

Supplementary information.

Chronology

The palynological zonation developed by Shell U.K. Exploration and Production for the Paleocene-Eocene for the North Sea basin¹ is applied to the cored sediments from 22/11-N1. The main events and zonal assignments are presented in **Figure S1**, detailed in **Table S1** and discussed below.

Zonule PT15.2.4 (2279.3-2284.4mbsf).

This Zonule is characterized by common occurrence of *Alisocysta margarita* and common to abundant *Areoligera gippingensis* (*Areoligera cf. senonensis*). This biozone is comparable to the lower part of the *A. margarita* zone in NW Europe² and the North Sea dinocyst zone P5a³. Abundant *A.gippingensis* is also recorded from the Thanet Sand and Ormesby Clay Formations of East Kent and Essex^{2, 4-7}, where it is calibrated to magnetozone C26n-C25r, Nannoplankton zone NP6-NP8^{2, 4, 7, 8}. However, the top of the Thanet Sand and Ormesby Clay Formations in southern England are unconformable⁹⁻¹⁰, which we infer has resulted in the truncated top range of *A.gippingensis* and *Alisocysta margarita* in these sediments. This interpretation is supported by the abundant occurrence of *A.gippingensis* in the basal Upnor Formation from the Jubilee line Borehole 404T, which are directly calibrated to Chron C25n, and Nannoplankton Zone NP9¹¹. In addition, the top common occurrence of Deep Water Agglutinated Foraminifera (DWAF), characterised by *Spiroplectamins spectabilis* in

well 22/11-N1 (2281.1 mbsf), marks the Benthic Extinction Event (BEE) and has been calibrated in the Contessa Road section to the middle part of NP9¹².

Zonule PT15.2.5 (2273.9-2279.3mbsf).

The top of this Zonule is defined by the last consistent occurrences *Alisocysta margarita* and *Areoligera gippingensis* and corresponds the top of *A. margarita* zone in NW Europe² and the North Sea dinocyst zone P5b³. The last occurrences of *Alisocysta margarita* and *Areoligera gippingensis* in the Danish Viborg 1 borehole slightly above the top of the Helmehus Formation, within dinocyst zone 5¹³, which was indirectly calibrated to NP9¹⁴.

Zone PT19

The top of Zone PT19 is defined by the last occurrence of *Apectodinium augustum*, while its base is defined by the last consistent occurrences *Alisocysta margarita* and *Areoligera gippingensis*¹. When published by Schroder (1992) this zone could be subdivided into four subzones, PT19.1; PT19.2; PT19.3 and PT19.4. However, subsequent high resolution analyses has enabled the definition of a further eleven zonules, and three sub-zonules. The main subdivision is presented below.

Subzone PT19.1 (2251.4-2273.9mbsf).

The top of this subzone is defined by the top abundance of *Apectodinium parvum* and increase in *Palaeoperidinium pyrophorum*, with supporting events including the increase in *Inaperturopollenites hiatus*. The base of the subzone is defined by the last consistent occurrences *Alisocysta margarita* and *Areoligera gippingensis*¹. The subzone can be subdivided into two zonules: an upper PT19.1.2 and lower PT19.1.1.

47 Zonule PT19.1.1 is characterized by the top super-abundance of Bisaccate pollen,
48 common *Pediastrum* spp., an increase in *Spiniferites* spp., and usually the absence of
49 *Apectodinium augustum*. This zonule corresponds with the *Apectodinium*
50 *hypercanthum* Interval Biozone from NW Europe² and the North Sea dinocyst Zone
51 P6 (*Apectodinium augustum*)³. However, from the cored sediments from well 22/11-
52 N1, *Apectodinium augustum* remains abundant in this interval. This corresponds with
53 the inferred warming in terrestrial climates prior to the CIE, and suggests a coeval
54 increase in SST in some parts of the central North Sea, including well 22/11-N1.

55 **Subzone PT19.2 (2236.1-2248.9mbsf).**

56 The top of this subzone is defined on the relative top abundance of *Apectodinium*
57 *paniculatum*, while *Apectodinium augustum* remains abundant. This subzone can be
58 subdivided into three zonules based primarily on terrestrial sporomorphs: The
59 lowermost zonule, PT19.2.1 is characterized by the frequent occurrence of the
60 terrestrial palynomorph *Crassotrilites* spp. and abundant occurrence of
61 *Deltoidosporites* spp. The top of Zonule PT19.2.2 is defined by the frequent
62 occurrence of *Bombacacidites reticulatus*, while the uppermost zonule PT19.2.3 is
63 defined by the relative top abundance of *Apectodinium paniculatum*. The presence of
64 all three zonules in the cored sediments from well 22/11-N1 would indicate a
65 relatively complete recovery of this North Sea sequence.

