

Supplement of Biogeosciences Discuss., 11, 13067–13126, 2014  
<http://www.biogeosciences-discuss.net/11/13067/2014/>  
doi:10.5194/bgd-11-13067-2014-supplement  
© Author(s) 2014. CC Attribution 3.0 License.



*Supplement of*

## **Organic carbon production, mineralization and preservation on the Peruvian margin**

**A. W. Dale et al.**

*Correspondence to:* A. W. Dale ([adale@geomar.de](mailto:adale@geomar.de))

# Organic carbon production, mineralization and preservation on the Peruvian margin

A. W. Dale<sup>1</sup>, S. Sommer<sup>1</sup>, U. Lomnitz<sup>1</sup>, I. Montes<sup>2</sup>, T. Treude<sup>1</sup>, J. Gier<sup>1</sup>, C. Hensen<sup>1</sup>, M. Dengler<sup>1</sup>, K. Stolpovsky<sup>1</sup>, L. D. Bryant<sup>1</sup> and K. Wallmann<sup>1</sup>

[1] {GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany}

[2] {Instituto Geofísico del Perú (IGP), Lima, Perú}

Correspondence to: A. W. Dale (adale@geomar.de)

## Supplementary material

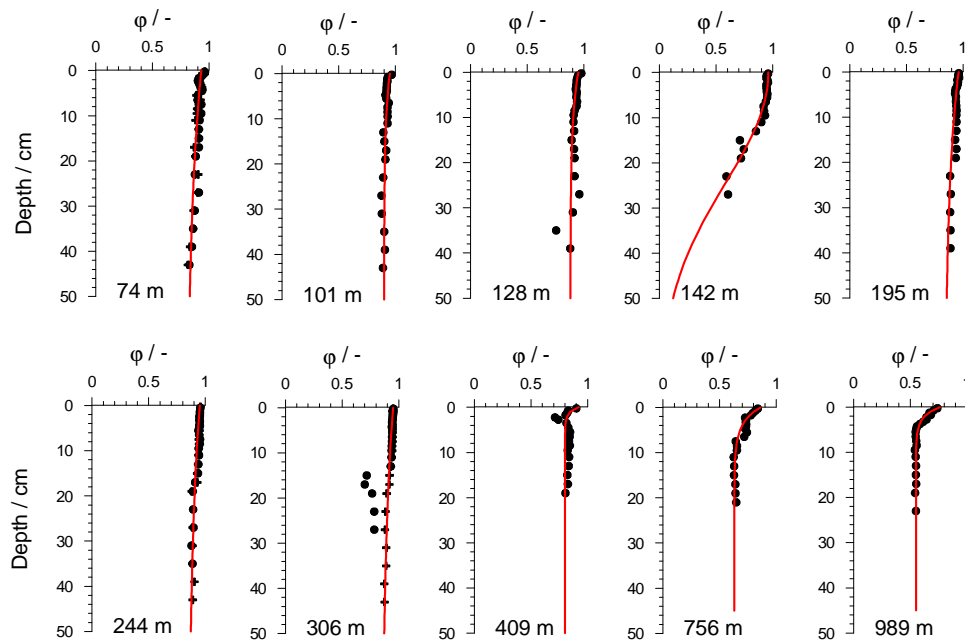


Figure S1. Measured (symbols) and modeled porosity at 12°S using the parameters listed in Table S2 (see Bohlen et al. (2011) for porosity parameters at 11°S). Data correspond to the multi-cores (MUC) listed in Table 1 in the main text.

