SUPPLEMENTARY MATERIAL

A1. Separation or organic carbon mixtures by ramped oxidation

We used the ramped oxidation method to separate POC mixtures preserved in river and turbidite samples (Fig. 3).

Sample preparation

All samples analyzed in the ramped oxidation system were acidified by fumigation using 12 mol/L HCL for 72 hours at 60°C in order to remove any potential carbonates. We used a mass of sediment that depended on the amount of organic carbon present in each sample (e.g. 50 mg for OC rich samples and 1000 mg for OC poor samples).

General principle

The ramped oxidation method separates different carbon structures based on thermal lability by heating each sample in an oxygenated oven, thus combusting particulate carbon into CO_2 (Rosenheim et al., 2008[1], Hemingway et al., 2017[2]). CO_2 concentrations were measured by an infrared gas analyser in parts per million (ppm). The energy required to activate combustion was modelled following Hemingway et al. (2017). Resulting ppm CO2 were plotted against energy of activation (Ea) in a "thermogram".

Trapping and quantification of gas fractions

The CO_2 produced from combustion in the oven was transferred through a vacuum line to a series of cryogenic traps, and was split between user-defined temperature intervals. For each sample we collected between 3 and 5 CO_2 gas fractions which were then quantified based on pressure measurements and were sealed into pre-combusted pyrex tubes containing 100mg

[1] Rosenheim, B. E., Day, M. B., Domack, E., Schrum, H., Benthien, A. and Hayes, J. M. (2008), `Antarctic sediment chronology by programmed-temperature pyrolysis: Methodology and data treatment', Geochemistry, Geophysics, Geosystems 9(4).

[2] Hemingway, J. D., Rothman, D.H., Rosengard, S. Z., and Galy, V., 2017. Technical note: An inverse method to relate organic carbon reactivity to isotope composition from serial oxidation. Biogeosciences, v. 14, p. 5099–5114.

CuO and 10mg Ag pellets. All sealed tubes were finally combusted at 525 °C for 1 h in order to remove any trace contaminant gas. The proportion (%) of each gas fraction compared to the initial sample was calculated based on the total amount of CO_2 combusted from a given sample.

Isotope measurement

Each sealed fraction was measured for stable carbon isotope ratios ($^{13}C/^{12}C$) and radiocarbon isotopes ratios ($^{14}C/^{12}C$) at the National Ocean Sciences Accelerator Mass Spectrometry (Woods Hole Oceanographic Institution, USA). Stable carbon isotope rations are reported in $\delta^{13}C$ relative to the Vienna Pee Dee Belemnite and were measured using an Isotope Ratio Mass Spectrometer as described in McNichol et al. (1994a[3]). Small splits issued from the ramped oxidation fractions were graphitized following the established methods of the NOSAMS facility (McNichol et al., 1994b[4]). Radiocarbon isotopes were then measured on these fractions and on process blanks using an Accelerator Mass Spectrometer. Radiocarbon isotopes are expressed as Fraction modern (Fm). Fraction modern is a measurement of the deviation of the $^{14}C/^{12}C$ ratio of a sample from "modern". Modern is defined as 95% of the radiocarbon concentration in 1950 of Oxalic Acid I normalized to $\delta^{13}C$ = -19 ‰.

A2. Identification of organic carbon types and calculation of their proportions for the turbidite

Below we describe the methods used to identify POC types preserved in the turbidite sequence and to quantify their relative proportions compared to the overall sequence (Figs. 4 and S7).

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[3] McNichol, AP, Osborne, EA, Gagnon, AR, Fry, B, Jones, GA, 1994a. TIC, TOC, DIC, DOC, PIC, POC— unique aspects in the preparation of oceanographic samples for 14C-AMS, Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 92, 1-4, 162-165

[4] McNichol, AP, Jones, GA, Hutton, DL, Gagnon, AR and Key, RMnbsp, 1994b. The rapid preparation of seawater ΣCO 2 for radiocarbon analysis at the National Ocean Sciences AMS facility, Radiocarbon, v. 36 (2), p 237-246.

