

Supplementary Information Text

Luminescence and radiocarbon dating of beach ridges

We collected a total of 16 samples for luminescence: 10 from different ridges at depths between 0.4 to 2.1 m; 4 samples from ridge 11 (2 at each flank) to observe the variation according to the dated zone; and 2 samples for luminescence from the modern dune at a depth of 0.1 and 0.4 m (fig. S23 and Table S1). We collected these samples from the clean, straight walls of the pits by pushing plastic (PVC) tubes horizontally into the sand and capping them appropriately before extraction. We collected additional sand samples from each pit in plastic bags to determine dose rates.

We analyzed the beach ridge samples at the Cologne Luminescence Laboratory. Luminescence dating relies on the time-dependent accumulation of latent energy in quartz and feldspar minerals due to ionizing radiation, and the resetting of this energy during sunlight exposure. Sediment ages are inferred by measuring the energy dose accumulated since the last sunlight exposure (burial dose) and the ionizing radiation received by the sediment per unit of time (dose rate). Since quartz, usually, the preferred mineral for dating Holocene sediments, turned out to have thermally unstable luminescence signals (fig S24 and S25) and thus underestimates contextual radiocarbon ages (Table S2) we used potassium feldspar for the chronologies presented in this study.

Minerals for burial dose determination were extracted by sieving to grain sizes of 100–150 μm , and treatment with HCl (10%), H_2O_2 (10%), and sodium oxalate to remove carbonates, organic matter, and clay. Density liquid was used to separate potassium-rich feldspar grains ($<2.58 \text{ g/cm}^3$). For luminescence measurements, feldspar grains were fixed on steel discs using 2-mm patches of silicon spray. All samples were measured on an automated Risø TL/OSL reader with $^{90}\text{Sr}/^{90}\text{Y}$ beta source delivering $\sim 0.075 \text{ Gy/s}$ at the sample position. Luminescence signals were stimulated with infrared LEDs centered at $870 \pm 40 \text{ nm}$ and detected through an interference filter with peak transmission at 410 nm.

Equivalent dose (D_e) measurements followed a low-temperature post-infrared-infrared protocol with an IR signal measured at 50°C (IR_{50}) followed by an IR signal at 150°C (pIR_{150}); pIRIR_{150} protocol¹ (Table S3). For the samples investigated in this study, the selected protocol presents the best compromise between low laboratory residual doses and low fading rates for both signals (fig. S26). While generally both signals measured within the pIRIR_{150} protocol may be used for dating², ages based on the pIR_{150} signal tend to overestimate associated radiocarbon ages for samples from Isla Santa Maria (Table S2). The chronology used for all further discussion in this paper is therefore solely based on ages derived from the IR_{50} signal. For each sample, between 17 and 27 aliquots were

accepted for burial dose calculation. Due to the ~gaussian shape (fig. S27) and the low scatter of equivalent dose distributions (<20% over-dispersion for all samples older ~200 yrs) the IR₅₀ signals of all samples were assumed to be completely reset prior to burial and the central age model³ was applied to calculate burial doses.

Dose rates (see Table S4 for a summary) were obtained from radionuclide concentrations of uranium (²³⁸U), thorium (²³²Th), and potassium (K) determined with high-resolution gamma spectrometry (Ortec HPGe gamma-ray detector). Based on radionuclide concentrations and in-situ water contents, dose rates were derived using the DRAC software⁴. The reduced efficiency of alpha particles in generating feldspar luminescence signals was corrected using a-values of 0.07 ± 0.02 ⁵. The internal potassium content of feldspar grains was assumed as $12.5 \pm 0.5\%$ ⁶. Cosmic dose rates were calculated according to Prescott and Hutton⁷ by accounting for geographical position, altitude, and sediment cover. Finally, all ages were corrected for signal loss due to anomalous fading using a mean g-value of 4.2 ± 0.1 %/decade and the approach of Huntely and Lamothe⁸.

Finally, to test luminescence dating, we dated ridges 11, 17 and 24 using radiocarbon from remains of calcareous tubes from *polychaete* worms, left as drift debris on the ancient beaches. These samples were collected from pits in each of these ridges (fig. S15). Because the tubes are only ~0.2 mm thick and very delicate, we assumed very little transport, and that their age should be close to the deposition time, i.e. close to beach abandonment and ridge formation. The tubes contain enough organic carbon (chitin) for radiocarbon dating (fig. S10 and Table S5). Radiocarbon measurements were performed at the DirectAMS laboratory, USA, and calibrated to years BP using Oxcal v.4.4⁹ with the Marine 20 calibration curve¹⁰. We used the marine reservoir age offset of 43 ± 52 yr¹¹ included in the Global marine reservoir database (<http://calib.org/marine>).

Supplementary figures



Figure S1. a) Contour curvature of the coastal plain digital elevation model. Note ridge crest in yellow and swales in blue. b) Profile curvature of the coastal plain digital elevation model. Note clear surface geomorphic expression of ridge crests. NNE-SSW oriented crests correspond to elongated dunes.

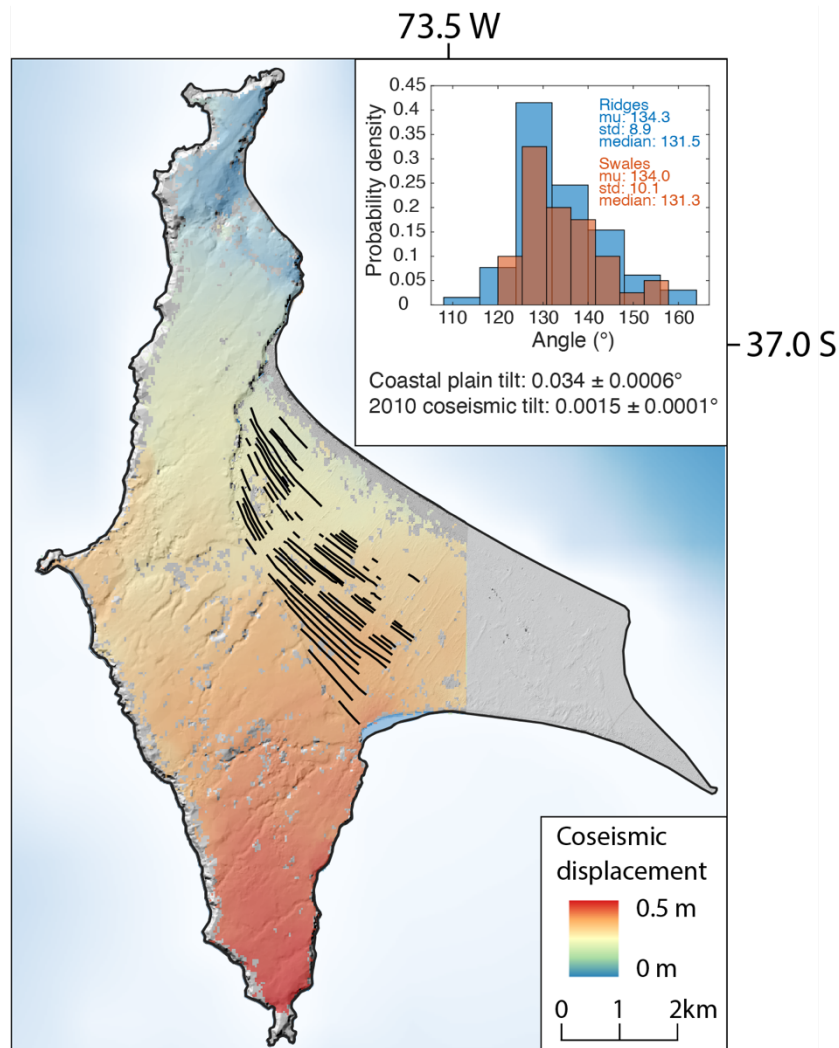


Figure S2. Deformation during the 2010 Maule earthquake at ISM¹². Color-coded displacement from unwrapped Advanced Land Observing Satellite interferogram. Inset shows histogram of ridge/swale orientations.

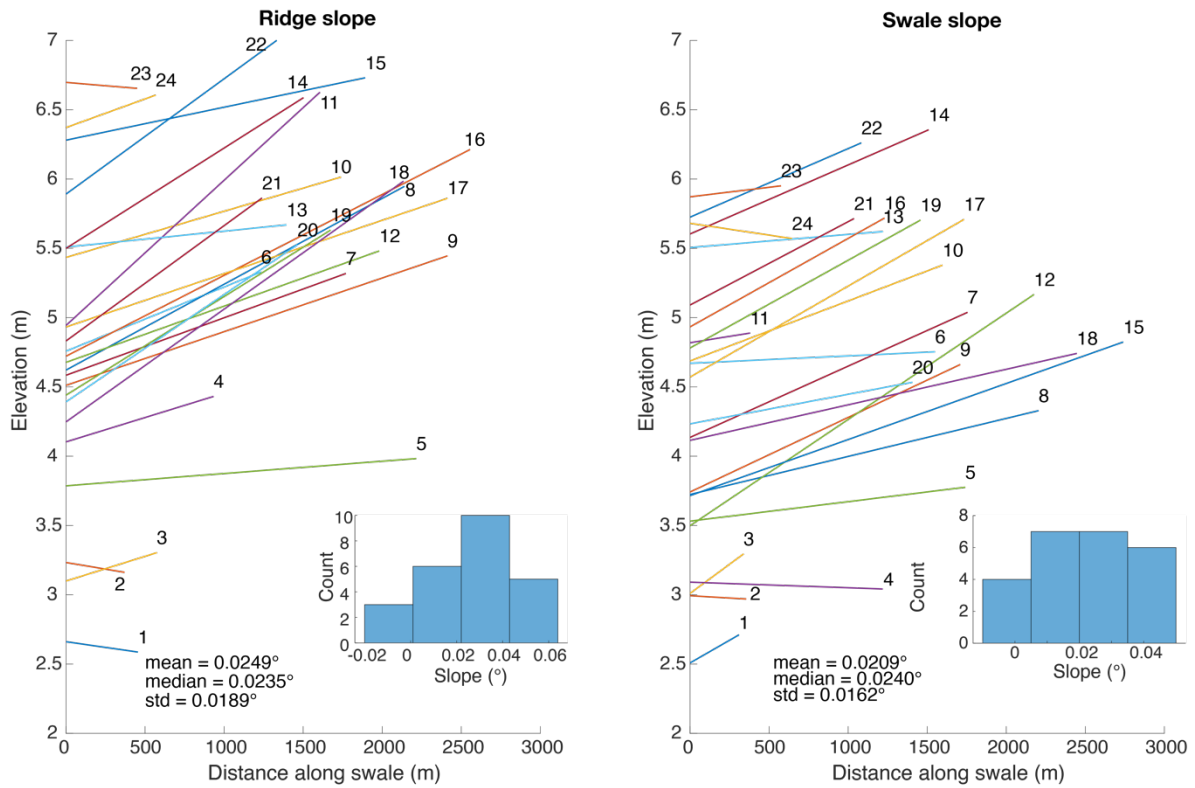


Figure S3. Stacks of ridge (left) and swale (right) tilt estimates using linear regressions. Insets show tilt histograms with labeled statistics.