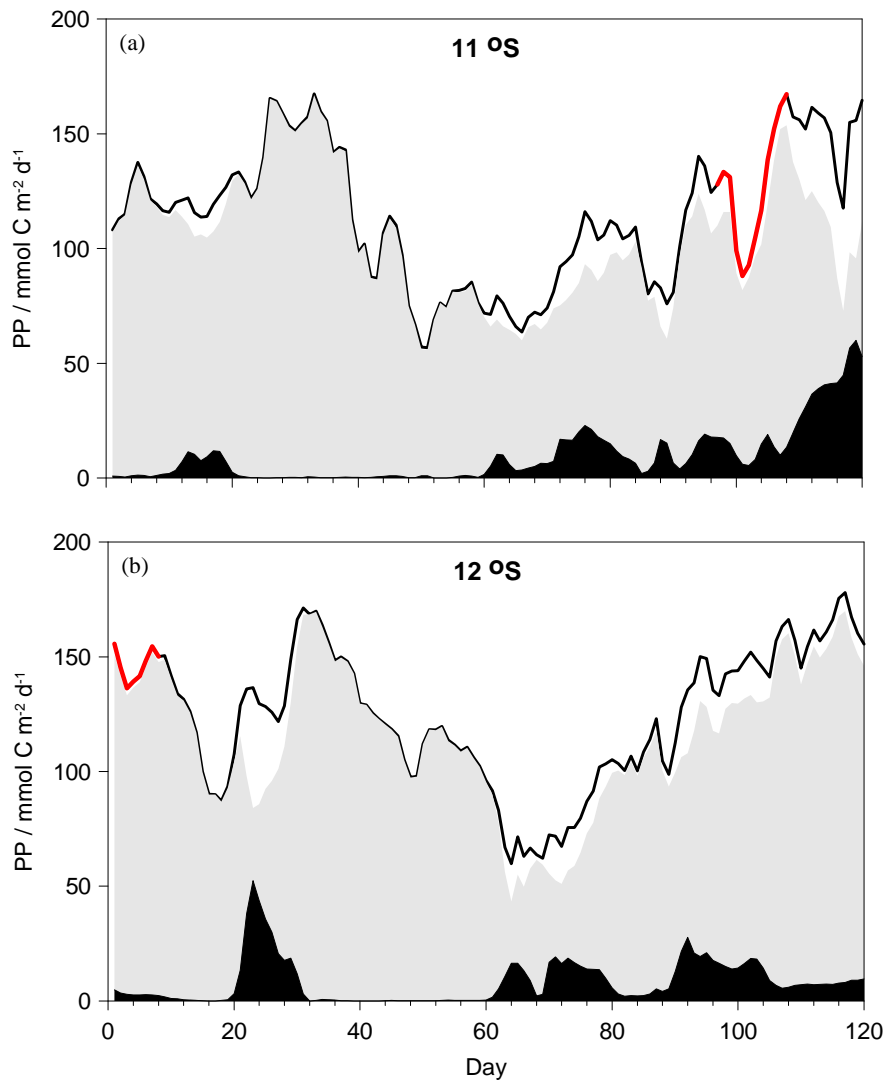


Figure S2. Three-day moving average primary production ( $\text{mmol C m}^{-2} \text{d}^{-1}$ ) at ca. 100 m water depth on the 11 and 12 °S transects calculated by the ROMS-BioEBUS model (thick black line). The contribution from small and large phytoplankton groups are shown in black and grey, respectively. The red lines show the periods when the fieldwork was conducted.

