GSA Data Repository item 2015xxx **[including detailed information on location, analytical methods, quantitative results, outcrop photographs, Scan Electron Micrographs of benthic foraminifera, whole-rock C and O stable isotope data, XRD mineralogy and indices, foraminiferal data and indices, and previously published information on the EECO]** is available online at www.geosociety.org/pubs/ft2015.htm, or by request to editing@geosociety.org.

# The Early Eocene Climatic Optimum: environmental impact on the North Iberian continental margin

**Aitor Payros[1*], Silvia Ortiz[1, 2], Isabel Millán[3], Javier Arostegi[4], Xabier Orue-Etxebarria[1], Estibaliz Apellaniz[1]**

*[1] Department of Stratigraphy and Paleontology, Faculty of Science and Technology, University of the Basque Country (UVP/EHU), Bº Sarriena s/n, 48940 Leioa, Spain. a.payros@ehu.es; xabi.orueetxebarria@ehu.es; estibaliz.apellaniz@ehu.es*

*[2] PetroStrat Ltd, Tan-y-Graig, Parc Caer Seion, Conwy, Wales, UK, LL32 8FA. silvia.ortiz@petrostrat.com*

*[3] Earth Sciences Department, Geological Institute, ETH Zürich, Sonneggstrasse 5, 8092 Zürich, Switzerland. isabel.millan@erdw.ethz.ch*

*[4] Department of Mineralogy and Petrology, Faculty of Science and Technology, University of the Basque Country (UVP/EHU), Bº Sarriena s/n, 48940 Leioa, Spain. javier.arostegi@ehu.es*

## DETAILED ANALYTICAL METHODS AND QUANTITATIVE RESULTS

This study provides new data on hemipelagic mineralogy, bulk carbonate $\delta^{13}C$ and $\delta^{18}O$, and foraminiferal assemblages from the 0-900 m interval of the Barinatxe-Gorrondatxe section (Figs.1, DR1, DR2). In order to characterize the lower Eocene succession completely, the new information is complemented with previously published geochemical (stable isotopes), mineralogical and foraminiferal data from the lower-middle Eocene transition at the Gorrondatxe section (900 to 1100 m; Payros et al., 2012).

The sampling was carried out at coastal cliffs (Figs. DR1, DR2) that expose the so-called Marly Flysch at the Barinatxe beach (from UTM X499.780 Y4.803.660 to X499.380 Y4.803.210), the Azkorri Sandstone at the Azkorri headland (from UTM X499.380 Y4.803.210 to X499.850 Y4.803.235) and the Sandy Flysch at the Gorrondatxe beach (from UTM X499.850 Y4.803.235 to X498.820 Y4.802.930). Unfortunately, the upper part of the Marly Flysch (440-530 m) is poorly exposed at the Barinatxe beach. In order to solve this hindrance, a well-exposed, laterally equivalent succession (335-570 m) was sampled on the slopes of a newly built road between Sopela and Barinatxe (from UTM X500.190 Y4.802.985 to X500.310 Y4.802.590). Comparison of the overlapping stratigraphic portions (those exposed in both the beach and road sections) allowed a precise bed-by-bed correlation at cm scale, demonstrating that all types of deposits (turbidites, marls, limestones and red layers; Figs. DR1, DR2) extend laterally and maintain their stratigraphic characteristics for more than 1 km.

## Geochemical Analysis

Two hundred and three samples were collected from 180 stratigraphic levels for $\delta^{13}C$ and $\delta^{18}O$. When possible, the samples were alternatively collected from hemipelagic limestone and marlstone beds every 5 m of stratigraphic thickness (excluding the faulted interval between 222 and 268 m). However, some parts of the succession are almost devoid of limestone beds and, consequently, 90 samples correspond to limestones and 113 to marlstones. Taking into account that the studied succession spans from approximately 55 Ma to 47 Ma, the average sampling resolution is of ca. 44 kyr.

The geochemical analysis was carried out at the Stable Isotope Laboratory of the Swiss Federal Institute of Technology Zurich (ETH). Carbonate powder was extracted with a microdrill from freshly cut rock, avoiding skeletal components and vein material. Approximately 250 µg of powder was analysed on a FinniganGasBench II carbonate device connected to a ThermoFisher Delta V PLUS mass spectrometer. The reproducibility of the measurements based on replicated standards was ±0.04‰ for $\delta^{13}C$ and ±0.05‰ for $\delta^{18}O$. The instrument is calibrated with the international standards NBS19 and NBS18. The results thus obtained are shown in Figure 2 and in Table DR1, the isotope values being reported in the conventional delta notation with respect to VPDB. Oxygen isotope values are prone to diagenetic alteration during burial and, therefore, they were not used for paleotemperature estimations but only to assess the degree of diagenetic overprinting on the $\delta^{13}C$ record.

**Mineralogical Analysis**

One hundred and forty-one samples of hemipelagic limestones (67) and marlstones (74) were analyzed for their mineralogical content by X-ray diffraction (XRD) using a Philips PW1710 diffractometer at the University of the Basque Country. All samples were mechanically ground to powder in order to determine their general mineralogy in randomly oriented samples. For clay mineral analysis, samples were decarbonated using diluted HCl and the suspension obtained was centrifuged until chlorides were removed. Oriented aggregates of the $<2$ μm fraction were analyzed by XRD following three steps: first, air-dried without any additional treatment; second, after treatment with ethylene glycol during 48 hours, in order to identify smectite; and, third, after being treated with dimethyl sulphoxide and heated at 75ºC for 72 hours, in order to identify kaolinite and chlorite. Semiquantitative abundances were assessed using the intensity (area) of the major XRD reflections and applying the corresponding correction factors. The results thus obtained are shown in Figure 3 and Table DR2.

The clay mineral results were used to obtain significant paleoclimate indices. The sum of illite plus chlorite is commonly regarded as proportional to the intensity of physical weathering in arid (either hot or cold) source areas, whereas the sum of smectite plus kaolinite is indicative of the intensity of chemical weathering (hydrolysis) under hot humid climates (Arostegi et al. 2011; Thiry 2000). Therefore, the (illite+chlorite)/(smectite+kaolinite) ratio is indicative of predominant physical/chemical weathering (PhW/ChW) in the source area. The smectite/kaolinite ratio (Sm/Kl) provides evidence of the rainfall regime (perennial if lg Sm/Kl $<0$; seasonal if $>0$) (Thiry, 2000; Gertsch et al., 2010; Arostegi et al., 2011).

## Benthic Foraminifera

One hundred and four marly layers were sampled for benthic foraminifera >100 µm. In order to determine the environmental evolution, shallow-water allochthonous taxa, which were probably transported downslope by turbidity currents, were removed from the foraminifera counts (see Ortiz et al., 2011 for more details). Tubular taxa (e.g., *Nothia* and nodosariids species) are usually broken into fragments and to avoid biased results, we counted one specimen per every three fragments.

To infer seafloor conditions and the paleoecological evolution of benthic foraminifera, we analyzed the diversity of the assemblages calculating the Fisher-α index, the planktic-to-benthic foraminifera ratio (P%), agglutinated-to-calcareous benthic taxa ratio (A%), and agglutinated and calcareous-agglutinated benthic taxa ratio (calcareous-to calcareous- plus organic-agglutinated taxa). The results are shown in Figures 4 and DR3 and in Table DR3.

Species simultaneously respond to bottom and pore-water oxygenation as well as to the organic flux level. Many taxa that have been proposed as low oxygen indicators should probably also be considered as high productivity markers. We interpret the abundance of taxa such as *Globobulimina*, *Chilostomella*, *Nonionella*, *Quadrimorphina*, *Hopkinsina* and *Fursenkoina* species as indicative of a high and continuous food supply to the seafloor (Jorissen et al., 2007 and references therein).

In addition, shell diameters of benthic foraminifera *Nuttallides truempyi* were measured to evaluate stratigraphic variations in size. Measurements are expressed as mean values of the five largest specimens in the >100 µm size fraction.

**Planktic Foraminifera**

Planktic foraminifera were not specifically analyzed in this study, but previously published information was compiled from Orue-Etxebarria et al. (1984, 2006), Orue-Etxebarria and Apellaniz (1985), Orue-Etxebarria and Lamolda (1985), Bernaola et al. (2006b), and Payros et al. (2007, 2009b). These studies aimed at obtaining biostratigraphic information from the entire 2300 m thick Eocene succession, but only those corresponding to the 0-1100 m interval were considered herein.

