**Supplementary Table 1**

Latest Miocene to early Pliocene alkenone sea surface temperatures (annual) for ODP Hole 907A.

| **Site, Hole** | **Core-section** | **Depth in section** (cm) | **Depth** (mbsf) | **Age** (Ma) | $U^{k'}_{37}$ | **SST** (°C) |
|---|---|---|---|---|---|---|
| 907A | 8H2 | 40–42 | 66.2 | 3.55 | 0.261 | **6.57** |
| 907A | 8H2 | 140–142 | 67.2 | 3.66 | 0.264 | **6.66** |
| 907A | 8H3 | 90–92 | 68.2 | 3.82 | 0.203 | **4.82** |
| 907A | 8H4 | 43–45 | 69.2 | 3.98 | 0.346 | **9.16** |
| 907A | 8H4 | 140–142 | 70.2 | 4.14 | 0.326 | **8.56** |
| 907A | 8H5 | 90–92 | 71.2 | 4.26 | 0.332 | **8.72** |
| 907A | 8H6 | 32–34 | 72.1 | 4.34 | 0.301 | **7.80** |
| 907A | 8H6 | 140–142 | 73.2 | 4.45 | 0.447 | **12.23** |
| 907A | 9H1 | 40–42 | 74.2 | 4.55 | 0.404 | **10.90** |
| 907A | 9H1 | 140–142 | 75.2 | 4.64 | 0.223 | **5.42** |
| 907A | 9H2 | 90–92 | 76.2 | 4.74 | 0.415 | **11.23** |
| 907A | 9H3 | 41–43 | 77.2 | 4.84 | 0.350 | **9.26** |
| 907A | 9H3 | 140–142 | 78.2 | 4.94 | 0.299 | **7.72** |
| 907A | 9H4 | 93–95 | 79.2 | 5.04 | 0.415 | **11.25** |
| 907A | 9H5 | 40–42 | 80.2 | 5.13 | 0.339 | **8.95** |
| 907A | 9H5 | 140–142 | 81.2 | 5.23 | 0.337 | **8.88** |
| 907A | 9H7 | 40–42 | 83.2 | 5.42 | 0.359 | **9.54** |
| 907A | 10H2 | 40–42 | 85.2 | 5.62 | 0.277 | **7.06** |
| 907A | 10H2 | 140–142 | 86.2 | 5.71 | 0.438 | **11.94** |
| 907A | 10H3 | 90–92 | 87.2 | 5.81 | 0.275 | **7.1** |
| 907A | 10H4 | 17.5–19.5 | 88.0 | 5.88 | 0.372 | **9.94** |
| 907A | 10H4 | 140–142 | 89.2 | 6.00 | 0.427 | **11.61** |

**SUPPLEMENTARY TABLE 2**

Age estimates for dinoflagellate cyst extinctions recorded in the early Pliocene. Ages are for highest occurrence (HO), unless specified otherwise. Highest common occurrence = HCO; highest persistent occurrence = HPO. All raw data is available from the indicated references.

| **Hole** | **ODP Hole 642C** | **ODP Hole 907A** | **DSDP Hole 610A** | **ODP Hole 646B** | **ODP Hole 603C** |
|---|---|---|---|---|---|
| **Region** | **Norwegian Sea** | **Iceland Sea** | **E. North Atlantic** | **Labrador Sea** | **W. North Atlantic** |
| References | This study | Refs. 1,2 | Refs. 3,4 | Refs. 2,5,6 | Refs. 2,7,8 |
| *Batiacasphaera micropapillata* complex | 4.64 Ma | 4.55 Ma (HCO) | 3.83 Ma as *B. minuta* | c. 3.7 Ma as *B. sphaerica* | 3.7 Ma as *B. micropapillata* (microreticulate) |
| *Corrudinium devernaliae* | 4.49 Ma | 4.45 Ma | 3.90 Ma | c. 3.8 Ma as *Corrudinium* sp. 1 | 4.1 Ma |
| *Operculodinium? eirikianum* | < 3.0 Ma | 4.45 Ma | 2.62 Ma | c. 3.5 Ma as *Operculodinium longispinigerum* | 3.1 Ma (HO)<br>3.6 Ma (HPO) |
| *Operculodinium tegillatum* | 4.49 Ma | 4.45 Ma | 3.71 Ma | c. 3.7 Ma as *O. crassum* | 3.6 Ma (HO)<br>4.0 Ma (HCO) |
| *Pyxidinopsis vesiculata* | 4.91 Ma | 4.45 Ma | 3.92 Ma | Not recorded | 4.5 Ma |
| *Reticulatosphaera actinocoronata* | 4.64 Ma | 4.45 Ma | > 4.0 Ma (base of core) | c. 4.0 Ma as *Impletosphaeridium* sp. | 4.0 Ma (HO)<br>4.5 Ma (HCO) |