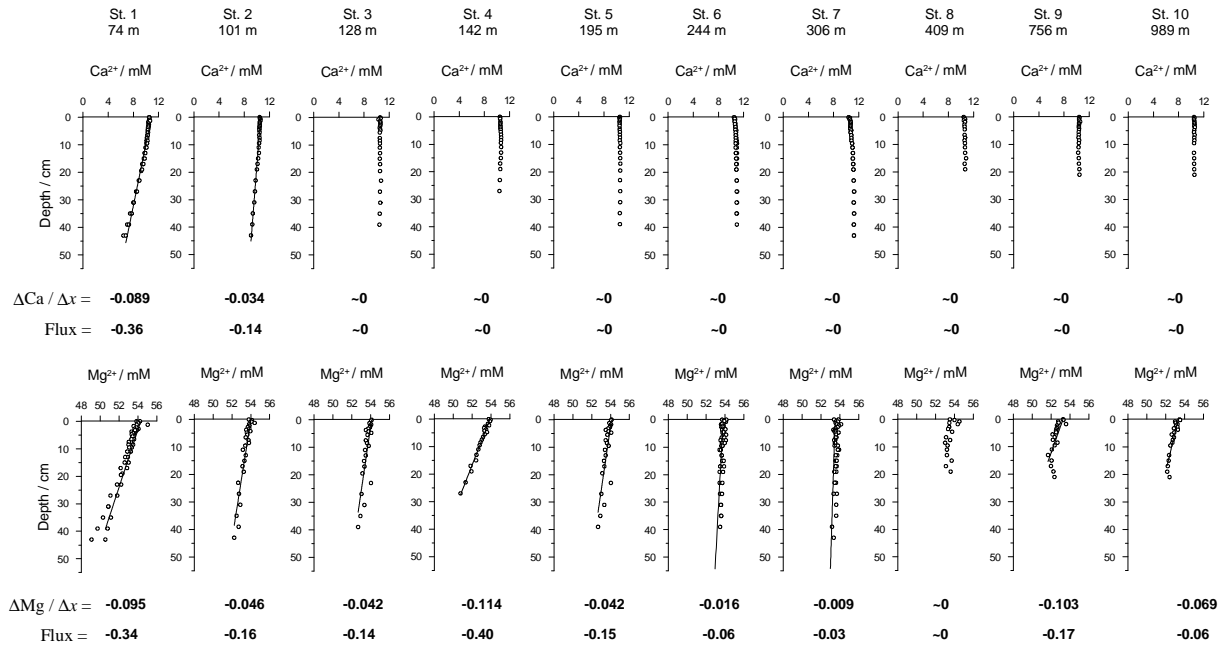


Figure S3. Dissolved porewater calcium ( $Ca^{2+}$ ) and magnesium ( $Mg^{2+}$ ) concentrations at  $12^{\circ}S$ . The solid lines denote linear regression curves where a concentration gradient ( $\Delta Ca / \Delta x$ ,  $\Delta Mg / \Delta x$ ) was apparent. The concentration gradients are given (in  $\mu mol cm^{-4}$ ) from which the diffusive fluxes were calculated (in  $mmol cm^{-2} d^{-1}$ ) using Fick's First Law and diffusion coefficients corrected for site-specific tortuosity and temperature.

Table S1. Measured TA and  $p\text{CO}_2$  concentrations in the benthic chambers. TA measured in the syringe samples was corrected for dilution by distilled water in the Vygon tubes using the chloride concentration. Linear regression of the syringe samples was used to adjust TA to the times when the glass tubes samples were withdrawn for  $p\text{CO}_2$  analysis. DIC was calculated as described in the main text. (C1 = chamber 1, C2 = chamber 2).

| BIGO I-II (74 m) | Time syringes<br>(h) | TA corrected<br>(mM) | Time tubes<br>(h) | TA<br>(mM) | $p\text{CO}_2$<br>(ppm) | DIC<br>( $\mu\text{M}$ ) |
|------------------|----------------------|----------------------|-------------------|------------|-------------------------|--------------------------|
| C1_1             | 0.25                 | 2.31                 | 0.5               | 2.474      | 1402                    | 2434                     |
| C1_2             | 4                    | 2.57                 |                   |            |                         |                          |
| C1_3             | 8                    | 2.70                 | 9                 | 2.631      | 1561                    | 2579                     |
| C1_4             | 12                   | 2.78                 |                   |            |                         |                          |
| C1_5             | 16                   | 2.77                 | 18                | 2.798      | 1654                    | 2725                     |
| C1_6             | 20                   | 2.88                 |                   |            |                         |                          |
| C1_7             | 24                   | 2.86                 |                   |            |                         |                          |
| C1_8             | 28                   | 2.92                 | 27                | 2.964      | 1757                    | 2872                     |
| C2_1             | 0.25                 | 2.39                 | 0.5               | 2.433      | 1367                    | 2385                     |
| C2_2             | 4                    | 2.45                 |                   |            |                         |                          |
| C2_3             | 8                    | 2.55                 | 9                 | 2.510      | 1469                    | 2454                     |
| C2_4             | 12                   | 2.57                 |                   |            |                         |                          |
| C2_5             | 16                   | 2.59                 | 18                | 2.591      | 1550                    | 2523                     |
| C2_6             | 20                   | 2.59                 |                   |            |                         |                          |
| C2_7             | 24                   | 2.58                 |                   |            |                         |                          |
| C2_8             | 28                   | 2.72                 | 27                | 2.672      | 1621                    | 2591                     |