Payros et al. (2006) used the planktic foraminiferal biostratigraphic information to deduce the environmental evolution of the Barinatxe-Gorrondatxe area. To this end, they counted only certain species occurrences (those labelled as frequent and rare in Orue-Etxebarria et al., 1984 and in Orue-Etxebarria and Apellaniz, 1985) and excluded uncertain occurrences. The usefulness of Eocene planktic foraminifers as paleobiogeographic, paleoecological and paleoceanographic indices was demonstrated, among others, by Orue-Etxebarria and Lamolda (1985), Premoli Silva and Boersma (1988, 1989) and Boersma and Premoli Silva (1991). They reasoned that the more specialized the planktic foraminiferal morphology, the greater the tendency to inhabit lower latitudes. These authors defined several groups of planktic foraminiferal species that are assumed to be representative of different paleolatitudinal and/or paleoenvironmental settings. In order to apply this paleobiogeographic scheme, Payros et al. (2006) adapted the genus-level classification of the Barinatxe-Gorrondatxe planktic foraminifera (Orue-Etxebarria et al., 1984; Orue-Etxebarria and Apellaniz, 1985) to that of Premoli Silva and Boersma (1988, 1989) and Boersma and Premoli Silva (1991), and individual species were subsequently ranked as low, middle-low, middle, middle-high and high latitude taxa. The ratio of lower to higher latitude index species was calculated for each sample by counting the occurrence of paleobiogeographically significant taxa and by adding the abundance of middle-low and middle-high indices to that of low and high indices respectively. The results thus obtained are shown in Figure 1 and in Table DR4.

## AGE CONTROL

Age data of the Barinatxe-Gorrondatxe section derives from previously published planktic foraminifera and calcareous nannofossil biostratigraphic studies (Orue-Etxebarria et al., 1984; Orue-Etxebarria and Lamolda, 1985; Bernaola et al., 2006a; 2006b; Orue-Etxebarria et al., 2006; Payros et al., 2007; 2009a; 2009b; 2011). In the Barinatxe-Gorrondatxe section both the base and top of Interval 2 (upper part of the Marly Flysch, herein attributed to the Early Eocene Climatic Optimum, EECO) are distinctive stratigraphic features that can be accurately dated (Fig. 5).

In order to contrast our results, previously published information was compiled, evaluated and compared using the GTS2012 chronostratigraphy (Gradstein et al., 2012) as a reference framework (Table DR5). The EECO was originally described as the peak of the long-term early Cenozoic warming, which began in the mid-Paleocene (59 Ma) and was followed by a 17-myr-long cooling, much of which occurred between 50 and 48 Ma (Zachos et al., 2001). The EECO was thus dated between 53-52 and 50 Ma, extending from the lower part of the calcareous nannofossil NP12 zone to the lower part of NP13, from the lower part of the planktic foraminiferal E5 zone to the lower part of E7a, and from the mid part of Chron C23r to the upper part of C22r. From our comparative study we conclude that, despite the 53-50 Ma age range originally given for the EECO (Zachos et al., 2001), subsequent authors have referred to this interval rather inconsistently, each embracing different portions of the 54-46 Ma interval.

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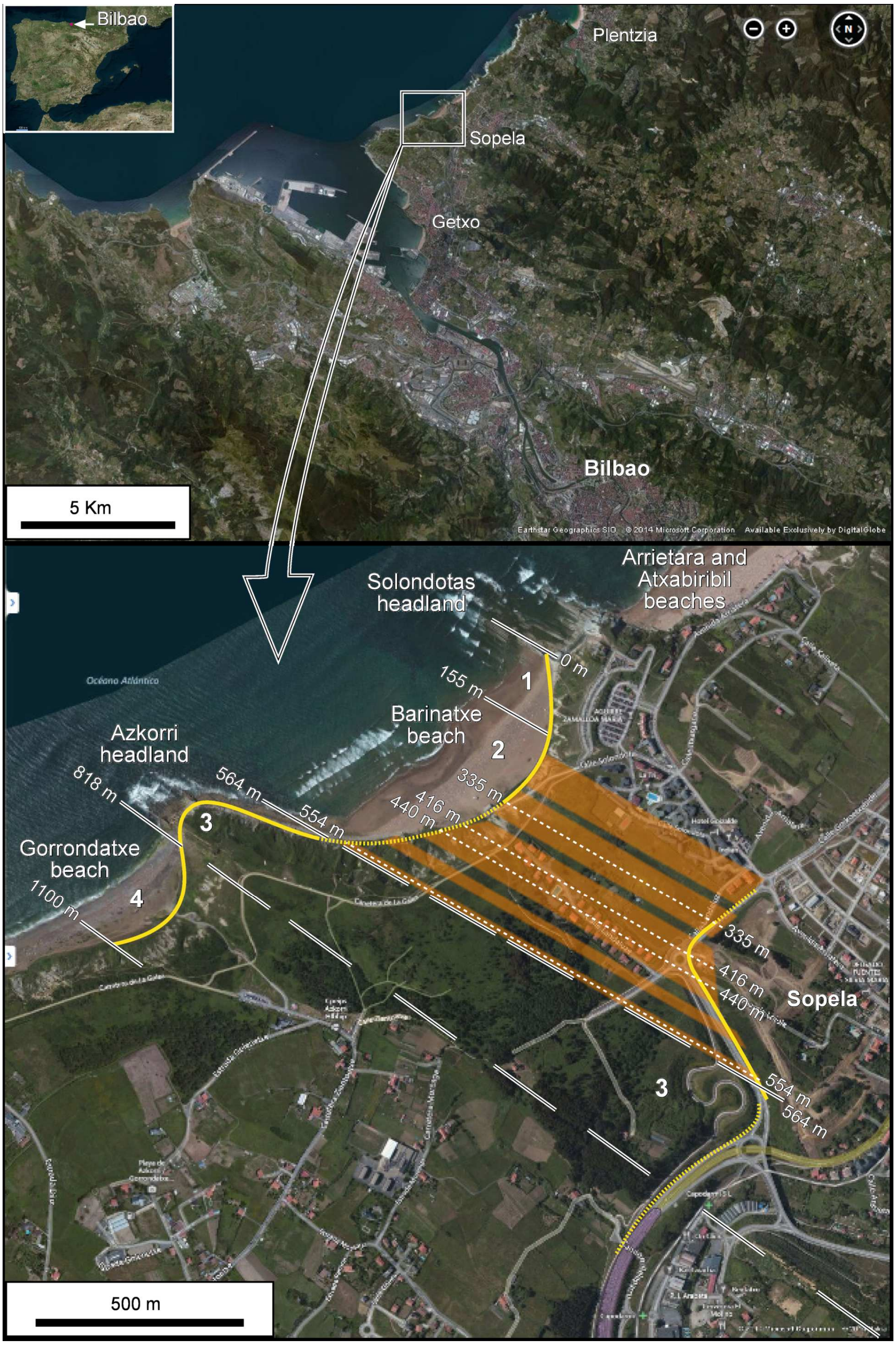


**Figure DR1:** Geographic location of the Barinatxe-Gorrondatxe section (images taken from Bing Maps at http://www.bing.com/maps/#). The lower picture shows key geographic points, the stratigraphic intervals defined in this study (1-4), the reddish slices within Interval 2 (orange) and key beds correlated between adjacent outcrops (dotted white lines; stratigraphic position from the base of the succession is given in metres). The yellow lines show the successions studied herein (dotted: examined; solid: examined and sampled). The upper part of Interval 2 (440-530 m) is poorly exposed at the Barinatxe beach, and so a laterally equivalent succession (335 to 570 m) was sampled on a newly built road between Sopela and Barinatxe.