66 **Subzone PT19.3 (2226.9-2232.7mbsf)**

67 This subzone can be subdivided into two zonules. The lowermost, PT19.3.1 is defined
68 by the top persistent occurrence of *Bombacacidites reticulatus*, while the upper zonule
69 PT19.3.2 is defined by the top abundant occurrence of the informal species *Areoligera*
70 *coronata* 'delicata' sensu Ichron Ltd. The dinocysts *Apectodinium augustum* and

Apectodinium homomorphum remain abundant throughout this subzone. The identification of both these zonules in cored sediments from well 22/11-N1 would indicate a relatively complete recovery of this North Sea sequence. A transition to coarser sandstone units at the base of zonule PT19.3.1 (2232.7mbsf) marks a transgressive surface (Shell nomenclature = T75 MFS).

Subzone PT19.4 (2218.1-2224.4mbsf)

This subzone is characterized by abundant *Apectodinium augustum* and *Apectodinium homomorphum* and corresponds with the 13C TOC maxima in well 22/11-N1 and other North Sea penetrations (e.g. Kallo and Doehl boreholes, Belgium¹⁵). This subzone can be divided into three zonules; PT19.4.1; PT19.4.2 and PT19.4.3. The lowermost zonule PT19.4.1 is defined by the top abundant occurrence of *Apectodinium homomorphum* and is not identified in well 22/11-N1 due to an inferred erosive surface at the base coarse sand unit (2225.2 mbsf), also corresponding to a shift in 13C TOC values. Zonule PT19.4.2 is identified in well 22/11-N1 based on the top common abundance of *Apectodinium augustum*. This zonule can be subdivide into three sub-zonules (PT19.4.2a; PT19.4.2b and PT19.4.2.c), the lowermost of which PT19.4.2a is identified on the basis of abundant algae *Bosedinia* spp. The abundance distribution of *Bosedinia* spp and thus PT19.4.2.a seems complete in well 22/11-N1 suggesting that the missing sediments are restricted to the underlying zonule (PT19.4.1). Subzonule PT19.4.2b is defined by the last frequent occurrence of *Glaphyrocysta reticulata*, which is recorded at 2218.1mbsf. However, also at this depth is the top abundant, and top occurrence *Apectodinium augustum*, which define the younger subzonule PT19.4.2c and zonule PT19.4.3, respectively. There is likely to be condensation of sediments in the transition to from heterolithic deposition of the

95 Forties sandstone member to pelagic shale deposition of the Sele Formation reservoir
96 seal. Therefore it is feasible that these events occur in the 1.5 meter sampling gap at
97 this interval, however an unconformity at this level is also possible. In either case, the
98 $\delta^{13}\text{C}$ TOC record from 22/11-N1 would indicate that most of the “recovery” phase of
99 the CIE is not captured in the present study.

100 **Zone PT20 (2216.6-2207.7 mbsf)**

101 The top and base of this zone is defined by the top common occurrence of *Plicapollis*
102 *pseudoexcelsius* and top occurrence of *Apectodinium augustum*, respectively. It is
103 comparable to the lowermost *Glaphyrocysta ordinata* interval Biozone of NW
104 Europe², and the lowermost E1a dinocyst zone of the North Sea³, being indirectly
105 calibrated to the basal part of NP10. Based on the high resolution data presented here,
106 Biozone PT20 can be further divided into two subzones, the lowermost PT20.1 and
107 uppermost PT20.2.

108 **Subzone PT20.1 (2216.6-2210.6 mbsf)**

109 Subzone PT20.1 can be further subdivided into two zonules; PT20.1.2 and PT20.1.1.
110 The uppermost PT20.1.2 is defined by the top common occurrence of prasinophycean
111 algae, the top persistent occurrence of *Cerodinium speciosum glabrum*. Secondary
112 diagnostic event includes the abundance of the dinocyst *Fromea* cf. *fragilis*. The
113 lower Zonule PT20.1.1 is defined by the acme of prasinophycean algae including
114 *Pterospermella* spp., and large leiospheres and is associated with the high gamma
115 shale package marking the maximum flooding surface (Shell nomenclature =
116 T80MFS), which floods the basin and results in the cessation of Forties basin fan
117 deposition. The dinocyst species *Deflandrea oebisfeldensis* does not occur below this
118 zonule.

