Supporting Information

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SI Materials and Methods

Age Models and Map. For age models for Ocean Drilling Program (ODP) sites 1210 and 1262 we used orbitally tuned age models (1) to determine sedimentation rates, and placed the Cretaceous/Paleogene (K/Pg) boundary at 65.5 Ma. For site 1210, we used the revised composite depth (2). Ages were estimated for samples from Deep Sea Drilling Project (DSDP) site 465 using the correlation of the carbon isotope record of benthic foraminifera, which shows the same pattern at all sites (3), to the orbitally tuned age model for site 1210. We used these benthic isotopes also to modify the age model in ref. 4, and correlate the record for site 690 more precisely to that at the other sites (Fig. 2). The map (Fig. 1) was made using ref. 5.

Benthic Foraminiferal Data. The consistency of our dataset is unprecedented (6): The same authors used the same procedures, studied the same size fraction (>63 μm) and used the same taxonomic concepts (7) for all sites. To construct Fig. 1 in the text, we used our published data from North-West Atlantic Blake Nose ODP site 1049 (8, 9); Gulf of Mexico sections La Lajilla, El Mulato, Coxquihui, and La Ceiba (8, 10–13); Caribbean section Loma Capiro (Cuba) (14); North-East Atlantic sections Bidart and Loya Bay (France) (15, 16); Tethyan sections Agost (Spain) (17); and Aïn Settara and El Kef (Tunisia) (8, 18).

As a proxy for diversity of the benthic foraminiferal assemblages, we calculated the Fisher-α diversity index (19) (Table S1, Table S2). As proxies for trophic conditions at the sea floor (20), we calculated the benthic foraminiferal accumulation rates (BFARs), and changes in relative abundance of habitat-related benthic foraminiferal morphogroups (infaunal vs. epifaunal) across the boundary (Table S1, Table S2). There is a relationship between test morphology and microhabitat (20, 21), and despite significant exceptions, this relation appears to be accurate about 75% of the time (22). Based on this assumption, variations in the proportion of habitat-related benthic foraminiferal morphogroups (infaunal vs. epifaunal) can be considered as proxies for the oxygenation and trophic conditions at the sea floor (20), with epifaunal morphogroups supposedly flourishing in more oligotrophic environments. We allocated all specimens to morphogroups (23–25), with extinct taxa assigned following ref. 3. Variations in the percentage of infaunal taxa across the K/Pg boundary are shown in Fig. 4, Fig. S1, and in Table S1 and Table S2.

The benthic foraminiferal data for sites 1262, 1210, and 465 have been published (3, 10, 26), but we checked all assignments to infaunal or epifaunal taxa to ensure consistency between sites, and recalculated all BFAR to ensure the use of the same age model for all sites. To calculate BFAR, we weighed the sample split from which benthic foraminifera were picked and obtained the number of benthic foraminifera per gram of sample in the size fraction larger than 63 μm. We then calculated the number of benthic foraminifera per gram bulk sediment, using the weight percent of dry sample material larger than 63 μm, as obtained during sample processing. We used sedimentation rates as determined from the orbitally tuned age models, number of foraminifera per gram dry bulk sediment, and density of sediment to calculate benthic foraminiferal accumulation rates (number of foraminifera per square cm per 1,000 y). Bulk density of the sediment is after ref. 27 for site 1262, ref. 28 for site 465, ref. 29 for site 1210, and ref. 30 for site 690.

Low-resolution benthic foraminiferal data but not BFAR across the K/Pg transition of Southern Ocean Maud Rise ODP site 690 were published (31), but we provide higher resolution data. Calcareous chalks and oozes were deposited at upper abyssal to lower bathyal depths (~1,900 m paleodepth). Benthic foraminiferal assemblages were quantitatively analyzed in 31 samples from sections 690C-24H-7 to 24H-1, comprising the upper 4.6 m of the Maastrichtian (planktic foraminiferal *Abathomphalus mayaroensis* zone and calcareous nannofossil *Cribrosphaerella daniae* zone) and the lower 9.8 m of the Danian (up to planktic foraminiferal zone AP1b and calcareous nannofossil zone CP2) (4). Samples were spaced at few centimeters directly below and above the K/Pg boundary, with decreasing resolution (50 cm to ~1 m) further away from the boundary. Sediments were dried, then soaked in warm water with detergent, and wet-sieved over a 63-μm sieve. Approximately 300 specimens of benthic foraminifera larger than 63 μm were picked and identified per sample (Table S2).

BFAR and percentage infaunal taxa are shown for each site compared to the carbon isotope record in Figs. 3 and 4, and for all sites combined in Figs. S1 and S2.