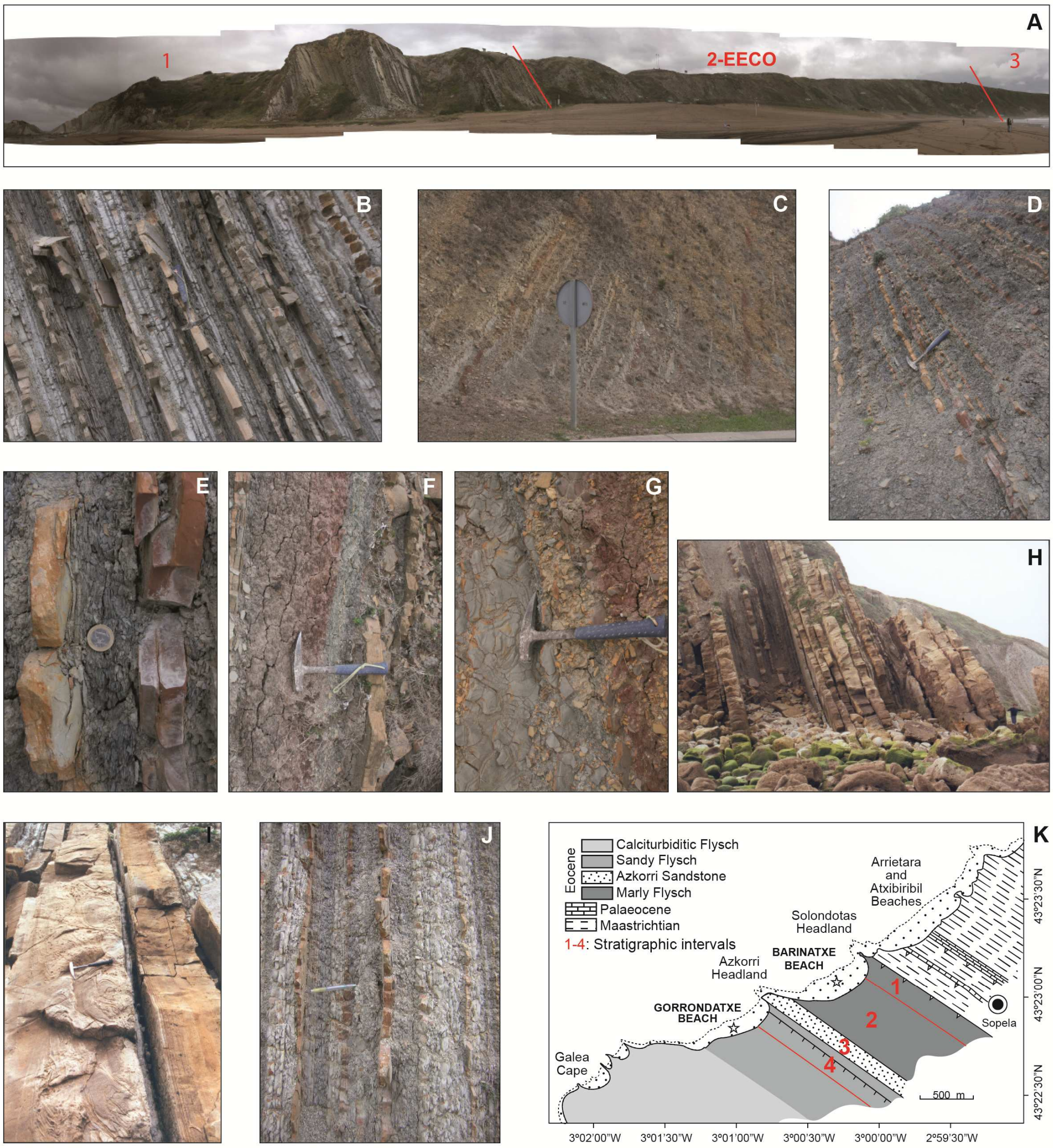


**Figure DR2. A.** General view of the Barinatxe beach section showing the stratigraphic intervals 1-3 discussed in the text. Interval 2 corresponds to the EECO. **B.** Detail of Interval 1: alternation of hemipelagic grey limestones and marls with intercalated brown turbidites. **C.** General view of reddish slice 3 in Interval 2. **D.** Detail of reddish slice 2: grey marls with intercalated brown to yellowish turbidites and common red layers. **E.** Close-up of A thin-bedded turbidite (left), its capping marl (middle) and a bright red, stiff wavy layer (right) in reddish slice 2. **F.** Close-up of a dull red soft layer, directly overlying a turbidite (left) in Interval 2 (reddish slice 3). **G.** Close-up of *Scolicia* furrows on top of a turbidite, subsequently overlain by a red layer (Interval 2, reddish slice 3). **H.** General view of Interval 3, Azkorri Sandstone. **I.** Close-up of Interval 3: Thick-bedded, convoluted turbidites with intercalated hemipelagic grey limestones. **J.** Detail of Interval 4: alterning hemipelagic grey marls and whitish limestones with intercalated thin-bedded turbidites (brown). Stratigraphic top to the right in all photos. **K.** Simplified geological map of the study area, showing lithostratigraphic units as used by Bernaola et al. (2006).

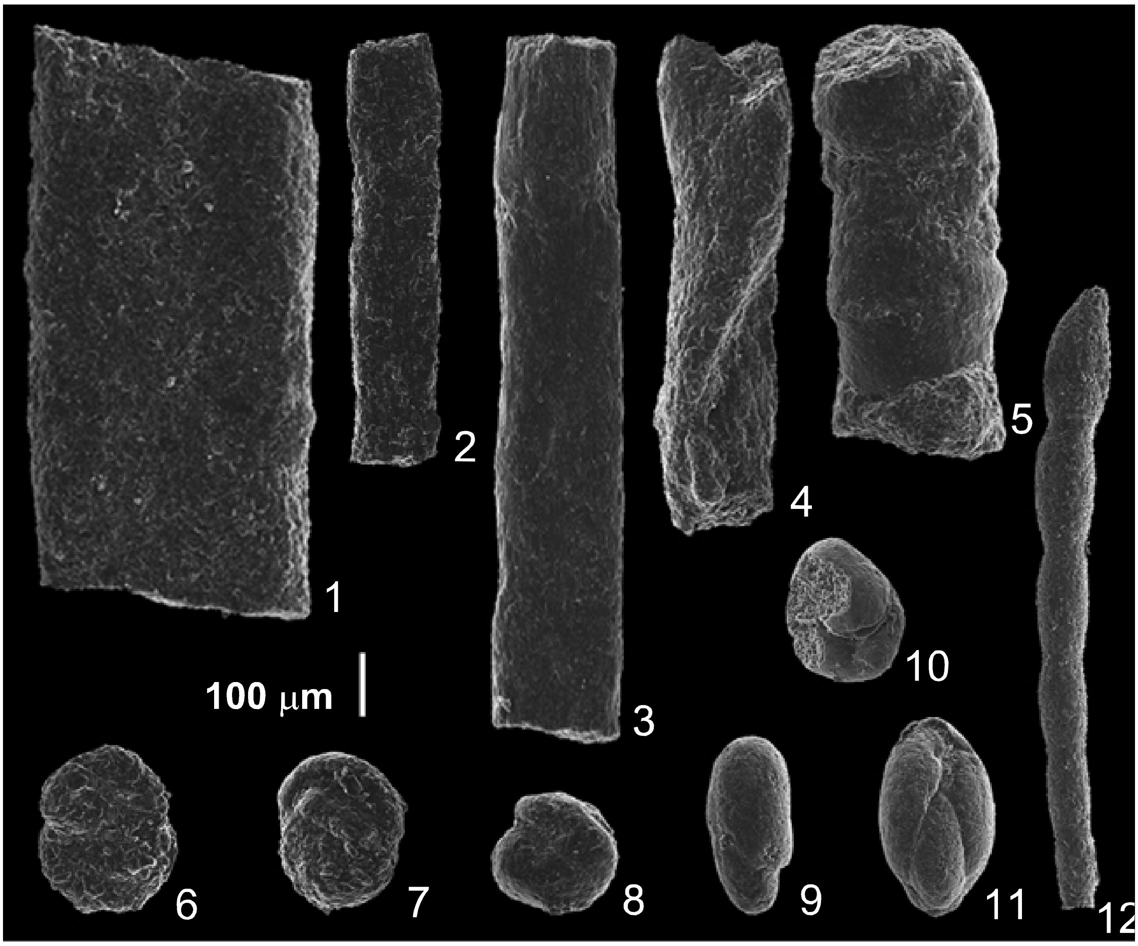


**Figure DR3.** Common benthic foraminifera from the EECO interval at the Barinatxe-Gorrondatxe section. 1-3. *Nothia excelsa*; 4-5. Astrorhizids; 6-8. Trochamminids; 9. *Chilostomella* sp.; 10. *Quadrimorphina allomorphinoides* (note the pyrite filling); 11. *Globobulimina pacifica*; 12. Nodosariid.