Subzone PT20.2 pars (2207.7mbsf- top not seen)

This subzone is principally defined on the FDO of frequent or common *Fromea fragilis* (or *F. cf. fragilis*). Other diagnostic features include the last downhole occurrence (LDO) of common to abundant *Glaphyrocysta ordinata*. In well 22/11-N1 only one sample attributable to this subzone had been analysed.

Ash Stratigraphy

Above the cored section, well 22/11-N1 penetrated the tuffaceous sediments of the Balder Formation (2153 – 2188 mbsf). These have been correlated with the positive ash series from Denmark, which based on laser total-fusion $^{40}\text{Ar}/^{39}\text{Ar}$ is dated ~54Ma¹⁶.

The older negative ash series from Denmark, dated as 54.52Ma¹⁷, may correspond with deeper ash layers recorded in the S2b unit of the Sele Formation^{18, 19}, which was penetrated in well 22/11-N1 from 2194.1 mbsf to 2208.1mbsf.

Pollen analyses and source area

The Forties Sandstone is dominated by an elongate NW–SE oriented depositional system, reflecting sediment dominant sediment supplied by extensive deltaic feeders located to the north and west of the main depocentre²⁰. The main source of sand to the submarine fan is derived from the rejuvenated and recently uplifted Mesozoic hinterland (Caledonian highlands)²⁰⁻²⁵ (**Figure S2**). Quantitative paleoenvironmental reconstruction of this system requires that records of terrestrial spores and pollen recovered from these sediments accurately reflect the vegetation zones of the hinterland at the time of deposition. Therefore, an understanding of the primary

factors controlling transport and sedimentation of pollen and spores is essential. Two main transportation mechanisms that account for the majority of spores and pollen in marine sediments are i) atmospheric transport by wind and ii) hydrodynamic transport by rivers and runoff. The majority of the cored sediments at well 22/11-N1 reflect heterolithic lowstand deposits, and are characterized by more continuous fluvial input of both sands and suspended muds as rivers and sediment bypass the shelf. Due to this relatively “short-time” recycling on the shelf, the sporomorphs are less likely than other deposits to be affected by sediment winnowing. There is potential for hydrodynamic sorting within the turbidite flow itself, although it is difficult to quantify. However, as the main sporomorph trends recorded in 22/11-N1 are identified regionally and in different depositional settings (shelf, slope and basin, fairway channel/margin) as per the Shell PT Zonation¹, the role of hydrodynamic sorting in the timescale presented here is likely to be limited.

Atmospheric transport by wind is mainly reflected by the abundance of Pinaceae counts, principally *Pinus* pollen, which is strongly over-represented in marine sediments due to significant long-distance dispersal, although counts > 50% likely reflect continental sources within 500km²⁶. Therefore, the abundances of the spore and pollen assemblages are expressed as percentages of the main sum, which includes all pollen except *Pinus*. Due to the over-representation of *Pinus* and *Picea* pollen in these sediments, these taxa were also excluded from the bioclimatic analyses so that the climate estimates reflect secular changes on the adjacent land mass, rather than more effective wind dispersal and/or variations in elevation, and/or distance from the source regions.

