Holocene Indian Ocean tsunami history in Sri Lanka

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SUPPLEMENTARY INFORMATION

This online supplement contains additional figures and tables referenced in the original text that provide important datasets and clarification to the Holocene Indian Ocean tsunami history recorded in Sri Lanka. Contents include: Figures DR1-DR15 and Tables DR1-DR5.

Figure DR1. The 26 December 2004 tsunami completely inundated the town of Hambantota and Karagan Lagoon. Images A. and B. show sand deposited by the tsunami over the town of Hambantota. Photos taken in August 2005.

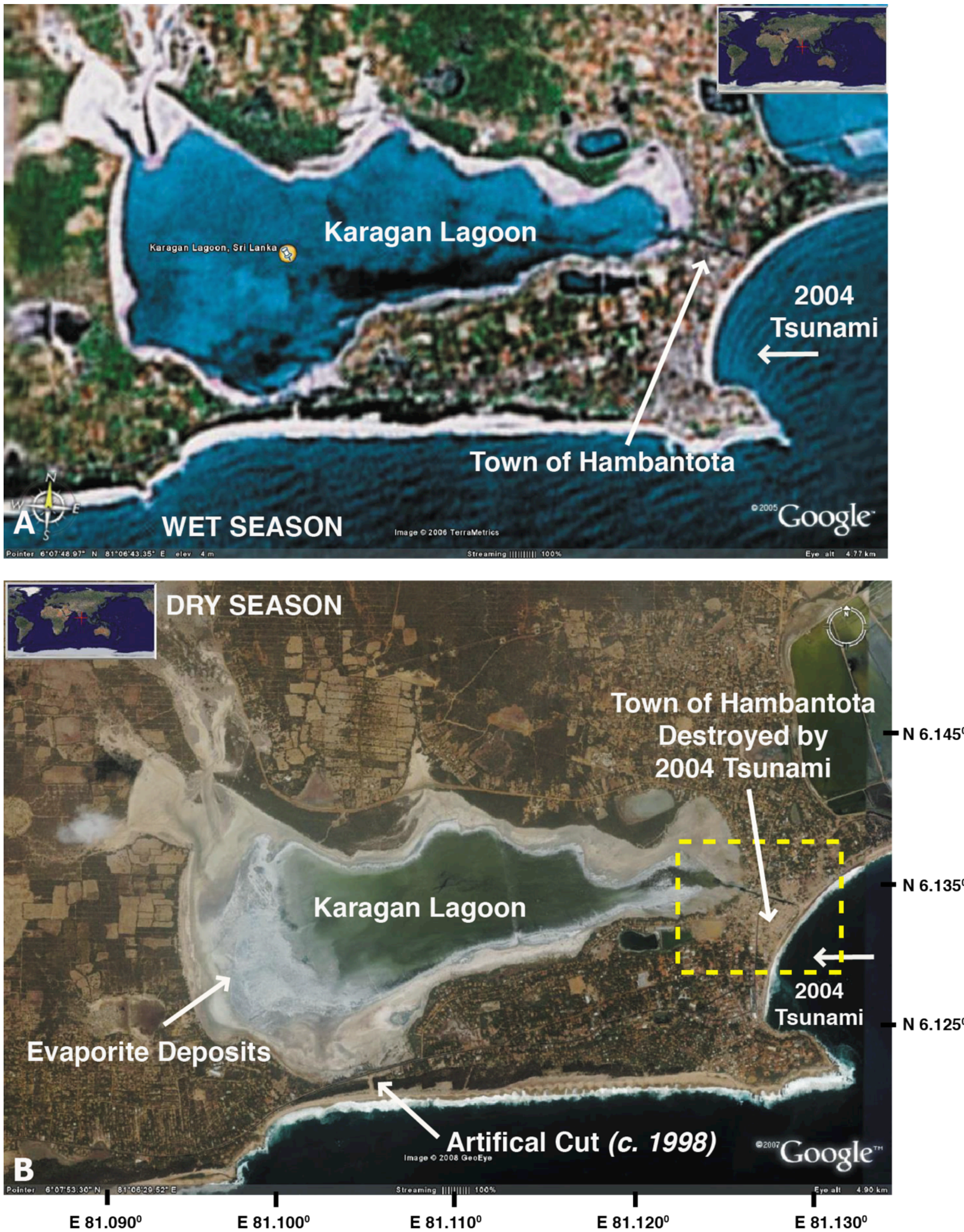

Figure DR2. Satellite images of Karagan Lagoon before and after the 2004 tsunami. A: Satellite image captured during the wet season, indicated by higher water levels in the lagoon, before the 2004 tsunami (acquisition date unknown). B: IKONOS image acquired 6 October 2005, ten months after the 26 December 2004 tsunami. Hambantota was destroyed and the tsunami deposited large quantities of sand across the land from beach and nearshore sediment sources. The yellow box indicates the view of Fig. DR3. The scale of each image is approximately 5 km across (Images courtesy of Google Earth, 2005, 2006).

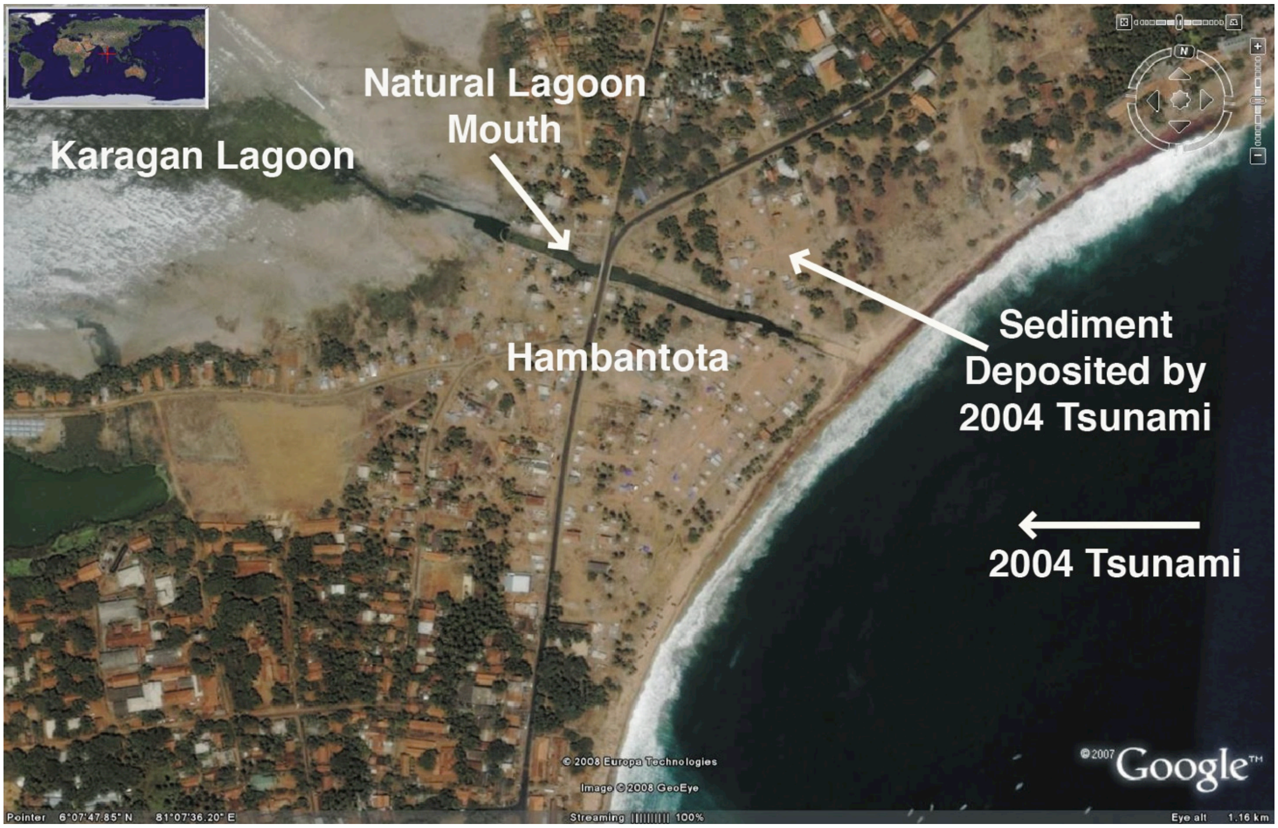

Figure DR3. Close-up view of the devastation of Hambantota visible on Google Earth acquired 7 October 2005 (area is the inset from Fig. DR2B) (Images courtesy of Google Earth, 2005, 2006).

MATERIALS AND METHODS

Sediment Coring

In August 2005, eight months following the 26 December 2004 tsunami, F. Amelung and K.L. Jackson traveled to Sri Lanka to survey the southeastern coastline, from Tangalle to Arugam Bay. The survey identified coastal lagoons inundated by the 2004 tsunami that had the highest preservation potential for paleotsunami deposits. Working with H.A.H. Jayasena and Soil Tech, Ltd., five sediment cores were collected from four different lagoons (Karagan, Lunama, Rekawa, and Arugam Bay Lagoons)

(Fig. DR4). Core D2 from Karagan Lagoon discussed in this paper contained the most well preserved sand units compared to any other lagoon sediments that were sampled.

In a second field season in October 2006, H.A.H. Jayasena together with Soil Tech, Ltd., retrieved additional cores from Karagan Lagoon. The cores range in total length from less than 1.0 to 4.0 m and were collected using a weighted tripod system (Fig. DR4). Custom steel casings and standard 6 cm diameter PVC pipes were both used for the coring casing.

A total of 22 sediment cores were collected from Karagan Lagoon in 2005 and 2006 (Table DR1) along transects parallel and perpendicular to the shoreline. All cores and field data were collected prior to the construction of the Port of Hambantota. Sediment cores were shipped to the University of Miami-RSMAS for analyses. Grain-size was measured by A. L. Moore using a Malvern Mastersizer 2000 laser diffractometer. Core descriptions, sedimentology, and chronology are further discussed in the M.S. thesis of Jackson (2008).

