**Electronic supplement**

**APPENDIX 1.** List of autochthonous calcareous nannofossil species.

*Braarudosphaera bigelowii* (Gran & Braarud, 1935) Deflandre, 1947

Calcidiscus leptoporus (Murray & Blackman 1898) Loeblich & Tappan, 1978

*Clausicoccus subdistichus* (Roth & Hay in Hay et al., 1967) Prins, 1979

*Coccolithus miopelagicus* Bukry, 1971

*Coccolithus pelagicus* (Wallich, 1877) Schiller, 1930

*Coronocyclus nitescens* (Kamptner, 1963) Bramlette & Wilcoxon, 1967

*Coronosphaera mediterranea* (Lohmann, 1902) Gaarder, in Gaarder & Heimdal, 1977

Cyclicargolithus floridanus (Roth & Hay, in Hay et al.*,* 1967) Bukry, 1971

*Discoaster deflandrei* Bramlette & Riedel, 1954

*Discoaster* sp.

*Helicosphaera ampliaperta* Bramlette & Wilcoxon, 1967

*Helicosphaera carteri* (Wallich, 1877) Kamptner, 1954

*Helicosphaera euphratis* Haq, 1966

*Helicosphaera intermedia* Martini, 196

*Helicosphaera mediterranea* Muller, 1981

*Helicosphaera obliqua* Bramlette & Wilcoxon, 1967

Helicosphaera recta (Haq, 1966) Jafar & Martini, 1975

*Helicosphaera scissura* Miller, 1981

*Helicosphaera walbersdorfensis* Müller, 1974

*Helicosphaera* sp.

*Holodiscolithus macroporus* (Deflandre, in Deflandre & Fert, 1954)

*Hughesius tasmaniae* (Edwards & Perch-Nielsen, 1975) de Kaenel &Villa, 1996

*Micrantholithus* sp.

*Pontosphaera multipora* (Kamptner, 1948 ex Deflandre, in Deflandre & Fert, 1954) Roth, 1970

*Pontosphaera* sp.

*Reticulofenestra antarctica* (Haq, 1976) Driever, 1988

Reticulofenestra daviesii (Haq, 1968) Haq, 1971

*Reticulofenestra gelida* (Geitzenauer, 1972) Backman, 1978

*Reticulofenestra haqii* Backman, 1978

*Reticulofenestra lockeri* Müller, 1970

*Reticulofenestra minuta* Roth, 1970

*Reticulofenestra producta* (Kamptner, 1963) Wei & Thierstein, 1991

*Reticulofenestra pseudoumbilicus* (Gartner, 1967) Gartner, 1969

*Sphenolithus belemnos* Bramlette & Wilcoxon, 1967

*Sphenolithus conicus* Bukry, 1971

*Sphenolithus disbelemnos* Fornaciari & Rio, 1996

*Sphenolithus moriformis* (Brönnimann & Stradner, 1960) Bramlette & Wilcoxon, 1967

Sphenolithus pseudoheteromorphus Fornaciari & Agnini, 2009

*Sphenolithus* sp.

Syracosphaera sp.

*Triquetrorhabdulus milowii* Bukry, 1971

*Triquetrorhabdulus* sp.

*Umbilicosphaera jafari* Müller, 1974

*Umbilicosphaera rotula* (Kamptner, 1956) Varol, 1982

**APPENDIX 2.** Abundance (%) of selected species for each investigated transect (zones NN2 and NN3). The minimum and maximum values are given only for taxa with more than 5 %.