Quantitative climate reconstructions based on sporomorph assemblages

The method of bioclimatic analysis is as described by Greenwood and others²⁷, and is comparable to coexistence analysis²⁸ but differs from that method in how outliers are removed and in how the estimate is calculated. The first step in bioclimatic analysis is to identify as many sporomorph taxa with nearest living relatives (NLRs) as possible from the fossil floras for which climate profiles are available or can be developed. The climatic ranges ('profiles') of the NLRs are mainly from the same sources as those used by Greenwood and others²⁷, Eldrett and others²⁹, and Contreras and others^{30, 31}. These included NLR climate data primarily obtained from references 34 and 35 which include climate range data for the majority of genera and species of tree occurring in North America, as recommended by ref. 39. For taxa not represented in these databases, we obtained geographical distribution data from the Australian National Herbarium online database³², from the Natural Resources Canada online database³⁶, or the Global Biodiversity Information Facility (<http://www.gbif.org/>) and determined the climate profile for each taxon using the mathematical climate surface software ANUCLIM 6.1 (33) for Australian and Canadian records, or using WorldCLIM^{37, 38} for NLRs distributed widely outside of these areas and not available from the other sources. Each profile contains the maximum and minimum values for a range of climate and related environmental variables. The estimate for each climate parameter is the mean value of the 10th and 90th percentile of the maximum and minimum values across all taxa recorded in a sample, with the error expressed as the total range between these^{27, 29, 30}. This statistical process objectively removes extreme outliers, consistent with recent recommendations³⁹. Consistent with concerns raised in reference 39, NLR climate range data is based largely on sources cited by those authors, as discussed above. Grimm and Denk (39) found that estimates of

temperature for modern forest sites using a NLR approach based on references 34 and 35 were much more accurate than using the PALAEOFLOA database²⁸ and recommended against using the latter database of NLR climate ranges. The sporomorph taxa that were utilised in this study and their NLRs can be found in Supplementary Table S1. All samples used in our analysis had at least 8 NLRs with climate profiles (mean = 18, maximum NLRs = 26).

Figure S1. Stratigraphy of well 22/11-N1. **a**, Depth scale; left Along Hole Depth in feet (AHD ft); right meters below sea floor (mbsf). Lithology; grey fill horizontal lines = claystone; yellow speckled = sandstone; solid badge = heterolithic; Lithostratigraphy. **b**, Gamma-Ray curve (API units); **c**, $^{13}\text{C}_{\text{TOC}}$. **d**, main algae, dinoflagellate cyst and sporomorph bioevents. **e**, Shell Biozone assignment and indirect calibration to Nannoplankton zone (NP; Martini et al. 1971). Horizontal red line = inferred erosion surface.

Figure S2A. The location of Well 22/11-N1 and other wells displayed on the seismic line (**Figure S2B**).

Figure S2B. Regional Seismic-sequence Stratigraphic interpretation. Seismic traverse from Nelson Field on the right to the NW Shelf on the left. Transect line displayed spatially in **Figure S2A**. Key strata surfaces identified: MFS = Maximum Flooding Surface; CC** = Correlatable Conformity; TS = Transgressive Surface. The Interval between the lowermost CC** and MFS equates to the PETM Interval. The

216 Basin Floor Fan deposited during initial Lowstand = Forties Sandstone Member;
217 Lowstand Delta deposited during late Lowstand = lower Dornoch Formation;
218 Transgressive Systems tract (TST), Highstand Delta representing the prograding
219 upper Dornoch Formation and condensation in the Basin.

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224 References

- 225 1. Schroder, T. A palynological zonation for the Paleocene of the North Sea. *J.*
226 *Micropalaeontol.* **11**, 113-126 (1992)
- 227 2. Powell, A. J. in stratigraphic index of dinoflagellate cysts (ed Powell, A.J.)
228 155–251 (London, Chapman and Hall, 1991)
- 229 3. Mudge, D. C. and Bujak, J. P. Paleocene biostratigraphy and sequence
230 stratigraphy of the central North Sea. *Marine and Petroleum Geology.* **13**,
231 295-312 (1996).
- 232 4. Jolley, D. W. Palynofloral association sequence stratigraphy of the Palaeocene
233 Thanet Beds and equivalent sediments in eastern England. *Rev. Palaeobot.*
234 *Palynol.* **74**, 207-237 (1992a)
- 235 5. Jolley, D. W. A new species of the genus *Areoligera* Lejeune-Carpentier from
236 the Late Palaeocene of the eastern British Isles. *Tert. Res.* **14**, 25-32 (1992b).
- 237 6. Jolley, D.W., Palynostratigraphy and depositional history of the Palaeocene
238 Ormesby/Thanet depositional sequence set in southeastern England and its
239 correlation with continental West Europe and the Lista Formation, North Sea.
240 *Rev. Paleobotany and Palynology*, **99**, 265-315 (1998).
- 241 7. Ali, J. R. and Hailwood, E. A. In: Geochronology, Time Scales and Global
242 Stratigraphic Correlation (eds Berggren, W A, Kent, D.V., Aubry, M-P., &
243 Hardenbol, J.) 54, 275-279. (SEPM Special Publication, 1995)