| BIGO I-V (101 m) | Time syringes<br>(h) | TA corrected<br>(mM) | Time tubes<br>(h) | TA<br>(mM) | $p\text{CO}_2$<br>(ppm) | DIC<br>( $\mu\text{M}$ ) |
|------------------|----------------------|----------------------|-------------------|------------|-------------------------|--------------------------|
| C1_1             | 0.25                 | 2.46                 | 0.5               | 2.450      | 1211                    | 2391                     |
| C1_2             | 4                    | 2.48                 |                   |            |                         |                          |
| C1_3             | 8                    | 2.51                 | 9                 | 2.511      | 1285                    | 2452                     |
| C1_4             | 12                   | 2.48                 |                   |            |                         |                          |
| C1_5             | 16                   | 2.60                 | 18                | 2.576      | 1347                    | 2511                     |
| C1_6             | 20                   | 2.57                 |                   |            |                         |                          |
| C1_7             | 24                   | 2.64                 |                   |            |                         |                          |
| C1_8             | 28                   | 2.64                 | 27                | 2.641      | 1399                    | 2568                     |
| C2_1             | 0.25                 | 2.36                 | 0.5               | 2.434      | 1201                    | 2375                     |
| C2_2             | 4                    | 2.52                 |                   |            |                         |                          |
| C2_3             | 8                    | 2.60                 | 9                 | 2.499      | 1274                    | 2442                     |
| C2_4             | 12                   | 2.46                 |                   |            |                         |                          |
| C2_5             | 16                   | 2.48                 | 18                | 2.569      | 1326                    | 2509                     |
| C2_6             | 20                   | 2.57                 |                   |            |                         |                          |
| C2_7             | 24                   | 2.69                 |                   |            |                         |                          |
| C2_8             | 28                   | 2.62                 | 27                | 2.638      | 1366                    | 2573                     |

| BIGO II-IV (128 m) | Time syringes<br>(h) | TA corrected<br>(mM) | Time tubes<br>(h) | TA<br>(mM) | $p\text{CO}_2$<br>(ppm) | DIC<br>( $\mu\text{M}$ ) |
|--------------------|----------------------|----------------------|-------------------|------------|-------------------------|--------------------------|
| C1_1               | 0.25                 | 2.24                 | 0.5               | 2.287      | 1260                    | 2246                     |
| C1_2               | 4                    | 2.33                 |                   |            |                         |                          |
| C1_3               | 8                    | 2.32                 | 9                 | 2.316      | 1223                    | 2269                     |
| C1_4               | 12                   | 2.42                 |                   |            |                         |                          |
| C1_5               | 16                   | 2.42                 | 18                | 2.346      | 1230                    | 2298                     |
| C1_6               | 20                   | 2.35                 |                   |            |                         |                          |
| C1_7               | 24                   | 2.47                 |                   |            |                         |                          |
| C1_8               | 28                   | 2.48                 | 27                | 2.377      | 1275                    | 2327                     |
| C2_1               | 0.25                 | 2.35                 | 0.5               | 2.276      | 1305                    | 2240                     |
| C2_2               | 4                    | 2.25                 |                   |            |                         |                          |
| C2_3               | 8                    | 2.29                 | 9                 | 2.340      | 1287                    | 2298                     |
| C2_4               | 12                   | 2.31                 |                   |            |                         |                          |
| C2_5               | 16                   | 2.30                 | 18                | 2.408      | 1254                    | 2358                     |
| C2_6               | 20                   | 2.41                 |                   |            |                         |                          |
| C2_7               | 24                   | 2.44                 |                   |            |                         |                          |
| C2_8               | 28                   | 2.33                 | 27                | 2.475      | 1301                    | 2425                     |