Isotope Analyses. Isotope analyses were performed at the University of Santa Cruz, Yale University, and the University of Michigan. All results are reported in per million (‰) relative to the Vienna Peedee belemnite (VPDB) standard (Table S3).

Stable isotopes for bulk samples of site 1262 were published in ref. 32. Stable isotope analyses on benthic foraminifera (*Nuttallides truempyi*) were performed at the University of Michigan on a Thermo MAT 253 coupled to a Kiel IV carbonate device. Samples were reacted at 70 °C and measured enrichments were converted to VPDB utilizing a normalization based on the analysis of National Bureau of Standards (NBS)-18, NBS-19, and Atlantis II, an isotopic standard whose composition closely approaches the benthic values. Analytical precision is maintained better than 0.1‰ for both $\delta^{18}O$ and $\delta^{13}C$, based upon routine replication of standard materials.

Stable isotope data for site 690 include data published in ref. 33, and additional data on bulk samples, benthic foraminifera (*N. truempyi*, *Stensioeina beccariiformis*) and calcareous dinocysts collected at the Earth Systems Center for Stable Isotopic Studies at Yale University, using a Thermo Gasbench II interfaced to a DeltaXP Stable Isotope Ratio mass spectrometer with a CTC Analytics GC-PAL autosampler, with analytical precision averages 0.07% for $\delta^{18}O$ and 0.04% for $\delta^{13}C$. Precision was monitored by analysis of NBS-19 and NBS-18 every 10 samples. Benthic foraminiferal (*N. truempyi*) and bulk isotope data for site 1210 were also collected at the Yale facility.

Stable isotopes on benthic foraminifera (*S. beccariiformis*) and bulk samples for site 465 were generated at an Autocarb coupled to a PRISM mass spectrometer at the University of California at Santa Cruz Stable Isotope Laboratory facilities. All values are reported relative to the VPDB standard. Analytical precision based on replicate analyses of in-house standard Carrara marble and NBS-19 averages 0.06% for $\delta^{18}O$ and 0.03% for $\delta^{13}C$ (1σ).

We used bulk fraction stable isotopes as recorder of the paleoenvironmental signal in waters relatively close to the ocean surface, i.e., within the mixed layer down to the lower thermocline, with dominant production of living coccolithophores occurring in the middle photic zone (~50–100 m depth) (34), see refs. 32 and 35. The persistent offset between carbon isotope values for bulk and benthic foraminifera during the Cretaceous and after the disturbance due to the extinction indicates that the two signals indeed reflect bottom waters and waters closer to the surface, with bulk values more positive.

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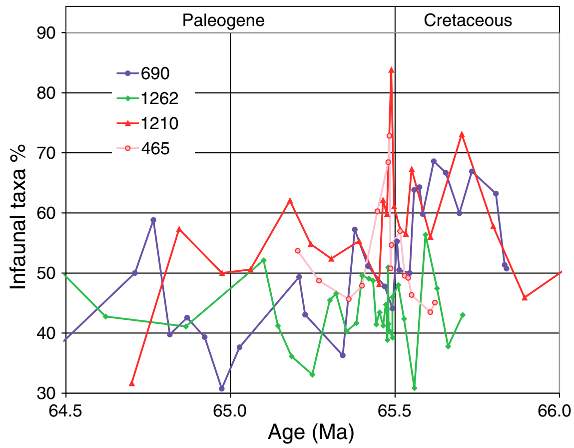

Fig. S1. Relative abundance of infaunal species across the K/Pg boundary at sites in the Pacific, Southeast Atlantic, and Southern Ocean. See Fig. 1 for location.

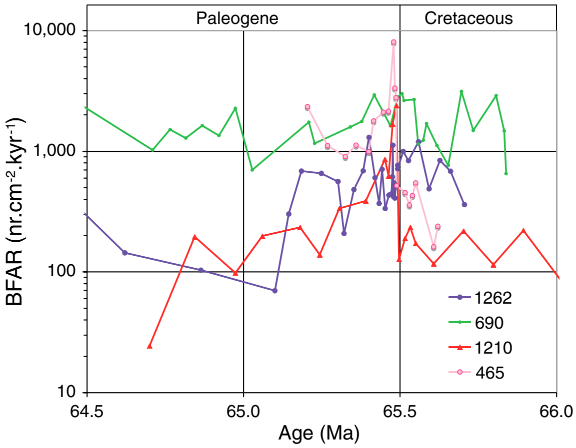

Fig. S2. BFAR across the K/Pg boundary at sites in the Pacific, Southeast Atlantic, and Southern Ocean. See Fig. 1 for location.

Other Supporting Information Files

Table S1 (DOC)
Table S2 (DOC)
Table S3 (DOC)