- 244 8. Ellison, R. A et al. A revision of the lithostratigraphical classification of the
245 early Palaeogene strata of the London Basin and east Anglia. *Proceedings of*
246 *the Geologists' Association* , **105**, 187-197 (1994).
- 247 9. Ali, J. R., King, C. & Hailwood, E. A. In: High Resolution Stratigraphy (eds
248 Hailwood, E. A. & Kidd, R. B.) 70, 99-125 (Geological Society Special
249 Publication,1993)
- 250 10. Jolley, D. W. in Correlation of the Early Paleogene in Northwest Europe (eds
251 Knox, R.W.O'B., Corfield, R., Dunay, R.E.), **101**, 219-254 (Special
252 Publication,Geological Society of London, 1996)
- 253 11. Ellison, R. A. et al. Recognition of Chron C25n in the upper Paleocene, Upnor
254 Formation of the London Basin, UK. *Geological Society Special Publication*,
255 101, 185-193 (1996).
- 256 12. Galeotti, S., et al.. Integrated stratigraphy across the Paleocene/Eocene
257 boundary in the Contessa-Road section, Gubbio (central Italy). *Bulletin de la*
258 *Societe Géologique de France*, 171, 355-365 (2000).
- 259 13. Heilmann-Clausen, C. Dinoflagellate stratigraphy of the uppermost Danian to
260 Ypresian in the Viborg 1 borehole, central Jylland, Denmark *Dansk. Geol*
261 *Undersogelse Ser. A*, **7**, 69 pp. (1985)
- 262 14. Heilmann-Clausen, C. Review of Paleocene dinoflagellates from the North
263 Sea region. *Meeting proceedings "Stratigraphy of the Paleocene"*, *GFF*, **116**,
264 51-53 (1994).
- 265 15. Steurbaut, E. et al. in Causes and Consequences of Globally Warm Climates in
266 the Early Paleogene (eds Wing, S. L., Gingerich, P. D., Schmitz, B. &
267 Thomas, E.) **369**, 291–317 (Geological Society of America Special Paper,
268 2003).
- 269 16. Egger, H. and Brückl, E. Gigantic volcanic eruptions and climatic change in
270 the early Eocene. *Int. J. Earth Sci.* **95**, 1065–1070 (2006).

- 271 17. Chambers, L. M, et al. Recalibration of the Palaeocene–Eocene boundary (P-
272 E) using high precision U-Pb and Ar-Ar isotope dating. Abstract, EGS-AGU-
273 EGU Joint Assembly Nice (2003).
- 274 18. Jolley, D. W. and Bell, B. R., in: The North Atlantic Igneous Province;
275 Stratigraphy, Tectonic, Volcanic and Magmatic Processes (eds Jolley, D.W.,
276 Bell, B. R.), **197**, 1-14 (Special Publication-Geological Society of London,
277 2002).
- 278 19. Berggren, W. A., et al. in Time Scales and Stratigraphic Correlation: a
279 Framework for an Historical Geology (eds Berggren, W. A., Kent, D. V. &
280 Hardenbol, J.), **54**, 129-212 (Society of Economic Paleontologists and
281 Mineralogists, 1995)
- 282 20. Bowman, M. B. J. In Petroleum geology of the North Sea: Basic concepts and
283 recent advances (ed Glennie, K. W.), 350-375. (Oxford: Blackwell Science,
284 1998).
- 285 21. White, N. and Lovell, B. Measuring the pulse of a plume with the sedimentary
286 record. *Nature*, **387**, 888–891 (1997).
- 287 22. Håland et al. Paleogene tuffaceous intervals, Grane Field (Block 25/11),
288 Norwegian North Sea: their depositional, petrographical, geochemical
289 character and regional implications. *Marine and Petroleum Geology*, **17**, 101-
290 118 (2000).
- 291 23. Underhill, J. R. Controls on the genesis and prospectivity of Paleogene
292 palaeogeomorphic traps, East Shetland Platform, UK North Sea. *Marine and*
293 *Petroleum Geology*. **18**, 259-281 (2001).
- 294 24. Mudge, D. C and Jones, S. M. Paleocene uplift and subsidence events in the
295 Scotland-Shetland and North Sea region and their relationship to the Iceland
296 plume. *J. Geol. Soc., London*, **161**, 381–386 (2004).