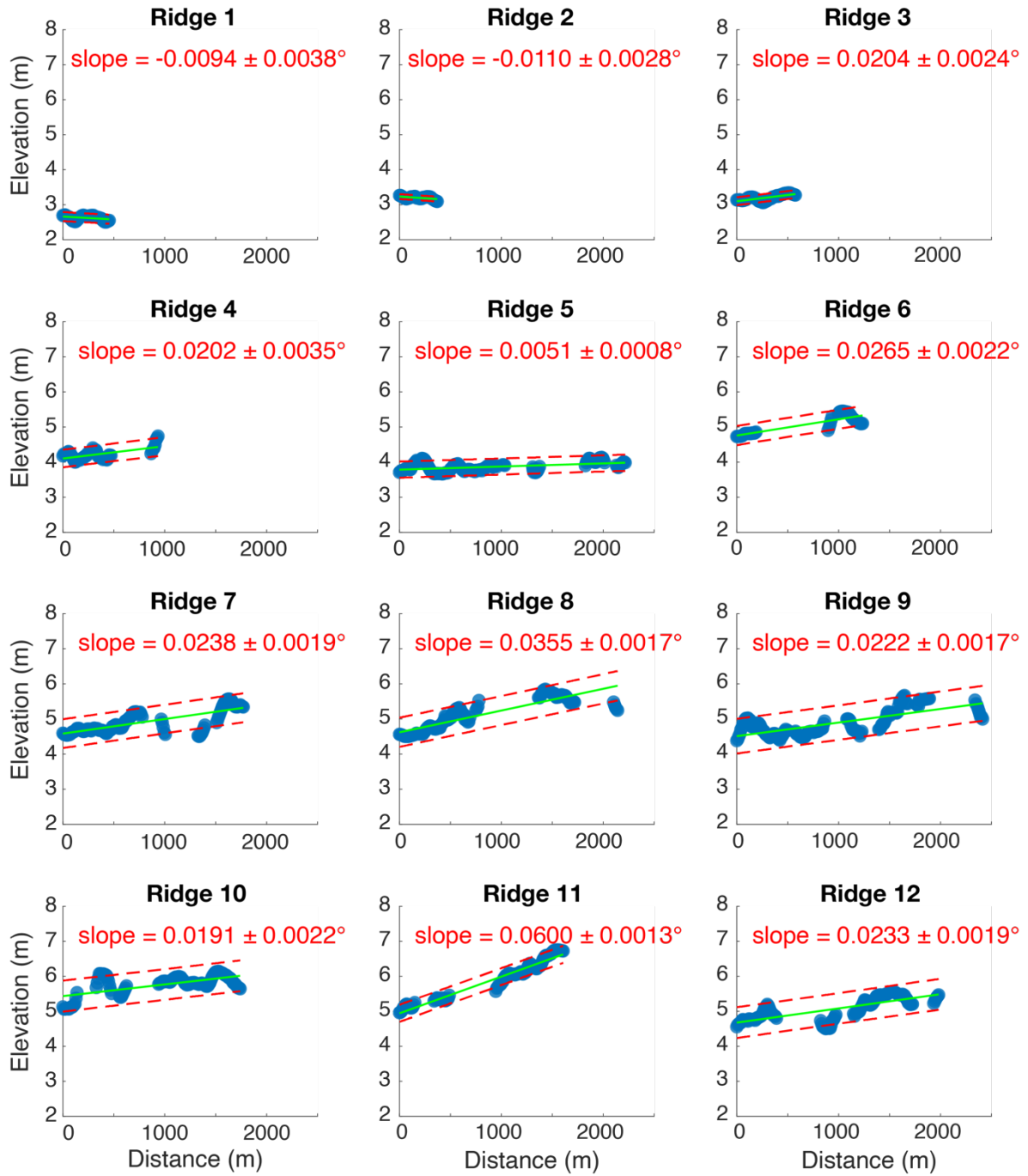


Figure S4. Linear regressions used to estimate tilt angles for individual ridge.

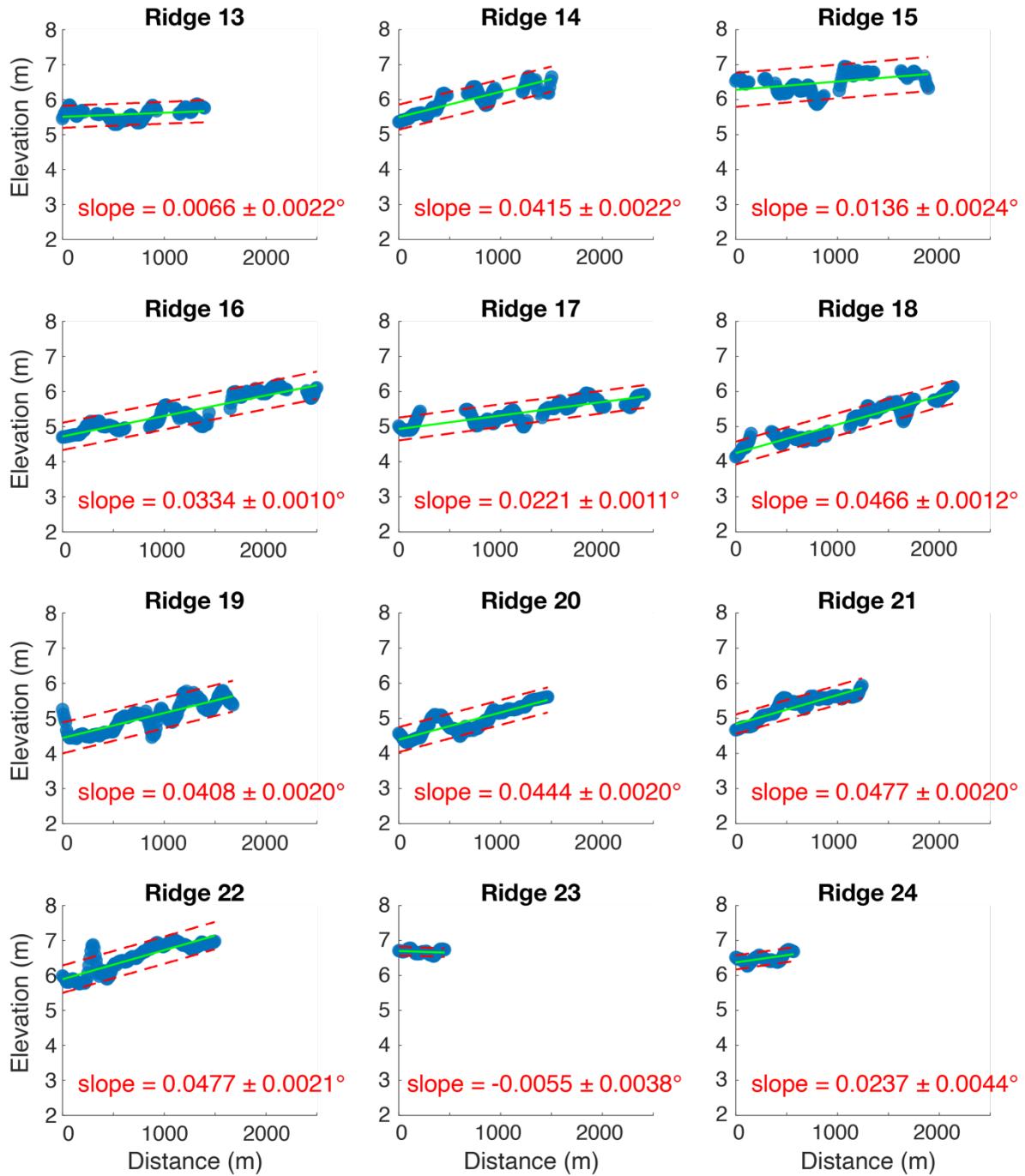


Figure S4. Linear regressions used to estimate tilt angles for individual ridge (continued).