Figure DR4. Field photographs of Soil Tech, Ltd. coring in August 2005. The cores were collected using a weighted tripod system with a mixture of steel and PVC casings.

TABLE DR1. SEDIMENT CORE NAMES, LENGTHS, AND LOCATIONS FROM KARAGAN LAGOON, SRI LANKA

Location	Year core collected	Core name	Corresponding core and section names Jackson (2008)		Cored length (m)	Recovered length (cm)	Latitude (north)°†	Longitude (east)°†
Karagan Lagoon, Sri Lanka	2005	D2	SLHAM05	H1	0.0-1.0	37	6.131	81.123
				H2	1.0-2.0	93		
				H3	2.0-2.5	26		
				H4	2.5-3.0	47		
				H5	3.0-3.5	48		
				H6	3.5-4.0	42		
		S11	SLHAM05_B/ HB1	HAMB or HB1	0.0-1.0	58	6.133	81.123
	2006	S12	SLHAM06_00	*N/A*	0.0-1.0	61	6.134	81.124
		S1	SLHAM06_L0	*N/A*	0.0-1.0	52	6.132	81.124
		S2	SLHAM06_L1	*N/A*	0.0-1.0	94	6.131	81.122
		S3	SLHAM06_L2	*N/A*	0.0-1.0	59	6.130	81.121
		S4	SLHAM06_L3	*N/A*	0.0-1.0	69	6.130	81.118
		S5	SLHAM06_L4	*N/A*	0.0-1.0	70	6.129	81.117
		S10	SLHAM06_R1	*N/A*	0.0-1.0	49	6.134	81.123
		S9	SLHAM06_R2	*N/A*	0.0-1.0	60	6.134	81.122
		S8	SLHAM06_R3	*N/A*	0.0-1.0	39	6.134	81.121
		S7	SLHAM06_R4	*N/A*	0.0-1.0	73	6.133	81.119
		S6	SLHAM06_R5	*N/A*	0.0-1.0	77	6.132	81.118
		D1	SLHAM06_DC1	DC1(1)	0.0-1.0	80	6.132	81.124
				DC1(2)	1.0-2.0	80		
				DC1(3)	2.0-3.0	94		
				DC1(4)	3.0-4.0	100		
		D3	SLHAM06_DC2	DC2(1)	0.0-1.0	74	6.132	81.121
				DC2(2)	1.0-2.0	88		
				DC2(3)	2.0-3.0	19		
				DC2(4)	3.0-4.0	97		
		D4	SLHAM06_DC3	DC3(1)	0.0-1.0	64	6.131	81.117
				DC3(2)	1.0-2.0	48		
				DC3(3)	2.0-3.0	52		
				DC3(4)	3.0-4.0	95		
		D7	SLHAM06_DC4	DC4(1)	0.0-1.0	75	6.121	81.102
				DC4(2)	1.0-2.0	95		
				DC4(3)	2.0-3.0	75		
				DC4(4)	3.0-4.0	19		
		D5	SLHAM06_DC5	DC5(1)	0.0-1.0	60	6.127	81.108
				DC5(2)	1.0-2.0	50		
		D6	SLHAM06_DC6	DC6(1)	0.0-1.0	52	6.125	81.102
				DC6(2)	1.0-2.0	95		
				DC6(3)	2.0-3.0	70		
				DC6(4)	3.0-4.0	32		
		D8	SLHAM06_DC7	DC7(1)	0.0-1.0	52	6.131	81.097
				DC7(2)	1.0-2.0	72		
				DC7(3)	2.0-3.0	21		
		D10	SLHAM06_AL1	AL1(1)	0.0-1.0	55	6.134	81.099
				AL1(2)	1.0-2.0	22		
		D9	SLHAM06_AL2	AL2(1)	0.0-1.0	56	6.134	81.096
				AL2(2)	1.0-2.0	95		
				AL2(3)	2.0-3.0	52		
				AL2(4)	3.0-4.0	35		

† *All coordinates are reported in decimal degrees latitude (N), longitude (E), WGS84.*

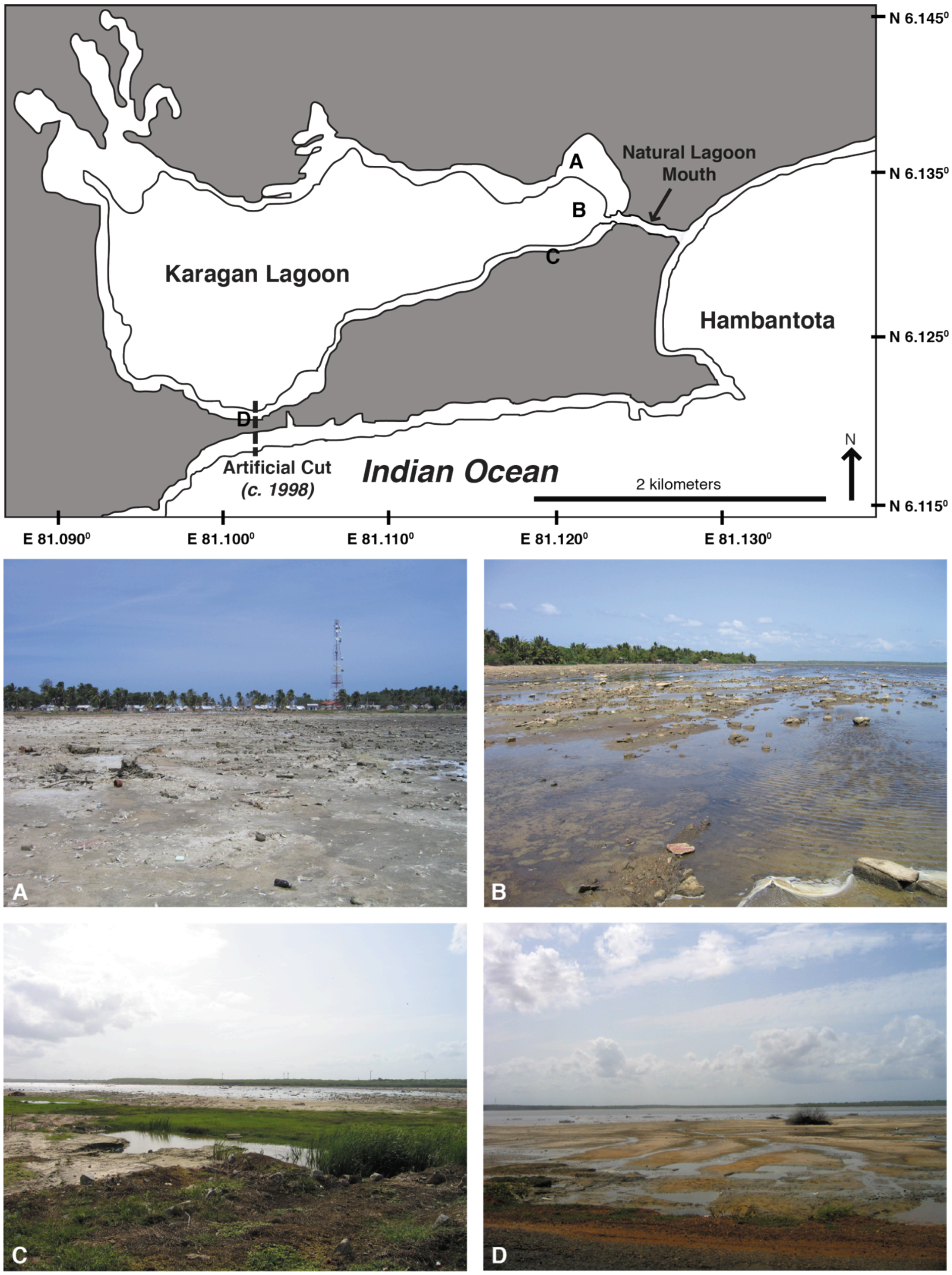

Figure DR5. Karagan Lagoon, Hambantota, Sri Lanka. A: View of Karagan Lagoon from northern rim near mouth looking south towards town. Note the dry surface and extent of debris left from the tsunami. B: View of lagoon looking west. Debris is from the 2004 tsunami. C: View of lagoon from southern rim looking north/northwest. D: View of lagoon from road near artificial cut on southern coast. All photos were taken in August 2005.

Figure DR6. A: Artificial cut created in 1998 to divert flooding on the southern coast of Karagan Lagoon (Stanzel et al., 2002). Photo is from the southern beach looking north with Karagan Lagoon in the background. B: The natural mouth of the lagoon runs through the town of Hambantota and was reinforced in 1998 with concrete walls to control the flow of water and prevent the town from flooding. Photos taken in August 2005.

