Detection of fossil Organic Carbon

Fossil organic carbon has been identified and characterized by Raman microspectroscopy and High-Resolution Transmission Electron Microscopy (HRTEM) in all suspended and bed loads river sediments as well as in oceanic sediment samples, even in samples with high $\Delta^{14}C$. On Figure S3, representative Raman spectra of metamorphic Carbonaceous Material (CM) from river and oceanic sediments are depicted; these spectra were obtained on CM particles with at least micrometric dimensions. The general shape of these Raman spectra, in particular the intensity of defect bands relatively to the graphite band, shows some heterogeneity, but is systematically representative of graphitic CM with various degrees of structural organization (graphitization). In most cases, these spectra are highly similar to those observed by Beyssac et al.[36] in CM contained in metasedimentary rocks collected in the Lesser Himalaya of Nepal. Such CM were observed as isolated particles (no bands in the range 100-1100 cm^{-1}) or as inclusions within minerals (additional bands in the range 100-1100 cm^{-1}). HRTEM investigations were conducted to detail at the sub-nanometric scale the structural organization of such refractory CM in both river and marine sediments; some representative photomicrographs are presented in Figure S4. In all samples, refractory CM is observed spanning the range from disordered graphitic CM to perfectly crystallized graphite. Microtexture of this CM is heterogeneous, from porous to lamellar CM, but is highly similar to the variety of microtexture observed in CM extracted from metamorphic rocks[35,37].

Source of C_{org} in Bengal Fan sediments

The relative proportions of terrestrial and marine C_{org} in Bengal Fan sediments have already been evaluated in several studies following different approaches[20-22,31,38]. All concluded that C_{org} stored in Bengal Fan sediments is by far dominated by terrestrial inputs. The most recent and precise work used both n-alkanes relative abundance and isotopic composition in sediments from the distal Bengal Fan[21]. Here we use a similar approach for selected Channel-levee and Shelf sediments in order to confirm the terrestrial origin of the C_{org} in the studied sediments.

Odd C-numbered high molecular weight (HMW) n-alkanes (mainly C_{27} to C_{33}) are produced in the leaves of vascular higher plants and are therefore univocal tracers of terrestrial C_{org}[39]. Marine algae and phytoplankton do not significantly produce HMW n-alkanes and their n-alkanes distribution is dominated by low molecular weight odd C-numbered n-alkanes (C_{15}, C_{17} and C_{19})[39]. We analysed n-alkane abundance in river and Bengal Fan sediments. HMW n-alkanes are dominant in both types of sediments with a strong predominance of odd over even compounds. This is illustrated by elevated values of the Carbon Preference Index (CPI)[40]. CPI ranges from 1.8 to 5.0 in river sediments and from 2.5 to 5.2 in oceanic sediments (Table S3). CPI above 2 is typical of terrestrial higher plants. The comparatively low CPI value (1.8) of the bed sediment MO 217 associated with relatively high proportions of LMW n-alkanes indicates a significant proportion of fossil C_{org}, which is consistent with its low TOC and $\Delta^{14}C$ values.

Another line of evidence is provided by the comparison of carbon isotopic composition ($\delta^{13}C$) of bulk C_{org} and individual n-alkanes. Bulk C_{org} $\delta^{13}C$ in Bengal fan sediments is highly variable between -25 and -15 ‰[20]. Such large range has been attributed to variations in the proportion of C3 and C4 plants in the continental basin[20,41]. Freeman and

Collarusso[21] showed that $\delta^{13}C$ of odd C-numbered HNW n-alkanes co-vary with that of bulk C_{org}. This linear correlation implies a strong influence of vascular plants on bulk C_{org} $\delta^{13}C$ and minor contributions from bacteria or phytoplankton. Our river and marine samples reinforce this relationship (figure S5). The 5 ‰ variability in bulk $\delta^{13}C$ of our samples results from differences in C3-C4 vegetation between Ganga and Brahmaputra basins for river sediments, and over time for marine sediments[42]. Finally, the $\delta^{13}C$ offset between TOC and higher plants biomarker n-alkane is between 7 and 10 ‰ (table S3). This is consistent with the range reported by Collister et al.[43] for vascular plants. The offset is also constant from river to marine sediments, which is consistent with no significant addition of marine C_{org}.

The high CPI of marine sediments, the low abundance of C_{15}, C_{17} and C_{19}, the similarity of the n-alkane distribution between river and marine sediments, and stable $\delta^{13}C$ offset between TOC and higher plants biomarker n-alkanes, all support that only negligible proportion of marine C_{org} is incorporated during sedimentation in the Bay of Bengal.

Supplementary Notes

36 Beyssac, O., Bollinger, L., Avouac, J.-P., & Goffe, B., Thermal metamorphism in the lesser Himalaya of Nepal determined from Raman spectroscopy of carbonaceous material. *Earth and Planetary Science Letters* **225** (1-2), 233-241 (2004).

37 Buseck, P. R. & Huang, B.-J., Conversion of carbonaceous material to graphite during metamorphism. *Geochimica et Cosmochimica Acta* **49** (10), 2003-2016 (1985).

38 Poynter, J. & Eglinton, G., in Proc. ODP, Sci. Res., edited by Cochran, J. R., Stow, D. A. V., and al., e. (Ocean Drilling Program, College station TX, 1990), Vol. 116, pp. 155-161.

39 Peters, K. E. & Moldowan, J. M., The Biomarker Guide: Interpreting molecular fossils in petroleum and ancient sediments. (Prentice-Hall, Inc., Englewood Cliffs, 1993).