**SUPPLEMENTARY TABLE 3**

Ages of deposits in the North Sea and Nordic Seas containing cool-water mollusk species with a Pacific origin.

| Location | Stratigraphic unit | Age (Ma) | Age reference | Mollusks reference |
|---|---|---|---|---|
| **Belgium** | Luchtbal Sands member (Oorderen Sands Formation) | 4.2–3.7 | 9 | 10 |
| | Kattendijk Sands Formation | 4.7–4.4 | 9 | 11 |
| **Eastern England** | Coralline Crag | 4.4–3.8 | 9,12 | 10,13 |
| **The Netherlands** | Lower Mollusk Zone D1 Oosterhout Formation | Early Pliocene | 10,14 | 10 |
| **Iceland** | *Serripes* Zone, Tjörnes Beds | 4.5–4.0 Ma | 15 | 16 |

**SUPPLEMENTARY TABLE 4**

Age model and stratigraphic events of Ocean Drilling Program (ODP) Hole 642B. Tie-points (in bold) used to construct the age model of ODP Hole 642B are based on the palaeomagnetic reversals of ref. 17, which have been updated to the Geological Time Scale 2012 (GTS2012)[18]. In this study, we identify in ODP Hole 642B the stratigraphic events of *B. micropapillata* complex (HO at 77.80 mbsf), *C. devernaliae* (HO at 77.35 mbsf), *O.*? *eirikianum* (ranges up to the top of studied interval), *O. tegillatum* (HO at 77.35 mbsf), *P. vesiculata* (HO at 82.01 mbsf) and *R. actinocoronata* (HO at 77.80 mbsf).