**Table DR1.** Whole-rock C and O stable isotope results from hemipelagic deposits of the Barinatxe-Gorrondatxe section.

| Lithology *R: red layer | Stratigraphic level (m) | d13C (‰) | d18O (‰) |
|---|---|---|---|
| limestone | 4 | 0.66 | -2.40 |
| marlstone | 8 | 0.46 | -2.73 |
| limestone | 13 | 0.61 | -2.85 |
| marlstone | 19 | 0.28 | -3.20 |
| limestone | 28 | 0.36 | -2.19 |
| marlstone | 33 | -0.39 | -3.22 |
| marlstone | 73 | -1.30 | -6.46 |
| marlstone | 78 | 0.85 | -2.67 |
| marlstone | 85 | 0.73 | -2.62 |
| limestone | 90 | 0.86 | -2.34 |
| marlstone | 95 | 0.46 | -2.44 |
| limestone | 101 | 0.65 | -1.94 |
| marlstone | 108 | 0.53 | -2.25 |
| limestone | 111 | 0.85 | -2.17 |
| marlstone | 116 | 1.02 | -1.99 |
| limestone | 118 | 0.99 | -2.48 |
| marlstone | 121 | 0.68 | -2.43 |
| marlstone | 124 | 0.84 | -2.32 |
| marlstone | 127 | 0.47 | -2.85 |
| marlstone | 130 | 0.64 | -2.42 |
| limestone | 136 | 0.76 | -2.63 |
| marlstone | 142 | 0.93 | -2.42 |
| limestone | 147 | 0.77 | -2.33 |
| marlstone | 152 | 0.85 | -2.38 |
| limestone | 157 | 0.42 | -2.27 |
| limestone | 162 | -0.21 | -3.12 |
| marlstone | 165 | -1.06 | -4.87 |
| marlstone | 169 | -1.73 | -3.63 |
| limestone | 172 | -0.74 | -3.46 |
| limestone | 177 | -0.23 | -3.34 |
| limestone | 182 | 0.37 | -2.49 |
| marlstone | 187 | -0.98 | -3.71 |
| limestone | 191 | 0.30 | -3.57 |
| marlstone | 196 | -0.94 | -3.48 |
| marlstone | 202 | -1.17 | -4.67 |
| marlstone | 207 | -1.03 | -4.36 |
| limestone | 213 | -0.26 | -3.74 |
| marlstone | 220 | -1.51 | -4.46 |
| limestone | 250 | -0.17 | -3.38 |
| marlstone | 279 | -1.08 | -4.39 |
| marlstone | 287 | -2.60 | -5.44 |
| limestone | 292 | -0.40 | -4.00 |
| marlstone | 298 | -1.00 | -4.06 |
| marlstone | 305 | -4.84 | -4.36 |
| marlstone | 310 | -2.66 | -4.86 |
| marlstone | 315 | -2.76 | -5.69 |
| marlstone | 320 | -2.16 | -5.99 |
| marlstone | 325 | -2.92 | -4.98 |
| marlstone | 330 | -2.54 | -5.88 |
| marlstone | 335 | -1.57 | -4.42 |
| marlstone | 340 | -3.10 | -5.09 |
| marlstone | 344 | -1.41 | -3.64 |
| marlstone | 348 | -1.71 | -4.06 |
| marlstone | 352 | -2.41 | -4.1 |
| marlstone | 356 | -2.54 | -4.81 |
| marlstone | 360 | -3.09 | -4.72 |
| marlstone | 364 | -3.40 | -5.50 |
| limestone | 368 | -0.27 | -4.42 |
| marlstone | 372 | -1.99 | -5.01 |
| limestone | 376 | -0.21 | -4.10 |
| marlstone | 380 | -2.63 | -4.58 |
| marlstone | 384 | -2.83 | -4.65 |
| marlstone | 388 | -1.97 | -4.58 |
| marlstone | 395 | -2.65 | -5.15 |
| marlstone | 399 | -1.96 | -4.05 |
| marlstone | 403 | -2.08 | -4.54 |
| marlstone | 407 | -2.86 | -5.32 |
| marlstone | 411 | -2.66 | -5.54 |

**Table DR1.** Continued

| | | | |
|---|---|---|---|
| marlstone | 415 | -2.68 | -5.31 |
| marlstone | 416 | -4.07 | -5.12 |
| marlstone | 420 | -3.42 | -5.35 |
| marlstone | 425 | -2.91 | -5.28 |
| marlstone | 431 | -3.15 | -5.41 |
| *R marlstone | 436 | -2.77 | -5.66 |
| *R marlstone | 440.8 | -5.49 | -0.74 |
| *R marlstone | 442.4 | -3.39 | -4.48 |
| *R marlstone | 442.5 | -3.13 | -5.00 |
| *R marlstone | 443.2 | -4.15 | -4.39 |
| *R marlstone | 444 | -4.96 | -2.18 |
| marlstone | 445 | -2.50 | -5.34 |
| *R marlstone | 446 | -3.55 | -1.74 |
| *R marlstone | 446 | -2.21 | -3.18 |
| marlstone | 447 | -2.82 | -5.92 |
| marlstone | 448 | -2.48 | -5.54 |
| marlstone | 449 | -2.56 | -4.92 |
| *R marlstone | 451 | -5.48 | -2.49 |
| marlstone | 452 | -2.90 | -4.98 |
| *R marlstone | 453 | -3.62 | -4.96 |
| marlstone | 454 | -2.97 | -4.97 |
| marlstone | 455 | -2.73 | -5.41 |
| marlstone | 456 | -1.51 | -4.67 |
| marlstone | 457 | -1.96 | -1.94 |
| *R marlstone | 458 | -2.86 | -4.21 |
| *R marlstone | 458 | -2.64 | -5.02 |
| *R marlstone | 458 | -1.52 | -4.27 |
| marlstone | 459 | -2.03 | -5.47 |
| marlstone | 461 | -1.72 | -4.95 |
| marlstone | 465 | -1.48 | -4.83 |
| marlstone | 470 | -1.89 | -5.35 |
| limestone | 475 | 0.20 | -4.06 |
| marlstone | 475 | -1.63 | -5.00 |
| limestone | 480 | 0.15 | -4.11 |
| marlstone | 485 | -2.54 | -3.95 |
| marlstone | 490 | | |
| marlstone | 495 | -2.40 | -4.95 |
| marlstone | 500 | -3.02 | -5.26 |
| marlstone | 505 | -2.15 | -4.59 |
| marlstone | 510 | | |
| marlstone | 515 | -3.43 | -5.34 |
| marlstone | 520 | -2.41 | -5.45 |
| marlstone | 525 | -1.82 | -5.43 |
| limestone | 530 | -2.10 | -6.22 |
| marlstone | 535 | -0.81 | -4.45 |
| limestone | 535 | 0.42 | -3.37 |
| marlstone | 540 | -1.24 | -4.39 |
| marlstone | 546 | -2.09 | -4.39 |
| marlstone | 550 | -2.47 | -5.51 |
| marlstone | 555 | -1.97 | -4.52 |
| marlstone | 560 | -1.49 | -4.67 |
| marlstone | 568 | 0.86 | -3.60 |
| marlstone | 598 | 0.59 | -3.59 |
| limestone | 605 | 0.60 | -3.41 |
| limestone | 633 | 0.25 | -2.20 |
| marlstone | 645 | 1.02 | -2.98 |
| marlstone | 650 | 0.32 | -3.58 |
| marlstone | 665 | -0.94 | -4.55 |
| limestone | 670 | 0.86 | -2.63 |
| limestone | 677 | 1.04 | -3.07 |
| marlstone | 686 | -0.87 | -4.46 |
| marlstone | 693 | -0.53 | -3.67 |
| limestone | 703 | 0.94 | -2.62 |
| marlstone | 708 | -2.85 | -4.21 |
| limestone | 712 | 0.62 | -2.55 |
| limestone | 723 | 0.26 | -1.97 |
| limestone | 728 | 0.96 | -1.95 |
| marlstone | 733 | 0.89 | -1.81 |
| limestone | 739 | 1.11 | -2.13 |
| marlstone | 745 | 0.32 | -3.10 |
| limestone | 748 | 0.86 | -2.87 |
| marlstone | 756 | -2.39 | -5.25 |
| marlstone | 761 | -2.64 | -5.10 |