|  |  |  |  |
| --- | --- | --- | --- |
| **NN2 Zone** | **Minimum % in samples** | **Maximum % in samples** | **Average % per transect** |
| **Dardha Transect** |
| *Cyclicargolithus floridanus* | 0 % in Da-77 | 69.23 % in Da-58 | 26.28 % |
| *Coccolithus pelagicus* | 1.54 % in Da-55 | 26.67 % in Da-72 | 10.18 % |
| *Reticulofenestra haqii* |  |  | 3.08 % |
| *Reticulofenestra gelida* |  |  | < 1% |
| *Reticulofenestra* gr. 3-5μm | 0 % in two samples | 54.55 % in Da-20 | 24.37 % |
| *Reticulofenestra* *minuta* | 4 % in Da-24 | 35.71 % in Da-64 | 11.59 % |
| *Reticulofenestra* *pseudoumbilicus* |  |  | < 1% |
| *Helicosphaera* spp. |  |  | 1.94 % |
| *Sphenolithus* spp. |  | 37.50 % in Da-07 | 11.72 % |
| *Umbilicosphaera jafari* |  |  | < 1% |
| **Dardha-1 Transect** |
| *Cyclicargolithus floridanus* | 5 % in Da-1/10 | 17.82 % in Da-1/05 | 8.83 % |
| *Coccolithus pelagicus* |  |  | 3.49 %), |
| *Reticulofenestra haqii* |  |  | 4.03 %. |
| *Reticulofenestra gelida* |  |  | 3.06 %), |
| *Reticulofenestra* gr. 3-5μm | 30.69 % in Da-1/20 | 64.36 % in Da-1/08 | 44.46 %; |
| *Reticulofenestra* *minuta* | 5 % in Da-1/06 | 54.03 % in Da-1/25 | 28.88 % |
| *Reticulofenestra* *pseudoumbilicus* |  |  | < 1% |
| *Helicosphaera* spp. |  |  | < 1% |
| *Sphenolithus* spp. |  |  | 3.96 % |
| *Umbilicosphaera jafari* |  |  | 1.13 %), |
| **Kodra Partizani** |
| *Cyclicargolithus floridanus* |  |  | 2.65 %; |
| *Coccolithus pelagicus* | 14.81 % in KP-18 | 36.36 % in KP-14 | 22.83 % |
| *Reticulofenestra haqii* | 9.77 % in KP-12 | 26.27 % in KP-15 | 14.88 % |
| *Reticulofenestra gelida* | 2.70 % in KP-06 | 10.19 % in KP-17 | 6.47 % |
| *Reticulofenestra* gr. 3-5μm | 3.48 % in KP-15 | 12.73 % in KP-13 | 6.89 % |
| *Reticulofenestra* *minuta* | 6.01 % in KP-15 | 49.51 % in KP-05 | 26.97 % |
| *Reticulofenestra* *pseudoumbilicus* | 3.91 % in KP-05 | 16.93 % in KP-16 | 10.49 % |
| *Helicosphaera* spp. |  |  | 3.57 %; |
| *Sphenolithus* spp. |  |  | 3.84 %; |
| *Umbilicosphaera jafari* |  |  |  |
| **NN3 Zone** | **Minimum % in samples** | **Maximum % in samples** | **Average % per transect** |
| **Miras-3** |
| *Cyclicargolithus floridanus* |  |  | 1.91 %, |
| *Coccolithus pelagicus* | 4.12 % in Mi-3/13 and Mi-3/14 | 19.49 % in Mi-3/03 | 12.84 % |
| *Reticulofenestra haqii* | 3.24 % in Mi-3/35 | 17.16 % in Mi-3/42 | 7.34 % |
| *Reticulofenestra gelida* | 2.41 % in Mi-3/14 | 15.09 % in Mi-3/04 | 6.99 % |
| *Reticulofenestra* gr. 3-5μm | 3.24 % in Mi-3/35 | 19.49 % in Mi-3/03 | 12.01 % |
| *Reticulofenestra* *minuta* | 21.26 % in Mi-3/39 | 60 % in Mi-3/20 | 44.35 % |
| *Reticulofenestra* *pseudoumbilicus* | 0.63 % in Mi-3/14 | 11.78 % in Mi-3/33 | 5.59 % |
| *Helicosphaera* spp. | 1.64 % in Mi-3/41 | 27.88 % in Mi-3/02 | 10.80 % |
| *Sphenolithus* spp. |  |  | 3.11 % |
| *Umbilicosphaera jafari* |  |  | 1%. |
| **Miras-4** |
| *Cyclicargolithus floridanus* |  |  | 4.32 %. |
| *Coccolithus pelagicus* | 5.21 % in Mi-4/06 | 32.42 % in Mi-4/10 | 20.71 % |
| *Reticulofenestra haqii* | 2.58 % in Mi-4/07 | 18.87 % in Mi-4/09 | 9.09 % |
| *Reticulofenestra gelida* | 0.65 % in Mi-4/06 | 9.12 % in Mi-4/14 | 6.67 % |
| *Reticulofenestra* gr. 3-5μm |  |  | 4.38 % |
| *Reticulofenestra* *minuta* | 1.80 % in Mi-4/10 | 78.50 % in Mi-4/06 | 33.97 % |
| *Reticulofenestra* *pseudoumbilicus* | 3.29 % in Mi-4/02 | 20.86 % in Mi-4/09 | 11.20 % |
| *Helicosphaera* spp. | 2.61 % in Mi-4/06 | 12.61 % in Mi-4/10 | 6.24 % |
| *Sphenolithus* spp. |  |  | 4.50 % |
| *Umbilicosphaera jafari* |  |  | <1 % |