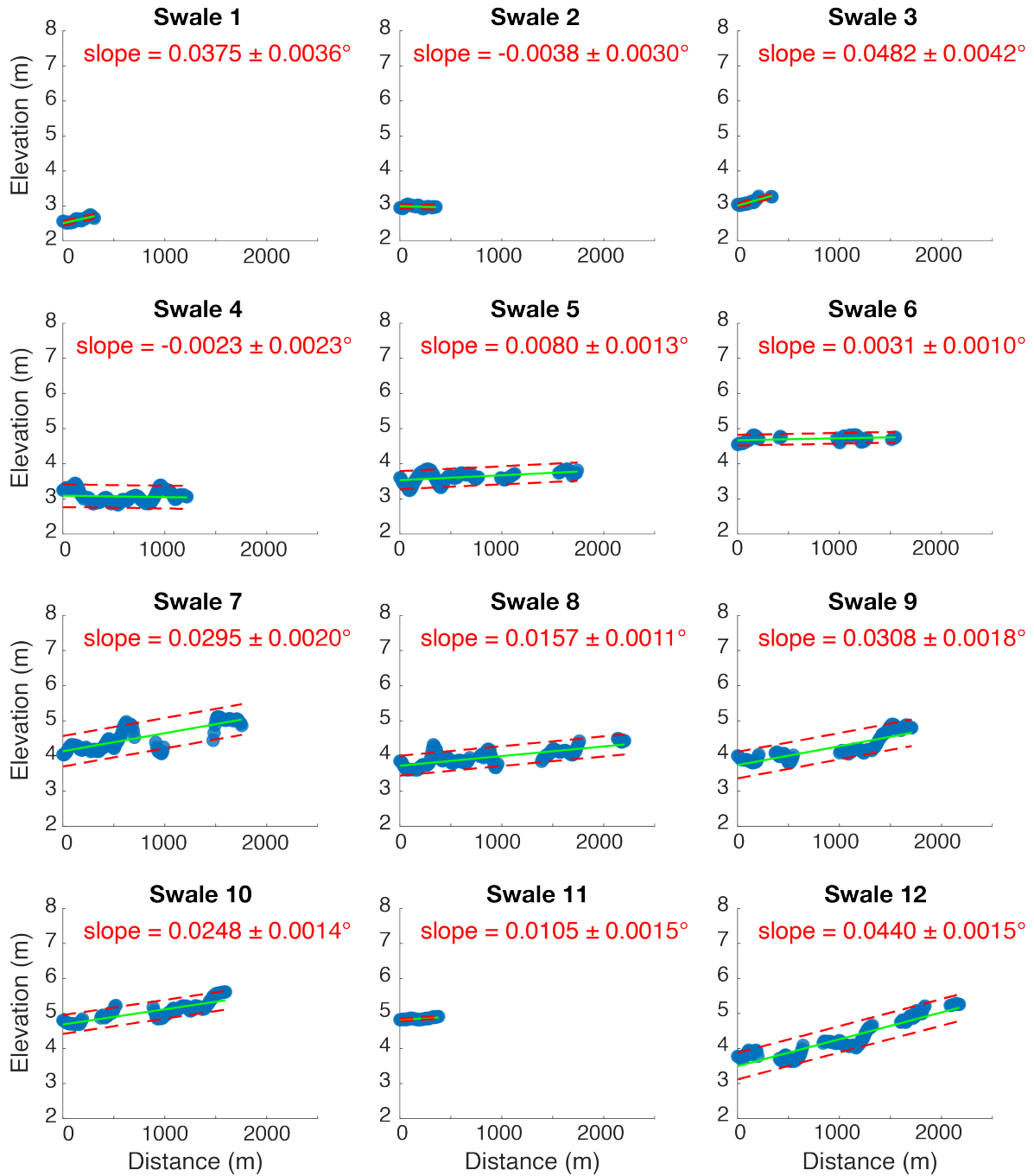


Figure S5. Linear regressions used to estimate tilt angles for individual swale.

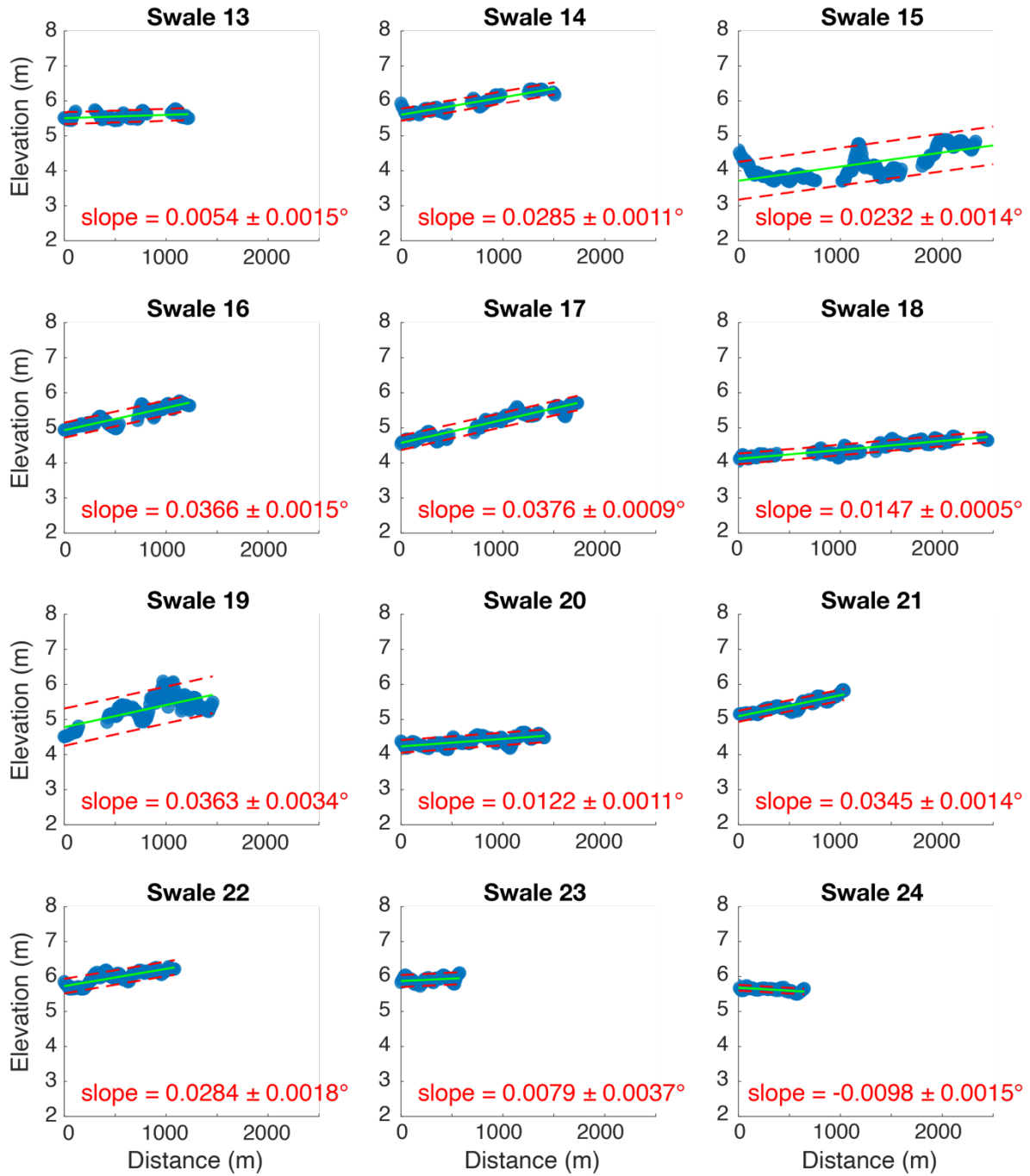


Figure S5. Linear regressions used to estimate tilt angles for individual swale (continued).

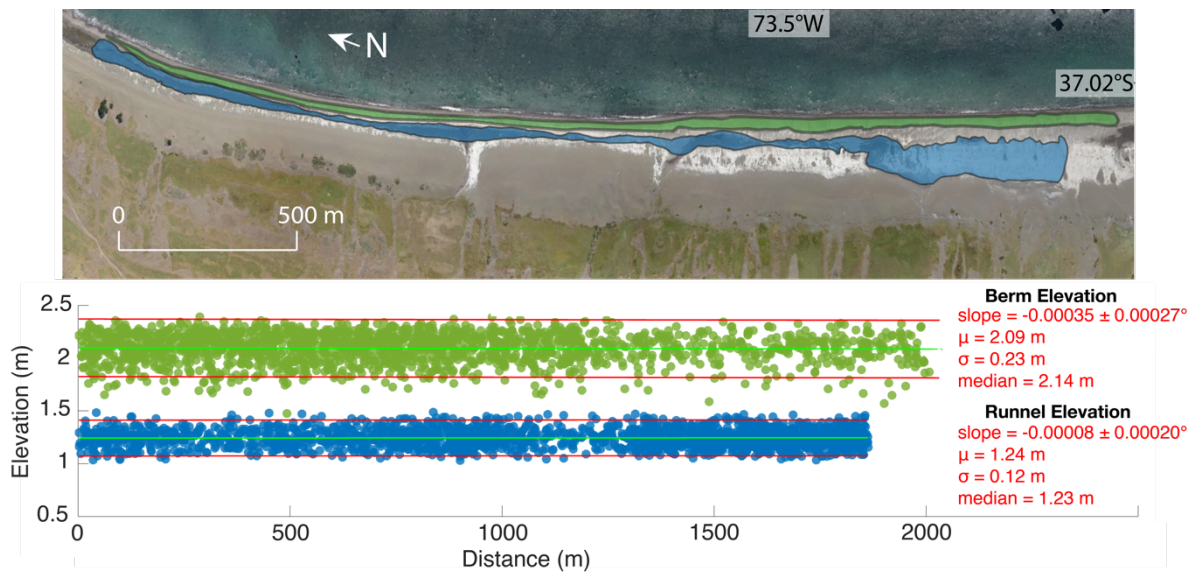


Figure S6. Elevation and extent of the modern berm and runnel calculated from 15-cm drone digital elevation model. Note both are essentially flat.

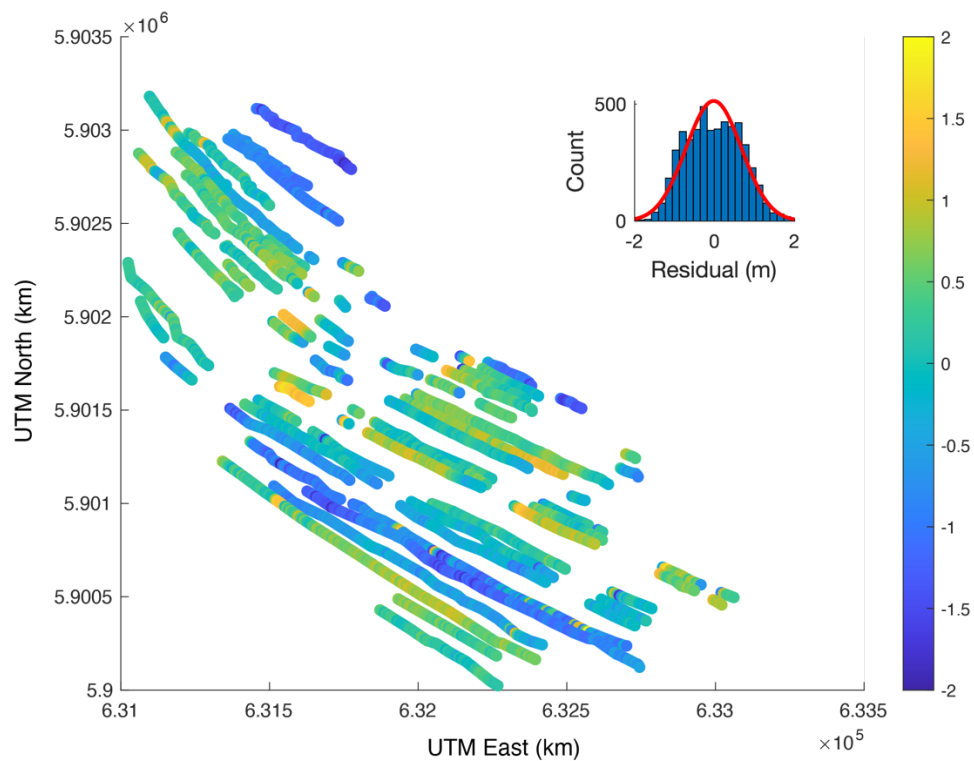


Figure S7. Map of ridge crests color-coded by residual elevation from the adjustment of a plane. Inset shows histogram of residuals and fit to a normal distribution; the X^2/X^{2crit} is below 1 suggesting residuals do not differ at 95% significance from a Gaussian distribution.

