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SUPPLEMENTARY INFORMATION

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High rates of microbial carbon turnover in sediments in the deepest oceanic trench on Earth

Bathymetry of study site:

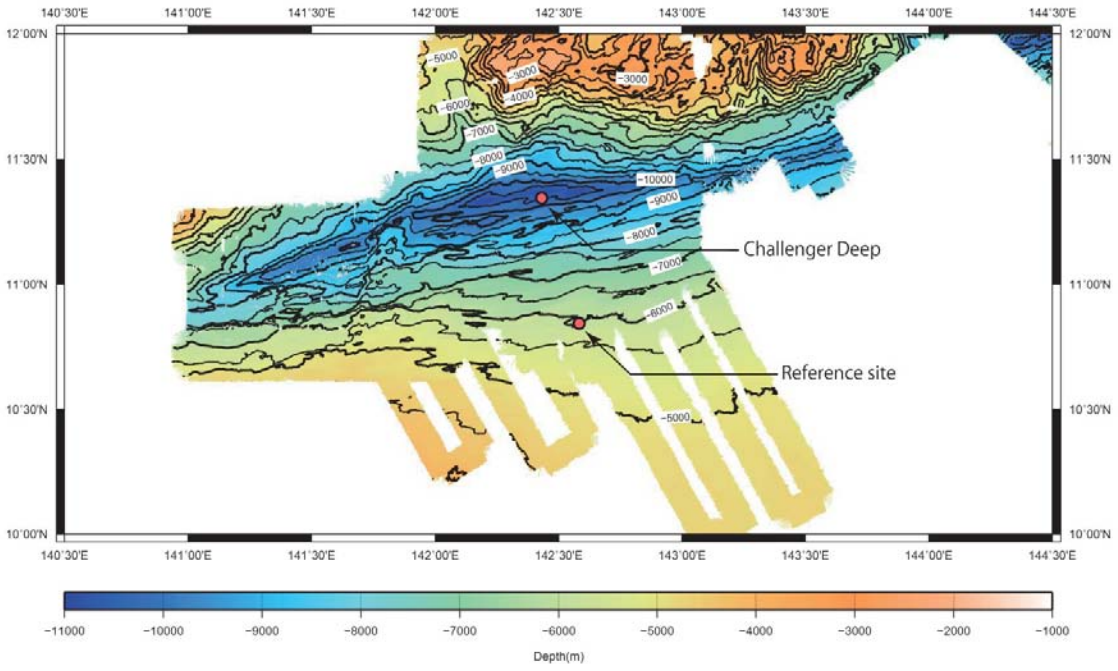

Figure S1. Bathymetric map of the study area indicating positions of the Challenger Deep (CD) at 10,900 m and the reference site (REF) at 6,000 m water depth. The map is constructed from several visits to the area by JAMSTEC-based research vessels equipped with a 2112 Seabeam operating at 12 kHz. The map is depicted by a grid interval of 300 m and a contour interval of 500 m.

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Detailed O_2 distribution across the sediment water interface