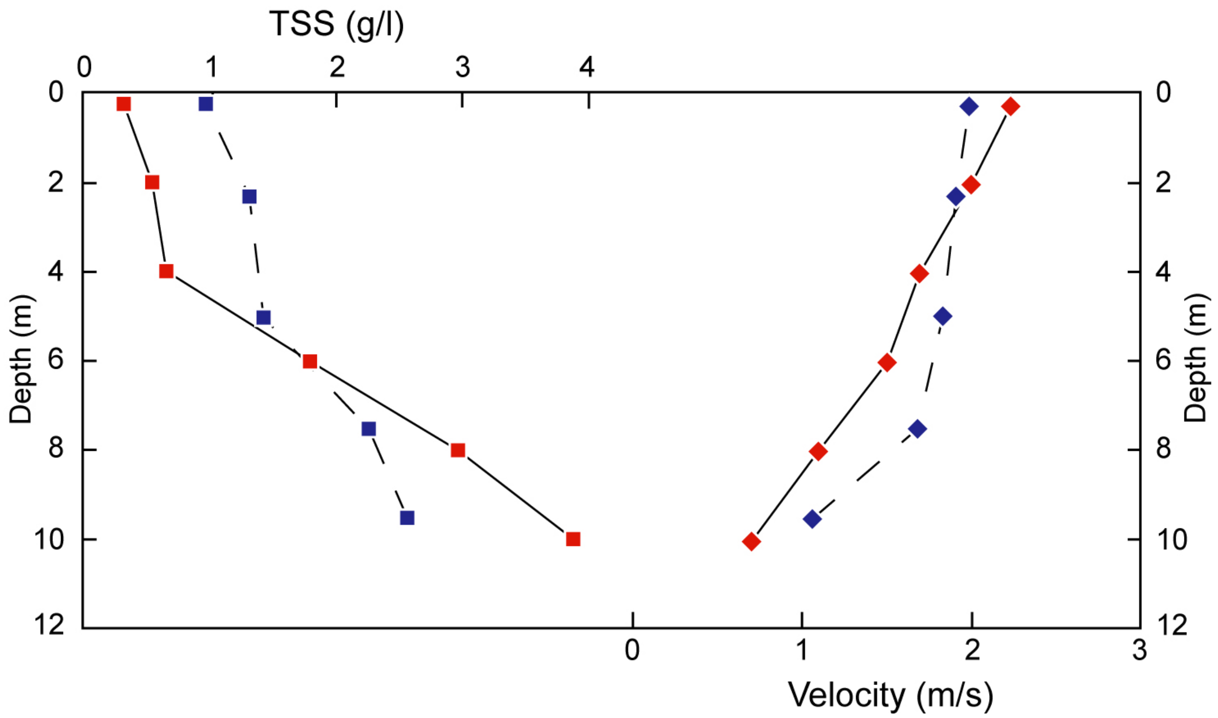
40 Eglinton, G. & Hamilton, R. J., Leaf epicuticular waxes. *Science* **156** (780), 1322-1335 (1967).

41 Quade, J., Cater, J. M. L., Ojha, T. P., Adam, J., & Harrison, T. M., Late Miocene environmental change in Nepal and the northern Indian subcontinent: stable isotopic evidence from paleosols. *Geological Society of America Bulletin* **107** (12), 1381-1397 (1995).

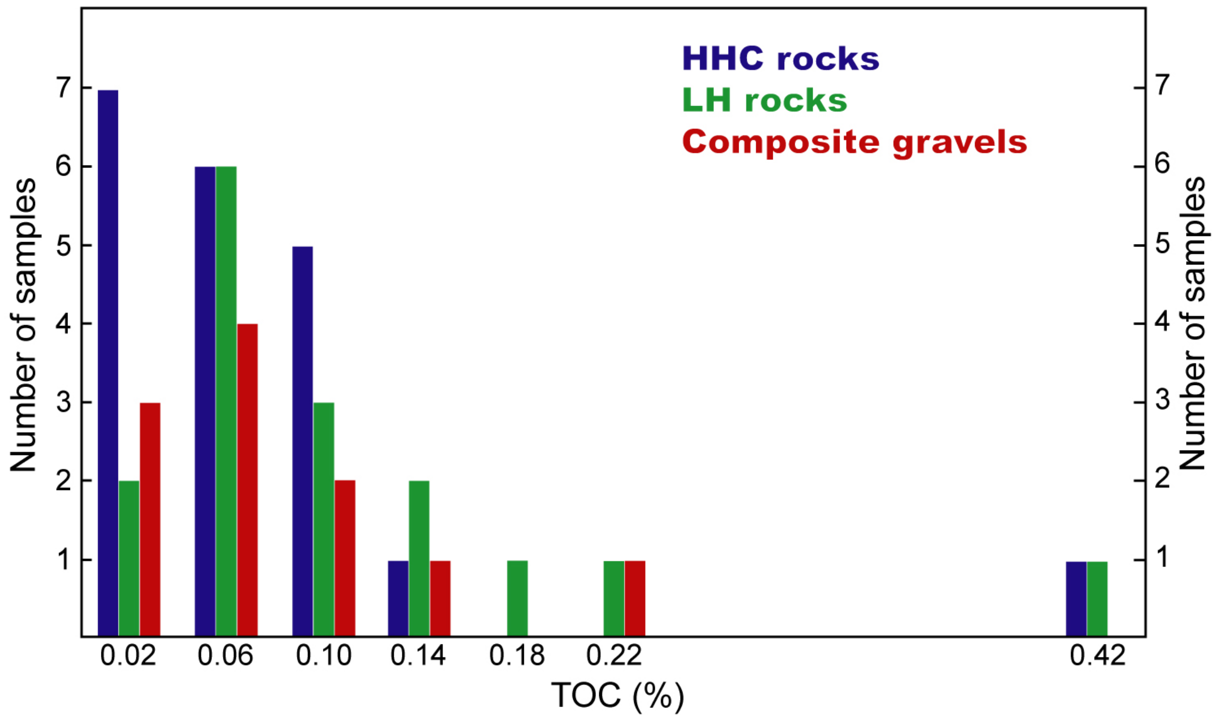
42 Galy, V. et al., C4 plants decline in the Himalayan basin since the Last Glacial Maximum. *Quaternary Science Reviews* (Submitted).

43 Collister, J. W., Rieley, G., Stern, B., Eglinton, G., & Fry, B., Compound-specific $\delta^{13}C$ analyses of leaf lipids from plants with differing carbon dioxide metabolisms. *Organic Geochemistry* **21** (6-7), 619-627 (1994).