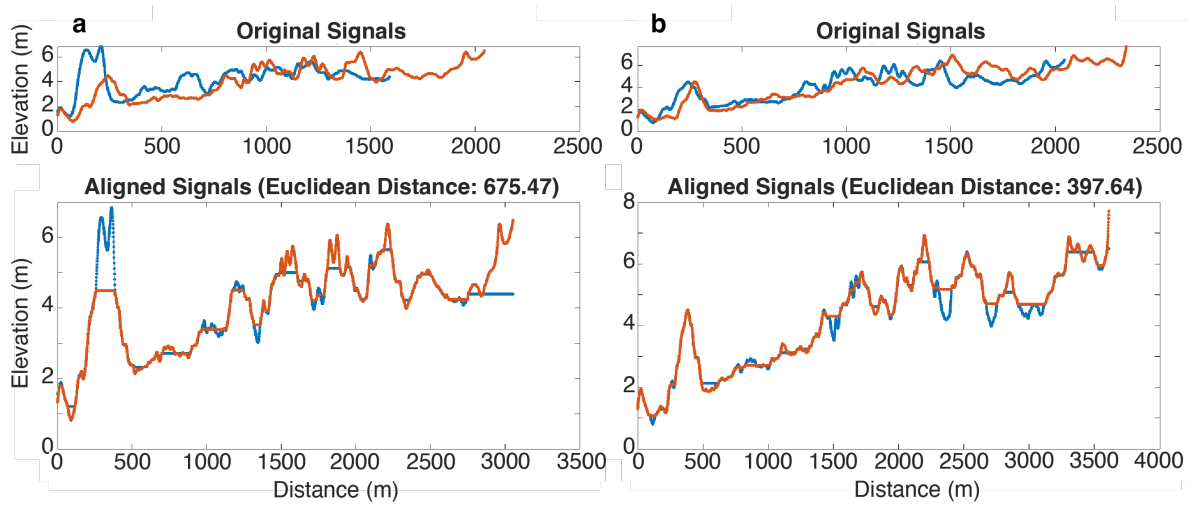


Figure S8. Construction of the composite topographic profile by aligning the three parallel profiles using a Dynamic Time Wrapper algorithm¹³. a) Profiles 1 and 2. b) Profiles 2 and 3.

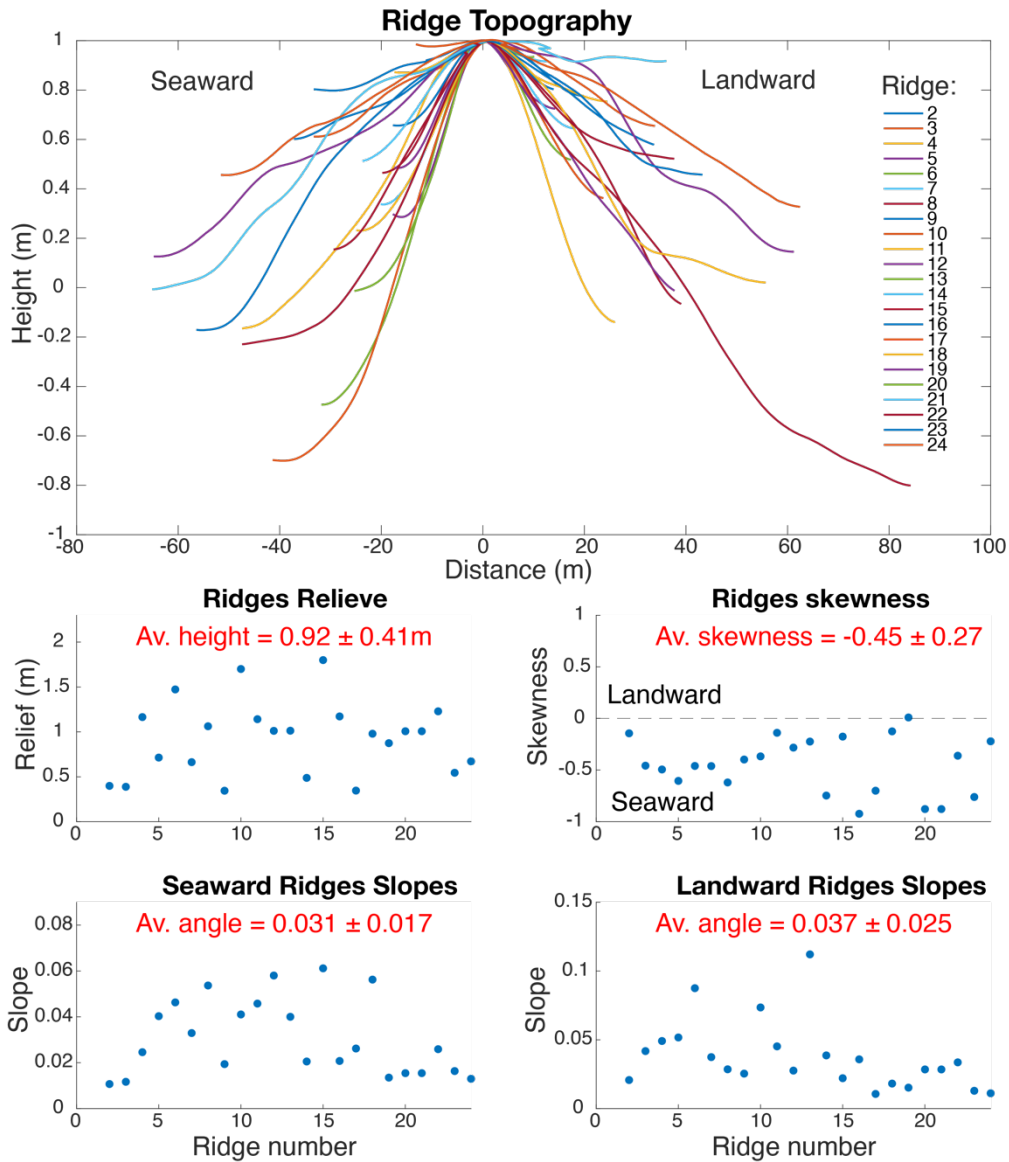


Figure S9. Top panel shows stacked topographic profiles across the 24 ridges. Ridge crests are set to 1 m elevation for stacking and visual comparison purposes. Lower panels show morphometric parameters of the 24 ridges. Note persistent asymmetry and seaward skewness suggesting analogous formation mechanisms.

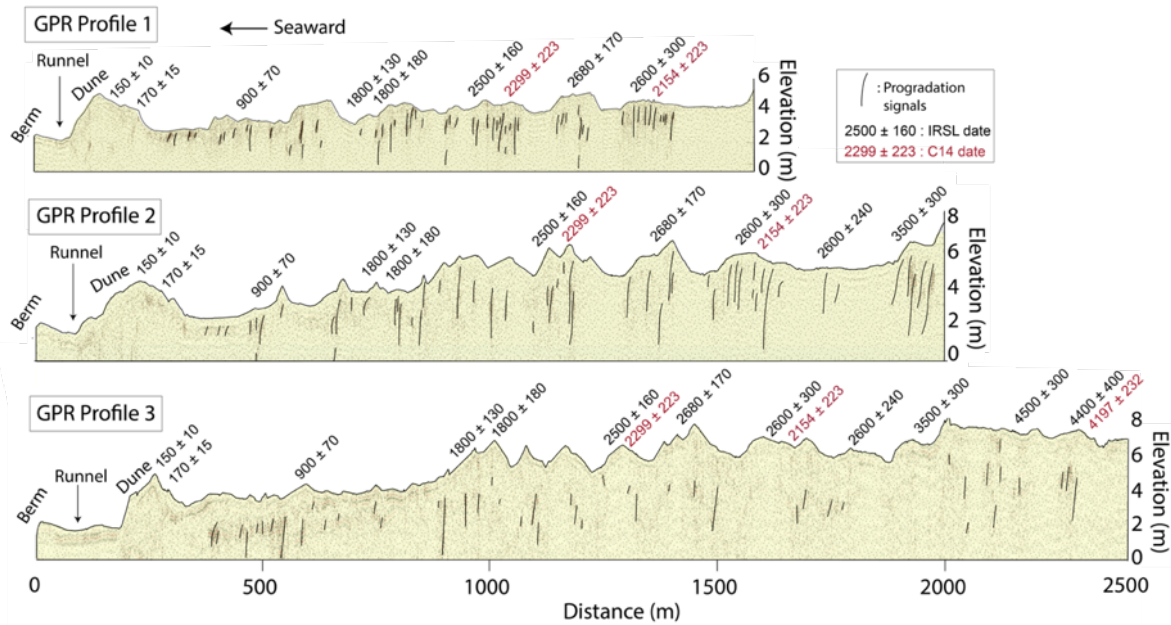


Figure S10. GPR profiles with IRSL and radiocarbon ages. Modern beach to the left with berm, runnel, and dune. Note the progradation signals inclined seaward under the ridges.



Figure S11. Oblique aerial view of the ISM coastal plain highlighting ridges numbers and swales (drone flight by D. Aedo).