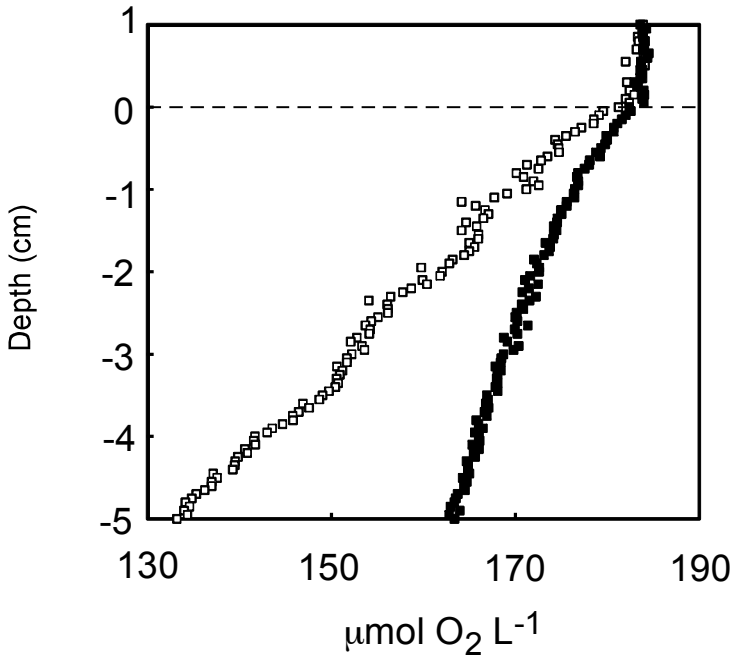

Figure S2. Close up of the O_2 distribution across the sediment water interface at CD (open symbols) and at the REF site (Close symbols), respectively. The two O_2 microprofiles represent averages of the profiles presented in Figure 2 of the manuscript and clearly reflect a steeper decline at the trench site. The horizontal broken line indicates the estimated position of the sediment surface.

Extended Methods on radionuclide work

The naturally occurring radioactive lead isotope ^{210}Pb is particle reactive and produced by non-particle-reactive ^{226}Ra. It is used to trace particulate matter on time scales of up to several decades. To assess topographically induced influences on the depositional particle flux into the sediment, estimated water column-derived ^{210}Pb inventories were compared with measured sediment-derived ^{210}Pb inventories[1].

To ensure high credibility in the analyses measurements of excess ^{210}Pb ($^{210}Pb_{xs}$ = total ^{210}Pb radioactivity – ^{226}Ra radioactivity) were performed at the Scottish Association for Marine Science (SAMS) as well as the Japanese Agency for Marine Earth Science and Technology (JAMSTEC). Measurements were performed on the same homogenized sediment samples. The data obtained at the two laboratories were very similar (Fig. S3).

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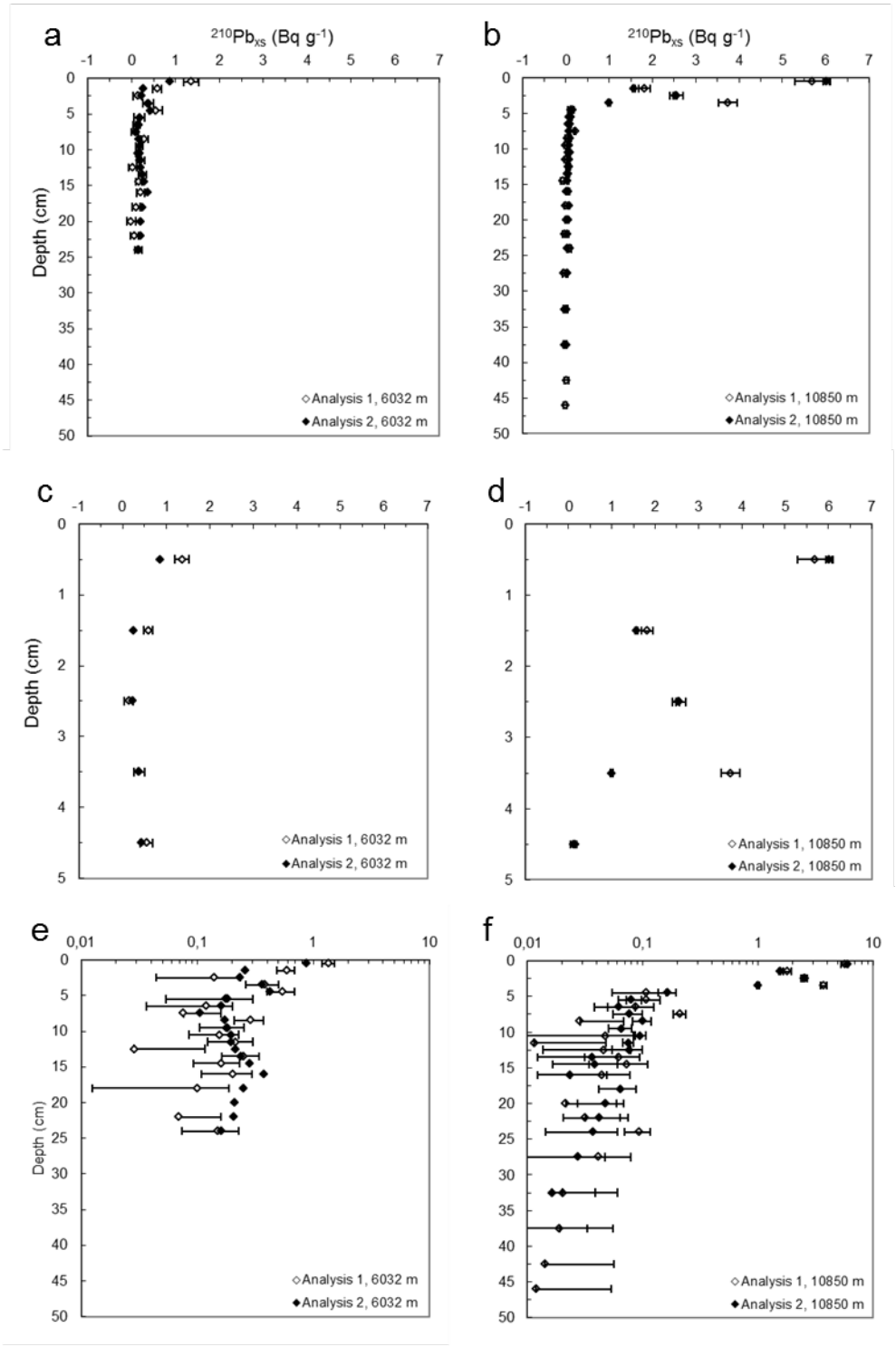