| **Chron/ Subchron** Ref. 17 | **Chron/Subchron** (GTS 2012) | **Chron boundary name** | **Upper boundary** | | **Lower boundary** | | **Mid-depth** (mbsf) | **Age** (Ma) ref. 17 | **Age** (Ma) updated to GTS 2012 |
|---|---|---|---|---|---|---|---|---|---|
| | | | **Sample** | **Depth** (mbsf) | **Sample** | Depth (mbsf) | | | |
| C2AN-2/C2AR-2 | C2An.2n/ C2An.2r | Top Mammoth | 9H-1, 41 | 66.81 | 9H-1, 71 | 67.11 | 66.96 | 3.08 | 3.207 |
| C2AR-2/C2AN-3 | C2An.2r / C2An.3n | Base Mammoth | 9H-2, 11 | 68.01 | 9H-2, 41 | 68.31 | 68.16 | 3.18 | 3.330 |
| C2AN-3/C2AR-3 | C2An.3n/C2Ar | Top Gilbert | 9H-3, 47 | 69.87 | 9H-3,71 | 70.11 | 69.99 | 3.40 | 3.596 |
| C2AR-3/C3N-1 | C2Ar/C3n.1n | Top Cochiti | 9H-7, 56 | 75.96 | 10H-1, 9 | 75.99 | 75.98 | 3.88 | 4.187 |
| C3N-1/C3R-1 | C3n.1n/C3n.1r | Base Cochiti | 10H-1, 70 | 76.60 | 10H-1, 101 | 76.91 | 76.76 | 3.97 | 4.300 |
| C3R-1/C3N-2 | C3n.1r/C3n.2n | Top Nunivak | 10H-1, 130 | 77.20 | 10H-2, 11 | 77.51 | 77.36 | 4.10 | 4.493 |
| C3N-2/C3R-2 | C3n.2n/C3n.2r | Base Nunivak | 10H-2, 11 | 77.51 | 10H-2, 41 | 77.81 | 77.66 | 4.24 | 4.631 |
| C3R-2/C3N-3 | C3n.2r/C3n.3n | Top Sidufjall | 10H-3, 71 | 79.61 | 10H-3, 100 | 79.90 | 79.76 | 4.40 | 4.799 |
| C3N-3/C3R-3 | C3n.3n/C3N.3r | Base Sidufjall | 10H-4, 126 | 81.66 | 10H-5, 11 | 82.01 | 81.84 | 4.47 | 4.896 |
| C3R-3/C3N-4 | C3N.3r/C3n.4n | Top Thvera | 10H-5, 130 | 83.20 | 10H-6, 10 | 83.5 | 83.35 | 4.57 | 4.997 |
| C3N-4/C3R-4(?) | C3n.4n/C3r | Base Thvera | 10H-6, 71 | 84.11 | 10H-6, 100 | 84.4 | 84.255 | 4.77 | 5.235 |
| C3R-4(?)/(C3A) C3AN-1 | C3R/C3An.1n | Top Gilbert | 12H-2, 71 | 97.11 | 12H-2, 101 | 97.41 | 97.26 | 5.35 | 6.033 |

**SUPPLEMENTARY TABLE 5**

Age model and stratigraphic events of Ocean Drilling Program (ODP) Hole 907A. Tie-points (in bold) used to construct the age model of ODP Hole 907A are based on the palaeomagnetic reversals of ref. 19. These reversals were updated to the Astronomically Tuned Neogene Time Scale (ATNTS) 2004[20] in ref. 2, and to the Geological Time Scale 2012[18] in this study. The ATNTS2004 and GTS2012 are identical back to 8.3 Ma[18]. Stratigraphic events in ODP Hole 907A of *C. devernaliae*, *O.*? *eirikianum*, *O. tegillatum*, *P. vesiculata*, *R. actinocoronata* (all HO at 73.2 mbsf) and *B. micropapillata* complex (HCO at 74.2 mbsf) are presented in ref. 2.

| **Chron boundary name** | **Chron/Subchron** | **Depth** (mbsf) | **Depth** (mcd) | **Age** (Ma) | **Age** (Ma) | **Age** (Ma) updated to GTS2012 |
|---|---|---|---|---|---|---|
| Top Mammoth | C2An.2n/ C2An.2r | **61.20** | 67.93 | 3.22 | 3.207 | **3.207** |
| Top Gilbert | C2An.2r / C2An.3n | **66.80** | 74.54 | 3.58 | 3.596 | **3.596** |
| Top Cochiti | C2An.3n/C2Ar | **70.50** | 78.24 | 4.18 | 4.187 | **4.187** |
| Base Gilbert | C2Ar/C3n.1n | **89.50** | 97.64 | 5.89 | 6.033 | **6.033** |
| Base 3An.1n | C3n.1n/C3n.1r | **92.25** | 100.39 | 6.14 | 6.252 | **6.252** |
| Top 3An.2n | C3n.1r/C3n.2n | **93.30** | 101.72 | 6.27 | 6.436 | **6.436** |
| Top 3Ar | C3n.2n/C3n.2r | **96.40** | 104.82 | 6.57 | 6.733 | **6.733** |

