonionella spp.
12 Elphidium excavatum
13 Elphidium incertum clavatum
14 B.CALCAREOUS FORAMINIFERA
15 Coscinodiscus sp33
16 Orbulina universa
17 Cassidulina teretis
18 Nodosaria SP A
19 ?Sphaeroidinella spp.
20 Cibicides grossus
21 Coscinodiscus sp44
22 Cassidulina spp.
23 Buccella hannai
24 Lenticulina spp.
25 Quiqueloculina lamarckina
26 Uvigerina peregrina
27 Coscinodiscus spi
28 Coscinodiscus sp7
29 PLANKTIC FORAMINIFERA
30 Cibicides spp.
31 Islandiella helenae
32 Nonion erucopsis
33 Globocassidulina cf.subglobosa
34 Coscinodiscus spp.
35 Planulina wuellerstorfi
36 Elphidium subarcticum
37 Melonis barleeanum
38 Islandiella spp.
39 Nonion orbiculare
40 Eponides spp.
41 Melonis spp.
42 Globigerina spp.
43 AGGLUTINATING FORAMINIFERA
44 Coscinodiscus sii
45 Cibicidoides pachyderma
46 Cibicidoides spp.
47 Cibicides refulgens
48 Elphidium cf.hughesi
49 Bulimina gibba
50 Cassidulina laevigata
51 ?Ammonia spp.
52 Reticulofenestra pseudoumbilicus
53 Cibicidoides dutemplei
54 Pullenia bulloides
55 Elphidium bartletti
56 Cassidulina pliocarinata
57 Pullenia quinqueloba
58 Quinqueloculina spp.
59 Cibicides perlucida
60 Oridorsalis spp.
61 Cibicidoides bradyi
62 Globocassidulina subglobosa
63 Plectofrondicularia vaughani
64 Elphidium incertum
65 Reticulofenestra callida
66 Gyroidina sp 1
67 Siphonina spp.
68 Asterigerina guerichi s.s
69 Sphaeroidina bulloides
70 Quadrimorphina spp.
71 Lagena spp.
72 Reophax nodolosus
73 Kalamopsis grzybowskii
74 Uvigerina spp.
75 Bulimina trinitatensis
76 Karrerulina conversa
77 Turrilina robertsi
78 Uvigerina eocaena
79 Gyroidina soldanii mamillata
80 Cibicidoides eocaenus
81 Gyroidinoides octocamerata
82 Chiasmolithus solitus
83 Coccolithus pelagicus
84 Transversopontis rectipons
85 Cassidulina reniforme
86 Bulimina spp.
87 Neoeponides spp.

ALPHABETICAL SPECIES LIST

51 ?Ammonia spp.
10 ?Nonion spp.
19 ?Sphaeroidinella spp.
43 AGGLUTINATING FORAMINIFERA
68 Asterigerina guerichi s.s
14 B.CALCAREOUS FORAMINIFERA
8 Buccella frigida
23 Buccella hannai
4 Buccella spp.
49 Bulimina gibba
86 Bulimina spp.
75 Bulimina trinitatensis
50 Cassidulina laevigata
56 Cassidulina pliocarinata
85 Cassidulina reniforme
22 Cassidulina spp.
17 Cassidulina teretis
82 Chiasmolithus solitus
20 Cibicides grossus
59 Cibicides perlucida
47 Cibicides refulgens
3 Cibicides scaldisiensis
30 Cibicides spp.
61 Cibicidoides bradyi
53 Cibicidoides dutemplei
80 Cibicidoides eocaenus
45 Cibicidoides pachyderma
46 Cibicidoides spp.
83 Coccolithus pelagicus
44 Coscinodiscus sii
27 Coscinodiscus spi
15 Coscinodiscus sp33
21 Coscinodiscus sp44
28 Coscinodiscus sp7
34 Coscinodiscus spp.
9 Elphidium asklundi
55 Elphidium bartletti
48 Elphidium cf.hughesi
12 Elphidium excavatum
64 Elphidium incertum
13 Elphidium incertum clavatum
6 Elphidium spp.
36 Elphidium subarcticum
40 Eponides spp.
42 Globigerina spp.
33 Globocassidulina cf.subglobosa
62 Globocassidulina subglobosa
7 Globorotalia inflata
79 Gyroidina soldanii mamillata
66 Gyroidina sp 1
81 Gyroidinoides octocamerata
31 Islandiella helenae
5 Islandiella islandica
38 Islandiella spp.
73 Kalamopsis grzybowskii
76 Karrerulina conversa
71 Lagena spp.
24 Lenticulina spp.
37 Melonis barleeanum
41 Melonis spp.
87 Neoeponides spp.
18 Nodosaria SP A
32 Nonion erucopsis
39 Nonion orbiculare
2 Nonion spp.
11 Nonionella spp.
16 Orbulina universa
60 Oridorsalis spp.
29 PLANKTIC FORAMINIFERA
1 Planulina ariminensis
35 Planulina wuellerstorfi
63 Plectofrondicularia vaughani
54 Pullenia bulloides
57 Pullenia quinqueloba
70 Quadrimorphina spp.
58 Quinqueloculina spp.
25 Quiqueloculina lamarckina
72 Reophax nodolosus
65 Reticulofenestra callida
52 Reticulofenestra pseudoumbilicus
67 Siphonina spp.
69 Sphaeroidina bulloides
84 Transversopontis rectipons
77 Turrilina robertsi
78 Uvigerina eocaena
26 Uvigerina peregrina
74 Uvigerina spp.

BIOSTRATIGRAPHICAL EVENTS

T: top + 5-9 | M: max ++10-24 | B: base +++25-59 | I: influx ++++ >59

- ← Planulina ariminensis T
- ← Islandiella islandica T
- ← Globorotalia inflata T
- ← Cassidulina teretis T
- Orbulina universa T
- Coscinodiscus sp33 T
- ← Cibicides grossus T
- ← Coscinodiscus sp44 T
- ← Cibicidoides pachyderma T
- ← Reticulofenestra pseudoumbilicus T
- Cibicidoides dutemplei T
- ← Pullenia bulloides T
- ← Cibicides perlucida T
- ← Gyroidina sp 1 T
- ← Kalamopsis grzybowskii T
- Reophax nodolosus T
- Turrilina robertsi T
- Karrerulina conversa T
- ← Cibicidoides eocaenus T
- Uvigerina eocaena T
- Chiasmolithus solitus T
- ← Plectofrondicularia vaughani T
- Reticulofenestra callida T