**Table DR1.** Continued

| | | | |
|---|---|---|---|
| marlstone | 768 | 0.23 | -2.93 |
| marlstone | 786 | -3.15 | -4.70 |
| marlstone | 793 | -1.01 | -3.11 |
| limestone | 840 | -0.03 | -2.76 |
| marlstone | 850 | 0.60 | -2.92 |
| limestone | 855 | 0.62 | -2.99 |
| marlstone | 860 | -0.33 | -3.83 |
| marlstone | 880 | -2.54 | -5.92 |
| limestone | 890 | -0.15 | -3.48 |
| Payros et al. (2012) | | | |
| limestone | 902 | 0.27 | -2.73 |
| limestone | 910 | 0.48 | -3.37 |
| limestone | 922 | 0.27 | -3.41 |
| limestone | 930 | 0.06 | -3.22 |
| limestone | 940 | 0.31 | -3.11 |
| limestone | 952 | 0.65 | -3.09 |
| limestone | 961 | 0.65 | -2.99 |
| limestone | 969 | 0.54 | -3.19 |
| limestone | 981 | 0.66 | -3.04 |
| limestone | 987 | 0.48 | -2.67 |
| limestone | 994 | 0.54 | -2.82 |
| limestone | 1000 | 0.51 | -2.76 |
| limestone | 1005 | 0.55 | -2.90 |
| limestone | 1010 | 0.53 | -2.68 |
| limestone | 1015 | 0.08 | -2.36 |
| limestone | 1015 | 0.11 | -2.55 |
| limestone | 1015 | 0.14 | -2.52 |
| limestone | 1015 | 0.08 | -2.27 |
| limestone | 1017 | 0.34 | -2.84 |
| limestone | 1017 | 0.30 | -2.83 |
| limestone | 1017 | 0.20 | -2.81 |
| limestone | 1017 | 0.33 | -2.88 |
| limestone | 1024 | -2.50 | -4.92 |
| limestone | 1024 | -2.69 | -4.82 |
| limestone | 1024 | -2.89 | -5.07 |
| limestone | 1024 | -2.72 | -5.10 |
| limestone | 1027 | -2.45 | -4.63 |
| limestone | 1027 | -2.38 | -4.63 |
| limestone | 1027 | -2.45 | -4.57 |
| limestone | 1027 | -2.27 | -4.63 |
| limestone | 1027 | -2.45 | -4.29 |
| limestone | 1027 | -2.46 | -4.31 |
| limestone | 1030 | 0.23 | -2.99 |
| limestone | 1030 | 0.30 | -2.89 |
| limestone | 1030 | -0.06 | -3.10 |
| limestone | 1030 | 0.07 | -2.86 |
| limestone | 1035 | -0.05 | -2.73 |
| limestone | 1035 | -0.14 | -2.70 |
| limestone | 1035 | 0.02 | -2.54 |
| limestone | 1035 | -0.09 | -2.59 |
| limestone | 1035 | -0.11 | -2.79 |
| limestone | 1038 | 0.17 | -2.97 |
| limestone | 1042 | 0.23 | -2.84 |
| limestone | 1046 | 0.30 | -2.73 |
| limestone | 1050 | 0.62 | -1.84 |
| limestone | 1050 | 0.55 | -1.95 |
| limestone | 1055 | 1.04 | -1.94 |
| limestone | 1060 | 1.28 | -1.41 |
| limestone | 1065 | 1.12 | -2.07 |
| limestone | 1069 | 1.03 | -1.57 |
| limestone | 1074 | 0.96 | -1.89 |
| limestone | 1080 | 1.31 | -1.07 |
| limestone | 1090 | 0.40 | -2.30 |
| limestone | 1100 | 0.85 | -1.85 |

**Table DR2.** XRD results for whole-rock and clay (<2 micrometer fraction) mineralogy of hemipelagic deposits from the Barinatxe-Gorrondatxe section. Weathering: physical/chemical weathering index given by the (illite+chlorite)/(smectite+kaolinite) ratio. Humidity: Humidity index (perennial vs. seasonal rainfall regime) given by the kaolinite/smectite ratio.