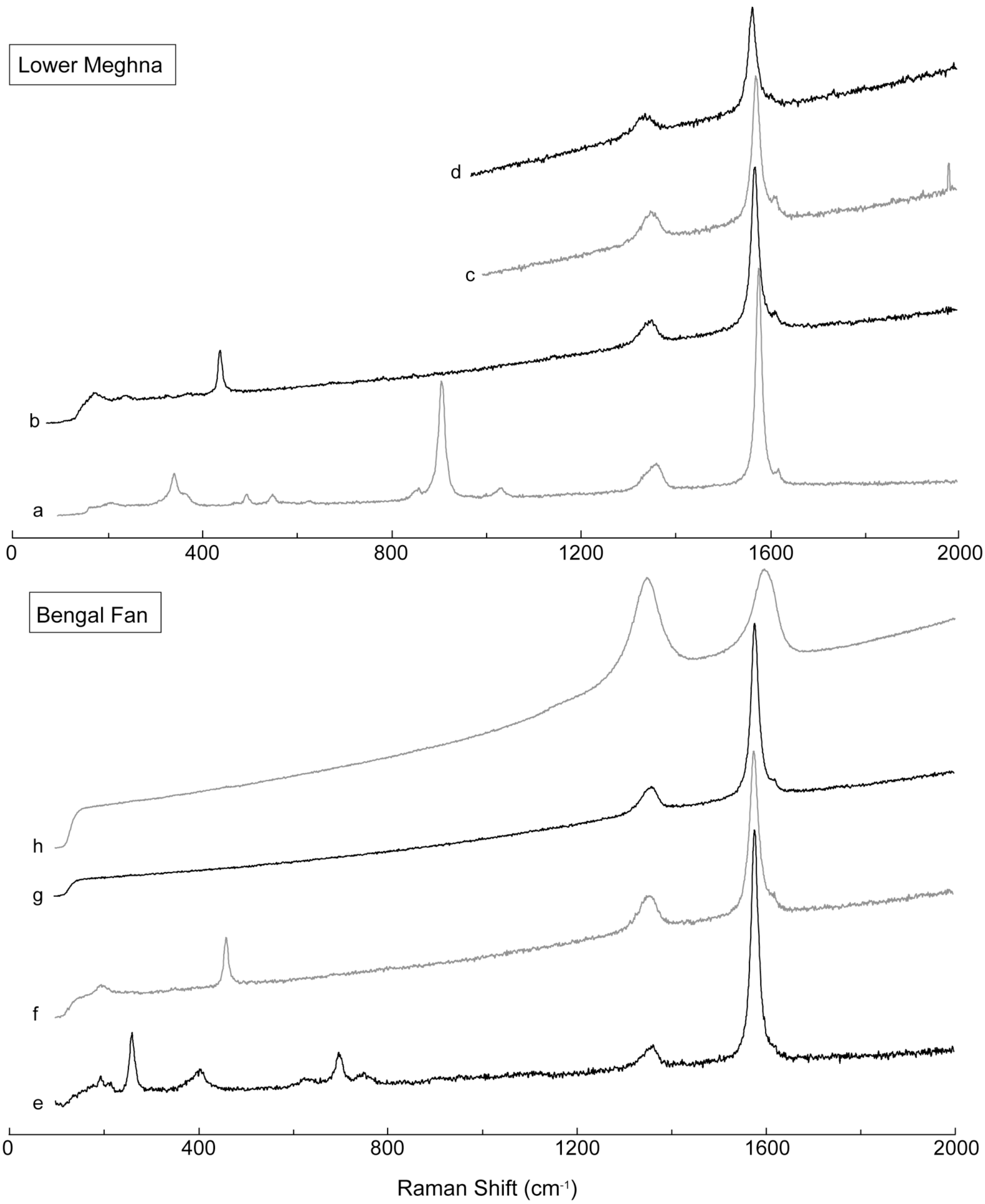
Supplementary Figures



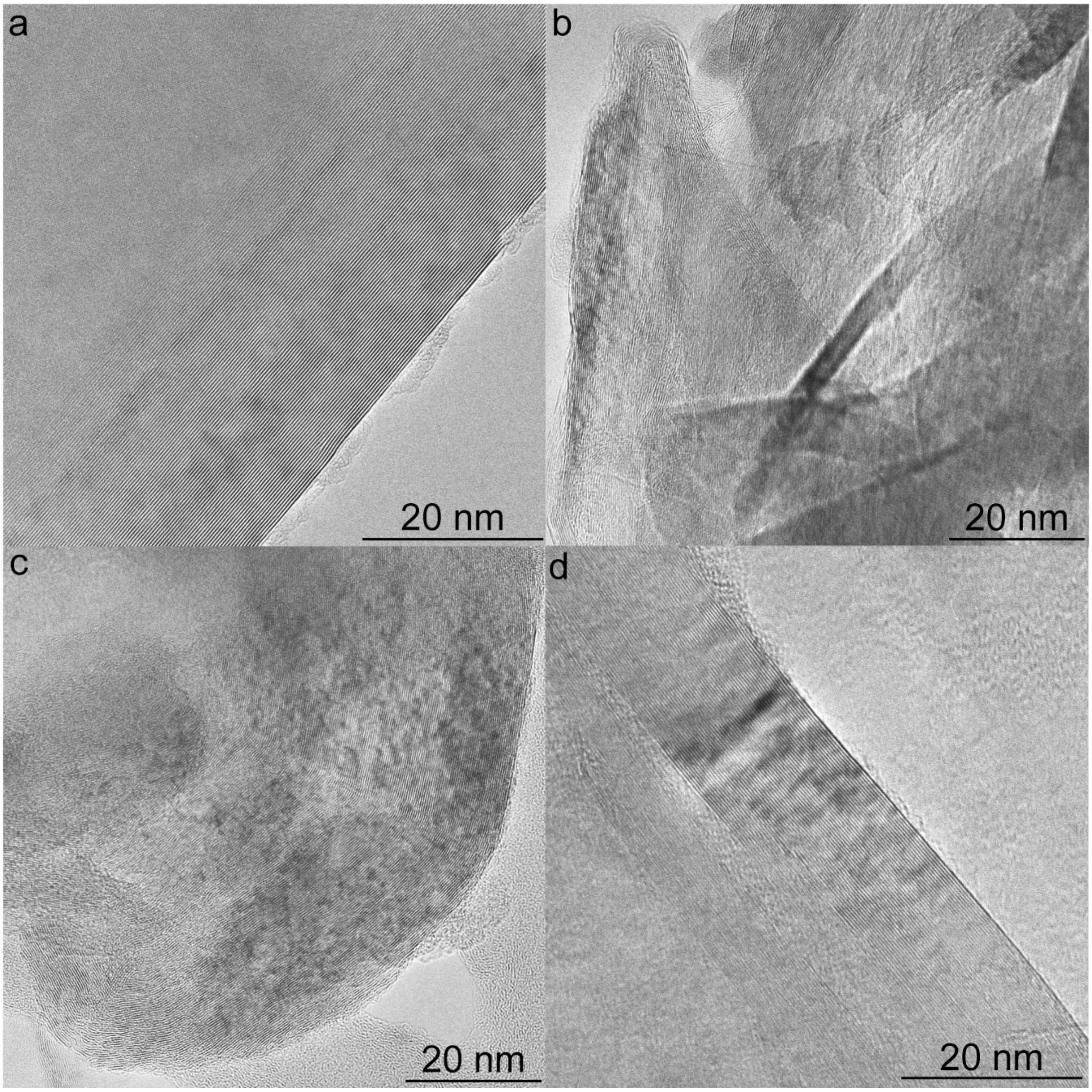
Supplementary Figure 1: Flow velocity (diamonds) and total suspended sediment concentration (squares) of the Lower Meghna main channel during the 2004 (red) and 2005 (blue) monsoon. 2 sd. uncertainties on TSS and flow velocity are respectively 0.05 g/l and 0.1 m/s. Velocity and TSS gradients are oposed and characterise the strong heterogeneity of the river section. Average suspended sediment transported by the river corresponds to the integration of velocity, TSS, and composition gradients on the whole river depth.