| BIGO I-I (142 m) | Time syringes<br>(h) | TA corrected<br>(mM) | Time tubes<br>(h) | TA<br>(mM) | $p$ CO <sub>2</sub><br>(ppm) | DIC<br>( $\mu$ M) |
|------------------|----------------------|----------------------|-------------------|------------|------------------------------|-------------------|
| C1_1             | 0.25                 | 2.40                 | 0.5               | 2.391      | 1570                         | 2372              |
| C1_2             | 4                    | 2.43                 |                   |            |                              |                   |
| C1_3             | 8                    | 2.39                 | 9                 | 2.404      | 1656                         | 2391              |
| C1_4             | 12                   | 2.39                 |                   |            |                              |                   |
| C1_5             | 16                   | 2.39                 | 18                | 2.418      | 1719                         | 2410              |
| C1_6             | 20                   | 2.41                 |                   |            |                              |                   |
| C1_7             | 24                   | 2.40                 |                   |            |                              |                   |
| C1_8             | 28                   | 2.48                 | 27                | 2.431      | 1786                         | 2427              |
| C2_1             | 0.25                 | 2.33                 | 0.5               | 2.383      | 1594                         | 2366              |
| C2_2             | 4                    | 2.41                 |                   |            |                              |                   |
| C2_3             | 8                    | 2.49                 | 9                 | 2.399      | 1701                         | 2390              |
| C2_4             | 12                   | 2.39                 |                   |            |                              |                   |
| C2_5             | 16                   | 2.37                 | 18                | 2.415      | 1808                         | 2414              |
| C2_6             | 20                   | 2.40                 |                   |            |                              |                   |
| C2_7             | 24                   | 2.41                 |                   |            |                              |                   |
| C2_8             | 28                   | 2.47                 | 27                | 2.431      | 1908                         | 2436              |

| BIGO I-IV (195 m) | Time syringes<br>(h) | TA corrected<br>(mM) | Time tubes<br>(h) | TA<br>(mM) | $p$ CO <sub>2</sub><br>(ppm) | DIC<br>( $\mu$ M) |
|-------------------|----------------------|----------------------|-------------------|------------|------------------------------|-------------------|
| C1_1              | 0.25                 | 2.34                 | 0.5               | 2.325      | 1366                         | 2294              |
| C1_2              | 4                    | 2.31                 |                   |            |                              |                   |
| C1_3              | 8                    | 2.33                 | 9                 | 2.325      | 1410                         | 2299              |
| C1_4              | 12                   | 2.36                 |                   |            |                              |                   |
| C1_5              | 16                   | 2.31                 | 18                | 2.325      | 1459                         | 2303              |
| C1_6              | 20                   | 2.31                 |                   |            |                              |                   |
| C1_7              | 24                   | 2.31                 |                   |            |                              |                   |
| C1_8              | 28                   | 2.32                 | 27                | 2.325      | 1476                         | 2305              |
| C2_1              | 0.25                 | 2.31                 | 0.5               | 2.317      | 1319                         | 2282              |
| C2_2              | 4                    | 2.32                 |                   |            |                              |                   |
| C2_3              | 8                    | 2.37                 | 9                 | 2.324      | 1342                         | 2291              |
| C2_4              | 12                   | 2.30                 |                   |            |                              |                   |
| C2_5              | 16                   | 2.28                 | 18                | 2.332      | 1351                         | 2300              |
| C2_6              | 20                   | 2.32                 |                   |            |                              |                   |
| C2_7              | 24                   | 2.37                 |                   |            |                              |                   |
| C2_8              | 28                   | 2.34                 | 27                | 2.340      | 1359                         | 2308              |