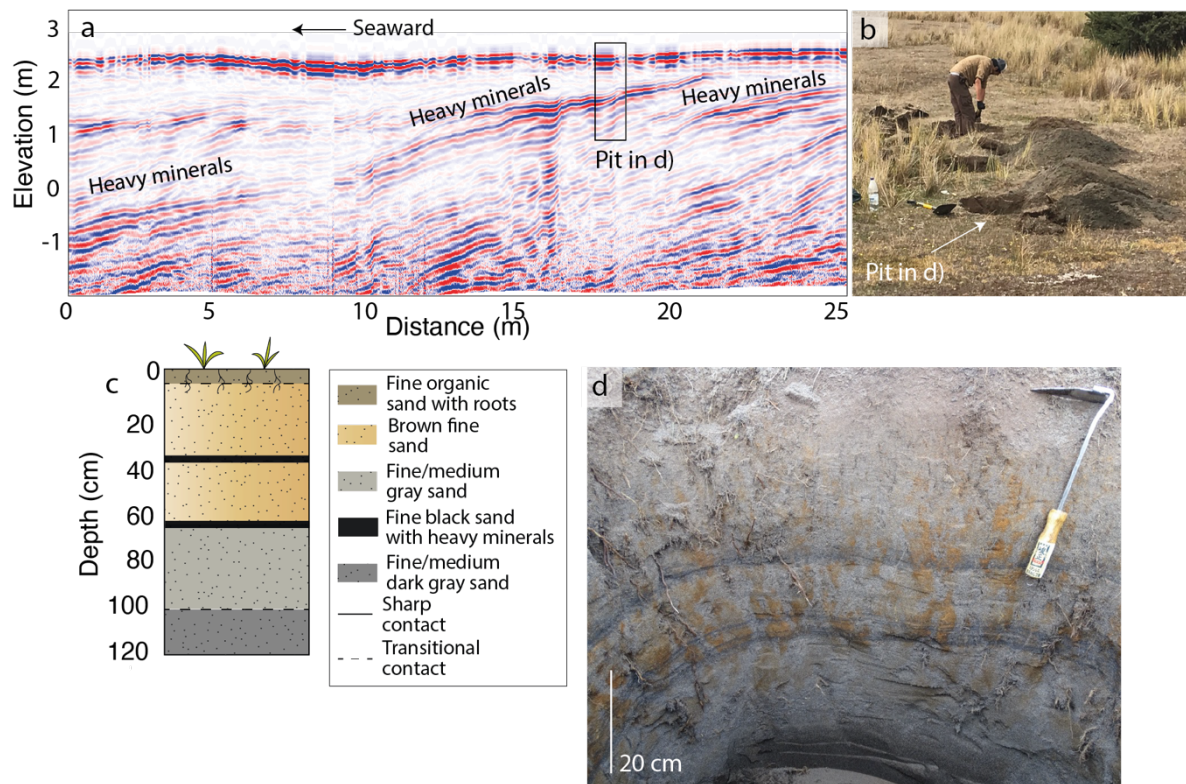


Figure S12. a) GPR profile showing monotonous sequence of prograding beach faces. Location in fig. S11. b) Excavations made in the profile shown in a). c-d) Pit stratigraphy, note the dark heavy mineral layers.

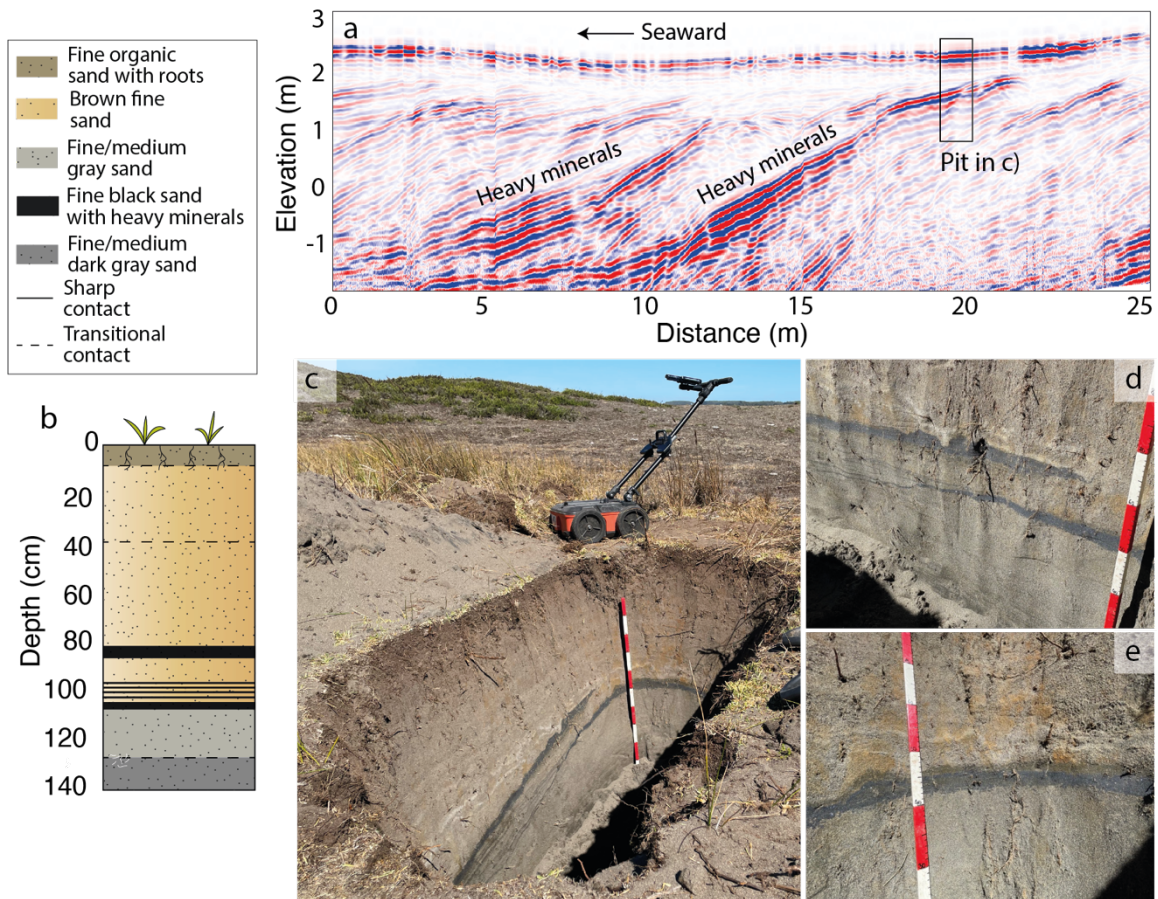


Figure S13. a) GPR profile showing monotonous sequence of prograding beach faces. Location in fig. S11. b) Pit stratigraphy, note the dark heavy mineral layers. c-e). Photos of the pit stratigraphy shown in a). Note the dark heavy mineral layers inclined seaward.

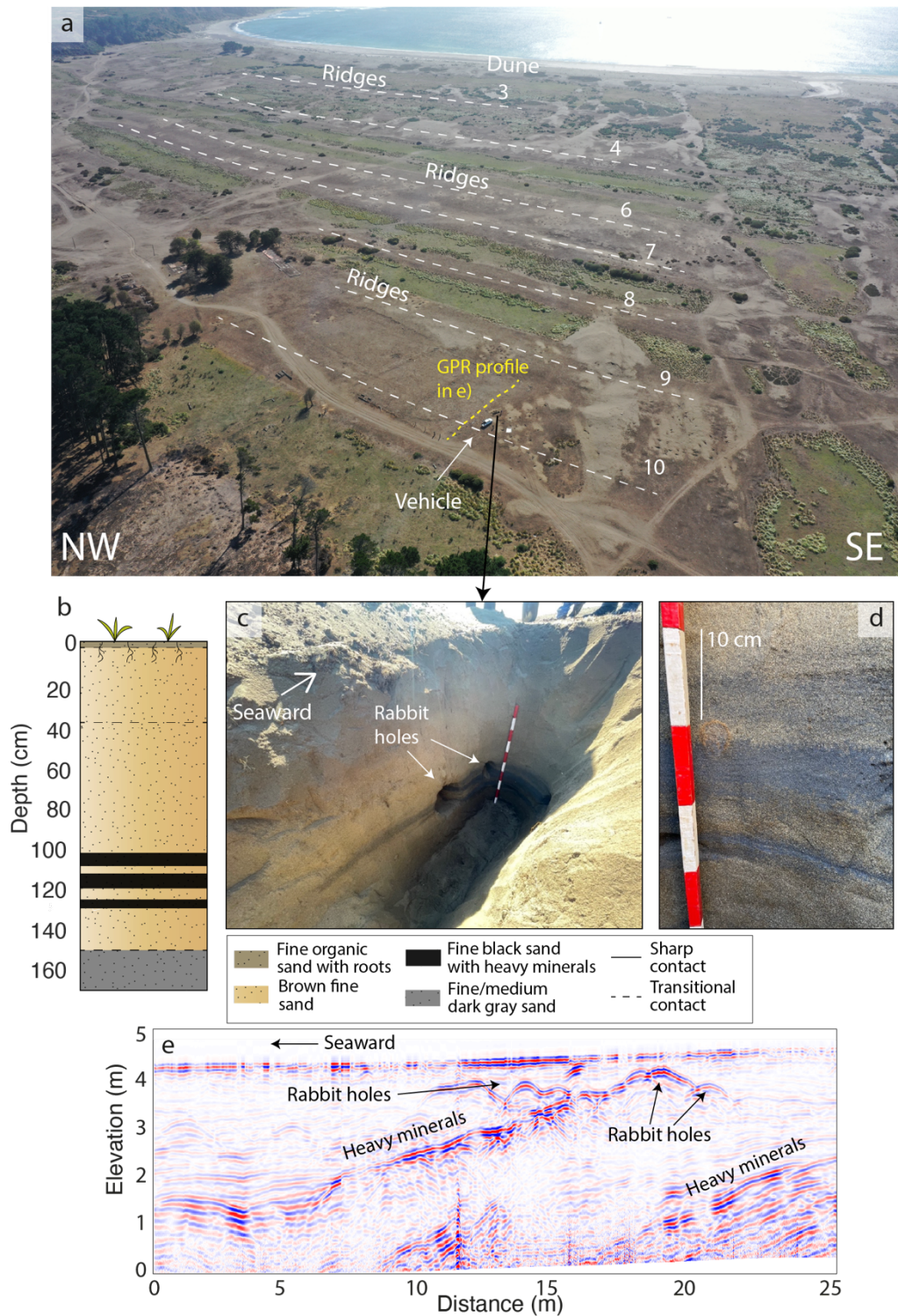


Figure S14. Aerial view of the ISM coastal plain, highlighting numbered ridges and swales (drone flight by D. Aedo), and location of GPR profile in e). b) Pit stratigraphy, note the dark heavy mineral layers. c-e). Images of the pit stratigraphy shown in a). Note the dark heavy mineral layers inclined seaward. e) GPR profile showing progradation signals.