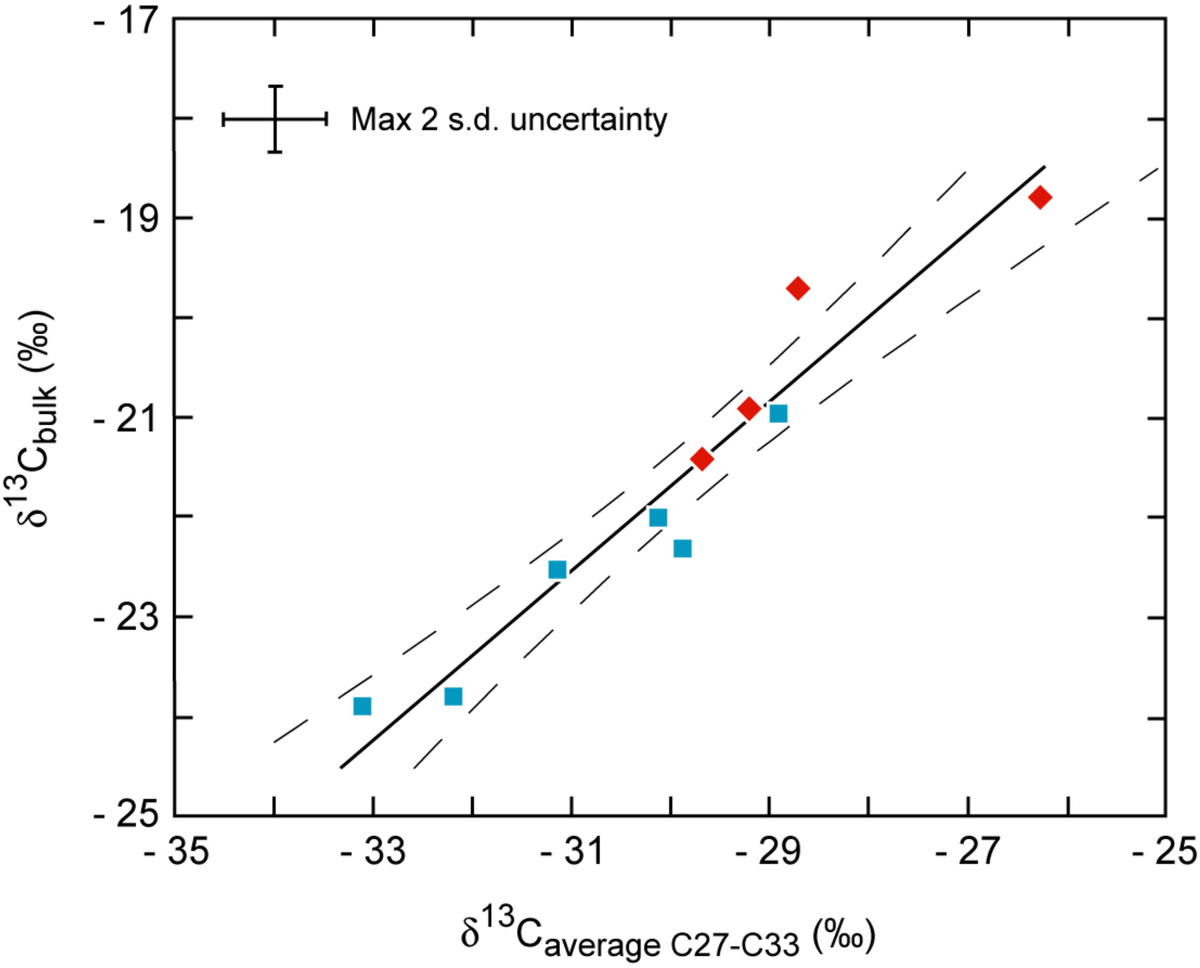
Supplementary Figure 2: Total organic carbon content of Himalayan source rocks and river gravels. Rocks from the High Himalaya Crystalline (HHC) and the Lesser Himalaya (LH) have an average TOC of 0.06 and 0.10 % respectively. Mean TOC of the eroding source rock was calculated on the basis of relative contributions of HHC and LH formations (respectively 80 and 20 %) estimated using Sr and Nd isotopes[8]. River gravels are bed sediments of Himalayan rivers sieved to eliminate the <2 mm fraction and cleaned with H_2O_2. Each sample corresponds to the integration of the TOC variability over the different lithologies eroded by the river (more than 500 gravels). Average TOC estimated from individual source rock and composite gravels are consistently between 0.05 and 0.08 %.