| BIGO II-II (244 m) | Time syringes<br>(h) | TA corrected<br>(mM) | Time tubes<br>(h) | TA<br>(mM) | $p$ CO <sub>2</sub><br>(ppm) | DIC<br>( $\mu$ M) |
|--------------------|----------------------|----------------------|-------------------|------------|------------------------------|-------------------|
| C1_1               | 0.25                 | 2.39                 | 0.5               | 2.371      | 1329                         | 2335              |
| C1_2               | 4                    | 2.36                 |                   |            |                              |                   |
| C1_3               | 8                    | 2.36                 | 9                 |            |                              |                   |
| C1_4               | 12                   | 2.37                 |                   |            |                              |                   |
| C1_5               | 16                   | 2.42                 | 18                | 2.390      | 1407                         | 2361              |
| C1_6               | 20                   | 2.38                 |                   |            |                              |                   |
| C1_7               | 24                   | 2.41                 |                   |            |                              |                   |
| C1_8               | 28                   | 2.39                 | 27                | 2.400      | 1453                         | 2375              |
| C2_1               | 0.25                 | 2.36                 | 0.5               | 2.418      | 1338                         | 2381              |
| C2_2               | 4                    | 2.48                 |                   |            |                              |                   |
| C2_3               | 8                    | 2.47                 | 9                 | 2.418      | 1509                         | 2397              |
| C2_4               | 12                   | 2.39                 |                   |            |                              |                   |
| C2_5               | 16                   | 2.38                 | 18                | 2.418      | 1551                         | 2401              |
| C2_6               | 20                   | 2.42                 |                   |            |                              |                   |
| C2_7               | 24                   | 2.45                 |                   |            |                              |                   |
| C2_8               | 28                   | 2.40                 | 27                | 2.418      | 1583                         | 2403              |

| BIGO II-I (306 m) | Time syringes<br>(h) | TA corrected<br>(mM) | Time tubes<br>(h) | TA<br>(mM) | <i>p</i> CO <sub>2</sub><br>(ppm) | DIC<br>(μM) |
|-------------------|----------------------|----------------------|-------------------|------------|-----------------------------------|-------------|
| C1_1              | 0.25                 | 2.44                 | 0.5               | 2.367      | 1134                              | 2313        |
| C1_2              | 4                    | 2.32                 |                   |            |                                   |             |
| C1_3              | 8                    | 2.33                 | 9                 | 2.373      | 1153                              | 2320        |
| C1_4              | 12                   | 2.37                 |                   |            |                                   |             |
| C1_5              | 16                   | 2.37                 | 18                | 2.379      | 1169                              | 2328        |
| C1_6              | 20                   | 2.41                 |                   |            |                                   |             |
| C1_7              | 24                   | 2.41                 |                   |            |                                   |             |
| C1_8              | 28                   | 2.37                 | 27                | 2.385      | 1169                              | 2333        |
| C2_1              | 0.25                 | 2.39                 | 0.5               | 2.385      | 1122                              | 2328        |
| C2_2              | 4                    | 2.38                 |                   |            |                                   |             |
| C2_3              | 8                    | 2.38                 | 9                 | 2.389      | 1143                              | 2334        |
| C2_4              | 12                   | 2.41                 |                   |            |                                   |             |
| C2_5              | 16                   | 2.40                 | 18                | 2.393      | 1159                              | 2340        |
| C2_6              | 20                   | 2.37                 |                   |            |                                   |             |
| C2_7              | 24                   | 2.40                 |                   |            |                                   |             |
| C2_8              | 28                   | 2.40                 | 27                | 2.398      | 1173                              | 2346        |