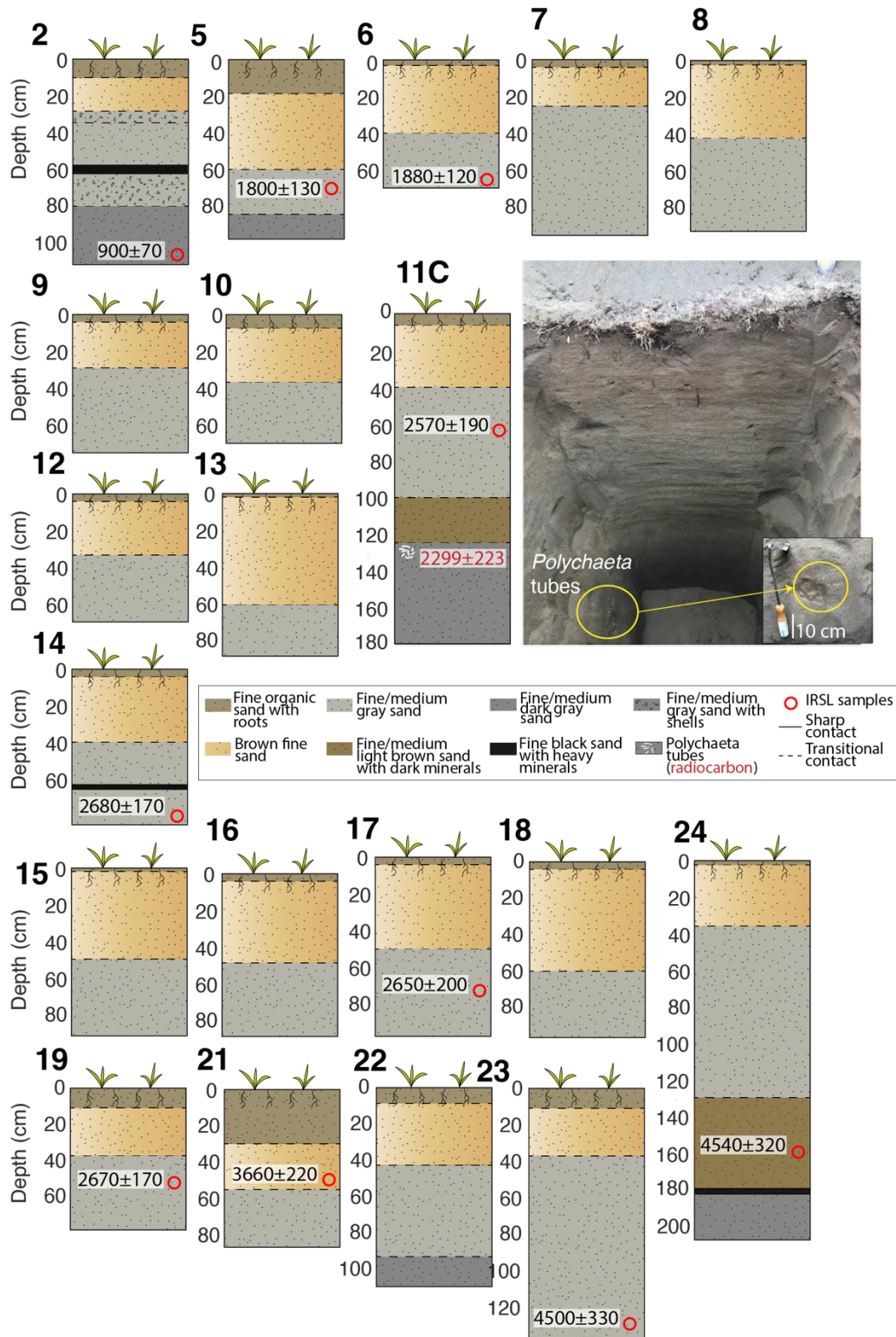
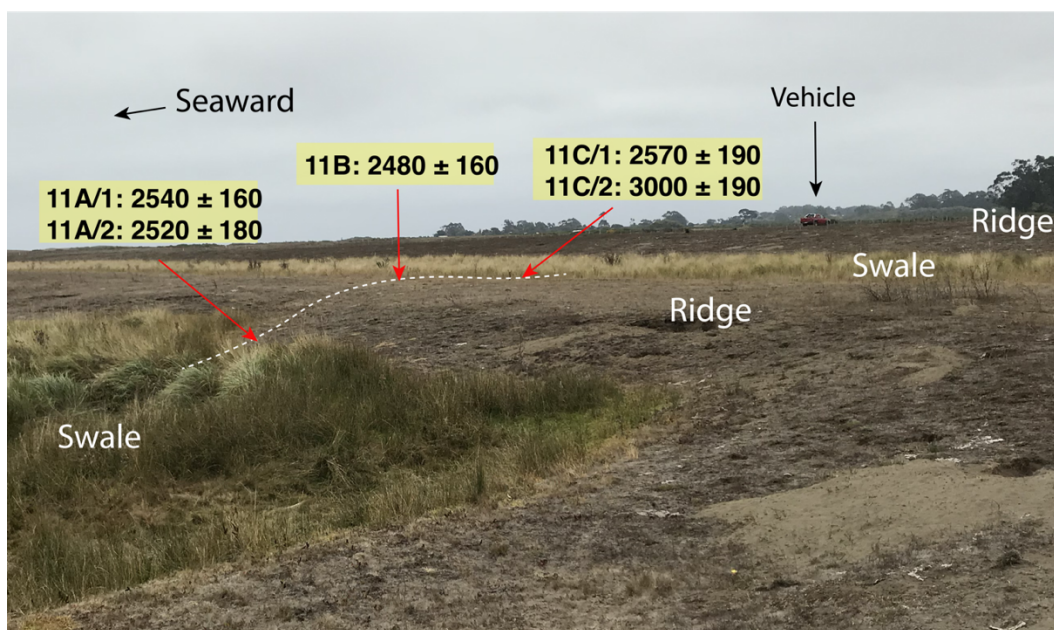


Figure S15. Stratigraphic sections of pits sampled sites for age dating. Pit 5c made on the crest of ridge 11 is highlighted in the center with the granulometry and position where the polychaete sample was taken for radiocarbon dating.

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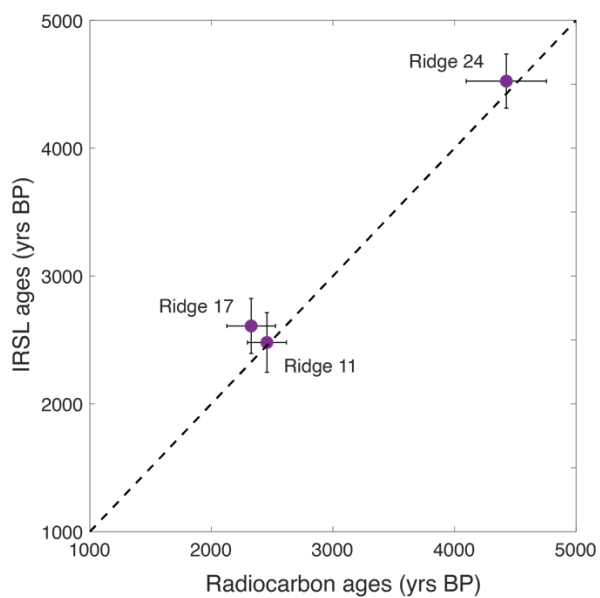


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159 **Figure S16.** Ridge 11 with all IRSL ages. Note overlap within uncertainties suggesting rapid ridge
160 abandonment.

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164 **Figure S17.** Comparison between IRSL and radiocarbon ages of *polychatea* tubes at ridges 11, 17
165 and 24. Note that radiocarbon dating of ridge 17 is younger than ridge 11 and is not consistent.