Identification of POC types per sample

We use results of ^{14}C, Ea and δ^{13}C in order to define three types of POC (suppl. Fig. S7). A gas fraction was defined as:

A. "young biospheric carbon" if (in order of priority):

    1. Fm > 1, and

    2. Ea < 200 Kj/mol, and

    3. δ^{13}C [-30 to -26 ‰]

B. "old biospheric carbon" if (in order of priority):

    1. Fm]0 – 1], and

    2. Ea < 220 Kj/mol, and

    3. δ^{13}C [-30 to -26 ‰]

C. "Petrogenic carbon" if (in order of priority):

    1. Fm = 0, and

    2. Ea > 220 Kj/mol, and

    3. δ^{13}C [-30 to -22 ‰]

The limit young versus old biospheric carbon was set at 200 kJ/mol because we ran pure debris of wood into the RPO and they finished the combustion before 200 KJ/mol. Petrogenic carbon was set at 220 Kj/mol based on the analysis of OC-poor river and Ta unit sands in turbidites. Our threshold is slightly higher than the one used in Hemingway et al. 2018[5] (185 kJ/mol) for petrogenic carbon in Taiwan. This is because the granitic rocks in our river catchments have lower concentrations and more highly refractory petrogenic C than the Taiwanese rocks analysed in Hemingway et al. (2018).

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[5] Hemingway, J.D., Hilton, R.G., Hovius, N., Eglinton, T.I., Haghipour, N. Wacker, L., Chen, M-C, Galy, V.V., 2018. Science v. 360 (6385), pp. 209-212.

If a gas fraction did not satisfy the three criteria, its expression on the thermogram was further divided into sub-fractions in order to satisfy the three conditions of one POC type. For example, fraction 3 of Bouma Tb sample (suppl. Fig. S7) originally had a Fm = 0.44 and an Ea that ranged from 150 to 275 Kj/mol. As it satisfies the old biospheric criteria 1 (Fm]0 – 1]) but it does not satisfy old biospheric criteria 2 (Ea < 220 Kj/mol), we divided this peak spectrum into sub-fractions F3a (<220 Kj/mol in green on Fig. S7) and F3b (>220 Kj/mol in brown on Fig. S7). Since F3b is radiocarbon free (Fm =0), we recalculated the Fm of F3a by using the average value of fraction 3 (Fm = 0.44), with a weight corresponding to the area above 220 Kj/mol.

Calculation of a carbon budget for the entire sequence

Once the proportions of carbon types were defined for each sample, we estimated a global budget for the entire turbidite sequence based on: 1) the sedimentary volume of each Bouma unit compared to the whole sequence; 2) the total organic carbon content for each Bouma unit (see Table S2).

A3. Comparison of TOC fluxes between sandy channel and fines outside channel

Surface areas

The surface areas of the sandy channel/lobe and the rest of the fjord were estimated in ArcGis based on a bathymetry map acquired in 2008 which covers the whole fjord (Conway et al., 2012).

Total organic carbon (TOC) content

TOC for the sandy channel corresponds to the weighted average of TOC contained in each sedimentary unit of the studied turbidites (suppl. Fig. S7), according to their relative thickness. We assume the rest of the fjord is covered by fine sediment only as a broad approximation. Grab samples and sediment cores collected outside of the sandy channel show

that these sediments have mostly similar grain size and TOC content as the mud cap of the turbidites. Fines outside of the channel are sourced either from the turbidity current overspills or from slow settling of the river plumes in the proximal parts of the fjord. Fines related to the turbidity current overspills are inferred to have a similar organic carbon composition as the mud cap (i.e. mostly old biospheric organic carbon). However, organic carbon composition in the fines related to slow settling from the plumes remains unresolved.

Sedimentation rate

Syvistski et al. (1987)[6] provide a range of 1 – 300 mm/year depending on the location in Bute Inlet. Given this wide range, we further estimated sedimentation rates for the fines outside the channel and for the sandy channel based on other approaches. First, we used a value of 1 cm/year as the sedimentation rate for the fines outside the channel, as estimated on long cores dominated by mud in a distal location of Howe Sound, i.e. a similar fjord (in terms of sedimentary processes and connection with rivers) and close to Bute Inlet (Stacey et al., 2019[7]). Second, we used the Homathko River annual sediment load (4.3 X 10^6 t/yr, Milliman & Syvitski, 1992) to estimate the amount of sand (with a density of 1800 kg/m^3) delivered to the sandy channel and lobe areas (58 km^2). This conservative approach resulted into a sedimentation rate of 41 mm/year, i.e. nearly one order of magnitude lower compared to the maximum value provided by Syvitski et al. (1987).