| BIGO II-V (409 m) | Time syringes<br>(h) | TA corrected<br>(mM) | Time tubes<br>(h) | TA<br>(mM) | <i>p</i> CO <sub>2</sub><br>(ppm) | DIC<br>(μM) |
|-------------------|----------------------|----------------------|-------------------|------------|-----------------------------------|-------------|
| C1_1              | 0.25                 | 2.27                 | 0.5               | 2.264      | 1367                              | 2254        |
| C1_2              | 4                    | 2.27                 |                   |            |                                   |             |
| C1_3              | 8                    | 2.30                 | 9                 | 2.266      | 1394                              | 2259        |
| C1_4              | 12                   | 2.26                 |                   |            |                                   |             |
| C1_5              | 16                   | 2.31                 | 18                | 2.269      | 1401                              | 2262        |
| C1_6              | 20                   | 2.34                 |                   |            |                                   |             |
| C1_7              | 24                   | 2.37                 |                   |            |                                   |             |
| C1_8              | 28                   | 2.29                 | 27                | 2.272      | 1406                              | 2266        |
| C2_1              | 0.25                 | 2.40                 | 0.5               | 2.264      | 1387                              | 2256        |
| C2_2              | 4                    | 2.26                 |                   |            |                                   |             |
| C2_3              | 8                    | 2.45                 | 9                 | 2.266      | 1409                              | 2260        |
| C2_4              | 12                   | 2.23                 |                   |            |                                   |             |
| C2_5              | 16                   | 2.31                 | 18                |            |                                   |             |
| C2_6              | 20                   | 2.32                 |                   |            |                                   |             |
| C2_7              | 24                   | 2.24                 |                   |            |                                   |             |
| C2_8              | 28                   | 2.26                 | 27                | 2.272      | 1398                              | 2265        |

| BIGO II-III (756 m) | Time syringes<br>(h) | TA corrected<br>(mM) | Time tubes<br>(h) | TA<br>(mM) | <i>p</i> CO <sub>2</sub><br>(ppm) | DIC<br>(μM) |
|---------------------|----------------------|----------------------|-------------------|------------|-----------------------------------|-------------|
| C1_1                | 0.25                 | 2.43                 | 0.5               | 2.356      | 1138                              | 2345        |
| C1_2                | 4                    | 2.32                 |                   |            |                                   |             |
| C1_3                | 8                    | 2.41                 | 9                 | 2.356      | 1161                              | 2348        |
| C1_4                | 12                   | 2.30                 |                   |            |                                   |             |
| C1_5                | 16                   | 2.35                 | 18                | 2.356      | 1139                              | 2345        |
| C1_6                | 20                   | 2.34                 |                   |            |                                   |             |
| C1_7                | 24                   | 2.37                 |                   |            |                                   |             |
| C1_8                | 28                   | 2.33                 | 27                | 2.356      | 1150                              | 2346        |
| C2_1                | 0.25                 | 2.37                 | 0.5               | 2.373      | 1144                              | 2362        |
| C2_2                | 4                    | 2.38                 |                   |            |                                   |             |
| C2_3                | 8                    | 2.33                 | 9                 | 2.381      | 1163                              | 2372        |
| C2_4                | 12                   | 2.41                 |                   |            |                                   |             |
| C2_5                | 16                   | 2.39                 | 18                | 2.389      | 1175                              | 2381        |
| C2_6                | 20                   | 2.40                 |                   |            |                                   |             |
| C2_7                | 24                   | 2.45                 |                   |            |                                   |             |
| C2_8                | 28                   | 2.34                 | 27                | 2.397      | 1172                              | 2388        |

| BIGO I-III (989 m) | Time syringes<br>(h) | TA corrected<br>(mM) | Time tubes<br>(h) | TA<br>(mM) | <i>p</i> CO <sub>2</sub><br>(ppm) | DIC<br>(μM) |
|--------------------|----------------------|----------------------|-------------------|------------|-----------------------------------|-------------|
| C1_1               | 0.25                 | 2.32                 | 0.5               | 2.357      | 1035                              | 2336        |
| C1_2               | 4                    | 2.42                 |                   |            |                                   |             |
| C1_3               | 8                    | 2.37                 | 9                 | 2.357      | 1077                              | 2341        |
| C1_4               | 12                   | 2.34                 |                   |            |                                   |             |
| C1_5               | 16                   | 2.32                 | 18                | 2.357      | 1068                              | 2340        |
| C1_6               | 20                   | 2.37                 |                   |            |                                   |             |
| C1_7               | 24                   | 2.40                 |                   |            |                                   |             |
| C1_8               | 28                   | 2.33                 | 27                | 2.357      | 1091                              | 2343        |
| C2_1               | 0.25                 | 2.31                 | 0.5               | 2.357      | 1039                              | 2337        |
| C2_2               | 4                    | 2.34                 |                   |            |                                   |             |
| C2_3               | 8                    | 2.32                 | 9                 | 2.357      | 1056                              | 2339        |
| C2_4               | 12                   | 2.37                 |                   |            |                                   |             |
| C2_5               | 16                   | 2.36                 | 18                | 2.357      | 1063                              | 2340        |
| C2_6               | 20                   | 2.36                 |                   |            |                                   |             |
| C2_7               | 24                   | 2.44                 |                   |            |                                   |             |
| C2_8               | 28                   | 2.39                 | 27                | 2.357      | 1081                              | 2342        |