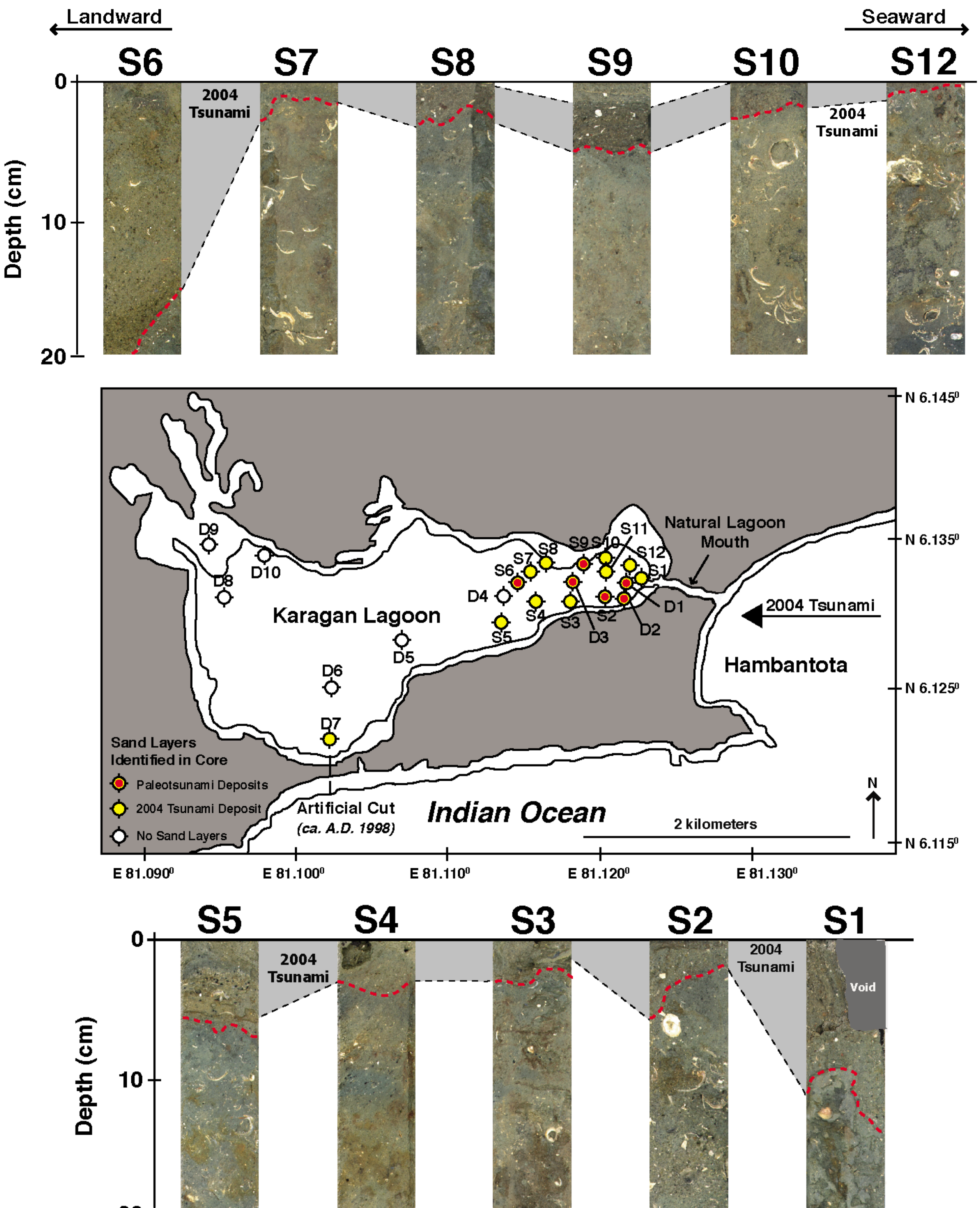

Figure DR7. Top 20 cm of short sediment cores from eastern Karagan Lagoon (locations indicated by circles on map). Red dashed line indicates the boundary between the normal lagoon sediment and the overlying 2004 tsunami deposit. The thickness of the 2004 tsunami layer varies between cores with the thickest layer in S6 (22 cm). The distance from core S5 to S1 is roughly 1 km with approximately 0.2 km of spacing between individual cores.

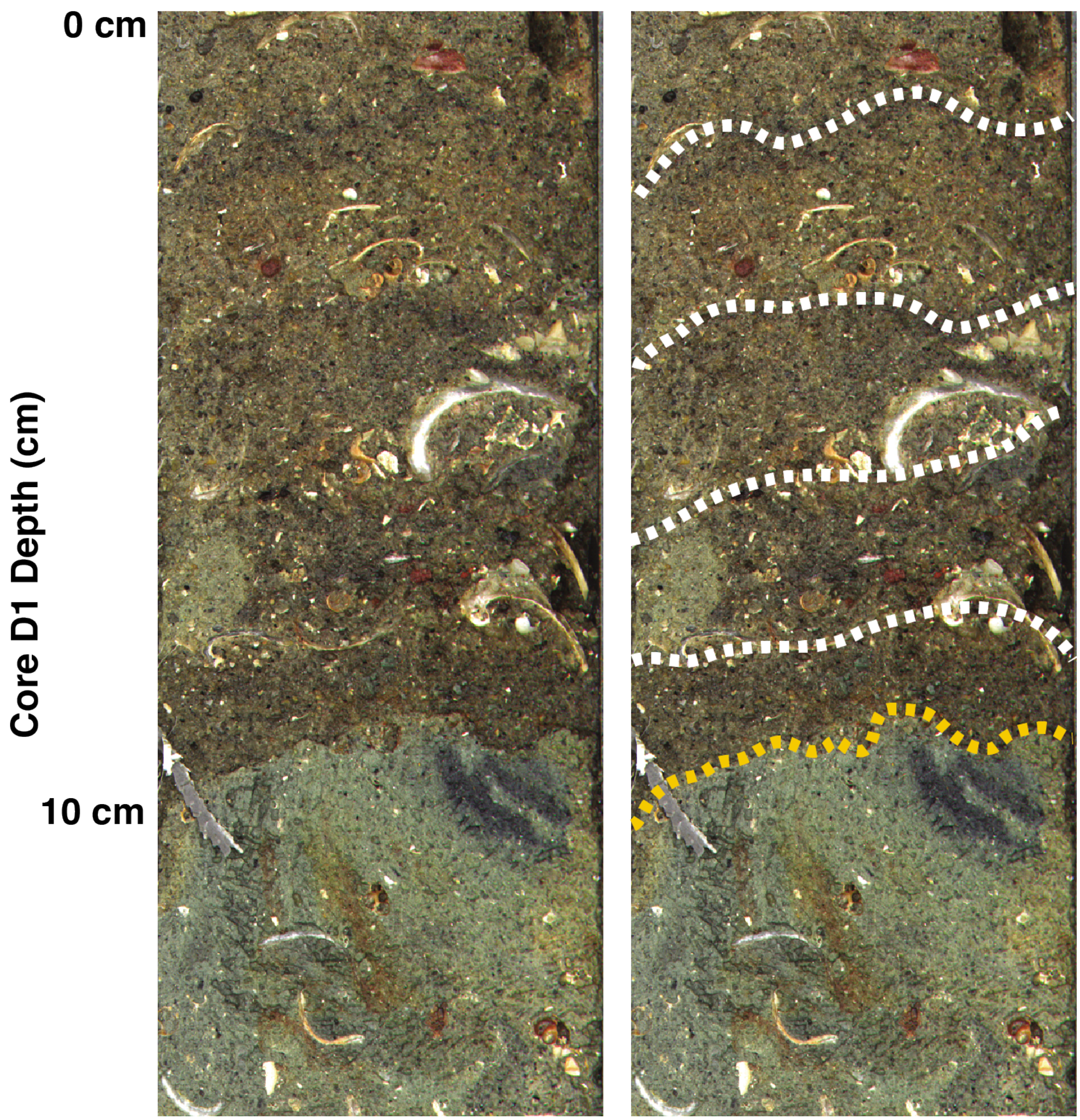

Figure DR8. The top portion of core D1 shows an illustrative example of the 26 December 2004 tsunami deposit featuring multiple cycles of grading. The deposit is 10 cm thick and the core is 6 cm in diameter. The left shows a core photograph; right shows the interpretation. Four faint nearly horizontal slightly darker layers are present in this coarse quartz sand unit (right: white dashed lines). The orange dashed line (right) marks the boundary between the lagoon sediments and the 2004 tsunami deposit.