**SUPPLEMENTARY TABLE 6**

Age model and stratigraphic events of Deep Sea Drilling Project (DSDP) Hole 603C. The tie-points based on the palaeomagnetic reversals[8] used to construct the age model for DSDP Hole 603C in ref. 21 are repeated here. The ages of all reversals are reported according to the Geological Time Scale 2012[18]. Stratigraphic events in DSDP Hole 603C of *B. micropapillata* complex (HO at 185.96 mbsf), *C. devernaliae* (HO at 215.68 mbsf), *O.*? *eirikianum* (HO at 123.08 mbsf, HPO at 172.77 mbsf), *O. tegillatum* (HO at 172.77 mbsf, HPO at 204.82 mbsf), *P. vesiculat*a (HO at 249.07 mbsf) and *R. actinocoronata* (HO at 208.16, HCO at 249.07 mbsf) are listed in Appendix A of ref. 2.

| **Chron boundary name** | **Chron/Subchron** | **Depth** (mbsf) | **Age** (Ma) |
|---|---|---|---|
| Top Olduvai | C1r.3r/C2n | 13.00 | 1.778 |
| Base Olduvai | C2n/C2r.1r | 45.00 | 1.945 |
| Top Gauss | C2r.2r/C2An.1n | 82.00 | 2.581 |
| Top Kaena | C2An.1n/C2An.1r | 116.00 | 3.032 |
| Base Kaena | C2An.1r/C2An.2n | 128.00 | 3.116 |
| Top Mammoth | C2An.2n/C2An.2r | 136.00 | 3.207 |
| Base Mammoth | C2An.2r/C2An.3n | 144.00 | 3.330 |
| Top Gilbert | C2An.3n/C2Ar | 174.00 | 3.596 |
| Top Cochiti | C2Ar/C3n.1n | 222.00 | 4.187 |
| Base Cochiti | C3n.1n/C3n.1r | 232.00 | 4.300 |
| Top Nunivak | C3n.1r/C3n.2n | 244.00 | 4.493 |
| Top Sidufjall | C3n.2n/C3n.3r | 277.00 | 4.799 |
| Base Thvera | C3n.4n/C3r | 314.00 | 5.235 |

**SUPPLEMENTARY TABLE 7**

Age model and stratigraphic events of Deep Sea Drilling Project (DSDP) Hole 610A. The tie-points based on the palaeomagnetic reversals[22], benthic isotope stratigraphy[23] and one calcareous nannofossil extinction event used to construct the age model for DSDP Hole 610A in ref. 4 are repeated here. The ages are reported according to the Geological Time Scale 2012[18]. Stratigraphic events in DSDP Hole 610A of *B. micropapillata* complex (HO at 186.49 mbsf), *C. devernaliae* (HO at 191.67 mbsf), *O.? eirikianum* (HO at 128.47 mbsf), *O. tegillatum* (HO at 177.35 mbsf) and *P. vesiculata* (HO at 193.28 mbsf) are listed in refs. 3 and 4.