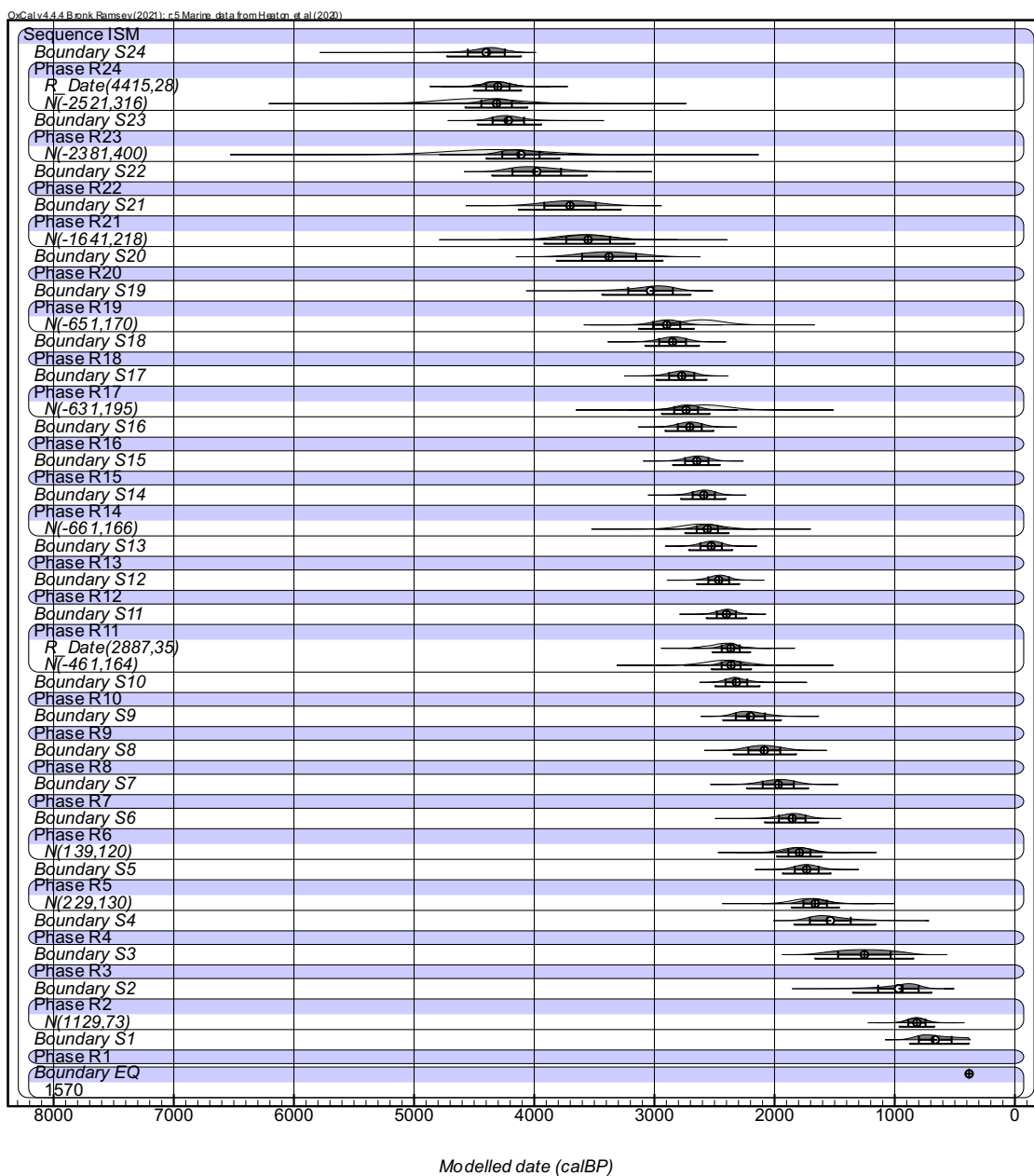


Figure S18. OxCal modeled ages.

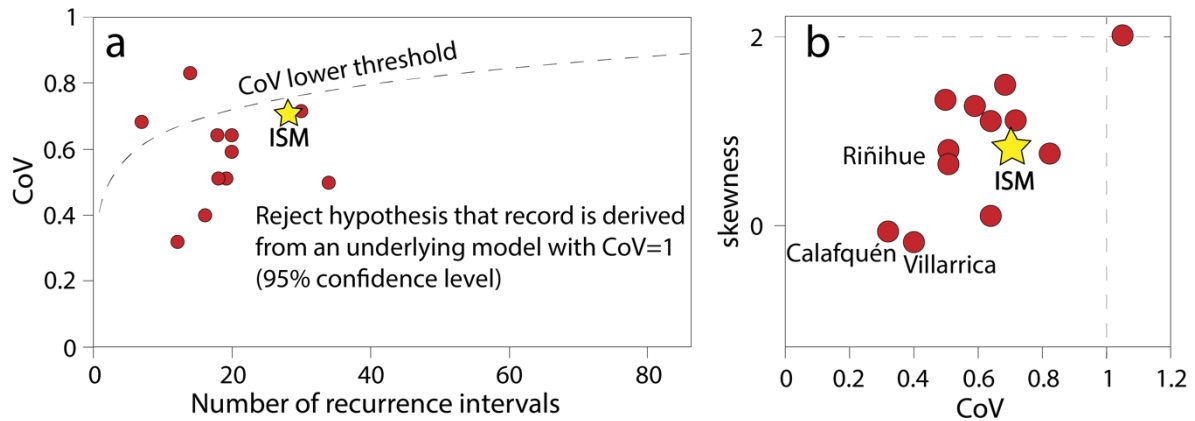


Figure S19. a) CoV and skewness of the ISM record and other subduction zones¹⁴. b) Test to determine whether the CoV can be the result of an underlying model with CoV = 1 of ISM values compared to other subduction zones¹⁴. For records that fall outside the threshold limits, the Poissonian model can be rejected at the 95% confidence level.

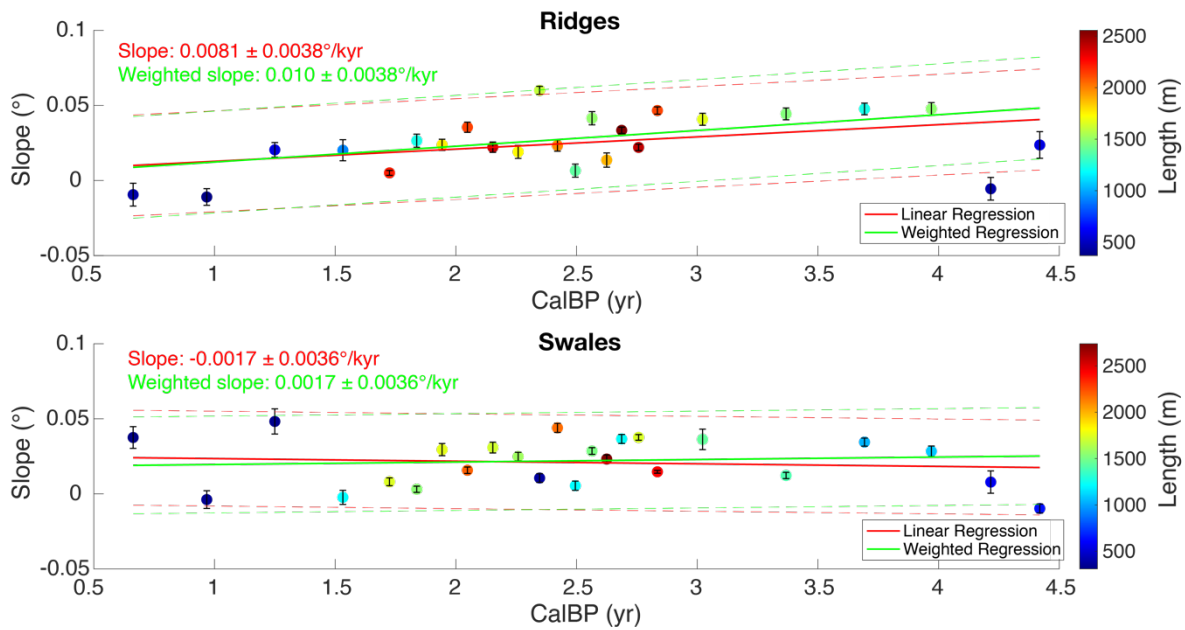


Figure S20. a) Ridges tilting rate using linear regression and weighted linear regression. b) Swale tilting rate using linear regression and weighted linear regression level.

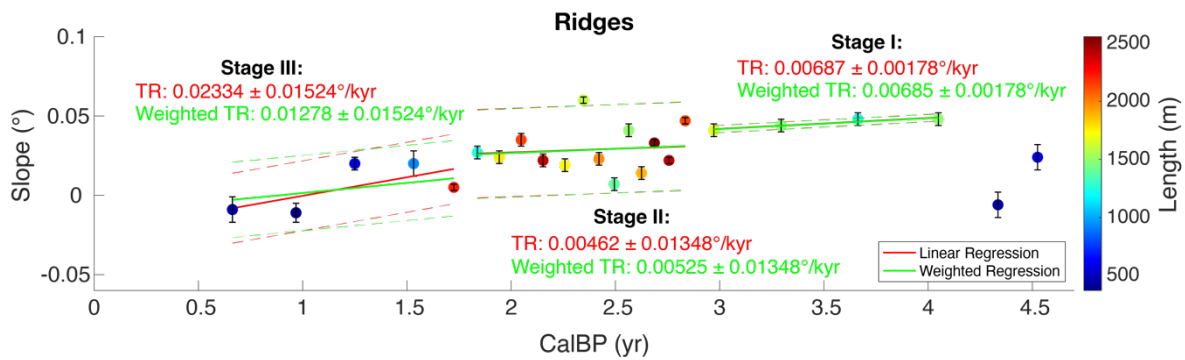


Figure S21. Tilt rate estimated using linear regression and weighted linear regression for the three stages of the beach ridge plain.

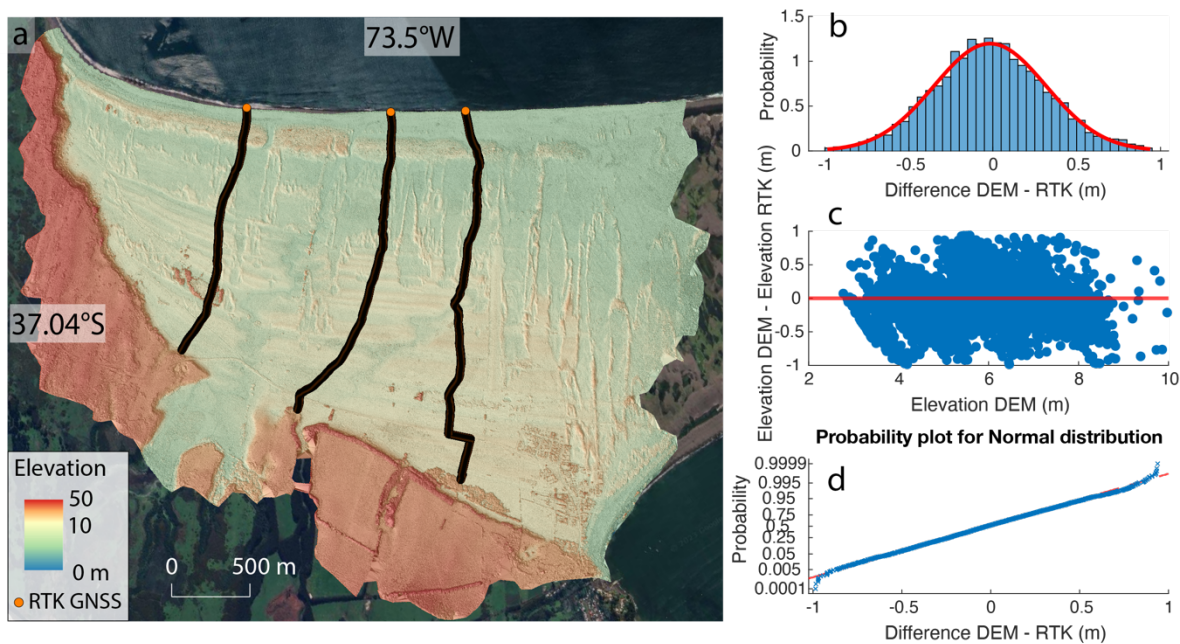


Figure S22. a) ISM coastal plain topography obtained from Ebee drone photogrammetry showing location of the three RTK GNSS control point profiles. b) Histogram with difference between DEM and RTK elevations. c) Comparison between difference between DEM and RTK elevations and DEM elevations. d) Probability plot for Normal distribution of difference between DEM and RTK elevations.