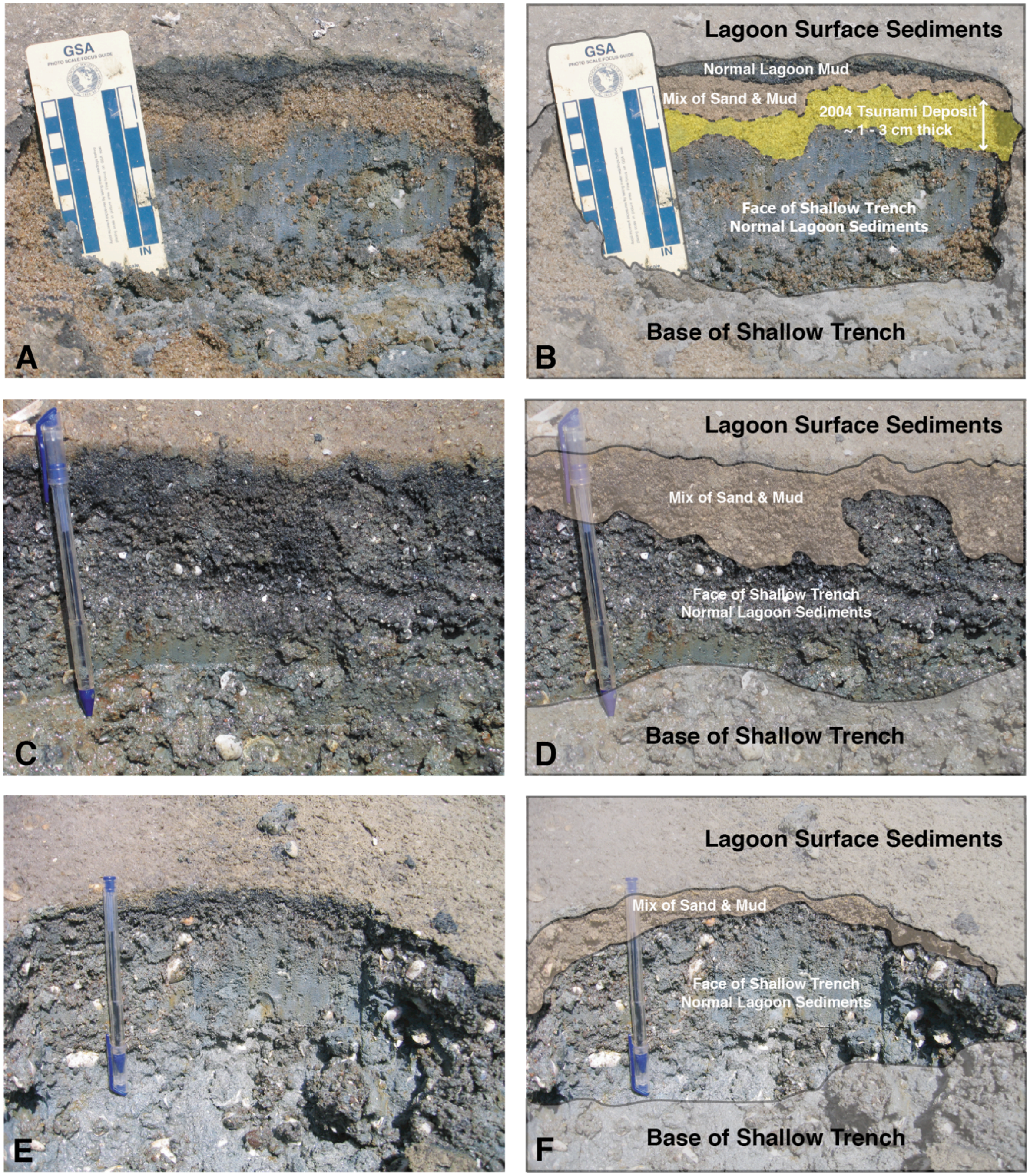

Figure DR9. Shallow trenches from tens of meters apart illustrate the variability of the 26 December 2004 tsunami deposit. A, C, and E show shallow trenches in Karagan Lagoon dug with a shovel at low water level in August 2005 in the vicinity of core D2. B, D, and F show interpreted sedimentary units. Note the 2004 layer is clearly visible in A-B and is approximately 1-3 cm thick. The upper gradational mixed sand and mud towards the surface in A-B, C-D, and E-F was also deposited by the 2004 tsunami. Pen for scale.

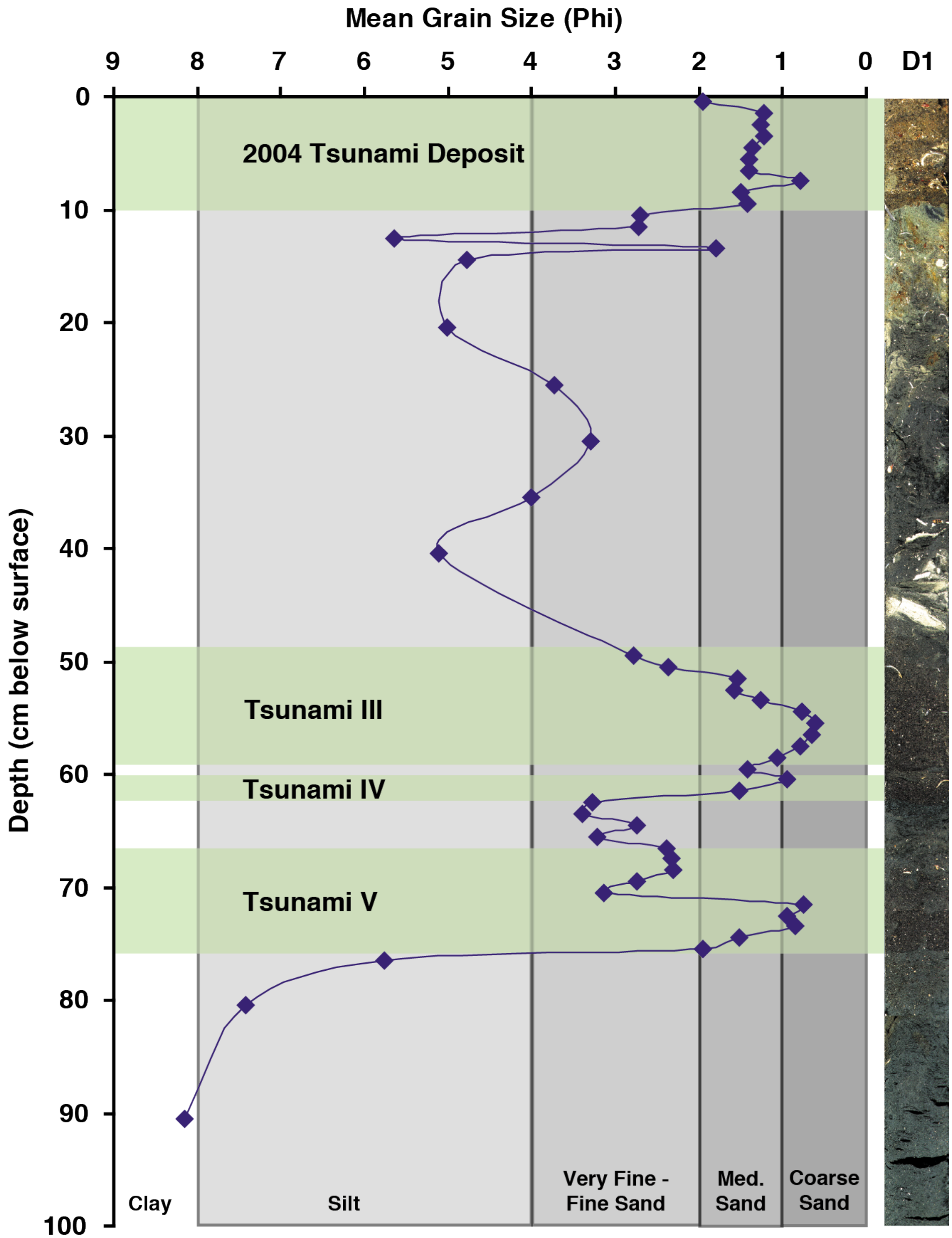

Figure DR10. Core D1 grain size. Mean grain size (phi) plotted against depth below surface of core in centimeters for the top meter of core D1. The mean grain size illustrates that this section of core is a mixture of silt (4-8 phi), very fine to fine sand (2-4 phi), medium sand (1-2 phi), and coarse sand (0-1 phi). Core photograph shown on right for reference.

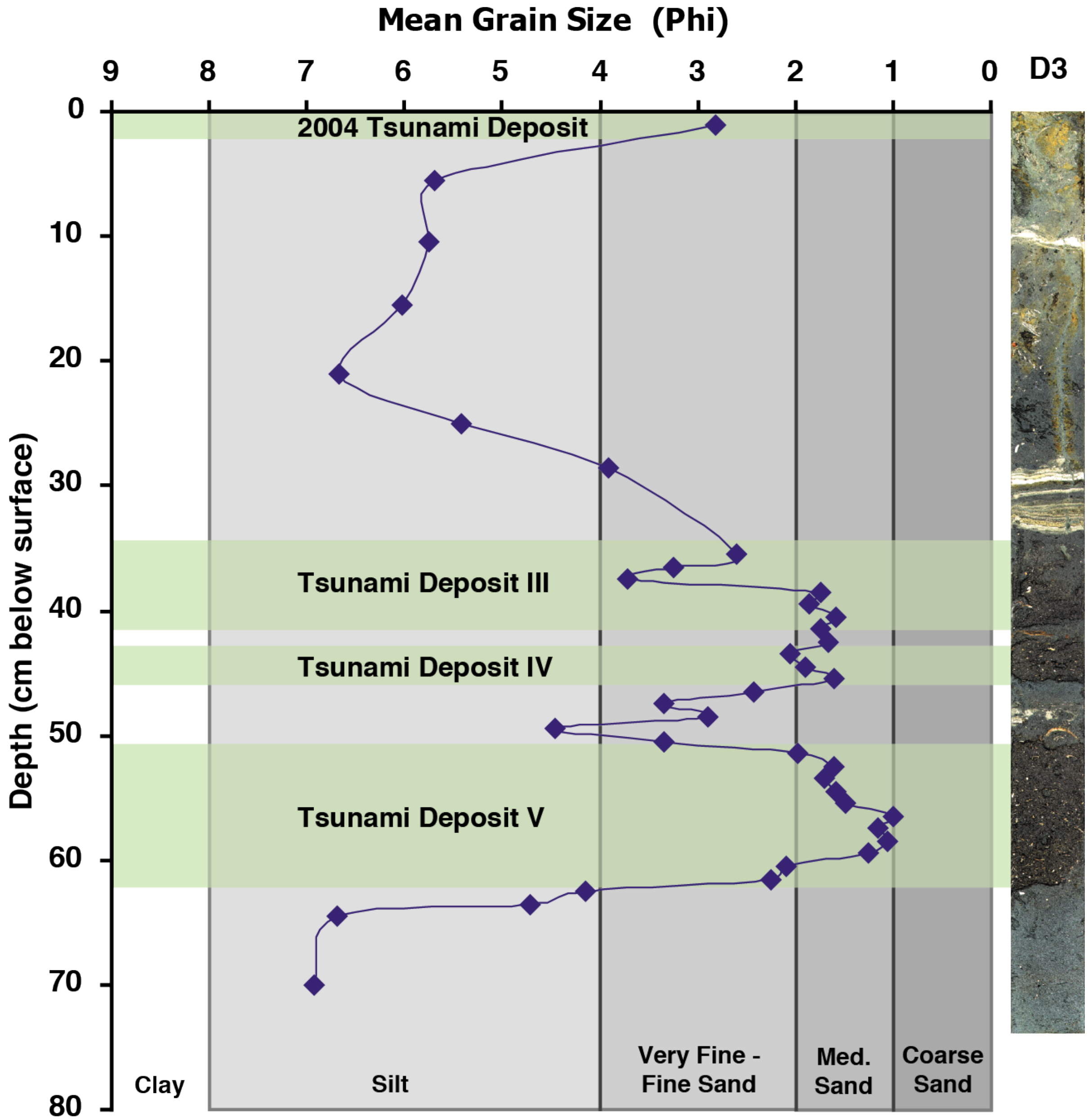

Figure DR11. Core D3 grain size. Mean grain size (phi) plotted against depth below surface of core in centimeters for core D3. The mean grain size illustrates that this section of core is a mixture of silt (4-8 phi), very fine to fine sand (2-4 phi), medium sand (1-2 phi), and coarse sand (0-1 phi). Core photograph shown on right for reference.