- 297 25. MacLennan, J. and Jones, S. M. Regional uplift, gas hydrate dissociation and
298 the origins of the Paleocene–Eocene Thermal Maximum. *Earth Planet. Sci.*
299 *Lett.* **245**, 65-80 (2006).
- 300 26. Hooghiemstra, H., Palynological records from northwest African marine
301 sediments: a general outline of the interpretation of the pollen signal.
302 *Philosophical Transactions Royal Society London B* 318, 431-449. (1998).
- 303 27. Greenwood, D. R., Archibald, S. B., Mathewes, R. W. & Moss, P. T. Fossil
304 biotas from the Okanagan Highlands, southern British Columbia and
305 northeastern Washington State: climates and ecosystems across an Eocene
306 landscape. *Can. J. Earth Sci.* 42, 167-185 (2005).
- 307 28. Mosbrugger, V. & Utescher, T. The coexistence approach - a method for
308 quantitative reconstructions of Tertiary terrestrial palaeoclimate data using
309 plant fossils. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 134, 61-86 (1997).
- 310 29. Eldrett, J. S., Greenwood, D. R., Harding, I. C., and Huber, M. 2009.
311 Increased seasonality through the Eocene to Oligocene transition in northern
312 high latitudes. *Nature*, 459 (7249): 969 – 974. doi:10.1038/nature08069
- 313 30. Pross, J., Contreras, L., Bijl, P.K., Greenwood, D. R., Bohaty, S. M., Bendle,
314 J. A., Röhl, U., Tauxe, L., Raine, J. I., Huck, C. E., van de Flierdt, T.,
315 Jamieson, S. S. R., Stickley, C. E., van de Schootbrugge, B., Schouten, S.,
316 Escutia, C., Brinkhuis, H., and IODP Expedition 318 Scientists. 2012.
317 Persistent near-tropical warmth on the Antarctic continent during the early
318 Eocene epoch. *Nature* (accepted, June 14th, 2012)
- 319 31. Utescher, T. & Mosbrugger, V. Palaeoflora, Data base for paleoclimatic
320 reconstructions using the Coexistence Approach. <http://www.palaeoflora.de>
321 (2011).
- 322 32. Australian National Herbarium Specimen Information Register (ANHSIR).
323 <http://www.anbg.gov.au/cpbr/program/hc/hc-ANHSIR.html> (2011).

- 324 33. Xu Tingbao & Hutchinson M, 2011. ANUCLIM 6.1. The Fenner School of
325 Environment and Society, Australian National University.
326 [http://fennerschool.anu.edu.au/research/publications/software-](http://fennerschool.anu.edu.au/research/publications/software-datasets/anuclim)
327 [datasets/anuclim](http://fennerschool.anu.edu.au/research/publications/software-datasets/anuclim)
- 328 34. Thompson, R.S., Anderson, K.H., & Bartlein, P.J. 1999. Atlas of Relations
329 Between Climatic Parameters and Distributions of Important Trees and Shrubs
330 in North America. U.S. Geological Survey Professional Paper 1650 A&B.
331 <http://pubs.usgs.gov/pp/p1650-a/>
- 332 35. Thompson, R.S., Anderson, K.H., Bartlein, P.J., Smith, S.A., 2000. Atlas of
333 relations between climatic parameters and distributions of important trees and
334 shrubs in North America; additional conifers, hardwoods, and monocots. U.S.
335 Geological Survey Professional Paper 1650 C. 386 p.
336 <http://pubs.er.usgs.gov/publication/pp1650C>
- 337 36. Canada's plant hardiness site. Natural Resources Canada.
338 <http://planthardiness.gc.ca/index.pl?lang=en&m=13&p=1>
- 339 37. Hijmans RJ, Cameron SE, Parra JL, Jones PG, Jarvis A. 2005. Very high
340 resolution interpolated climate surfaces for global land areas. International
341 Journal of Climatology 25: 1965–1978.
- 342 38. Hijmans RJ, Cameron S, Parra J, Jones P, Jarvis A, Richardson K. 2013.
343 WorldClim - Global Climate Data / DIVA-GIS. <http://www.worldclim.org/>
344 [accessed 2 April 2013]
- 345 39. Grimm GW, Denk T, 2012. Reliability and resolution of the coexistence
346 approach — A revalidation using modern-day data. Review of Palaeobotany
347 and Playnology, 172: 33 – 47.

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