| **Stratigraphic event** | **Chron/Subchron** | **Depth** (mbsf) | **Age** (Ma) |
|---|---|---|---|
| Top Matuyama | C1n/C1r.1r | 42.46 | 0.781 |
| Top Jaramillo | C1r.1r/C1r.1n | 53.57 | 0.988 |
| Base Jaramillo | C1r.1n/C1r.2n | 56.93 | 1.072 |
| Top Olduvai | C1r.3r/C2n | 93.48 | 1.778 |
| Base Olduvai | C2n/C2r.1r | 98.63 | 1.945 |
| Top Réunion | C2r.1r/C2r.1n | 106.72 | 2.128 |
| Base Réunion | C2r.1n/C2r.2r | 108.37 | 2.148 |
| $\delta^{18}O$ stratigraphy | | 120.76 | 2.440 |
| $\delta^{18}O$ stratigraphy | | 126.15 | 2.560 |
| Top Gauss | C2r.2r/C2An.1n | 127.35 | 2.581 |
| $\delta^{18}O$ stratigraphy | | 128.69 | 2.623 |
| $\delta^{18}O$ stratigraphy | | 133.95 | 2.723 |
| $\delta^{18}O$ stratigraphy | | 138.60 | 2.805 |
| Top Kaena | C2An.1n/C2An.1r | 150.89 | 3.032 |
| Base Kaena | C2An.1r/C2An.2n | 154.66 | 3.116 |
| $\delta^{18}O$ stratigraphy | | 155.26 | 3.135 |
| Top Mammoth | C2An.2n/C2An.2r | 157.06 | 3.207 |
| $\delta^{18}O$ stratigraphy | | 157.67 | 3.215 |
| $\delta^{18}O$ stratigraphy | | 158.32 | 3.220 |
| $\delta^{18}O$ stratigraphy | | 159.32 | 3.230 |
| $\delta^{18}O$ stratigraphy | | 159.60 | 3.235 |
| $\delta^{18}O$ stratigraphy | | 159.79 | 3.246 |
| $\delta^{18}O$ stratigraphy | | 159.91 | 3.255 |
| $\delta^{18}O$ stratigraphy | | 160.06 | 3.260 |
| $\delta^{18}O$ stratigraphy | | 160.29 | 3.265 |
| $\delta^{18}O$ stratigraphy | | 160.36 | 3.270 |
| $\delta^{18}O$ stratigraphy | | 160.96 | 3.280 |
| $\delta^{18}O$ stratigraphy | | 161.10 | 3.285 |
| $\delta^{18}O$ stratigraphy | | 161.43 | 3.294 |
| $\delta^{18}O$ stratigraphy | | 161.71 | 3.300 |
| $\delta^{18}O$ stratigraphy | | 162.91 | 3.320 |
| Base Mammoth | C2An.2r/C2An.3n | 162.95 | 3.330 |
| $\delta^{18}O$ stratigraphy | | 163.05 | 3.341 |
| $\delta^{18}O$ stratigraphy | | 163.22 | 3.350 |
| $\delta^{18}O$ stratigraphy | | 163.51 | 3.365 |
| $\delta^{18}O$ stratigraphy | | 163.66 | 3.375 |
| $\delta^{18}O$ stratigraphy | | 163.81 | 3.380 |
| $\delta^{18}O$ stratigraphy | | 163.95 | 3.395 |
| Top Gilbert | C2An.3n/C2Ar | 168.83 | 3.596 |
| HCO *Reticulofenestra pseudoumbilicus* (calcareous nannofossil) | | 185.80 | 3.820 |

**SUPPLEMENTARY TABLE 8**

Age model and stratigraphic events of Ocean Drilling Program (ODP) Hole 646B. The tie-points based on the palaeomagnetic reversals[24] and calcareous nannofossil stratigraphy[6] used to construct the age model for DSDP Hole 646B in ref. 21 are repeated here. The ages are reported according to the Geological Time Scale 2012[18]. Stratigraphic events in DSDP Hole 646B of *B. micropapillata* complex (HO at 323.40 mbsf), *C. devernaliae* (HO at 349.20 mbsf), *O.? eirikianum* (HO at 286.70 mbsf), *O. tegillatum* (HO at 325.12 mbsf), and *R. actinocoronata* (HO at 376.47 mbsf) are listed in Appendix A of ref. 2.

| **Chron boundary name**<br>**Nannoplankton stratigraphy** | **Chron/Subchron** | **Depth** (mbsf) | **Age** (Ma) |
|---|---|---|---|
| Top Matuyama | C1n/C1r.1r | 62.98 | 0.781 |
| Jaramillo Top | C1r.1r/C1r.1n | 76.70 | 0.988 |
| Jaramillo Base | C1r.1n/C1r.2n | 82.65 | 1.072 |
| NN17/NN18 - NN19a | | 162.14 | 2.06 |
| Top Gauss | C2r.2r/C2An.1n | 191.50 | 2.581 |
| Top Gilbert | C2An.3n/C2Ar | 292.90 | 3.596 |
| NN15 - NN16 | | 343.02 | 3.79 |
| NN13/NN14 - NN15 | | 385.48 | 4.13 |
| NN12 - NN13/NN14 | | 455.29 | 5.13 |
| NN11b - NN12 | | 502.00 | 5.59 |
| NN11a - NN11b | | 574.43 | 7.36 |
| Chronozone C4, Top N2* | | 628.71 | 7.695 |
| Chronozone C4, Base N2* | | 666.47 | 8.108 |