AMS Radiocarbon Dating

Accelerator Mass Spectrometry (AMS) radiocarbon dating, conducted at Woods Hole National Ocean Sciences Accelerator Mass Spectrometry Facility (NOSAMS), was used to construct the relative chronology of the sand deposits to constrain the timing of paleotsunamis in Sri Lanka. Dated samples included bulk organic matter from lagoon sediment from five cores (D1, D2, D3, S2, and S9).

To avoid sampling material potentially transported by tsunami waves, bulk sediment samples were collected from immediately above (representing a minimum age) and immediately below (representing a maximum age) the sand deposits (Fig. DR12). The sediment was frozen, freeze-dried, weighed, and shipped to NOSAMS for analyses (Tables DR2, DR3). AMS radiocarbon age dates were calibrated with OxCal v. 4.1 (Oxcal; Bronk Ramsey, 2009) using calibration curve IntCal09 (Reimer et al., 2009). OxCal v. 4.1 standard default settings were used and the dates were outputted in calendar years before present $\pm 2\sigma$ (cal. yr B.P.) with present defined as A.D. 1950. The resulting ages yields an event time range spanning from the youngest possible age (above the deposit) to the oldest possible age (below the deposit), where ages are reported as $\mu \pm 2\sigma$ cal. yr B.P. (Tables DR2, DR3). The age of the sand deposit is estimated by taking the midpoint of the time range from the oldest to youngest μ and rounding to the nearest hundredth year. Some sand deposits are less well constrained because only one sample below the deposit was dated. This age represents the oldest possible age of the sand deposit.

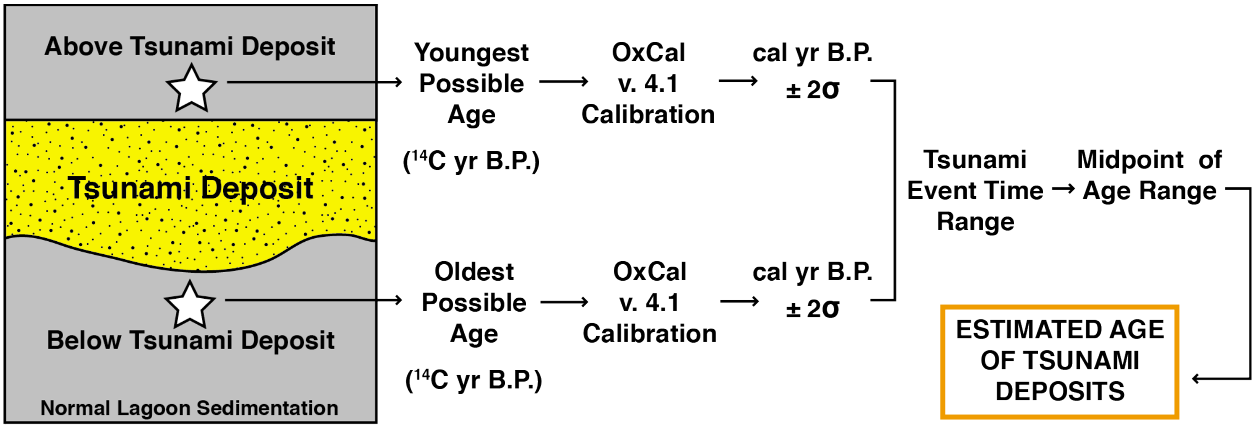

Figure DR12. Tsunami dating methodology. AMS radiocarbon dating of normal lagoon sediment from above and below the sand deposits was used to constrain the timing of sand events in Karagan Lagoon, Sri Lanka. The dates were calibrated using OxCal v. 4.1. The age of each tsunami deposit can be estimated by taking the midpoint between the oldest µ and the youngest µ and then rounding to the nearest hundredth year.

TABLE DR2. KARAGAN LAGOON AGE DATES REPORTED IN RADIOCARBON YEARS BEFORE PRESENT AND CALIBRATED AGES REPORTED AS μ cal. yr B.P. ± 1σ AND ± 2σ

Lagoon name	Core name	Corresponding core name: Jackson (2008)	Sample name	NOSAMS accession number	Depth in core (m)	Sample type	^{14}C yr B.P.†	Error ±	OxCal. 4.1 μ cal. yr B.P.§	1σ	2σ
Karagan Lagoon, Sri Lanka	D1	SLHAM06DC1(1)S	DC1(1)S 1a	OS-66115	0.120 – 0.140	Lagoonal Mud	1460	40	1353	36	72
	D1	SLHAM06DC1(1)S	DC1(1)S 2a	OS-66116	0.395 – 0.415	Lagoonal Mud	3720	40	4064	64	128
	D1	SLHAM06DC1(1)S	DC1(1)S 3a	OS-66117	0.630 – 0.650	Lagoonal Mud	4070	35	4583	98	196
	D1	SLHAM06DC1(1)S	DC1(1)S 7	OS-67384	0.755 – 0.770	Lagoonal Mud	4480	35	5152	89	178
	D1	SLHAM06DC1(3)S	DC1(3)S 22	OS-67385	2.090 – 2.110	Lagoonal Mud	5450	35	6249	34	68
	D1	SLHAM06DC1(3)S	DC1(3)S 23	OS-67386	2.815 – 2.835	Lagoonal Mud	5670	45	6455	59	118
	D1	SLHAM06DC1(4)S	DC1(4)S 26	OS-67387	3.405 – 3.425	Lagoonal Mud	5850	40	6665	55	110
	D1	SLHAM06DC1(4)S	DC1(4)S 25	OS-67388	3.975 – 3.990	Lagoonal Mud	6030	40	6874	58	116
	D3	SLHAM06DC2(1)S	DC2(1)S 1a	OS-66084	0.030 – 0.050	Lagoonal Mud	2260	45	2250	61	122
	D3	SLHAM06DC2(1)S	DC2(1)S 2a	OS-60876	0.260 – 0.280	Lagoonal Mud	3690	45	4029	67	134
	D3	SLHAM06DC2(1)S	DC2(1)S 3a	OS-60889	0.480 – 0.500	Lagoonal Mud	4150	35	4695	76	152
	D3	SLHAM06DC2(1)S	DC2(1)S 4a	OS-60890	0.660 – 0.680	Lagoonal Mud	4570	40	5227	111	222
	D3	SLHAM06DC2(4)S	DC2(4)S 21	OS-67389	3.715 – 3.735	Lagoonal Mud	6000	40	6840	54	108
	S2	SLHAM06(L1)S	L1S 1	OS-67390	0.020 – 0.040	Lagoonal Mud	> Modern*	–	–	–	–
	S2	SLHAM06(L1)S	L1S 3	OS-67364	0.290 – 0.310	Lagoonal Mud	1860	45	1794#	56	112
	S2	SLHAM06(L1)S	L1S 4	OS-67400	0.445 – 0.465	Lagoonal Mud	3900	40	4331	63	126
	S2	SLHAM06(L1)S	L1S 5	OS-67401	0.565 – 0.585	Lagoonal Mud	4230	40	4764	70	140
	D2	SLHAM05_H1S	H1SB	OS-78611	0.125 – 0.138	Lagoonal Mud	2370	35	2417	76	152
	D2	SLHAM05_H1S	H1SC	OS-78626	0.143 – 0.145	Bark/Plant	> Modern*	–	–	–	–
	D2	SLHAM05_H1S	H1S 8	OS-67705	0.020 – 0.035	Lagoonal Mud	280	30	357	64	128
	D2	SLHAM05_H1S	H1S 9	OS-67708	0.220 – 0.235	Lagoonal Mud	2820	35	2925	49	98
	D2	SLHAM05_H2S	H2S 10	OS-67680	1.045 – 1.060	Lagoonal Mud	4840	55	5563	71	142
	D2	SLHAM05_H2S	H2S 11	OS-67706	1.425 – 1.445	Lagoonal Mud	5210	35	5971	52	104
	D2	SLHAM05_H2S	H2S 12	OS-67707	1.680 – 1.700	Lagoonal Mud	5410	55	6197	78	156
	D2	SLHAM05_H3S	H3S 13	OS-67709	2.190 – 2.210	Lagoonal Mud	4980	45	5723	73	146
	D2	SLHAM05_H4S	H4S 14	OS-67710	2.935 – 2.955	Lagoonal Mud	6120	35	7022	74	148
	D2	SLHAM05_H5S	H5S 15	OS-67711	3.190 – 3.205	Lagoonal Mud	5640	35	6416	46	92
	D2	SLHAM05_H5S	H5S 16	OS-67712	3.325 – 3.340	Lagoonal Mud	5880	35	6702	40	80
	D2	SLHAM05_H6S	H6S 17	OS-67713	3.715 – 3.730	Lagoonal Mud	5800	40	6598	54	108
	S9	SLHAM06_R2S	R2S 27	OS-69910	0.005 – 0.015	Lagoonal Mud	70	40	126	78	156
	S9	SLHAM06_R2S	R2SB	OS-78594	0.006 – 0.018	Lagoonal Mud	> Modern*	–	–	–	–
	S9	SLHAM06_R2S	R2S 18	OS-67714	0.080 – 0.100	Lagoonal Mud	350	30	401	53	106

Note: Assumed δ^{13}C value of -25.00. Fraction Modern (Fm) is the measurement of the deviation of ^{14}C/C ratio of a sample from "modern."

*Modern is defined as A.D. 1950 therefore "> Modern" implies to post-1950 deposition.
†Raw AMS radiocarbon data reported in radiocarbon years before present (^{14}C yr B.P.).
§Calibrated radiocarbon data using OxCal v. 4.1 (Bronk Ramsey, 2009) with calibration curve IntCal09 (Reimer et al., 2009) reported in μ ± 1σ and 2σ calendar years before present (cal. yr B.P.).
#Based on stratigraphy, this is not a reliable age date. Bioturbation in top portion of S2 could have affected this ^{14}C date.