| Lithology *R: red layer | Stratigraphic level (m) | Quartz (%) | Phyllosilicates (%) | Calcite (%) | Siderite (%) | Pyrite (%) | Illite (%) | Chlorite (%) | Kaolinite (%) | Smectite (%) | Ig PhW / ChW | Ig Sm / K |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| limestone | 4 | 26 | 9 | 65 | 0 | 0 | 45 | 13 | 0 | 42 | 0.1 | 2.5 |
| marlstone | 8 | 36 | 28 | 35 | 0 | 0 | 30 | 2 | 0 | 67 | -0.3 | 2.5 |
| limestone | 13 | 24 | 7 | 69 | 0 | 0 | 22 | 9 | 0 | 69 | -0.3 | 2.5 |
| marlstone | 19 | 44 | 21 | 34 | 1 | 0 | 45 | 7 | 0 | 48 | 0.0 | 2.5 |
| marlstone | 33 | 45 | 26 | 29 | 0 | 0 | 42 | 4 | 0 | 54 | -0.1 | 2.5 |
| marlstone | 73 | 17 | 36 | 47 | 0 | 0 | 35 | 3 | 7 | 55 | -0.2 | 0.9 |
| marlstone | 85 | 21 | 22 | 57 | 0 | 0 | 34 | 4 | 0 | 62 | -0.2 | 2.5 |
| limestone | 90 | 15 | 14 | 71 | 0 | 0 | 20 | 6 | 0 | 73 | -0.4 | 2.5 |
| marlstone | 108 | 13 | 33 | 53 | 1 | 0 | 28 | 3 | 1 | 69 | -0.4 | 1.8 |
| marlstone | 116 | 23 | 14 | 62 | 1 | 0 | 36 | 2 | 0 | 62 | -0.2 | 2.5 |
| marlstone | 124 | 13 | 16 | 71 | 0 | 0 | 30 | 3 | 0 | 67 | -0.3 | 2.5 |
| marlstone | 130 | 8 | 58 | 33 | 0 | 0 | 30 | 2 | 2 | 66 | -0.3 | 1.5 |
| limestone | 136 | 15 | 7 | 78 | 0 | 0 | 18 | 6 | 1 | 75 | -0.5 | 1.9 |
| marlstone | 142 | 20 | 37 | 43 | 0 | 0 | 39 | 2 | 0 | 59 | -0.2 | 2.5 |
| limestone | 147 | 18 | 29 | 52 | 1 | 0 | 26 | 3 | 1 | 69 | -0.4 | 1.8 |
| marlstone | 152 | 21 | 29 | 47 | 2 | 2 | 27 | 3 | 0 | 71 | -0.4 | 2.5 |
| marlstone | 165 | 29 | 40 | 29 | 1 | 0 | 39 | 4 | 5 | 52 | -0.1 | 1.0 |
| marlstone | 187 | 28 | 51 | 21 | 0 | 0 | 44 | 3 | 2 | 51 | -0.1 | 1.4 |
| limestone | 191 | 14 | 25 | 62 | 0 | 0 | 25 | 4 | 0 | 71 | -0.4 | 2.5 |
| marlstone | 196 | 27 | 51 | 22 | 0 | 0 | 39 | 5 | 2 | 54 | -0.1 | 1.4 |
| marlstone | 202 | 36 | 45 | 19 | 0 | 0 | 52 | 7 | 28 | 12 | 0.2 | -0.4 |
| marlstone | 207 | 34 | 44 | 22 | 0 | 0 | 62 | 1 | 22 | 15 | 0.2 | -0.2 |
| marlstone | 220 | 22 | 59 | 17 | 0 | 1 | 29 | 6 | 23 | 42 | -0.3 | 0.3 |
| marlstone | 279 | 31 | 51 | 17 | 0 | 1 | 42 | 6 | 18 | 34 | 0.0 | 0.3 |
| marlstone | 287 | 39 | 42 | 18 | 0 | 0 | 54 | 11 | 18 | 17 | 0.3 | 0.0 |
| limestone | 292 | 20 | 40 | 40 | 0 | 0 | 45 | 9 | 13 | 34 | 0.1 | 0.4 |
| marlstone | 298 | 12 | 28 | 60 | 0 | 0 | 26 | 6 | 10 | 59 | -0.3 | 0.8 |
| marlstone | 305 | 17 | 80 | 2 | 0 | 0 | 48 | 4 | 37 | 11 | 0.0 | -0.5 |
| marlstone | 325 | 32 | 49 | 18 | 0 | 1 | 42 | 9 | 36 | 13 | 0.0 | -0.4 |
| marlstone | 330 | 30 | 55 | 15 | 0 | 0 | 47 | 9 | 29 | 14 | 0.1 | -0.3 |
| marlstone | 335 | 30 | 40 | 29 | 0 | 0 | 32 | 7 | 13 | 48 | -0.2 | 0.6 |
| marlstone | 344 | 13 | 61 | 26 | 0 | 0 | 48 | 3 | 24 | 25 | 0.0 | 0.0 |
| marlstone | 356 | 27 | 55 | 18 | 0 | 0 | 51 | 4 | 20 | 25 | 0.1 | 0.1 |
| marlstone | 372 | 24 | 56 | 19 | 0 | 0 | 38 | 4 | 16 | 42 | -0.1 | 0.4 |
| limestone | 376 | 10 | 18 | 72 | 0 | 0 | 23 | 1 | 5 | 71 | -0.5 | 1.2 |
| marlstone | 384 | 34 | 45 | 21 | 0 | 0 | 58 | 3 | 24 | 15 | 0.2 | -0.2 |
| marlstone | 388 | 38 | 46 | 16 | 0 | 0 | 59 | 4 | 26 | 12 | 0.2 | -0.3 |
| marlstone | 403 | 31 | 50 | 18 | 0 | 0 | 44 | 5 | 31 | 20 | 0.0 | -0.2 |
| marlstone | 411 | 36 | 44 | 19 | 1 | 0 | 41 | 7 | 32 | 19 | 0.0 | -0.2 |
| marlstone | 415 | 37 | 41 | 21 | 0 | 0 | 61 | 6 | 23 | 10 | 0.3 | -0.4 |
| marlstone | 416 | 16 | 63 | 20 | 0 | 1 | 53 | 12 | 25 | 11 | 0.3 | -0.4 |
| marlstone | 425 | 36 | 41 | 22 | 0 | 0 | 54 | 11 | 27 | 8 | 0.3 | -0.5 |
| marlstone | 431 | 35 | 42 | 22 | 0 | 1 | 53 | 14 | 25 | 8 | 0.3 | -0.5 |
| *R marlstone | 441 | 19 | 40 | 8 | 33 | 0 | 54 | 13 | 26 | 7 | 0.3 | -0.6 |
| *R marlstone | 441 | 16 | 24 | 7 | 53 | 0 | 63 | 15 | 19 | 3 | 0.5 | -0.8 |
| marlstone | 442 | 21 | 75 | 4 | 1 | 0 | 51 | 8 | 37 | 4 | 0.2 | -1.0 |
| *R marlstone | 443 | 31 | 36 | 20 | 13 | 0 | 66 | 16 | 12 | 7 | 0.6 | -0.2 |
| *R marlstone | 444 | 22 | 33 | 15 | 30 | 0 | 60 | 16 | 19 | 6 | 0.5 | -0.5 |
| marlstone | 446 | 39 | 55 | 6 | 0 | 0 | 55 | 7 | 33 | 5 | 0.2 | -0.8 |
| *R marlstone | 446 | 21 | 47 | 15 | 17 | 0 | 52 | 6 | 33 | 8 | 0.2 | -0.6 |
| marlstone | 448 | 34 | 61 | 5 | 0 | 0 | 53 | 8 | 28 | 12 | 0.2 | -0.4 |
| *R marlstone | 451 | 24 | 32 | 11 | 33 | 0 | 54 | 12 | 22 | 12 | 0.3 | -0.3 |
| marlstone | 455 | 33 | 44 | 21 | 1 | 1 | 53 | 10 | 22 | 15 | 0.2 | -0.2 |
| marlstone | 461 | 34 | 40 | 24 | 1 | 1 | 53 | 9 | 14 | 25 | 0.2 | 0.3 |
| marlstone | 465 | 19 | 59 | 20 | 0 | 3 | 36 | 6 | 15 | 42 | -0.1 | 0.4 |
| marlstone | 470 | 38 | 34 | 24 | 2 | 1 | 57 | 12 | 1 | 30 | 0.3 | 1.5 |
| marlstone | 475 | 32 | 43 | 22 | 2 | 1 | 56 | 17 | 2 | 25 | 0.4 | 1.1 |
| limestone | 480 | 9 | 23 | 68 | 0 | 0 | 28 | 3 | 1 | 68 | -0.3 | 1.8 |
| marlstone | 485 | 32 | 41 | 22 | 4 | 1 | 59 | 14 | 13 | 14 | 0.4 | 0.0 |
| marlstone | 495 | 29 | 46 | 23 | 0 | 1 | 55 | 8 | 24 | 12 | 0.2 | -0.3 |
| marlstone | 505 | 28 | 68 | 3 | 0 | 0 | 53 | 4 | 35 | 8 | 0.1 | -0.6 |
| marlstone | 520 | 38 | 35 | 26 | 1 | 1 | 51 | 12 | 17 | 20 | 0.2 | 0.1 |
| limestone | 530 | 20 | 49 | 31 | 0 | 0 | 53 | 11 | 2 | 33 | 0.3 | 1.2 |
| marlstone | 540 | 28 | 47 | 24 | 0 | 1 | 47 | 8 | 1 | 44 | 0.1 | 1.6 |
| marlstone | 546 | 38 | 32 | 29 | 0 | 1 | 48 | 11 | 21 | 20 | 0.2 | 0.0 |
| marlstone | 560 | 22 | 50 | 27 | 0 | 0 | 55 | 11 | 10 | 24 | 0.3 | 0.4 |
| marlstone | 568 | 13 | 49 | 38 | 0 | 0 | 26 | 0 | 0 | 73 | -0.4 | |
| marlstone | 598 | 24 | 48 | 27 | 0 | 0 | 35 | 2 | 4 | 60 | -0.2 | 1.2 |
| limestone | 605 | 10 | 21 | 69 | 0 | 0 | 29 | 3 | 4 | 64 | -0.3 | 1.2 |
| limestone | 633 | 6 | 10 | 84 | 0 | 0 | 22 | 2 | 1 | 75 | -0.5 | 1.9 |
| marlstone | 645 | 7 | 30 | 63 | 0 | 0 | 33 | 2 | 4 | 62 | -0.3 | 1.2 |
| marlstone | 650 | 16 | 58 | 25 | 0 | 0 | 24 | 2 | 1 | 74 | -0.5 | 1.9 |
| marlstone | 665 | 25 | 47 | 27 | 1 | 0 | 34 | 3 | 2 | 61 | -0.2 | 1.5 |
| limestone | 670 | 9 | 23 | 68 | 0 | 0 | 37 | 4 | 0 | 60 | -0.2 | 2.5 |
| marlstone | 686 | 29 | 66 | 5 | 0 | 0 | 50 | 2 | 15 | 32 | 0.0 | 0.3 |
| marlstone | 733 | 13 | 35 | 49 | 3 | 0 | 34 | 2 | 0 | 65 | -0.3 | 2.5 |
| limestone | 739 | 13 | 14 | 72 | 1 | 0 | 34 | 5 | 0 | 61 | -0.2 | 2.5 |
| marlstone | 745 | 22 | 36 | 42 | 0 | 0 | 25 | 1 | 0 | 74 | -0.5 | 2.5 |
| marlstone | 756 | 27 | 66 | 7 | 0 | 0 | 67 | 5 | 24 | 4 | 0.4 | -0.8 |
| marlstone | 761 | 39 | 58 | 3 | 0 | 0 | 58 | 5 | 29 | 8 | 0.2 | -0.6 |
| marlstone | 768 | 20 | 61 | 18 | 1 | 0 | 41 | 3 | 17 | 39 | -0.1 | 0.4 |
| marlstone | 786 | 41 | 56 | 3 | 1 | 0 | 50 | 5 | 28 | 17 | 0.1 | -0.2 |
| marlstone | 793 | 26 | 52 | 21 | 1 | 0 | 46 | 4 | 17 | 33 | 0.0 | 0.3 |
| limestone | 840 | 12 | 19 | 69 | 0 | 0 | 46 | 7 | 6 | 42 | 0.0 | 0.8 |
| marlstone | 850 | 18 | 50 | 31 | 0 | 0 | 32 | 5 | 3 | 60 | -0.2 | 1.3 |
| marlstone | 860 | 27 | 33 | 39 | 0 | 0 | 39 | 4 | 1 | 55 | -0.1 | 1.7 |
| marlstone | 880 | 27 | 53 | 20 | 0 | 0 | 36 | 5 | 15 | 44 | -0.2 | 0.5 |
| limestone | 890 | 9 | 16 | 75 | 0 | 0 | 44 | 4 | 4 | 48 | 0.0 | 1.1 |
| Payros et al. (2012) | | | | | | | | | | | | |
| limestone | 905 | 7 | 17 | 77 | 0 | 0 | 39 | 10 | 2 | 50 | 0.0 | 1.4 |
| limestone | 915 | 16 | 33 | 51 | 0 | 0 | 39 | 5 | 2 | 55 | -0.1 | 1.4 |
| limestone | 925 | 22 | 30 | 48 | 0 | 0 | 44 | 4 | 6 | 47 | 0.0 | 0.9 |
| limestone | 935 | 19 | 38 | 43 | 0 | 0 | 42 | 3 | 8 | 47 | -0.1 | 0.8 |
| limestone | 950 | 16 | 39 | 45 | 0 | 0 | 45 | 5 | 14 | 37 | 0.0 | 0.4 |
| limestone | 965 | 20 | 31 | 50 | 0 | 0 | 44 | 4 | 9 | 44 | 0.0 | 0.7 |
| limestone | 975 | 15 | 35 | 51 | 0 | 0 | 40 | 4 | 19 | 37 | -0.1 | 0.3 |
| limestone | 985 | 11 | 29 | 60 | 0 | 0 | 40 | 6 | 16 | 38 | -0.1 | 0.4 |
| limestone | 995 | 13 | 29 | 59 | 0 | 0 | 42 | 9 | 14 | 35 | 0.0 | 0.4 |
| limestone | 1,015 | 7 | 18 | 75 | 0 | 0 | 43 | 8 | 4 | 45 | 0.0 | 1.1 |
| limestone | 1,025 | 23 | 44 | 32 | 0 | 0 | 45 | 6 | 24 | 25 | 0.0 | 0.0 |
| limestone | 1,040 | 10 | 21 | 70 | 0 | 0 | 45 | 5 | 17 | 33 | 0.0 | 0.3 |
| limestone | 1,050 | 7 | 21 | 72 | 0 | 0 | 47 | 5 | 2 | 46 | 0.0 | 1.4 |
| limestone | 1,065 | 11 | 17 | 72 | 0 | 0 | 50 | 4 | 1 | 45 | 0.1 | 1.7 |
| limestone | 1,074 | 6 | 10 | 84 | 0 | 0 | 49 | 2 | 0 | 49 | 0.0 | 2.5 |
| limestone | 1,080 | 6 | 12 | 82 | 0 | 0 | 45 | 4 | 0 | 51 | 0.0 | 2.5 |
| limestone | 1,090 | 5 | 13 | 82 | 0 | 0 | 37 | 1 | 0 | 62 | -0.2 | 2.5 |
| limestone | 1,100 | 4 | 5 | 91 | 0 | 0 | 42 | 4 | 0 | 54 | -0.1 | 2.5 |