**APPENDIX 3.** Hierarchical Clustering values for zones NN2 and NN3.

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| **NN2 clusters** | **No. of samples** | **Clusters/Sub-clusters description** |
| **Cluster 1**  | 39 samples |  |
| Sub-cluster 1a | 21 samples | * highest *Cy. floridanus* (from 9.09 % in Da-03 to 52.63 % in Da-84);
* increased *Reticulofenestra* gr. 3-5μm (from 4.88 % in Da-97 to 30.39 % in Da-10);
* *Coccolithus pelagicus* (2.94 % in Da-69 to 26.67 % in Da-72),\;
* *Sphenolithus* spp. (2.44 % in Da-97 to 22.12 % in Da-40)
* less *Reticulofenestra minuta* (a maximum of 16.67 % in Da-79)
 |
| Sub-cluster 1b | 16 samples | * highest amount of *Cy. floridanus (*from 7.14 % in Da-64 and Da-56 to 69.23 % in Da-58);
* *Reticulofenestra* gr. 3-5μm (from 10 % in Da-13 to 40 % in Da-56);
* *Reticulofenestra minuta* (a minim of 15.50 % in Da-05 to 35.71 % in Da-64);
* moderate quantities of *Sphenolithus* spp. (from 0 % in Da-43 to 20 % in Da-56);
* less *C. pelagicus* (highest of 20 % in Da-13).
 |
| Sub-cluster 1c | 1. samples
 | * highest amount of *Sphenolithus* spp. (36.36 % in Da-08 and 37.50 % in Da-07);
* less *Cy. floridanus* and *Reticulofenestra minuta.*
 |
| **Cluster 2** | 16 samples  | * very high quantities of *Reticulofenestra* gr. 3-5μm (from 30.69 % in Da-1/20 to 53.47 % in Da-1/10);
* *Reticulofenestra minuta* (from 27.72 % in Da-10 to 45.03 % in Da-25);
* The rest of the species are in low amounts.
 |
| **Cluster 3** | 18 samples  | separated into two sub-clusters based on abundance fluctuations of *Reticulofenestra* gr. 3-5μm |
| Sub-cluster 3a | 12 samples | * high amount of *Reticulofenestra* gr. 3-5μm (from 30.30 % in Da-01 to 54.55 % in Da-20);
* *Cy. floridanus* (from 7.55 % in Da-1/22 to 32 % in Da-24);
* Additionally, some samples exhibit higher quantity of *Reticulofenestra minuta* and *Coccolithus pelagicus* than the rest of the taxa
 |
| Sub-cluster 3b | 6 samples  | * highest quantity of *Reticulofenestra* gr. 3-5μm (from 49.02 % in Da-1/04 to 64.36 % in Da-1/08);
* Two species, *Reticulofenestra minuta* (a maximum of 21 % in Da-1/03) and *Cy. floridanus* (highest of 17.82 % in Da-1/05) are found in higher quantities than the rest.
 |
| **Cluster 4** | 18 samples | fluctuations of long-ranging species and increase in abundance of species characteristic for Miocene. |
| Sub-cluster 4a | 11 samples | * highest quantity of *Coccolithus pelagicus* (from 14.81 % in KP-18 to 36.36 % in KP-14);
* *Reticulofenestra minuta* (from 6.01 % in KP-15 to 32.43 % in KP-06);
* *Reticulofenestra haqii* (from 11.71 % in KP-06 to 26.27 % in KP-15);
* *Reticulofenestra pseudoumbilicus* (from 6.36 % in KP-13 to 16.93 % in KP-16);
* Slightly elevated amounts of *R. gelida* and *Helicosphaera* spp. in some samples is recorded.