TABLE DR3. KARAGAN LAGOON BULK ORGANIC RADIOCARBON DATES FROM LAGOONAL MUD AND ONE BARK SAMPLE. RAW DATA AND OXCAL 4.1 OUTPUT DATA

Lagoon name	Core name	Corresponding core name: Jackson (2008)	Sample name	NOSAMS accession number	Depth in core (m)	Sample type	^{14}C yr B.P.	Error ±	From	To	%	From	To	%	From	To	%	μ	σ	M†
Karagan Lagoon, Sri Lanka	D1	SLHAM06DC1(1)S	DC1(1)S 1a	OS-66115	0.120–0.140	Lagoonal Mud	1460	40	1376	1311	68.2	1411	1295	95.4	1518	1283	99.7	1353	36	1349
	D1	SLHAM06DC1(1)S	DC1(1)S 2a	OS-66116	0.395–0.415	Lagoonal Mud	3720	40	4145	3988	68.2	4225	3929	95.3	4241	3897	99.7	4064	64	4061
	D1	SLHAM06DC1(1)S	DC1(1)S 3a	OS-66117	0.630–0.650	Lagoonal Mud	4070	35	4784	4447	68.3	4806	4438	95.4	4818	4421	99.7	4583	98	4561
	D1	SLHAM06DC1(1)S	DC1(1)S 7	OS-67384	0.755–0.770	Lagoonal Mud	4480	35	5280	5045	68.1	5291	4978	95.4	5310	4885	99.7	5152	89	5166
	D1	SLHAM06DC1(3)S	DC1(3)S 22	OS-67385	2.090–2.110	Lagoonal Mud	5450	35	6293	6213	68.2	6302	6193	95.4	6395	6118	99.7	6249	34	6246
	D1	SLHAM06DC1(3)S	DC1(3)S 23	OS-67386	2.815–2.835	Lagoonal Mud	5670	45	6496	6404	68.2	6600	6317	95.4	6635	6309	99.7	6455	59	6452
	D1	SLHAM06DC1(4)S	DC1(4)S 26	OS-67387	3.405–3.425	Lagoonal Mud	5850	40	6734	6636	68.2	6776	6551	95.4	6795	6494	99.7	6665	55	6669
	D1	SLHAM06DC1(4)S	DC1(4)S 25	OS-67388	3.975–3.990	Lagoonal Mud	6030	40	6936	6800	68.2	6984	6755	95.4	7154	6719	99.7	6874	58	6874
	D3	SLHAM06DC2(1)S	DC2(1)S 1a	OS-66084	0.030–0.050	Lagoonal Mud	2260	45	2341	2180	68.2	2349	2153	95.4	2365	2109	99.7	2250	61	2238
	D3	SLHAM06DC2(1)S	DC2(1)S 2a	OS-60876	0.260–0.280	Lagoonal Mud	3690	45	4136	3933	68.2	4150	3900	95.4	4235	3844	99.7	4029	67	4030
	D3	SLHAM06DC2(1)S	DC2(1)S 3a	OS-60889	0.480–0.500	Lagoonal Mud	4150	35	4819	4616	68.2	4828	4571	95.4	4836	4526	99.7	4695	76	4693
	D3	SLHAM06DC2(1)S	DC2(1)S 4a	OS-60890	0.660–0.680	Lagoonal Mud	4570	40	5436	5074	68.2	5445	5052	95.5	5467	5039	99.7	5227	111	5234
	D3	SLHAM06DC2(4)S	DC2(4)S 21	OS-67389	3.715–3.735	Lagoonal Mud	6000	40	6893	6787	68.2	6945	6741	95.4	6992	6677	99.7	6840	54	6839
	S2	SLHAM06(L1)S	L1S 1	OS-67390	0.020–0.040	Lagoonal Mud	> Modern*	–	–	–	–	–	–	–	–	–	–	–	–	–
	S2	SLHAM06(L1)S	L1S 3	OS-67364	0.290–0.310	Lagoonal Mud	1860	45	1864	1732	68.2	1897	1698	95.4	1948	1614	99.7	1794	56	1795
	S2	SLHAM06(L1)S	L1S 4	OS-67400	0.445–0.465	Lagoonal Mud	3900	40	4415	4291	68.2	4430	4160	95.3	4516	4151	99.7	4331	63	4334
	S2	SLHAM06(L1)S	L1S 5	OS-67401	0.565–0.585	Lagoonal Mud	4230	40	4851	4709	68.2	4863	4627	95.4	4957	4570	99.7	4764	70	4752
	D2	SLHAM05_H1S	H1SB	OS-78611	0.125–0.138	Lagoonal Mud	2370	35	2456	2343	68.2	2675	2335	95.4	2701	2313	99.7	2417	76	2405
	D2	SLHAM05_H1S	H1SC	OS-78626	0.143–0.145	Bark/Plant	> Modern*	–	–	–	–	–	–	–	–	–	–	–	–	–
	D2	SLHAM05_H1S	H1S 8	OS-67705	0.020–0.035	Lagoonal Mud	280	30	427	291	68.2	452	155	95.3	480	-4	99.7	357	64	372
	D2	SLHAM05_H1S	H1S 9	OS-67708	0.220–0.235	Lagoonal Mud	2820	35	2960	2870	68.2	3063	2845	95.4	3078	2784	99.7	2925	49	2923
	D2	SLHAM05_H2S	H2S 10	OS-67680	1.045–1.060	Lagoonal Mud	4840	55	5644	5482	68.2	5711	5335	95.4	5744	5325	99.7	5563	71	5582
	D2	SLHAM05_H2S	H2S 11	OS-67706	1.425–1.445	Lagoonal Mud	5210	35	5990	5925	68.2	6172	5907	95.4	6180	5894	99.7	5971	52	5962
	D2	SLHAM05_H2S	H2S 12	OS-67707	1.680–1.700	Lagoonal Mud	5410	55	6288	6130	68.2	6303	6005	95.4	6396	5990	99.7	6197	78	6216
	D2	SLHAM05_H3S	H3S 13	OS-67709	2.190–2.210	Lagoonal Mud	4980	45	5844	5645	68.2	5889	5604	95.4	5900	5596	99.7	5723	73	5708
	D2	SLHAM05_H4S	H4S 14	OS-67710	2.935–2.955	Lagoonal Mud	6120	35	7154	6938	68.2	7158	6906	95.4	7166	6858	99.7	7022	74	7002
	D2	SLHAM05_H5S	H5S 15	OS-67711	3.190–3.205	Lagoonal Mud	5640	35	6472	6354	68.2	6493	6317	95.4	6547	6303	99.7	6416	46	6422
	D2	SLHAM05_H5S	H5S 16	OS-67712	3.325–3.340	Lagoonal Mud	5880	35	6737	6666	68.2	6787	6636	95.4	6846	6556	99.7	6702	40	6702
	D2	SLHAM05_H6S	H6S 17	OS-67713	3.715–3.730	Lagoonal Mud	5800	40	6661	6554	68.2	6717	6493	95.4	6741	6451	99.7	6598	54	6600
	S9	SLHAM06_R2S	R2S 27	OS-69910	0.005–0.015	Lagoonal Mud	70	40	254	33	68.3	268	18	95.4	281	7	99.7	126	78	107
	S9	SLHAM06_R2S	R2SB	OS-78594	0.006–0.018	Lagoonal Mud	> Modern*	–	–	–	–	–	–	–	–	–	–	–	–	–
	S9	SLHAM06_R2S	R2S 18	OS-67714	0.080–0.100	Lagoonal Mud	350	30	470	320	68.2	494	315	95.4	503	306	99.7	401	53	395

*Modern is defined as A.D. 1950.
†Median.