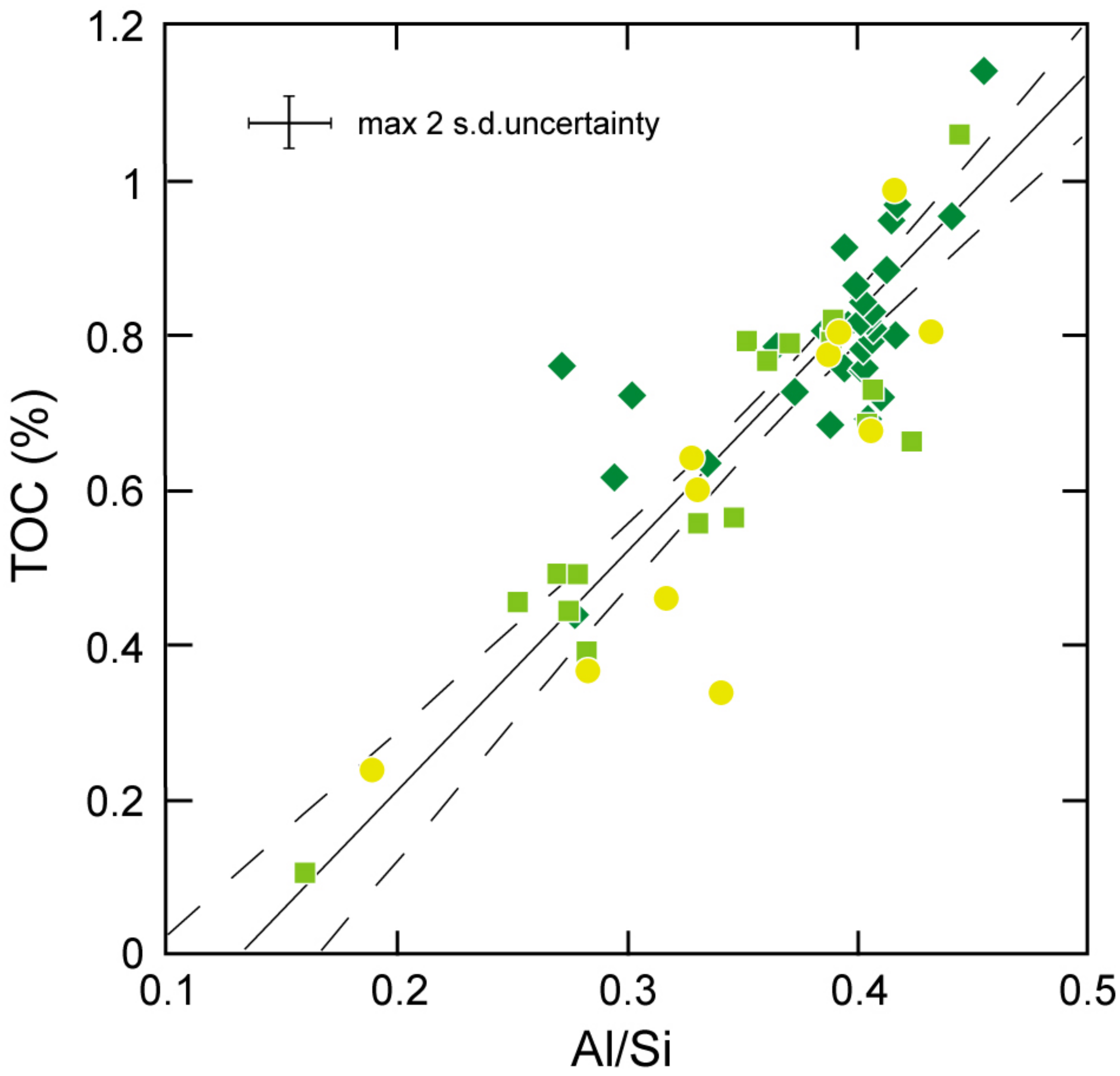
Supplementary Figure 3: Representative Raman spectra of carbonaceous material (CM) observed in bed and suspended sediments of the Lower Meghna (top) and in marine sediments from the Bengal Shelf and Channel-levee system (bottom). a: Polycrystalline graphite inclusion in garnet. b,f: Polycrystalline graphite inclusion in quartz (Si-O stretching mode at ca. 464 cm^{-1}). c,d: Polycrystalline graphite. e: Polycrystalline graphite inclusion in mica. g: Polycrystalline graphite, isolated particle. h: Poorly ordered CM, isolated particle.