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[6] Syvitski, J., Burrell, D. and Skei, J. 1987. Fjords, Springer-Verlag New York.

[7] Stacey, C.D., Hill, P.R., Talling, P.J., Enkin, R.J., Hughes Clarke, J. and Lintern, D.G., 2019. How turbidity current frequency and character varies down a fjord delta system: Combining direct monitoring, deposits and seismic data. Sedimentology, v. 66(1), p.1-31.
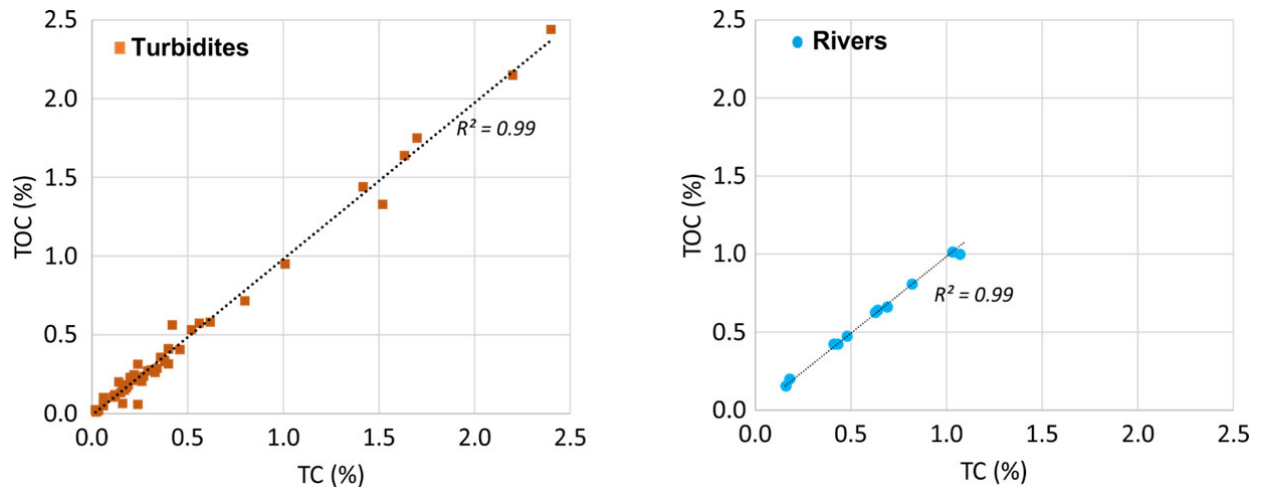
Fig. S5: Total Organic Carbon (TOC) content versus Total Carbon (TC) content in turbidite and river samples. TC was measured by a VarioMax Elementar CNS Macro Elemental Analyzer. TOC was measured by LECO elemental carbon analyzer after acidification by rinsing with 4mol/L hydrochloric acid. The absence of carbonates in this system is consistent with 1) the absence of carbonate rocks in the Homathko and Southgate river catchments and 2) negligible contributions of marine productivity to turbidites.
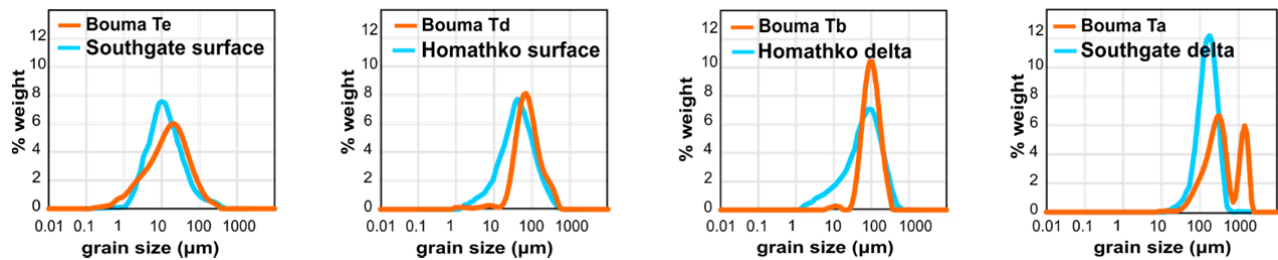