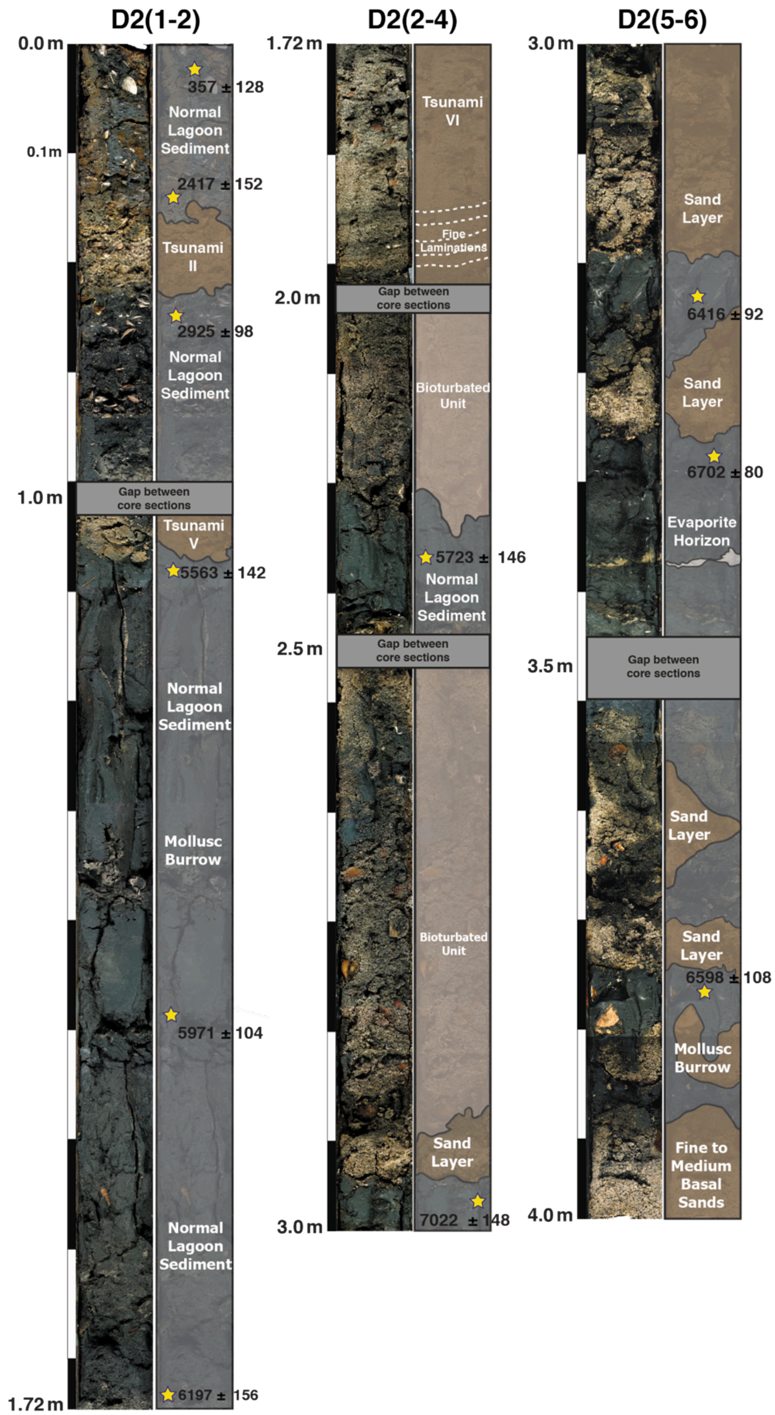

Figure DR13. Photographs and interpretations of core D2 from Karagan Lagoon. Yellow stars indicate where samples were dated using AMS radiocarbon analyses (Tables DR2, DR3); text indicates calibrated age of the bulk organic content as $\mu \pm 2\sigma$ cal. yr B.P. Core D2 features numerous sand layers from 2.0-4.0 m though extensive bioturbation and possible disturbance during coring caused age reversals in the sediment therefore these layers can not be properly correlated to cores D1 and D3. All depths are reported in m below lagoon sediment surface; the lower 2.0 m of core were cored in 0.5 m sections.

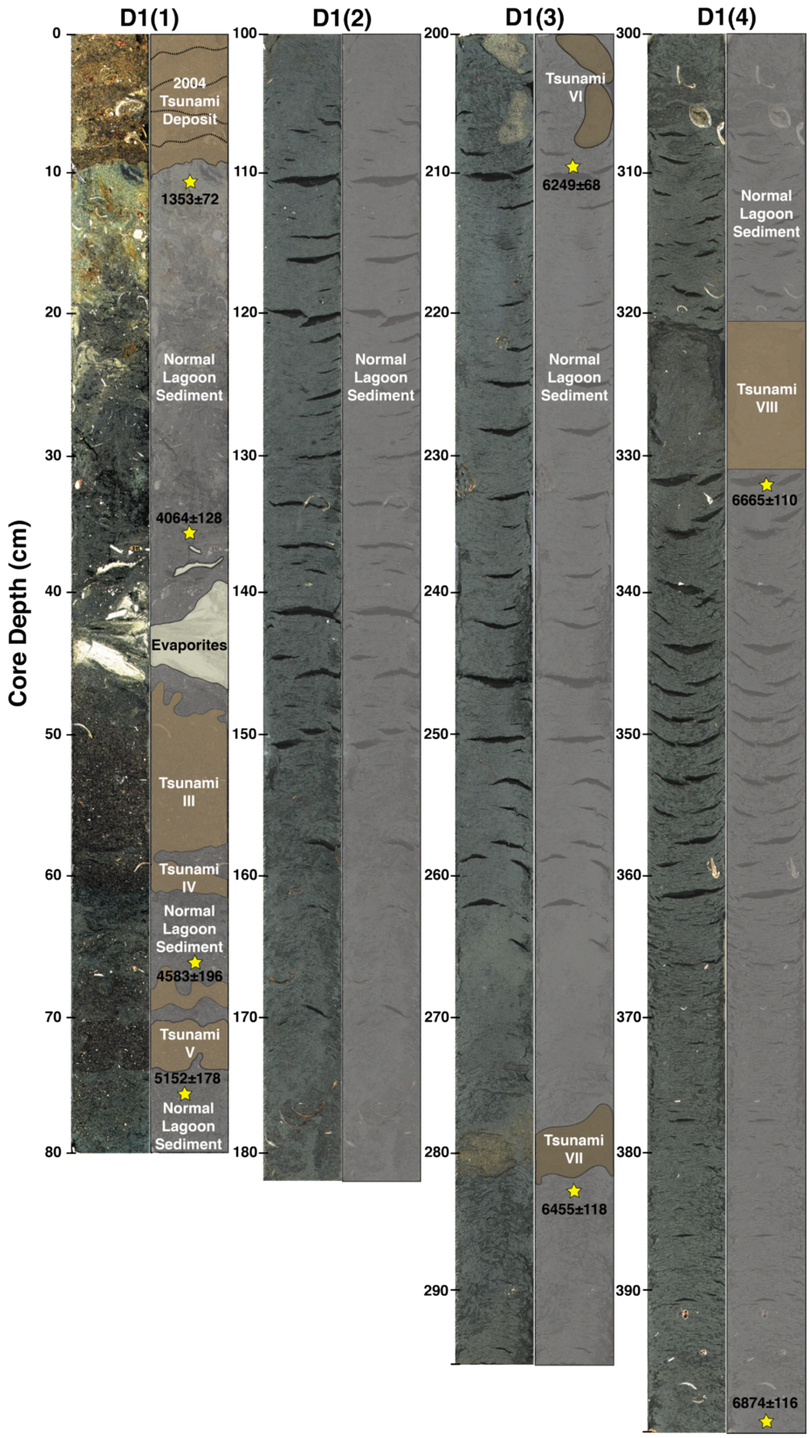

Figure DR14. Core D1 photographs and interpretation. Yellow stars indicate where samples were collected to conduct AMS radiocarbon dating (Tables DR2, DR3); text indicates calibrated age of the bulk organic content presented as $\mu \pm 2\sigma$ cal. yr B.P. Numbers in parentheses (e.g. D1(3) indicates core D1, section 3). All depths are reported in cm below lagoon sediment surface where each new section starts a new meter of core.

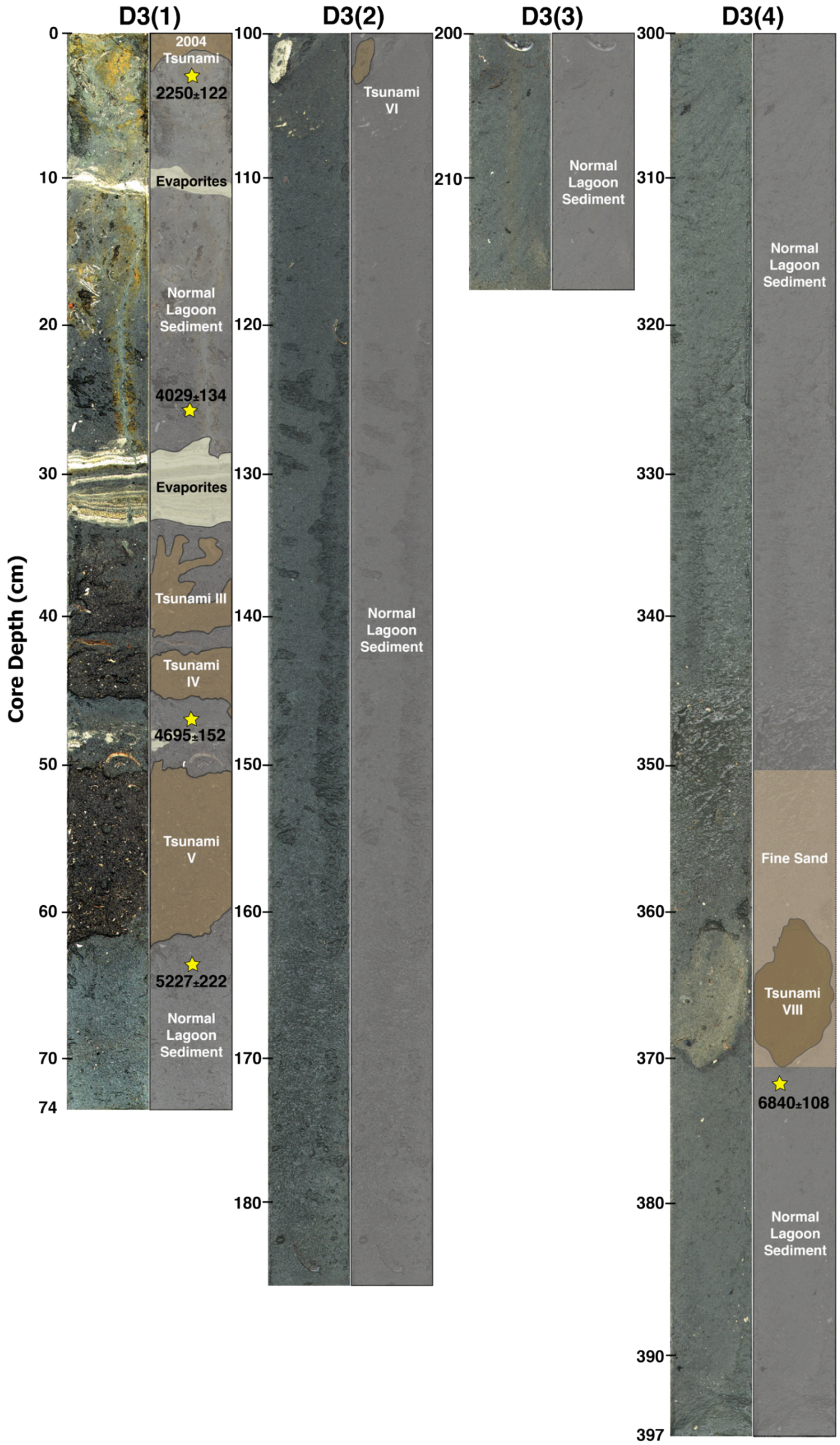

Figure DR15. Core D3 photographs and interpretation. Yellow stars indicate where samples were collected to conduct AMS radiocarbon dating (Tables DR2, DR3); text indicates calibrated age of the bulk organic content μ ± 2σ cal. yr B.P. Numbers in parentheses (e.g. D3(3) indicates core D3, section 3). All depths are reported in cm below lagoon sediment surface where each new section starts a new meter of core.