Figure S3. Sediment profiles of excess ^{210}Pb measured by two different procedures (analysis 1 and 2) at the reference station (a, c, e) and in the Challenger Deep (b,d,f). The two procedures were applied to the same homogenized sediment samples.

Error bars for Analysis 1 reflect ± one standard deviation of propagated analytical uncertainties, including counting uncertainties. Error bars for Analysis 2 reflect ± one standard deviation of counting uncertainties. The data are plotted using different axes to facilitate detailed inspections at the interface (c,d) and of the data quality in the deeper sediment layers (e,f).

Measurements of $^{210}Pb_{xs}$ (analysis 1, SAMS)

Sediment slices were freeze-dried and ground in an agate mill. Porewater salt was not removed but accounted for when calculating specific excess ^{210}Pb assuming identical bottom water and porewater salinities. 5 or 10 g of dried and ground sediment were pressed into 47 mm-diameter discs and placed in polystyrene petri dishes that were sealed with epoxy adhesive. Prior to any measurement the sealed samples equilibrated for at least 1 month to ensure radioactive equilibrium between ^{222}Rn and its parent ^{226}Ra. The gamma-ray spectra were determined using planar germanium detectors (Canberra). ^{210}Pb and ^{214}Bi decay counts were registered for 1 day at gamma-ray energies of 46.5 keV and 610 keV, respectively. Counts were corrected for detector backgrounds and counting efficiencies for ^{210}Pb and ^{214}Bi. $^{210}Pb_{xs}$ data were corrected for the radioactive decay that occurred between sample collection and sample measurement. To be able to calculate sedimentary $^{210}Pb_{xs}$ inventories, radioactive disintegrations per mass unit of dried sediment (Bq g^{-1}) were translated into radioactive disintegrations per volume unit of wet sediment (Bq cm^{-3}) using measured dry bulk sediment densities.

Measurements of $^{210}Pb_{xs}$ (analysis 2, JAMSTEC)

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Basic calculations, corrections and conversions were the same as described above. Here we only specify differences between the two procedures. The respective sediment slices were placed in plastic cubes and dried at (80 ^{o}C) for 48 hours. The dried sediments were milled and 2g were packed into a plastic vessel and left for 2 months to ensure equilibrium between ^{226}Ra and ^{222}Rn. The $^{210}Pb_{xs}$ concentrations were measured using an ORTEC 12030 well-type gamma ray detector and a SEIKO EG&G MCA7800 spectrum analyser. The respective peak areas of the raw data of ^{210}Pb (46.5keV) and ^{214}Pb (351.9keV) were calculated by Gaussian curve fitting using KareidGraph 4.1. Both ^{210}Pb and ^{214}Pb concentrations were referenced against a CANMET DL-1a uranium-thorium standard. Total counting times for the samples ranged from 1 to 3 days.