Fig. S6: Grain Size distributions for river and turbidite samples displayed in Fig. 3. Measurements were performed using a Malvern Master sizer 2000 at the National Oceanography Centre Southampton (UK). %weight corresponds to the relative amount of particles by mass relative to the total sample.
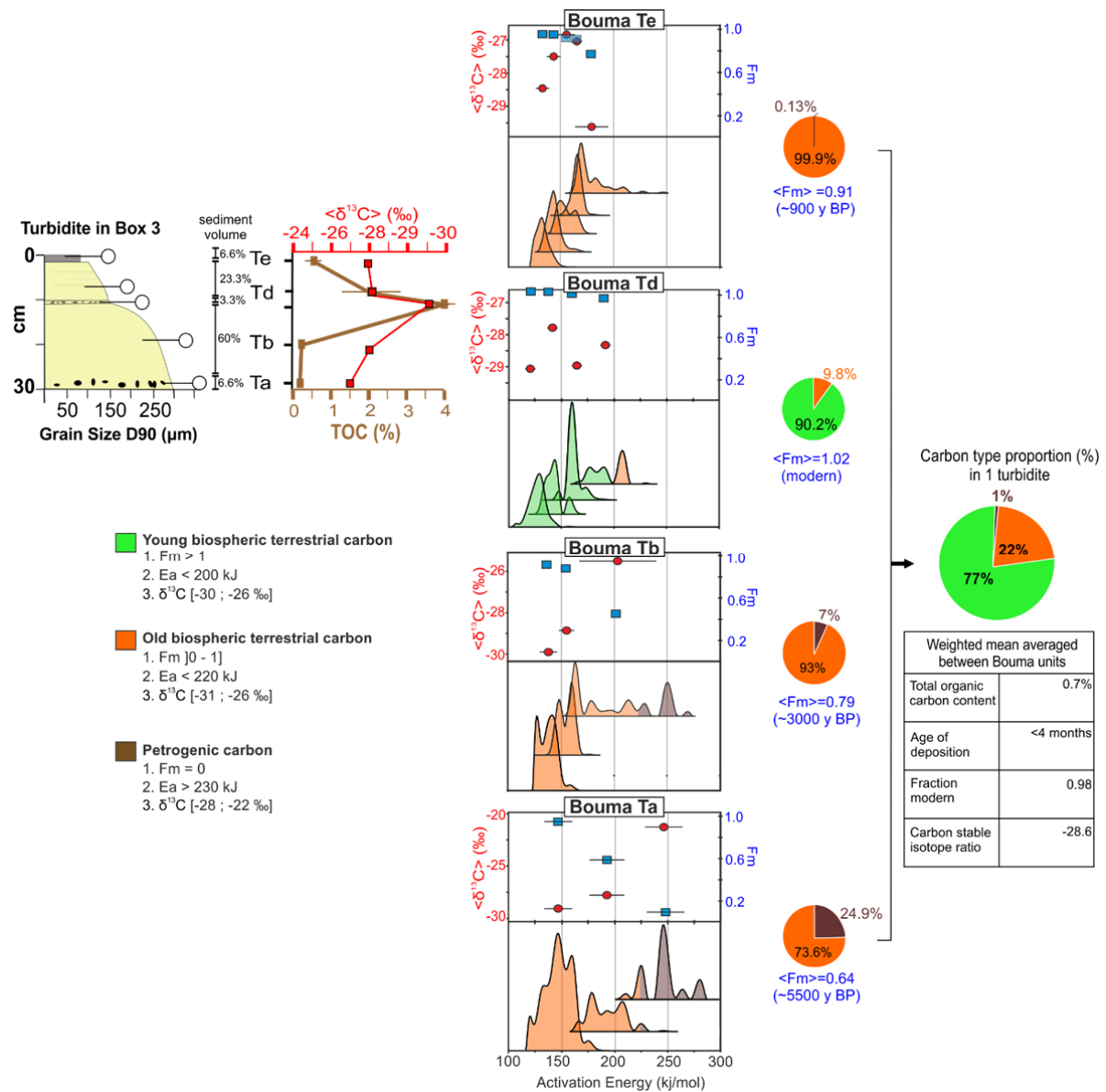
Fig. S7: Identification of organic carbon types included in one turbidite. The following parameters were taken into account: Turbidite unit volumes, total organic carbon content per unit, thermograms performed on each unit