* Questionable identification of the palaeomagnetic reversal

## Supplementary Note 1

At Iceland Sea ODP Hole 907A, prior to 4.5 Ma, the cool-tolerant taxa *Spiniferites elongatus* and *Impagidium pallidum* co-occur with thermophilic taxa suggesting temperate conditions. Although *S. elongatus* and *I. pallidum* can be considered as cool water species, both taxa have Northern Hemisphere distributions that reach as far south as 30°N and 45°N, respectively. *S. elongatus* comprises 1–10% of the total assemblage between 5 and 4.5 Ma at ODP Hole 907A. Such abundances are found today mainly in regions with sea surface temperature (SST) between –1 and 11 °C in winter and between 2 and 16 °C in summer, but can also occur in SSTs up to 25°C[25,26]. The other cool-water species *I. pallidum* is recorded occasionally in low abundances (1–2%) in the studied interval. In the modern and Pliocene oceans, such abundances occur in water temperatures mainly below 16°C, but have been recorded in SSTs up to ~25 °C[25–27]. The recorded abundances of *S. elongatus* and *I. pallidum* are thus not in conflict with temperate conditions for the Iceland Sea.
In contrast to the presence of cool-water taxa in temperate conditions, the diverse warm-water assemblage (including *Impagidinium aculeatum*, *Invertocysta lacrymosa*, *Melitasphaeridium choanophorum, Operculodinium israelianum, Operculodinium tegillatum*, and *Operculodinium*? *eirikianum*) at ODP Hole 907A has never been reported from (sub)polar waters and indicates temperate conditions in the Iceland Sea. For example, *M. choanophorum* is extinct in the mid- to high latitude North Atlantic since the late Pliocene[3] but was recently discovered in modern sediments of the northern Gulf of Mexico where summer SSTs are higher than 29°C[28]. Also, *O. israelianum* is a subtropical to tropical species that does not occur north of 50°N in the modern ocean[26]. The presence of these thermophilic taxa indicate the inflow of warm Atlantic waters at ODP Hole 907A, comparable to ODP Hole 642B.

## SUPPLEMENTARY NOTE 2

The barren interval in Iceland Sea ODP Hole 907A between 4.14 and 2.6 Ma is only interrupted by three mono-specific *Spiniferites* sp. samples at 3.66 Ma, 3.42 Ma and 3.34 Ma. The paleoenvironmental significance of such assemblages is unclear, as the aberrant *Spiniferites* specimens with elaborate morphologies could not be determined to species level. Elaborate morphologies of *Spiniferites* could be a reflection of fresh water, possibly affecting the site via the East Greenland Current and/or melting sea ice and icebergs. The morphology–salinity relationship has been observed in the *Spiniferites cruciformis* complex from low-salinity environments[e.g.29-32].

## SUPPLEMENTARY NOTE 3

Due to the warm temperate waters in the Norwegian Sea and the overall temperate conditions where tropical taxa can survive in the Iceland Sea between 5 and 4.5 Ma, a pronounced temperature gradient between the Iceland Sea and Norwegian Sea was absent. In fact, the dinoflagellate cyst records at ODP Hole 642B and ODP Hole 907A attest for a coupled temperature evolution of the Norwegian and Iceland Sea. Furthermore, a cooling recorded in the alkenone sea surface temperatures around 4.9–4.8 Ma (Supplementary Table 1) is accompanied by extremely high abundances of *Spiniferites elongatus* up to ~50% at ODP Hole 907A. Such abundances occur in the modern ocean only in Baffin Bay, where summer SSTs are around 5–6 ˚C. In Norwegian Sea ODP Hole 642B, an increase in the cool water species *Filisphaera filifera* causes a drop in the W/C index around this time (Figure 3), suggesting that the Iceland and Norwegian Sea temperature evolution are coupled. This Nordic Seas cooling may have been related to a global glaciation event (4.9–4.8 Ma) when glaciers expanded to the coastline in Greenland, Iceland and Scandinavia[33].