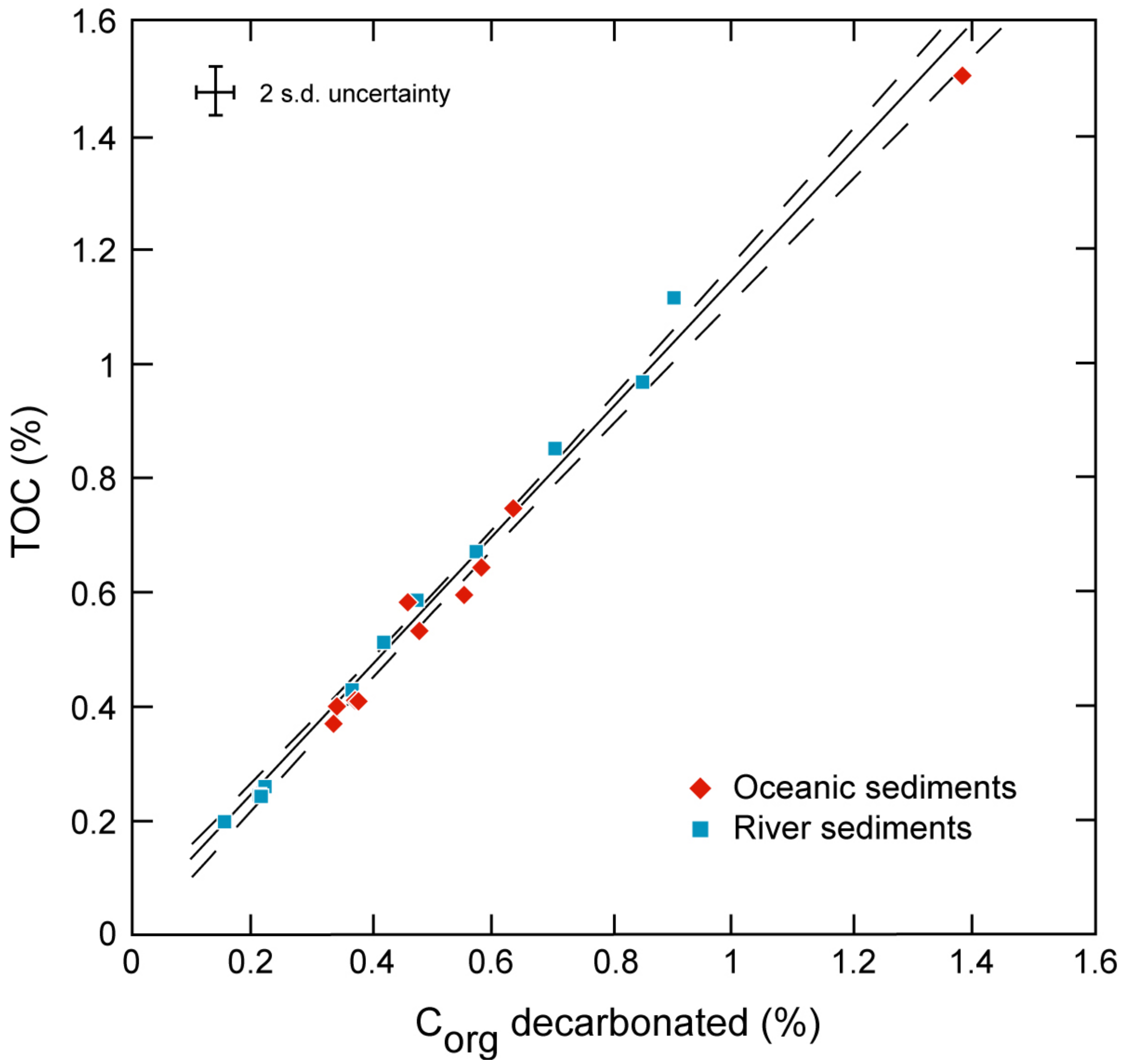
Supplementary Figure 4: Transmission Electron Microscopy photomicrograph of graphitized C_{org} observed in surface suspended sediments of the Brahmaputra (a), Ganga (b) and Lower Meghna (c-d). These 002 lattice fringes images directly represent the profile of the aromatic layers in such carbonaceous materials.



Supplementary Figure 5: $\delta^{13}C$ of higher plant biomarkers as a function of bulk C_{org} isotopic composition. Odd C-numbered high molecular weight n-alkanes (C_{27}-C_{29}-C_{31}-C_{33}) are univocal tracers of terrestrial higher plants. Their weighted average isotopic composition is positively correlated with bulk C_{org} isotopic composition. The black line represents the best fit of the whole dataset and the dashed curves define the 95 % confidence interval. G-B river (blue squares) and Bengal Fan (red diamonds) sediments define a unique trend showing that marine C_{org} contribution is minor in the later.



Supplementary Figure 6: Total C_{org} content of sediments from the Bengal shelf (yellow dots), Channel-levee system (green diamonds) and deep Fan (green squares) as a function of their Al/Si ratio. Best fit and 95% confidence interval are shown for the whole data set. Sediments from the different parts of the Bengal Fan define similar positive trends, indicating comparable C_{org} loading in every parts of the Fan. This implies that C_{org} oxidation is minor during the sediment transfer from the shelf to the channel-levee and to the deep Fan.



Supplementary Figure 7: C_{org} content determined on decarbonated fractions as a function of total organic carbon content (TOC). River and oceanic sediments define a unique trend showing that the proportion of C_{org} solubilized during the decarbonation is quite constant and comparable in these 2 types of sediment.