Table S2. Parameters and boundary conditions for simulating  $^{210}\text{Pb}_{\text{xs}}$ .

| Description  | St. 1<br>(74 m) | St. 2<br>(101 m)                            | St. 3<br>(128 m) | St. 5 <sup>a</sup><br>(142 m) | St. 5<br>(195 m) | St. 6<br>(244 m)                            | St. 7<br>(306 m) | St. 8<br>(409 m) | St. 9<br>(756 m) | St. 10<br>(989 m) |
|--|-----------------|---|------------------|-------------------------------|------------------|---|------------------|------------------|------------------|-------------------|
| Dry sediment density, $\rho$ ( $\text{g cm}^{-3}$ )  | 2.0             | 2.0   | 2.0              | 2.0                           | 2.0              | 2.0   | 2.0              | 2.0              | 2.0              | 2.0               |
| Porosity at sediment surface (0 cm), $\varphi(0)$ (-)  | 0.93            | 0.95  | 0.95             | 0.96                          | 0.96             | 0.95  | 0.95             | 0.92             | 0.86             | 0.76              |
| Porosity at sediment base ( $L$ cm), $\varphi(L)$ (-)  | 0.80            | 0.90  | 0.88             | -                             | 0.84             | 0.87  | 0.85             | 0.80             | 0.63             | 0.55              |
| Porosity attenuation length, $z_{\text{por}}$ (cm)   | 0.03            | 0.1   | 0.10             | -                             | 0.04             | 0.03  | 0.03             | 0.90             | 0.30             | 0.50              |
| Sediment accumulation rate, $\omega_{\text{acc}}$ ( $\text{cm yr}^{-1}$ )                                    | 0.45            | No<br>$^{210}\text{Pb}_{\text{xs}}$<br>data | 0.2              | 0.04                          | 0.10             | No<br>$^{210}\text{Pb}_{\text{xs}}$<br>data | 0.05             | 0.011            | 0.035            | 0.06              |
| Bioturbation coefficient at sediment surface, $D_B(0)$ ( $\text{cm}^2 \text{yr}^{-1}$ )                      | 1.0             | No<br>$^{210}\text{Pb}_{\text{xs}}$<br>data | 4.0              | 2.0                           | 1.0              | No<br>$^{210}\text{Pb}_{\text{xs}}$<br>data | 0.5              | 0.05             | 0.1              | 0.1               |
| Bioturbation halving depth, $x_s$ (cm)   | 3.0             | No<br>$^{210}\text{Pb}_{\text{xs}}$<br>data | 3.0              | 1.4                           | 2.0              | No<br>$^{210}\text{Pb}_{\text{xs}}$<br>data | 1.4              | 1.4              | 1.4              | 1.4               |
| Flux of $^{210}\text{Pb}_{\text{xs}}$ to the sediment surface, $F(0)$ ( $\text{Bq cm}^{-2} \text{yr}^{-1}$ ) | 0.11            | No<br>$^{210}\text{Pb}_{\text{xs}}$<br>data | 0.088            | 0.019                         | 0.026            | No<br>$^{210}\text{Pb}_{\text{xs}}$<br>data | 0.023            | 0.0016           | 0.025            | 0.015             |

<sup>a</sup> Porosity at St. 5 (Figure S1) was better simulated using the function:  $\varphi(x) = \varphi(0) \cdot \exp(-\frac{x^2}{1200})$