by ramped oxidation and radiocarbon and carbon stable isotopes ratios measured for each fraction. Fm = Fraction modern (age), Ea = Activation of energy in kilojoules per mol (kj/mol), $\delta^{13}C$ = Carbon stable isotope ratio in ‰.
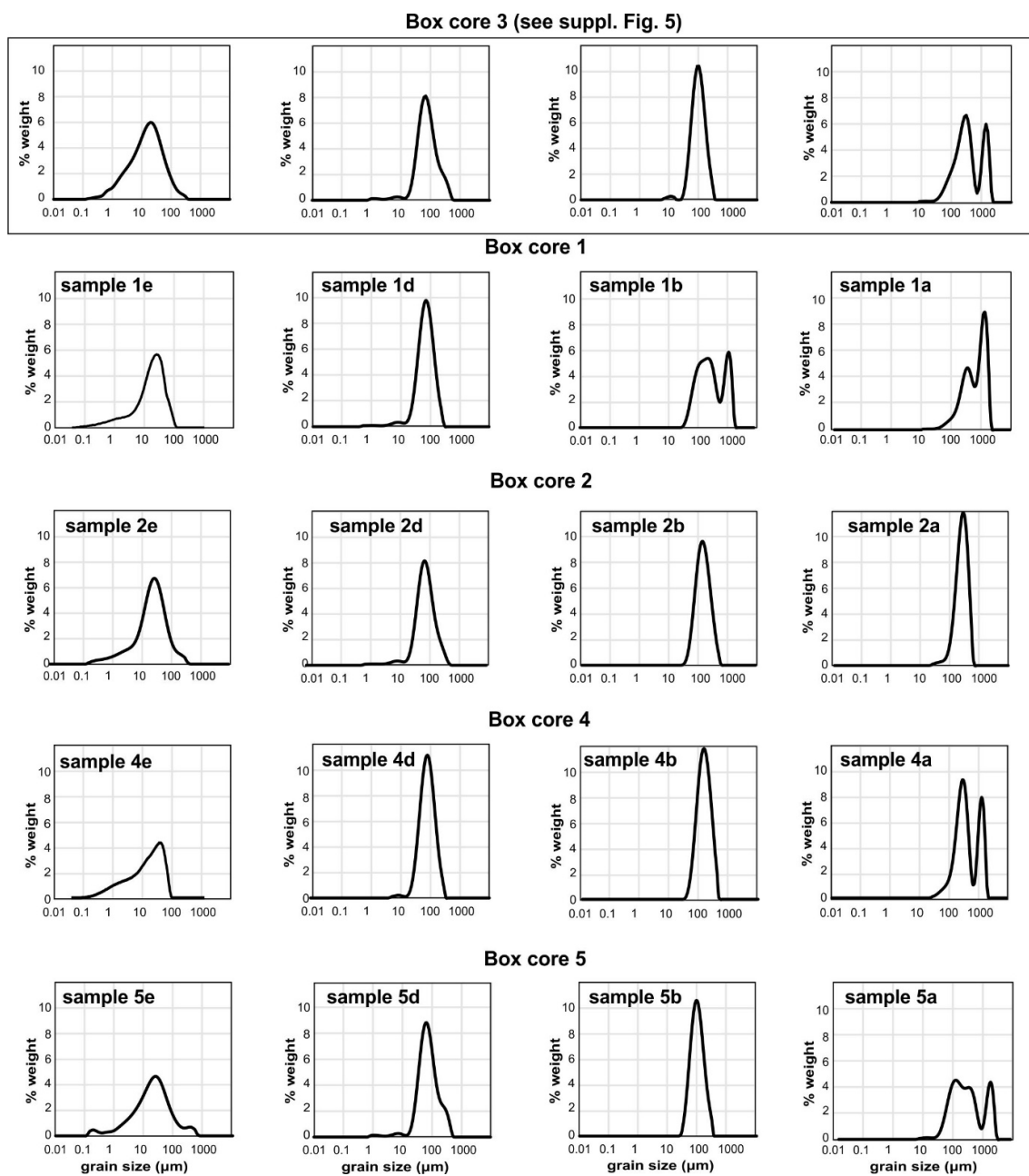