Table S1: TSS, Al/Si, TOC and $\Delta^{14}C$ of river sediments and gravels

Sample	River	Location	Type	Date	TSS g/l	Al/Si at	TOC %	acid-insoluble C_{org} $\Delta^{14}C$ ‰
BR 212			SL 1m		0.57	0.38	0.66	
BR 211			SL 3.5m		0.75	0.34	0.62	
BR 209			SL 5m	16/07/02	0.71	0.35	0.67	
BR 208			SL 10m		0.74	0.34	0.62	-311
BR 210			SL 17m		1.25	0.28	0.47	-363
BR 214			BL			0.14	0.10	-434
BR 417			SL surf			0.38	0.53	
BR 415			SL surf		0.77	0.38	0.53	-259
BR 414			SL 2m		1.02	0.33	0.46	-254
BR 413			SL 4m		1.31	0.29	0.42	-284
BR 412			SL 6.5m		1.48	0.28	0.38	
BR 411			SL 9m	13/07/04	2.93	0.21	0.22	-294
BR 418			BL			0.13	0.03	-814
BR 419			Bank			0.19	0.15	
BR 420	Ganga	Harding bridge	Bank			0.26	0.33	
BR 421			Bank			0.22	0.28	
BR 422			Bank			0.21	0.33	
BR 515			SL surf		0.94	0.37	0.71	
BR 514			SL 2.5m		1.42	0.32	0.57	
BR 513			SL 5m		1.71	0.28	0.45	
BR 512			SL 7m		1.81	0.27	0.42	
BR 511			SL 10m		2.44	0.24	0.32	
BR 516			BL	23/07/05		0.13	0.05	-712
BR 519			SL surf		0.66	0.41	0.82	
BR 518			SL 5m		1.53	0.31	0.53	
BR 517			SL 9.8m		1.81	0.28	0.47	
BR 520			BL			0.17	0.14	
BR 522			SL surf			0.40	0.71	-215
BR 205			SL 0.5m		1.18	0.31	0.57	
BR 204			SL 2m			0.27	0.53	
BR 201			SL 6m			0.26	0.52	
BR 202			SL 9.5m	15/07/02	1.44	0.21	0.29	
BR 203			SL 11.5m		5.89	0.19	0.14	
BR 206			BL			0.20	0.06	
BR 207			SL 1m			0.23	0.25	
BR 401			SL 6.5m	11/07/04	4.34	0.23	0.26	
BR 405			SL 5m		6.00	0.22	0.22	
BR 406			SL 3m		3.13	0.24	0.32	
BR 407			SL 11m	12/07/04	6.39	0.22	0.26	
BR 408			SL 1.5m		1.82	0.29	0.44	
BR 409			SL surf		1.32	0.32	0.54	
BR 402			SL surf			0.32	0.50	
BR 459			SL surf			0.37	0.64	
BR 457	Brhamaputra	Sirajganj	SL surf		1.34	0.36	0.69	-340
BR 456			SL 3m		2.94	0.28	0.45	-395
BR 455			SL 6m	23/07/04	2.45	0.29	0.50	
BR 454			SL 9m		6.20	0.22	0.29	-421
BR 460			BL			0.17	0.04	-769
BR 450			BL			0.31	0.68	
BR 453			BL			0.22	0.19	
BR 500			SL surf	21/07/05		0.31	0.62	-474
BR 501			SL 6.5m		1.99	0.29	0.51	
BR 502			SL 2.5m		0.77	0.33	0.59	
BR 503			BL			0.18	0.11	
BR 504			SL 9.8m		2.29	0.25	0.37	
BR 505			SL 7m	22/07/05	2.13	0.27	0.40	
BR 506			SL 5m		1.57	0.29	0.49	
BR 507			SL 2.75m		1.38	0.32	0.53	
BR 508			SL surf		0.77	0.36	0.64	
BR 509			BL			0.15	0.05	

TSS: total suspended sediment, SL: suspended load with depth of sampling, BL: bedload

Table S1 (continued from previous page)

Sample	River	Location	Type	Date	TSS g/l	Al/Si at	TOC %	acid-insoluble C_{org} $\Delta^{14}C$ ‰
BR 528	Lower Meghna	Mawa	SL surf	24/7/05	0.99	0.35	0.67	
BR 527			SL 2.3m		1.31	0.31	0.56	
BR 526			SL 5m		1.43	0.29	0.48	
BR 524			SL 7.5m		2.25	0.24	0.38	
BR 525			SL 9.5m		2.56	0.24	0.33	
BR 529			BL			0.15	0.06	
BR 218		Bhola	SL 1.5m	18/07/02	0.36	0.36	0.71	
BR 220			SL 3m		0.84	0.28	0.59	
BR 217			SL 5m		0.50	0.30	0.50	
BR 216			SL 10m		1.67	0.21	0.27	
BR 219			BL			0.20	0.04	
BR 448			SL surf	18/07/04		0.34	0.59	
BR 441			SL surf		0.33	0.39	0.80	-421
BR 444			SL 2m		0.55	0.34	0.63	
BR 442			SL 4m		0.67	0.33	0.58	
BR 440			SL 6m		1.79	0.26	0.42	
BR 439			SL 8m		2.97	0.23	0.40	-370
BR 445			SL 10m		3.88	0.26	0.57	
BR 446			BL			0.16	0.05	-710
PB 5	Kali Gandaki	Jomsom	gravels			0.11	0.20	
PB 19	Lete Kola	confluence				0.20	0.01	
PB 22	Rukse Kola	confluence				0.18	0.08	
PB 28	Miristi Kola	confluence				0.20	0.02	
MO 94	Jarang	Muchchok				0.08	0.02	
MO 102	Marsel Kola	confluence				0.14	0.02	
MO 112	Isul kola	confluence				0.08	0.07	
MAR 3	Marsyandi	Krishnebhir				0.30	0.10	
AR 25	Tenga tributary					0.15	0.02	
AR 32	Tenga tributary					0.15	0.04	
AR 67	Manas tributary					0.17	0.05	

TSS: total suspended sediment, SL: suspended load with depth of sampling, BL: bedload

Table S2: Al/Si and TOC of Bengal Fan sediments

Core	Depth cm	Location	Dep. Age yrs	Al/Si at	TOC %
19KL	73	Deep fan		0.16	0.10
	154			0.44	1.06
27KL	631		9085	0.42	0.66
	711		10236	0.39	0.80
	726		10452	0.37	0.79
40KL	172			0.40	0.69
	196			0.41	0.73
	216			0.35	0.56
	229			0.28	0.39
	243			0.27	0.44
	381			0.33	0.56
	394			0.27	0.49
47KL	622			0.25	0.45
	728			0.28	0.49
51KL	207			0.36	0.77
	304			0.35	0.79
	482			0.39	0.82
86KL	40	Shelf	11	0.33	0.64
	819		234	0.42	0.99
96KL	79		2	0.28	0.37
	1109		29	0.43	0.80
105KL	81		45	0.34	0.34
	282		157	0.41	0.68
	568		316	0.33	0.60
	669		371	0.39	0.80
	682		379	0.32	0.46
	688		382	0.19	0.24
	762		423	0.39	0.77
117KL	725	Channel-levee	11524	0.40	0.81
	774		11829	0.39	0.76
	822		12128	0.41	0.72
	925		12769	0.39	0.91
	932		12812	0.42	0.95
	972		13061	0.39	0.81
	1029		13416	0.40	0.84
	1109		13914	0.40	0.78
118KL	29		291	0.40	0.86
	580		5742	0.39	0.69
	657		5907	0.40	0.82
	920		6474	0.29	0.62
	1144		6956	0.34	0.64
120KL	54		1144	0.44	0.95
	84		1779	0.41	0.83
	141		2987	0.37	0.73
	348		6924	0.45	1.14
	412		8133	0.42	0.80
	556		9593	0.41	0.81
	579		9607	0.30	0.72
	593		9615	0.27	0.76
	702		9683	0.41	0.88
	763		10001	0.40	0.82
	849		10785	0.36	0.79
	864		10926	0.42	0.97
	960		11844	0.41	0.80
	966		11901	0.40	0.76
	1031		12523	0.40	0.76
	1071		13470	0.29	0.77
	1107		15661	0.40	0.69
	1114		16088	0.28	0.44

Deposition age were estimated as explained in the "Methods" supplementary section.