 |
| Sub-cluster 4b | 7 samples | * very high percentages of *Reticulofenestra minuta* (from 31.80 % in KP-11 to 49.51 % in KP-05),;
* *Coccolithus pelagicus* (from 16.71 % in KP10 to 24.19 % in KP-04);
* less *Reticulofenestra haqii* (9.77 % in KP-12 to 15.92 % in KP-03);
* The rest of the species display very low amounts.
 |
| **NN3 clusters** | **No. of samples** | **Clusters/Sub-clusters description** |
| **Cluster 1**  | 11 samples | * high quantity of *Reticulofenestra minuta* (from 21.26 % in Mi-3/39 to 41.47 % in Mi-3/05);
* *Coccolithus pelagicus* (from 12.78 % in Mi-3/05 to 22.70 % in Mi-3/40);
* *Reticulofenestra* gr. 3-5μm (9.48 % in Mi-3/38 to 19.49 % in Mi-3/03);
* *Helicosphaera* spp. (from 1.64 % in Mi-3/41 to 27.89 % in Mi-3/02);
* *Reticulofenestra haqii* (from 4.15 % in Mi-3/03 to 17.16 % in Mi-3/42);
* *Reticulofenestra gelida* (from 6.77 % in Mi-3/07 to 15.09 % in Mi-3/04).
 |
| **Cluster 2** | 9 samples | * high quantity of *Reticulofenestra minuta* (from 42.95 % in Mi-3/34 to 56.77 % in Mi-3/36),\;
* *Coccolithus pelagicus* (from 15.18 % in Mi-3/23 to 26.97 % in Mi-4/02);
* *Helicosphaera* spp. (a maximum of 17.60 % in Mi-3/33).
 |
| **Cluster 3** | 11 samples | * high amount of *Reticulofenestra minuta* (from 31.72 % in Mi-4/23 to 49.84 % in Mi-3/29);
* *Coccolithus pelagicus* (between 9.97 % in Mi-3/29 and 17.57 % in Mi-3/37);
* *Reticulofenestra pseudoumbilicus* (8.31 % in Mi-3/37 to 11.63 % in Mi-3/32);
* Lower amounts display the rest of the species.
 |
| **Cluster 4** | 22 samples |  |
| Sub-cluster 4a | 12 samples | * very high quantity of *Reticulofenestra minuta* (between 43.56 in Mi-3/10 and 56.70 % in Mi-3/13 and Mi-3/14);
* *Reticulofenestra* gr. 3-5μm (from 12.66 % in Mi-3/11 to 18.56 % in Mi-3/14);
* *Helicosphaera* spp. (from 8.04 % in Mi-3/14 to 21.57 % in Mi-3/16).
 |
| Sub-cluster 4b | 8 samples | * very high percentages of *Reticulofenestra minuta* (between 49.04 in Mi-3/26 and 60 % in Mi-3/20);
* *Reticulofenestra* gr. 3-5μm (between 6.64 % in Mi-4/21 to 13.14 % in Mi-3/26);
* Lower percentages display the rest of the species which are found in more or less equal amounts.
 |
| Sub-cluster 4c | 2 samples  | * highest content of *Reticulofenestra minuta* (78.50 % in Mi-4/06 and 73.55 % in Mi-4/07).
 |
| **Cluster 5** | 13 samples | * higher *Coccolithus pelagicus* (between 18.48 % in Mi-4/22 and 32.43 % in Mi-4/10);
* high *Reticulofenestra minuta* (from 1.80 % in Mi-4/10 to 32.57 % in Mi-4/03);
* *Reticulofenestra pseudoumbilicus* display the highest percentages (from 5.54 % in Mi-4/03 and 20.86 % in Mi-4/09);
* *Reticulofenestra haqii* reach a maximum of 18.87 % in Mi-4/09;
* *Helicosphaera* spp. register a highest peak of 12.61 % in Mi-4/10.
 |