**Table DR3**. Foraminiferal indices at the Barinatxe-Gorrondatxe section: percentage of planktic foraminifera (P%), Fisher-α diversity index, percentages of agglutinated, calcareous-agglutinated (calcareous- to calcareous- plus organic-agglutinated taxa), benthic foraminifera characteristic of high-food/low-oxygen conditions, *Nuttallides truempyi* size and distribution of radiolarians and diatoms.

| Stratigraphic level (m) *R: red layer | P (%) | Fisher-α | Agglutinated taxa (%) | Calc-cem aggl. taxa (% aggl.) | Low oxygen benthic foraminifera (%) | *Nuttallides truempyi* size (µm) | Radiolarians (X: common) | Diatoms (X: common) |
|---|---|---|---|---|---|---|---|---|
| 11 | 94.4 | 29.3 | 68.1 | 4.3 | 0 | | X | |
| 22.8 | 90.7 | 39.5 | 49 | 5.3 | 1.9 | | X | |
| 104 | 93.8 | 38.5 | 33.1 | 2.4 | 0.8 | | X | |
| 117 | 92.3 | 34.8 | 53.8 | 0.9 | 0 | 332.11 | | |
| 130 | 97.15 | 31 | 29.6 | 14.5 | 0 | 345.54 | X | |
| 143 | 93.75 | 43.2 | 40 | 13.5 | 3.1 | 301.50 | X | |
| 157 | 95.2 | 44 | 32.8 | 4.6 | 0.5 | 316.63 | X | |
| 162 | 85 | 34.7 | 13.1 | 3.1 | 2.6 | | X | |
| 165 | 83.3 | 35.6 | 54.5 | 1.8 | 2 | 289.04 | X | |
| 169 | 92.6 | 32.6 | 40.2 | 5.2 | 1 | 297.65 | X | |
| 172 | 91.9 | 47.3 | 38.5 | 0,0 | 1.9 | 315.58 | X | |
| 177 | 92.8 | 30 | 24.8 | 3.6 | 1.8 | 338.56 | X | |
| 182 | 94.6 | 32.2 | 18.4 | 14.1 | 1.3 | | X | |
| 187 | 84.3 | 35.7 | 21.7 | 0,0 | 2 | 243.23 | X | |
| 191 | 83.7 | 31.9 | 34.7 | 0,0 | 0.7 | | | |
| 196 | 89.8 | 32.6 | 35.3 | 1.7 | 0 | 311.97 | X | |
| 205 | 90.9 | 20.7 | 49.1 | 1.2 | 0 | 242.31 | | |
| 207 | 85.6 | 30.4 | 51.4 | 0,0 | 2.2 | 236.62 | X | |
| 220 | 92.6 | 26.4 | 55.8 | 3,0 | 0 | 351.38 | | |
| 299 | 93.6 | 39.7 | 51.1 | 7.6 | 0.7 | 305.38 | | |
| 333 | 87.5 | 16.5 | 73.1 | 0,0 | 0 | 271.60 | | |
| *R 345 | ALMOST BARREN | | | | | | | |
| 365 | 94.5 | 19.6 | 71.4 | 3.1 | 0 | 315.73 | | |
| 392 | 78.6 | 22 | 80.1 | 1.2 | 8.4 | 238.94 | | |
| 400 | 94 | 43.2 | 45.6 | 18.2 | 0.8 | 303.83 | | |
| 405 | 89.6 | 32.4 | 57.4 | 1.4 | 1.6 | 246.30 | | |
| 413 | 49 | 8 | 90.8 | 0.7 | 0 | | | |
| 416 | 31.25 | 8.8 | 83.1 | 0,0 | 0 | | | |
| 420 | 69 | 7 | 89.3 | 0,0 | 0 | | | |
| 425 | BARREN | | | | | | | |
| 431 | BARREN | | | | | | | |
| *R 436 | BARREN | | | | | | | |
| *R 440.8 | 79.4 | 16.1 | 75.8 | 2.2 | 0 | 260.15 | | |
| *R 441 | 56.9 | 8.7 | 84 | 0,0 | 0 | | | |
| *R 442.4 | 47 | 8.8 | 73.2 | 0,0 | 15.2 | 193.93 | | |
| *R 442.5 | BARREN | | | | | | | |
| *R 443.2 | BARREN | | | | | | | |
| *R 444 | BARREN | | | | | | | |
| 445 | 90 | 16.3 | 50.3 | 7,0 | 23.6 | 231.66 | | |
| *R 446 | ALMOST BARREN | | | | | | | |
| 446 | 88 | 14.2 | 71.6 | 6.3 | 0.5 | 266.58 | | |
| 447 | 73 | 18.2 | 67.4 | 3.3 | 0.6 | 294.38 | | |
| 448 | 62.5 | 11.2 | 80.3 | 0,0 | 9.9 | | | |
| *R 451 | 58.3 | 5.9 | 24.3 | 11.9 | 67.1 | | | X pyritized |
| *R 453 | BARREN | | | | | | | |
| 455 | 88.8 | 25.8 | 64.6 | 4.2 | 0.4 | | | |
| 457 | 95.4 | 32.3 | 47.6 | 2.5 | 1.2 | | | |
| *R 458 | 88.3 | 22.4 | 33.3 | 28.5 | 6.3 | 257.17 | | X pyritized |
| 458 | 98 | 11.6 | 29.2 | 0,0 | 8.3 | | X | |
| 461 | 88 | 39.8 | 43.1 | 7,0 | 1.5 | 269.87 | | X pyritized |
| 465 | 90 | 26.5 | 46.8 | 6,0 | 2.1 | 307.49 | | X pyritized |
| 470 | 95 | 19.4 | 59.3 | 4.6 | 1.3 | | | X pyritized |
| 510 | 87 | 27.4 | 66.1 | 15.3 | 1.8 | 247.37 | X | |
| 552 | 92.8 | 39.3 | 32.1 | 8.4 | 0 | 314.47 | X | |
| 598 | 86 | 28.2 | 39.2 | 5.4 | 0 | 344.13 | X | |
| 619 | 85 | 26.9 | 27.2 | 12.1 | 1.1 | 373.17 | X | |
| 650 | 92.9 | 39 | 40.1 | 16,0 | 0.6 | 354.39 | X | |
| 677 | 87.1 | 31.4 | 43.2 | 3.2 | 2.7 | | X | |
| 707 | 82.2 | 19.5 | 67.5 | 0.9 | 1.3 | | | |
| 728 | 90 | 21.3 | 29.8 | 9.4 | 14.9 | | X | |
| 755.5 | 95 | 48.7 | 48 | 7.3 | 9.6 | | | |
| 791 | 92.8 | 37.1 | 63.8 | 13.6 | 2.9 | | | |
| 804 | 90.9 | 30.1 | 16.7 | 19.8 | 18.3 | | | |
| 820 | 88.1 | 45.8 | 56.7 | 19.2 | 0.8 | 349.02 | | |
| 865 | 90.1 | 55.4 | 17.2 | 21.5 | 4 | 267.93 | | |
| 902 | 93.9 | | | | | | | |
| 909 | 88.6 | 46.8 | 33.2 | 14.2 | 0.7 | | X | |
| 925 | 93.5 | 47 | 37.2 | 8.3 | 5.1 | | X | |
| 935 | 93.1 | 33.2 | 46.4 | 9.3 | 1.6 | | | |
| 943.9 | 95.6 | 37.1 | 33.9 | 13.6 | 1.1 | | | |
| 960.8 | 93.4 | 34.9 | 31.9 | 7.5 | 1.6 | | X | |
| 966.6 | 97.9 | 46.3 | 20.9 | 21.5 | 1.6 | | | |
| 971.8 | 91.3 | 44.6 | 22.6 | 16.8 | 2.5 | | | |
| 976.4 | 97.5 | 37.8 | 40 | 11.5 | 0 | | | |
| 983.9 | 96.7 | 38.3 | 40.2 | 10.9 | 0.9 | | | |
| 990.8 | 94.7 | 39.6 | 55.7 | 15.4 | 0.3 | | | |
| 1003 | 91.2 | 44.6 | 24.4 | 9.4 | 2.7 | | | |
| 1011 | 92 | 34 | 22.8 | 18,0 | 2.5 | | X | |
| 1016 | 95 | 42.6 | 21.4 | 9.8 | 1.5 | | | |
| 1019.2 | 92.3 | 27.5 | 14.4 | 22.9 | 3.3 | | | |
| 1019.4 | 94.4 | 29 | 30.2 | 20.2 | 7.6 | | | |
| 1019.8 | 97 | 32 | 13.2 | 12.9 | 1.7 | | | |
| 1019.9 | 95.4 | 25 | 72.1 | 5.8 | 3.8 | | | |
| 1021 | 89.6 | 25.3 | 51.6 | 11.8 | 13.1 | | | |
| 1022 | 85.9 | 17.1 | 57.1 | 8.2 | 20.9 | | | |
| 1023 | 86.9 | 14 | 30.2 | 6.6 | 57.3 | | | |
| 1024 | 95.3 | 20 | 62.7 | 10.5 | 3.7 | | | |
| 1024.9 | 95.5 | 32.5 | 40.9 | 19.1 | 2.5 | | | |
| 1025 | | 27.7 | 52.3 | 18.2 | 0 | | | |
| 1025.9 | 87.7 | 28.5 | 41.9 | 29.4 | 5.3 | | | |
| 1026 | 90.2 | 26.5 | 53.7 | 22.5 | 7.4 | | | |
| 1027 | 91.7 | 31.5 | 35.7 | 5.6 | 4.8 | | | |
| 1027.5 | 87.8 | 30 | 22.5 | 4.4 | 18.5 | | | |
| 1029 | 94.3 | 30.2 | 24.9 | 23.7 | 28.5 | | | |
| 1031 | 94.3 | 32.5 | 36.6 | 42.6 | 2.2 | | | |
| 1035 | 94.1 | 32 | 15.6 | 17.9 | 7.2 | | | |
| 1042 | 92.9 | 23.7 | 55.6 | 5,0 | 1.7 | | | |
| 1046 | 92.6 | 24 | 19.7 | 14.7 | 8.8 | | | |
| 1050 | 92.6 | 34.8 | 23 | 38.7 | 1.9 | | X | |
| 1054 | | 24 | 34.8 | 18.7 | 2.2 | | | |
| 1060 | 96.4 | 36 | 57.9 | 28.5 | 0 | | X | |
| 1065 | 97.1 | 39.2 | 43.5 | 14,0 | 0.7 | | X | |
| 1069 | 98 | 27.5 | 33.6 | 16.1 | 0.7 | | X | |
| 1077 | 90 | 22.6 | 10.5 | 29.5 | 1.2 | | | |
| 1083 | 90.9 | 52.7 | 15.4 | 31.2 | 4.4 | | X | |