Calculation of ^{210}Pb focusing

To assess the extent of ^{210}Pb focussing into the Challenger-Deep sediments, measured sediment-derived $^{210}Pb_{xs}$ inventories (see above) were compared with estimated water column-derived $^{210}Pb_{xs}$ inventories. To estimate the latter, information on both ^{226}Ra and ^{210}Pb activities throughout the water column is needed. Here we used previously published water-column data for ^{210}Pb and ^{226}Ra in the Northwest Pacific[2,3,4].

Although detectable horizontal basin-scale ^{226}Ra gradients exist the overall range of ^{226}Ra concentrations is well constrained[3]. Despite the lack of ^{226}Ra measurements from the Mariana Trench region it therefore seems reasonable to assume that any bathyal and abyssal concentrations from the Mariana Trench region would fall into the presently known range of values for the western Central and Northwest Pacific. Except for a couple of measurements from 6,433 and 7,233 m water depth (867 and 67 m above the seafloor) in the Aleutian Trench there does not seem to be any direct information on

^{226}Ra distributions in deep-sea trenches[3]. These two samples showed no evidence for changes of ^{226}Ra activities within the trench as compared to the overlying abyssal water column. This is consistent with the fact that, in comparison to a flat seafloor, the tilt of the trench slopes increases the seafloor area by only up to ~ 1%. Therefore we assume that the range of hadal ^{226}Ra activities in the Mariana Trench would be the same as the range of known ^{226}Ra concentrations in waters from > 3,000m in the Northwest Pacific.

The most comprehensive total-^{210}Pb water-column profile including a hadal trench was measured in the Izu-Ogasawara Trench[2]. This trench merges into the Mariana Trench and because of the relative spatial proximity of the Izu-Ogasawara and Mariana Trenches we assume similar total ^{210}Pb values would be found for the Mariana Trench and its overlying waters.

Data compilations of ^{226}Ra and ^{210}Pb data show that in the topmost few hundred meters there is a total ^{210}Pb excess over ^{226}Ra. This excess is usually interpreted as being atmospherically deposited ^{210}Pb. Although a large fraction of total ^{210}Pb in this excess layer of the water column tends to be in the dissolved phase[5] we assume that this dissolved ^{210}Pb will eventually also be scavenged and exported into the deep waters and underlying sediments. Below the topmost ~ 500 – 1,000 m of the water column the situation reverses and there is a deficit of total ^{210}Pb compared to ^{226}Ra. We assume all the 'missing' ^{210}Pb is scavenged onto settling particles and deposited in the underlying sediments.

The depth-integrated disequilibria between total ^{210}Pb and ^{226}Ra now allow us to estimate sediment inventories of $^{210}Pb_{xs}$ that would be expected if the system was in a steady state. Any discrepancies between expected and actually observed sediment inventories would indicate 'focusing' or 'winnowing' of particle-associated ^{210}Pb.

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The calculation reveals that the sediment inventories of $^{210}Pb_{xs}$ as expected from the water-column disequilibria are 1.15 ± 0.43 Bq cm^{-2} and 2.64 ± 0.99 Bq cm^{-2} for the shallower reference site and the Challenger Deep, respectively. The uncertainties result from running the calculations with minimum and maximum values of the deep-water ranges of total ^{210}Pb and ^{226}Ra. For the two analytical procedures (see above) the measured sediment inventories at the reference site were 1.72 ± 0.16 Bq cm^{-2} and 1.85 ± 0.05 Bq cm^{-2}, and 5.50 ± 0.23 Bq cm^{-2} and 4.55 ± 0.07 Bq cm^{-2} for the Challenger Deep.

Within uncertainties, the expected and observed inventories at the reference site were similar, suggesting the sediments mainly consist of material from the primary flux, with only a slight possibility of some lateral input. By contrast, in the Challenger Deep measured inventories were ~ 2 times higher than the expected inventories. Some of this focussed $^{210}Pb_{xs}$ is likely to have been scavenged during downslope-particle transport. That is, not all of the focussed $^{210}Pb_{xs}$ may have initially been particle-associated. The focussing factor for particulate matter and its chemical constituents could therefore be somewhat smaller than 2, an estimate that compares well with the differences observed for organic carbon and phytopigments between the two sites.

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