Figure S8. Grain size distributions measured on samples from the 5 box cores displayed in Fig. 1.
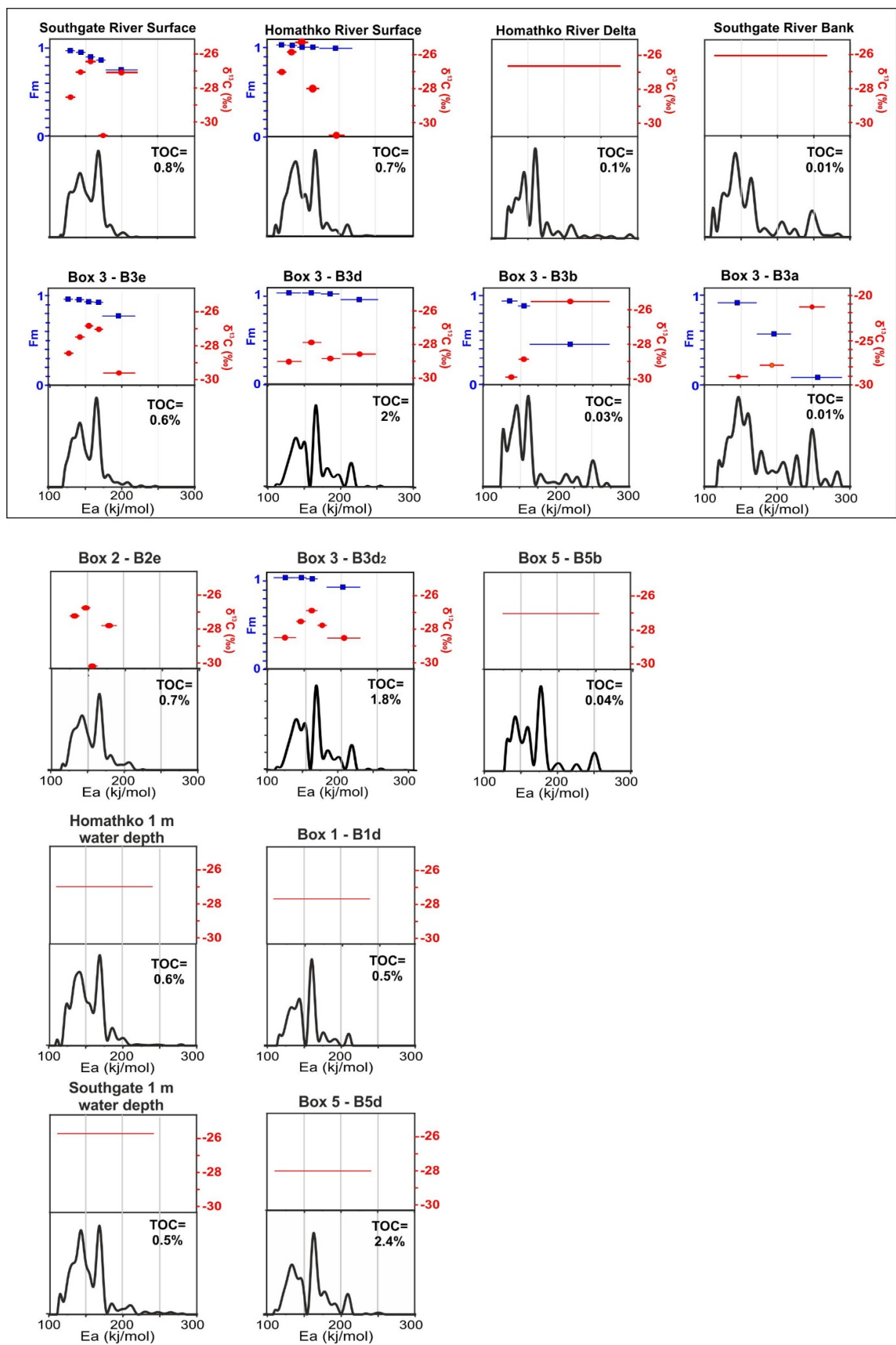
Figure S9. Additional thermograms and isotope data on turbidite and river samples displayed in Fig. 1
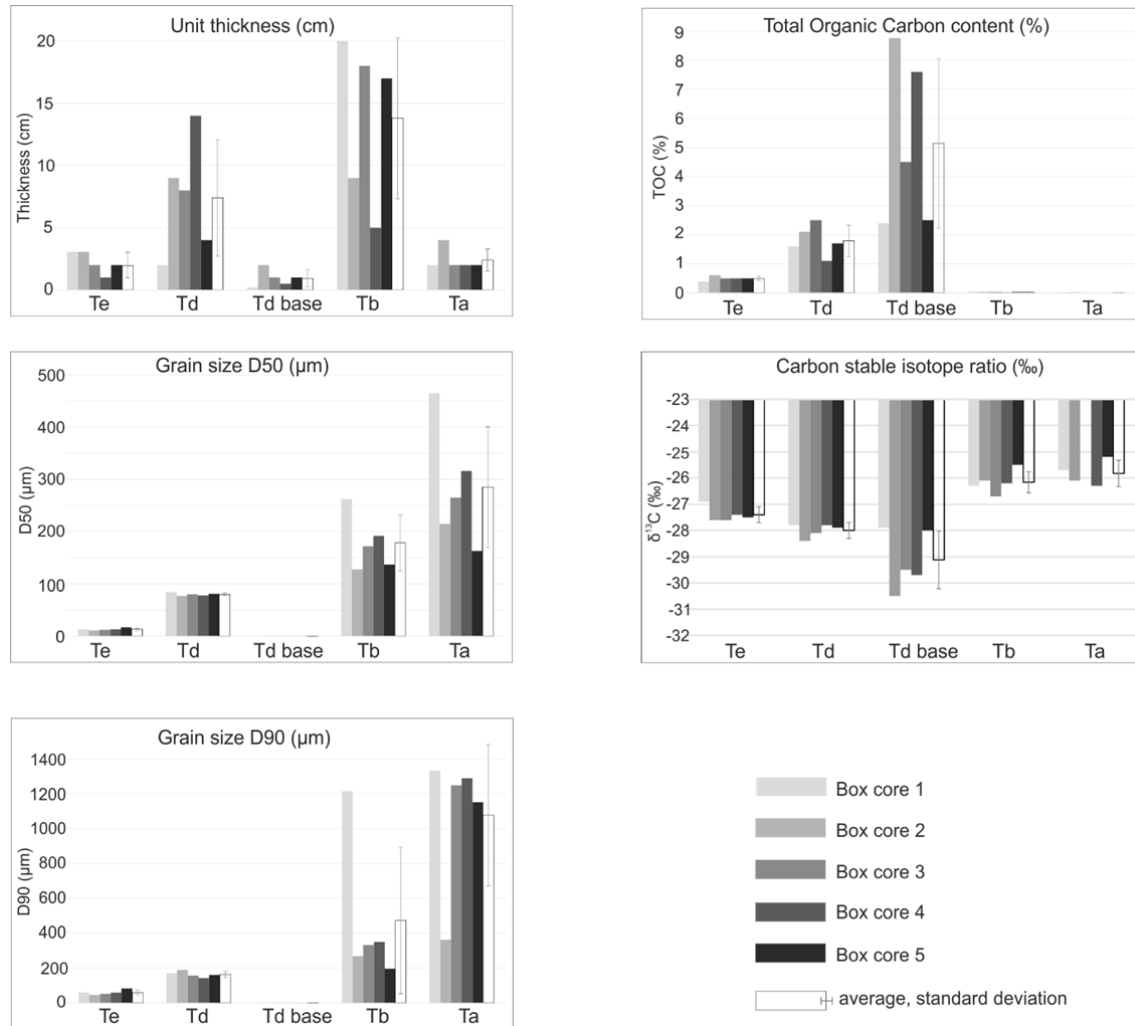