**SUPPLEMENTARY NOTE 4**

List with full authorial citation of the dinoflagellate cyst and acritarch taxa in the text, figures and supplementary notes. The dinoflagellate cyst nomenclature follows ref. 34, and full authorial citations can be found there. Authorial citations not listed in ref. 34 can be found in refs. 5, 21, 35–37.

***Dinoflagellate cysts***

*Achomosphaera* Evitt 1963

*Achomosphaera andalousiensis* subspecies *suttonensis* Head 1997

*Ataxiodinium*? sp. A (this study)

*Batiacasphaera micropapillata* complex (Schreck and Matthiessen 2013)

This complex comprises *Batiacasphaera micropapillata* Stover 1977 and *Batiacasphaera minuta* (Matsuoka 1983) Matsuoka and Head 1992

*Bitectatodinium tepikiense* Wilson 1973

*Corrudinium devernaliae* Head and Norris 2003

Cysts of *Protoceratium reticulatum (*Claparède and Lachmann, 1859) Bütschli, 1885

Note: the name cysts of *Protoceratium reticulatum* was recently proposed for *Operculodinium centrocarpum* sensu Wall and Dale (1966) in ref. 36

*Dapsilidinium pseudocolligerum* (Stover 1977) Bujak et al. 1980

*Filisphaera filifera* Bujak (1984) Head 1994

*Habibacysta tectata* Head et al. 1989

*Hystrichokolpoma rigaudiae* Deflandre and Cookson 1955

*Impagidinium* Stover and Evitt 1978

*Impagidinium aculeatum* (Wall 1967) Lentin and Williams 1981

*Impagidinium* cf. *pacificum* Bujak 1984

*Impagidinium pallidum* Bujak 1984

*Impagidinium paradoxum* (Wall 1967) Stover and Evitt 1978

*Impagidinium patulum* (Wall 1967) Stover and Evitt 1978

*Impagidinium solidum* Versteegh and Zevenboom 1995

*Invertocysta* Edwards 1984

*Invertocysta lacrymosa* Edwards 1984

*Invertocysta tabulata* Edwards 1984

*Lingulodinium machaerophorum* (Deflandre and Cookson 1955) Wall 1967

*Melitasphaeridium choanophorum* (Deflandre and Cookson 1955) Harland and Hill 1979

*Nematosphaeropsis labyrinthus* (Ostenfeld 1903) Reid 1974

*Operculodinium centrocarpum* s.s. (Deflandre and Cookson 1955) Wall 1967

*Operculodinium*? *eirikianum* (Head et al. 1989) Head 1997

*Operculodinium israelianum* (Rossignol 1982) Wall 1967

*Operculodinium tegillatum* Head 1997

*Pyxidinopsis vesiculata* Head and Norris 2003

*Reticulatosphaera actinocoronata* (Benedek 1972) Bujak and Matsuoka 1986

Protoperidinioids

*Spiniferites* (Mantell 19850) Sarjeant 1970

*Spiniferites elongatus* Reid 1974

*Spiniferites mirabilis* (Rossignol 1964) Sarjeant 1970

*Spiniferites hyperacanthus* (Deflandre and Cookson 1955) Cookson and Eisenack 1974

*Tectatodinium pellitum* (Wall 1967) Head 1994

*Tuberculodinium vancampoae* Wall 1967

***Acritarchs***

*Cymatiosphaera*? *invaginata* Head, Norris and Mudie 1989

Cyst type I of de Vernal and Mudie (1989)

*Lavradosphaera crista* De Schepper and Head 2008

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