**Table DR4.** Planktic foraminiferal paleobiogeographic indices at the Barinatxe-Gorrondatxe section (Payros et al., 2006).

| Stratigraphic level (m) | High-latitude PF | | Low-latitude PF | |
|---|---|---|---|---|
| | nº species | % | nº species | % |
| 11 | 4 | 36 | 7 | 64 |
| 18 | 3 | 30 | 7 | 70 |
| 26 | 4 | 36 | 7 | 64 |
| 70 | 4 | 29 | 10 | 71 |
| 85 | 5 | 36 | 9 | 64 |
| 103 | 5 | 33 | 10 | 67 |
| 118 | 5 | 36 | 9 | 64 |
| 139 | 5 | 36 | 9 | 64 |
| 143 | 5 | 36 | 9 | 64 |
| 155 | 5 | 36 | 9 | 64 |
| 182 | 5 | 36 | 9 | 64 |
| 187 | 5 | 31 | 11 | 69 |
| 207 | 5 | 31 | 11 | 69 |
| 219 | 5 | 31 | 11 | 69 |
| 265 | 4 | 33 | 8 | 67 |
| 275 | 4 | 31 | 9 | 69 |
| 295 | 4 | 31 | 9 | 69 |
| 315 | 4 | 36 | 7 | 64 |
| 333 | 7 | 47 | 8 | 53 |
| 363 | 6 | 46 | 7 | 54 |
| 393 | 6 | 46 | 7 | 54 |
| 425 | 4 | 36 | 7 | 64 |
| 460 | 5 | 50 | 5 | 50 |
| 510 | 4 | 36 | 7 | 64 |
| 552 | 4 | 40 | 6 | 60 |
| 566 | 8 | 57 | 6 | 43 |
| 571 | 8 | 57 | 6 | 43 |
| 580 | 8 | 57 | 6 | 43 |
| 589 | 7 | 50 | 7 | 50 |
| 598 | 6 | 55 | 5 | 45 |
| 615 | 7 | 54 | 6 | 46 |
| 650 | 7 | 58 | 5 | 42 |
| 678 | 8 | 62 | 5 | 38 |
| 705 | 7 | 58 | 5 | 42 |
| 733 | 5 | 46 | 6 | 54 |
| 755 | 6 | 50 | 6 | 50 |
| 791 | 4 | 40 | 6 | 60 |
| 804 | 5 | 46 | 6 | 54 |
| 820 | 5 | 46 | 6 | 54 |
| 865 | 5 | 46 | 6 | 54 |
| 892 | 4 | 44 | 5 | 56 |
| 937 | 3 | 40 | 9 | 60 |
| 998 | 3 | 40 | 9 | 60 |
| 1024 | 2 | 33 | 9 | 67 |
| 1039 | 2 | 33 | 9 | 67 |
| 1054 | 2 | 33 | 6 | 67 |
| 1065 | 2 | 40 | 6 | 60 |
| 1103 | 5 | 55 | 3 | 45 |

**Table DR5.** Published information on the EECO. Ages (*) are relative to the Geologic Time Scale 2012 (Gradstein et al., 2012).

| Reference | Location; paleolatitude | Age* of onset of the EECO | Age* of end of the EECO |
|---|---|---|---|
| Zachos et al. (2001) | Multiple oceanic sites (Atlantic, Indian and Pacific Oceans) | 52.2 Ma (equivalent to early NP12, early E5, mid C23r) | 49.61 Ma (equivalent to early NP13, early E7a, late C22r) |
| Agnini et al. (2006) | Possagno (Italy); ~30°N | C24n.1n. (equivalent to approx. 52.82 Ma) | Late C22r |
| Muttoni & Kent (2007) | Multiple oceanic sites (Atlantic, Indian, Pacific Oceans,…) | 54.77 Ma (peak at 49.61 Ma) | 45.48 Ma |
| Zachos et al. (2008) | Multiple oceanic sites (Atlantic, Indian and Pacific Oceans) | 53.41 Ma (equivalent to earliest NP12, mid E4, C24n.2r) | 50.89 Ma (equivalent to late NP12, late E5, C23n) |
| Bijl et a. (2009) | ODP 189, Site 1172 (SW Pacific Ocean); ~65°S | C23r/C23n boundary at 51.83 Ma | 48.57 Ma at top of C22n |
| Dallanave et al. (2009) | Cicogna (Italy); ~30°N | C24n.1n. (equivalent to approx. 52.82 Ma) | Not given |
| Hollis et al. (2009) | Waipara (New Zealand); ~55ºS | 53.41 Ma (quoting Zachos et al. (2001) | Early C22n at 49.09 Ma |
| Westerhold & Röhl (2009) | ODP 207, Site 1258 (W Atlantic Ocean); ~0°N | C23r at 53.41 Ma (quoting Zachos et al., 2008) | Mid C22r, 49.92 Ma |
| Creech et al. (2010) | Waipara (New Zealand); ~55°S | 53.41 Ma (quoting Zachos et al. (2001) | 48.2 Ma |
| Coccioni et al. (2012) | Contessa (Italy); ~25°N | Approx. 51.65 Ma, mid NP12, mid E5, early C23n | 50.17 Ma at NP12/13 boundary, E6/7a boundary, early C22r |
| Hollis et al. (2012) | Waipara (New Zealand); ~55˚S | Poorly defined but placed at 53.92 Ma, within NP12 | 48.86 Ma, mid NP13 |
| Slotnick et al. (2012) | Mead Stream (New Zealand); ~55°S | J event in mid NP11 (equivalent to C24n, approx. 53.41 Ma) | Early NP13? |
| Shamrock & Watkins (2012) | ODP 762, Site 762 (E Indian Ocean); ~38°S | Mid-late NP12 | 48.57 Ma at NP13/14a boundary and mid C22r |
| Shamrock et al. (2012) | ODP 762, Site 762 (E Indian Ocean); ~38°S | Not given | 48.57 Ma, within early NP14a and late C22r |
| Chew & Oheim | Central Bighorn | 53.41 Ma, within C24n | Not given |

| | | | |
|---|---|---|---|
| (2013) | Basin (Wyoming);<br>~47°N | | |