TABLE DR4. REGIONAL INDIAN OCEAN TSUNAMI RECORDS COMPARED TO KARAGAN LAGOON, SRI LANKA

Location	Paleotsunami events	Material dated	Dating method	^{14}C yr B.P.*	Reported calibrated ages†	Possible correlation to this study	Reference
Okanda and Kirinda, Sri Lanka	1	Bulk organic matter, inorganic $CaCO_3$, woods, molluscs	^{14}C	Table 7.1, Fig. 7.39 of reference	~4200 cal. yr B.P.§	Karagan Tsunami III	Ranasinghage, 2010
	2				~4500 cal. yr B.P.§	Karagan Tsunami IV	
	3				~5000 cal. yr B.P.§	Karagan Tsunami V	
Panama Lagoon, Sri Lanka	4 (Panama P12-1)	Bulk organic matter			6817 ± 132 cal. yr B.P.	Karagan Tsunami VIII(?)	
Kirinda Estuary, Sri Lanka	1	Sand Grains	Thermo-Luminescence (TL)	N/A	1682 ± 126, 1637 ± 122 cal. yr B.P.	No correlation	Abeyratne et al., 2007
	2	Sand Grains			4829 ± 362 cal. yr B.P.	Karagan Tsunami V	
	3	Sand Grains			829 ± 62, 1745 ± 130, 2667 ± 200, 4606 ± 345 cal. yr B.P.	Dating too inconsistent to correlate	
Peraliya Lagoon, Sri Lanka	1 (30 cm deep)	Sediment separated into carbonate & organic fractions	^{14}C	$CaCO_3$: 2187 ± 392 Organic: 539 ± 233	$CaCO_3$: 1670 ± 440 Organic: 130 ± 130	No correlation; Dating inconclusive	Dahanayake et al., 2011
	2 (75 cm deep)			$CaCO_3$: 4380 ± 354 Organic: 2129 ± 162	$CaCO_3$: 4350 ± 470 Organic: 1560 ± 190	No correlation; Dating inconclusive	
Mamallapuram, Southeastern India	1 (S1)	Charcoal Piece (above & below tsunami)	^{14}C	955 ± 30	A.D. 1019-1161	No correlation	Rajendran et al., 2006
	2 (S2)			1581 ± 35 – 1674 ± 30	(A.D. 405-564)- (A.D. 321-421); Reported as ~1000 and ~1500 years ago	No correlation	
Kaveripattinam, Southeastern India	1	Sediment	Optically stimulated luminescence date	N/A	1091 ± 66 cal. yr B.P.	No correlation	Rajendran et al., 2011
		Pottery Shards	Thermoluminescence	N/A	993 ± 73 cal. yr B.P.		
Andaman and Nicobar Islands	"At least 1"	Mangrove roots, peat, wood, gastropods, coral fragments	^{14}C	Table 5 of reference	900-1000 years ago	No correlation	Rajendran et al., 2007
Andaman and Nicobar Islands	1	Coral Breccias & Peaty Sand	^{14}C	Tables 1 and 2 of reference	A.D. 1881	No correlation	Rajendran et al., 2013
	2				A.D. 1762	No correlation	
	3	Unclear			A.D. 1250-1450	No correlation	
	4	Paleo-Mangrove Root Horizon			A.D. 770-1040	No correlation	
	5	Mollusc			A.D. 430-750	No correlation	
	6	Mollusc			BC 20-A.D. 440	No correlation	
Rasdhoo Atoll, Maldives	1	Bulk organic carbon, corals	^{14}C	Table 1 of reference	420-890 cal. yr B.P.	No correlation	Klostermann et al., 2014
	2				890-1560 cal. yr B.P.	No correlation	
	3				2040-2340 cal. yr B.P.	No correlation	
	4				2420-3380 cal. yr B.P.	Karagan Tsunami II	
	5				3890-4330 cal. yr B.P.	Karagan Tsunami III	
	6				5480-5760 cal. yr B.P.	No correlation; Event 6 (Maldives) is only found in one core	

TABLE DR4. REGIONAL INDIAN OCEAN TSUNAMI RECORDS COMPARED TO KARAGAN LAGOON, SRI LANKA (CONTINUED)

Location	Paleotsunami events	Material dated	Dating method	^{14}C yr B.P.*	Reported calibrated ages†	Possible correlation to this study	Reference
Meulaboh, Northern Sumatra, Indonesia	1 (Unit A)	Wood (below sand unit)	^{14}C	< 190 ± 40 – 270 ± 40	A.D. 1907	No correlation	Monecke et al., 2008
	2 (Unit B)	Wood (above & below sand unit)	^{14}C	250 ± 40 – 620 ± 40	A.D. 780-990	No correlation	
	3 (Unit C)	Wood and plant debris (above & below sand unit)	^{14}C	(830 ± 40 – 960 ± 40) to 1130 ± 40	A.D. 1290-1400	No correlation	
Northern Sumatra, Indonesia	1	Wood, gastropod	^{14}C	Table 1 of reference	6500-7000 cal. yr B.P.	Karagan Tsunami VIII	Grand Pre et al., 2012
Phra Thong Island, Thailand	1 (Sheet B)	Bark (below sand sheet B)	^{14}C	< 530 ± 40 – 570 ± 40	550-700 sidereal yr B.P.	No correlation	Jankaew et al., 2008
	2 (Sheet C)	Bark (below sand sheet C)	^{14}C	< 2250 ± 40	< 2200-2400 sidereal yr B.P.	Karagan Tsunami II	
Ban Bang Sak, Thailand	1	Wood, plant fragments, charcoal, shells	^{14}C	Tables 1 and 2 of reference	500-700 cal. yr B.P.	No correlation	Brill et al., 2011
	2 (C1, C2)				1180-1350 cal. yr B.P.#	No correlation	
	3 (C3)				< 2000 cal. yr B.P.#	No correlation	
Andaman Coast, Thailand	1	Above and below: Bark, wood, twigs Within: Shell, piece of coral	^{14}C	Table 4 of reference	2720-4290 cal. yr B.P.	Karagan Tsunami II or III	Rhodes et al., 2011

*Radiocarbon years before present where present is defined as A.D. 1950.
†Calibrated ages reported by corresponding reference. Noted as reported (for example A.D. or cal. yr B.P.).
§Estimated/rounded based on numerous radiocarbon dates. See Ch. 7, Ranasinghage (2010).
#Brill et al. (2011) reports these layers could be deposited by paleotsunamis or storms.

TABLE DR5. RECURRENCE INTERVALS OF TSUNAMI DEPOSITS IN KARAGAN LAGOON, SRI LANKA

Time periods (cal. yr B.P.)	**Number of tsunamis**	**Minimum date μ ± 2σ**	**Maximum date μ ± 2σ**	**Minimum age above cal. yr B.P.** (min μ - 2σ)	**Maximum age above cal. yr B.P.** (min μ + 2σ)	**Minimum age below cal. yr B.P.** (max μ - 2σ)	**Maximum age below cal. yr B.P.** (max μ + 2σ)	**Mean recurrence interval (yr)**	**Shortest recurrence interval (yr)**	**Longest recurrence interval (yr)**	**Recurrence interval difference ± (yr)**
0-3000	2 (I-II)	Present*	2925 ± 98	0*	0*	2827	3023	**1463**	1414	1512	±49
0-4000	2 (I-II)	Present*	4064 ± 128	0*	0*	3936	4192	**2032**	1968	2096	±64
0-7000	8 (I-VIII)	Present*	6665 ± 110	0*	0*	6555	6775	**833**	819	847	±14
4000-5500†	3 (III, IV, V)	4064 ± 128	5152 ± 178	3936	4192	4974	5330	**363**	261	465	±102
4000-7000	6 (III-VIII)	4064 ± 128	6665 ± 110	3936	4192	6555	6775	**434**	394	474	±40
Shortest time between tsunamis 4000-7000	IV and V	4583 ± 196	4764 ± 140	4387	4779	4624	4904	**181**	- §	517	+336
Longest time between tsunamis 4000-7000	V and VI	5152 ± 178	6197 ± 156	4974	5330	6041	6353	**1045**	711	1379	±334

Note: Minimum and maximum dates are reported as μ ± 2σ cal. yr B.P.
Minimum and maximum dates are from Table 1.
Minimum age above and below: Take the minimum age from Table 1 and add/subtract the 2σ error.
Maximum age above and below take the maximum age from Table 1 and add/subtract the 2σ error.
Mean recurrence interval = (maximum date value μ – minimum date value μ) / number of tsunamis during that interval, (rounded to nearest year).
Shortest recurrence interval = (minimum age below – maximum age above) / number of tsunamis during that interval, (rounded to nearest year).
Longest recurrence interval = (maximum age below – minimum age above) / number of tsunamis during that interval, (rounded to nearest year).
Recurrence interval difference is the difference between the mean recurrence interval and the shortest and longest recurrence intervals. The mean recurrence interval – recurrence interval difference = shortest recurrence interval; mean recurrence interval + recurrence interval difference = longest recurrence interval.

*Present or 0 is defined as A.D. 1950 because these ages are derived from radiocarbon dates.
†Most well-constrained tsunami interval based on AMS radiocarbon dating and stratigraphy.
§The shortest recurrence interval can not be calculated because the maximum age above is greater than the minimum age below.