Figure S10. Bulk measurements made on each Bouma unit of the turbidite samples from the 5 box cores displayed in Fig. 1. D50 and D90 = median and 90th percentile of the grain size distribution for each sample. TOC = Total organic carbon content; $\delta^{13}C$ = carbon stable isotope ratios.

	Sandy channel/Lobe	Fines outside the channel
Weighted mean TOC (%)	0.7	0.5
Surface area (km²)	58	295
Sedimentation rate (mm/year)	41	10
Volume of organic carbon annually (m³/year)	16,646	14,750

Table S1. Comparison between sandy channel and fine sediments outside the channel in terms of total organic carbon (TOC) content, surface area, sedimentation rate and total organic carbon buried per year. See Materials and methods for sedimentation rates estimates based on Syvitski et al. (1987)[6] and Stacey et al. (2019)[7].

	a = Thickness (cm)	b = Unit part in total deposit (%) $a/\Sigma(a)*100$	c = TOC (%)	d = Carbon part per Bouma unit $b*c/100$	e = Part of petrogenic carbon in unit TOC (%) (based on RPO results, Fig. S7)	f = Part of old biospheric carbon in unit TOC (%) (based on RPO results, Fig. S7)	g = Part of young biospheric carbon in unit TOC (%) (based on RPO results, Fig. S7)	h = part of petrogenic carbon in total deposit TOC $e*d/100$	i = part of old biospheric carbon in total deposit TOC $f*d/100$	j = part of young biospheric carbon in total deposit TOC $g*d/100$
Ta	2.0	6.7	0.1	0.0	24.9	73.6	0.0	0.002	0.005	0.000
Tb	18.0	60.0	0.2	0.1	7.0	93.0	0.0	0.006	0.084	0.000
Td1	1.0	3.3	4.5	0.2	0.0	12.0	88.0	0.000	0.018	0.132
Td2	7.0	23.3	2.0	0.5	0.1	9.7	90.2	0.001	0.045	0.421
Te	2.0	6.7	0.5	0.0	0.1	99.9	0.0	0.000	0.033	0.000
								0.009	0.185	0.553
								1.2	24.8	74

0.75 Sum
%

Table S2. Values and calculations used to obtain the proportions of organic carbon types in a turbidite.

Box core 3					
Sample		Fraction Modern (Fm)	Fm Error	Age (years)	Age Error
Bouma Te	Fraction 1	0.9670	0.0041	270	35
	Fraction 2	0.9519	0.0053	395	45
	Fraction 3	0.9230	0.0074	645	65
	Fraction 4	0.9164	0.0053	700	45
	Fraction 5	0.7780	0.0042	2,020	45
Bouma Td	Fraction 1	1.0458	0.0025	>Modern	
	Fraction 2	1.0358	0.0019	>Modern	
	Fraction 3	1.0241	0.0019	>Modern	
	Fraction 4	0.9375	0.0031	520	25
Bouma Tb	Fraction 1	0.8743	0.0039	1,080	35
	Fraction 2	0.5466	0.0062	4,850	90
	Fraction 3	0.1001	0.0039	18,500	320
Bouma Ta	Fraction 1	0.9263	0.0021	615	20
	Fraction 2	0.8854	0.0030	975	25
	Fraction 3	0.4400	0.0017	6,600	30

River samples					
Sample		Fraction Modern (Fm)	Fm Error	Age (years)	Age Error
Homathko River surface	Fraction 1	1.0407	0.0021	>Modern	
	Fraction 2	1.0329	0.0021	>Modern	
	Fraction 3	0.9956	0.0020	35	15
	Fraction 4	1.0020	0.0022	>Modern	
	Fraction 5	0.9864	0.0024	110	20
Southgate River surface	Fraction 1	0.9771	0.0023	185	20
	Fraction 2	0.9577	0.0022	345	20
	Fraction 3	0.9068	0.0024	785	20
	Fraction 4	0.8751	0.0025	1,070	25
	Fraction 5	0.7531	0.0048	2,280	50

Table S3. Radiocarbon measurements (in Fraction modern and years) performed on ramped oxidation fractions collected on samples from Box Core 3 and two river suspended samples.