Table S3: n-alkanes relative abundance and isotopic composition of Bengal Fan and river sediments

Sample	Type	Location	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	$\delta^{13}C_{bulk}$	$\delta^{13}C_{C27-C33}$	M/T	CPI
			%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	‰	‰		
SO 93 120KL 138-144	OS	Channel-levee	0.0	0.4	0.5	1.6	0.9	1.3	1.1	1.6	1.3	2.3	1.6	4.0	2.3	8.9	3.2	17.7	3.5	23.3	3.0	15.3	1.3	4.7	-21.4	-29.7	0.05	5.2
SO 93 120KL 591-596			0.1	0.9	1.0	3.4	1.5	1.8	1.4	2.3	1.9	3.2	2.2	4.6	2.6	9.1	3.6	15.6	3.3	20.5	2.8	13.1	1.3	4.0	-19.7	-28.7	0.10	4.5
SO 93 120KL 848-853			0.0	0.3	0.5	1.8	1.0	1.3	1.1	1.9	1.5	2.9	1.8	4.7	2.6	9.2	3.8	15.7	3.7	22.9	3.3	14.2	1.3	4.2	-20.9	-29.2	0.06	4.5
SO 93 120KL 1104-1111			0.0	0.2	0.7	2.4	0.9	1.1	1.1	1.7	1.5	3.4	2.2	5.8	3.5	12.9	4.0	17.6	3.2	19.4	2.3	12.3	0.8	3.1	-18.8	-26.3	0.06	4.7
SO 93 105KL 77-86	OS	Shelf	0.0	0.0	0.0	0.3	0.1	0.3	0.6	1.2	1.9	3.4	4.0	6.2	5.6	9.7	5.6	13.9	5.3	17.5	4.1	12.4	2.2	5.5	-21.5	n.d.	0.01	2.5
SO 93 105KL 279-285			0.0	0.1	0.2	1.2	0.8	1.3	1.4	2.1	2.1	3.1	2.7	5.8	4.1	9.0	3.8	13.6	4.0	18.6	3.5	14.7	1.7	6.1	-21.1	n.d.	0.05	3.5
SO 93 105KL 564-572			0.0	0.0	0.1	0.5	0.5	1.1	1.3	2.2	2.3	3.4	3.5	6.1	4.7	9.1	4.6	14.5	4.5	19.2	3.6	12.7	1.5	4.6	-20.9	n.d.	0.03	3.1
SO 93 105KL 678-685			0.0	0.7	2.1	3.9	3.5	3.7	3.3	3.1	2.7	3.2	3.0	5.0	3.7	7.6	4.2	11.5	3.8	15.1	2.9	11.0	1.4	4.5	-21.4	n.d.	0.18	3.0
SO 93 105KL 758-765			0.0	0.1	0.4	1.4	1.0	1.4	1.5	2.0	2.1	3.5	3.7	6.7	5.3	8.9	4.7	12.0	4.4	16.2	3.8	13.0	2.1	5.9	-21.7	n.d.	0.06	2.7
MO 217	BL	Narayani	2.1	3.6	8.4	10.5	13.0	8.8	9.4	6.3	5.1	3.9	2.4	2.6	2.2	2.8	1.8	4.5	2.2	4.1	1.3	2.6	1.3	1.1	-23.8	-32.2	1.64	1.8
BR 325	Bank	Ganga	0.8	0.4	1.4	1.0	1.8	0.8	2.3	1.6	1.3	2.6	1.6	4.1	2.3	8.6	3.0	18.6	3.3	22.5	3.3	12.9	1.5	4.4	-22.0	-30.1	0.04	5.0
BR 420	Bank	Ganga	3.7	2.7	7.7	4.0	5.9	2.1	4.6	1.5	0.0	2.6	1.4	3.5	2.4	6.7	2.7	13.3	3.3	13.6	2.3	9.5	1.9	4.2	-22.3	-29.9	0.2	3.8
BR 417	SL	Ganga	0.3	0.3	0.3	1.8	1.7	2.2	4.1	4.3	6.3	5.5	2.7	3.3	2.5	7.2	4.0	13.1	4.9	14.8	4.1	9.3	2.6	4.5	-21.0	-28.9	0.1	2.6
BR 402	SL	Brahmaputra	1.1	1.5	1.8	4.5	3.8	4.3	5.2	7.8	11.8	9.9	4.4	3.8	1.9	4.8	2.4	8.0	2.5	9.2	2.0	5.9	1.1	2.2	-22.5	-31.1	0.37	2.8
BR 459	SL	Brahmaputra	0.5	1.2	1.6	4.3	3.7	4.3	5.2	7.2	10.4	8.6	3.6	3.7	1.7	4.9	1.9	10.0	2.2	13.0	1.9	7.4	0.7	2.2	-23.9	-33.1	0.28	4.1
BR 448	SL	Lower Meghna	1.3	1.8	2.0	4.7	3.5	4.0	4.8	6.1	8.7	7.6	3.7	3.8	2.1	4.8	3.1	8.8	3.3	10.8	3.0	7.1	1.8	3.1	-23.0	n.d.	0.33	2.5

OS: oceanic sediment, SL: suspended load with depth of sampling, BL: bedload, $\delta^{13}C_{C27-C33}$: weighted average composition of C_{27},C_{29},C_{31} and C_{33} n-alkanes,
M/T: Relative proportions of (C_{15}+C_{17}+C_{19}) and (C_{27}+C_{29}+C_{31}+C_{33}) n-alkanes. CPI: Carbon Preference Index, calculated as described in Eglinton and Hamilton[40].