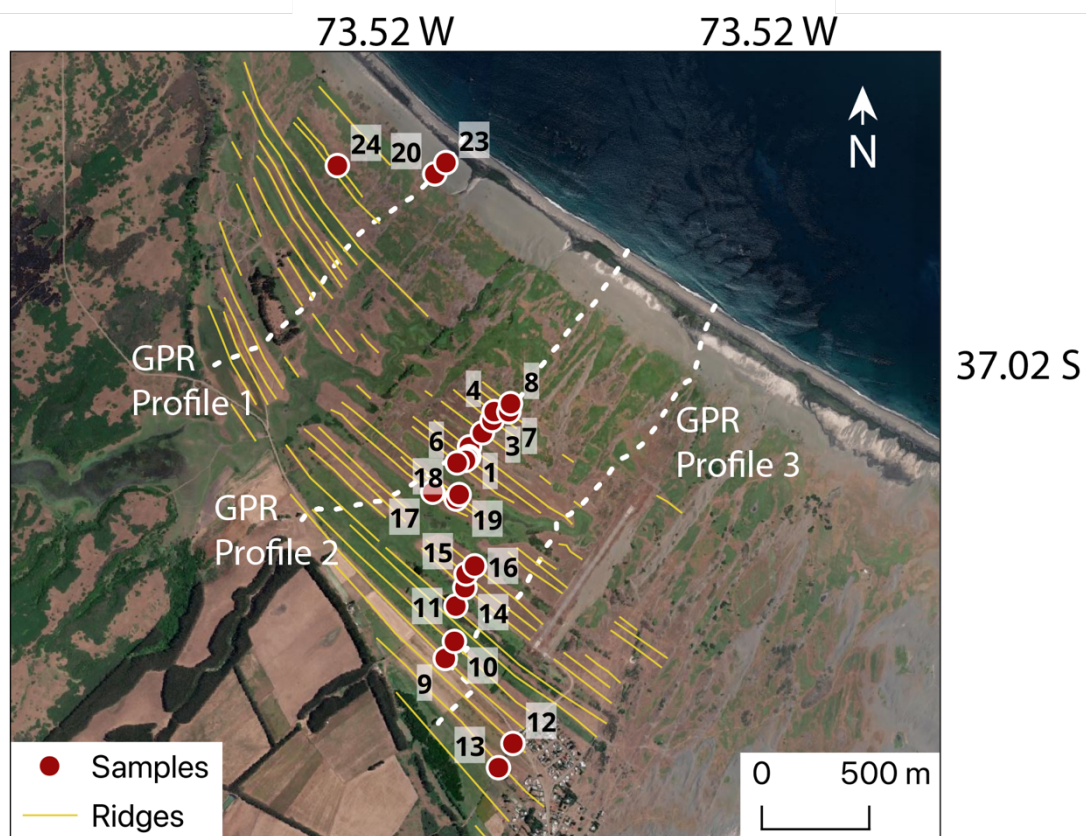


Figure S23. Location of all samples collected for age dating and GPR profiles.

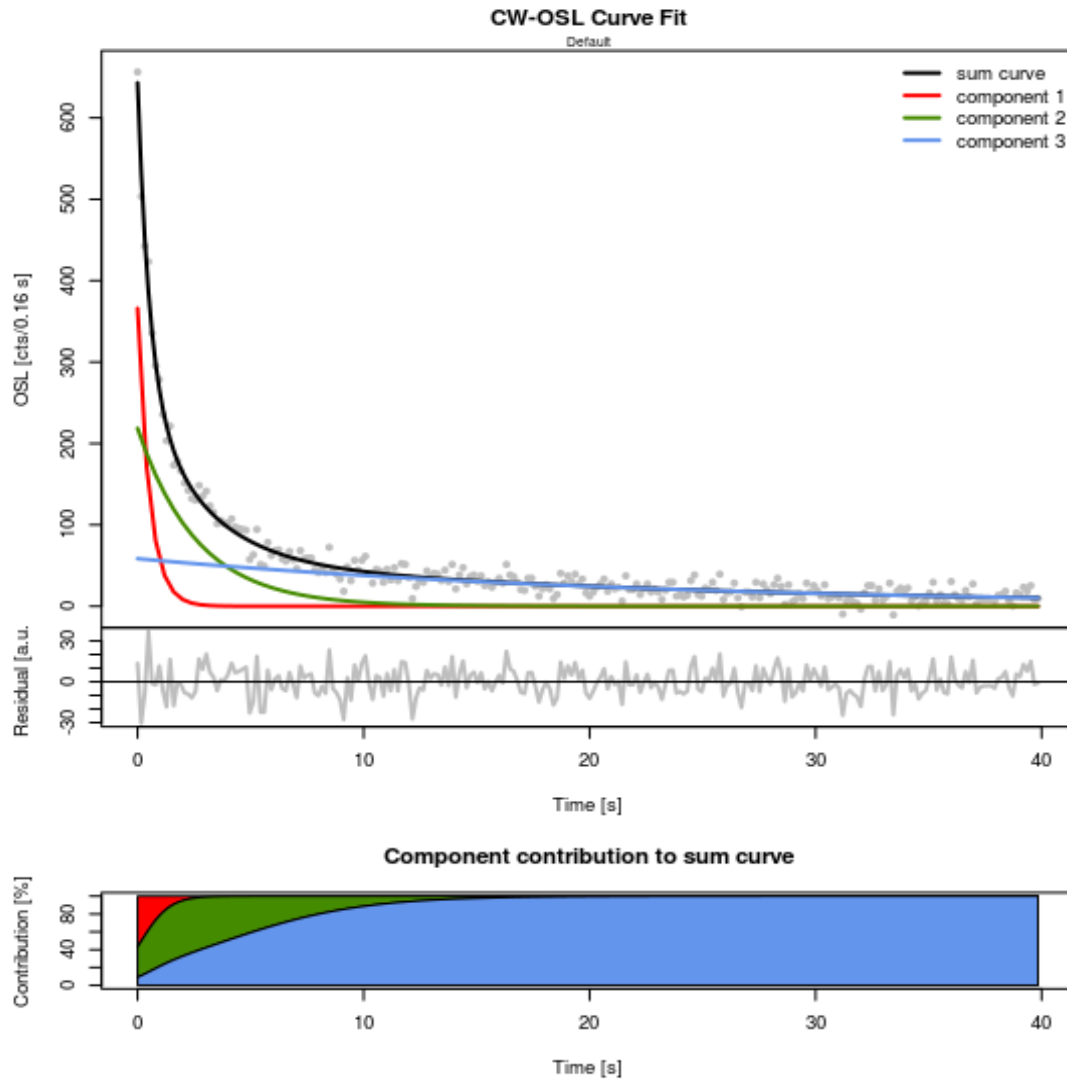


Figure S24. Contributions of signal components to quartz luminescence signals from ISM. A stable fast component (component 1) is present, but there is a strong contribution ($\sim 20\%$ even when early background subtraction is used) of an unstable medium component (component 2) in all samples. Fitting was performed with the R-package "Luminescence"¹⁵.

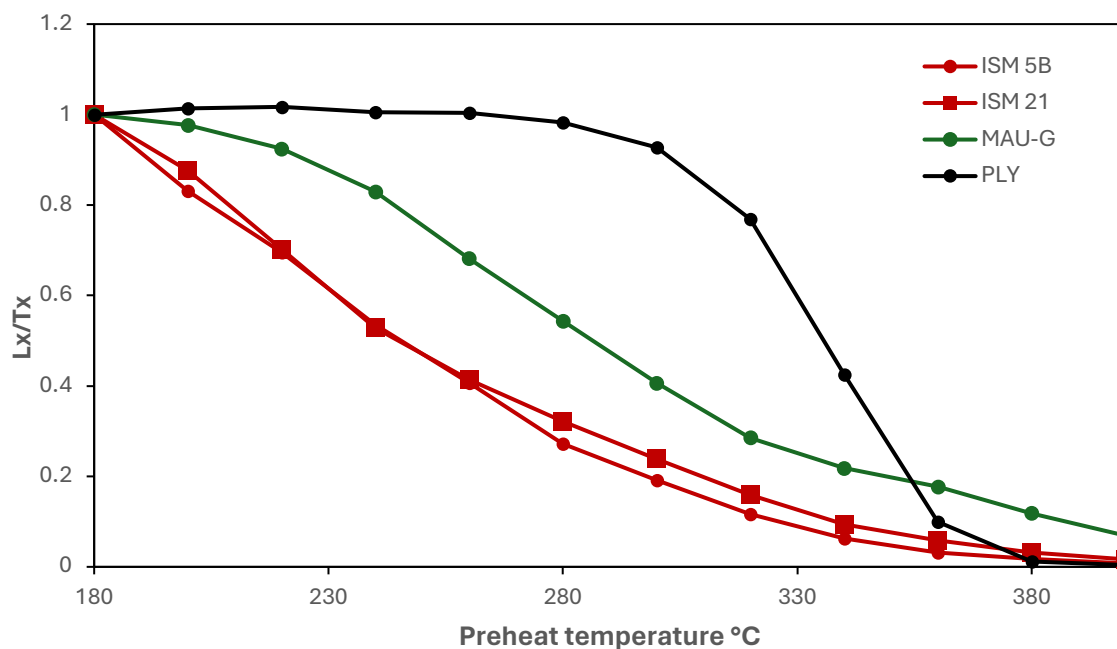


Figure S25. Pulse annealing experiment for two quartz samples from ISM in comparison with an Australian quartz sample with perfect signal behavior (PLY 25-1) and a quartz sample from Maullín, Chile with proven thermal instability^{2,16}.

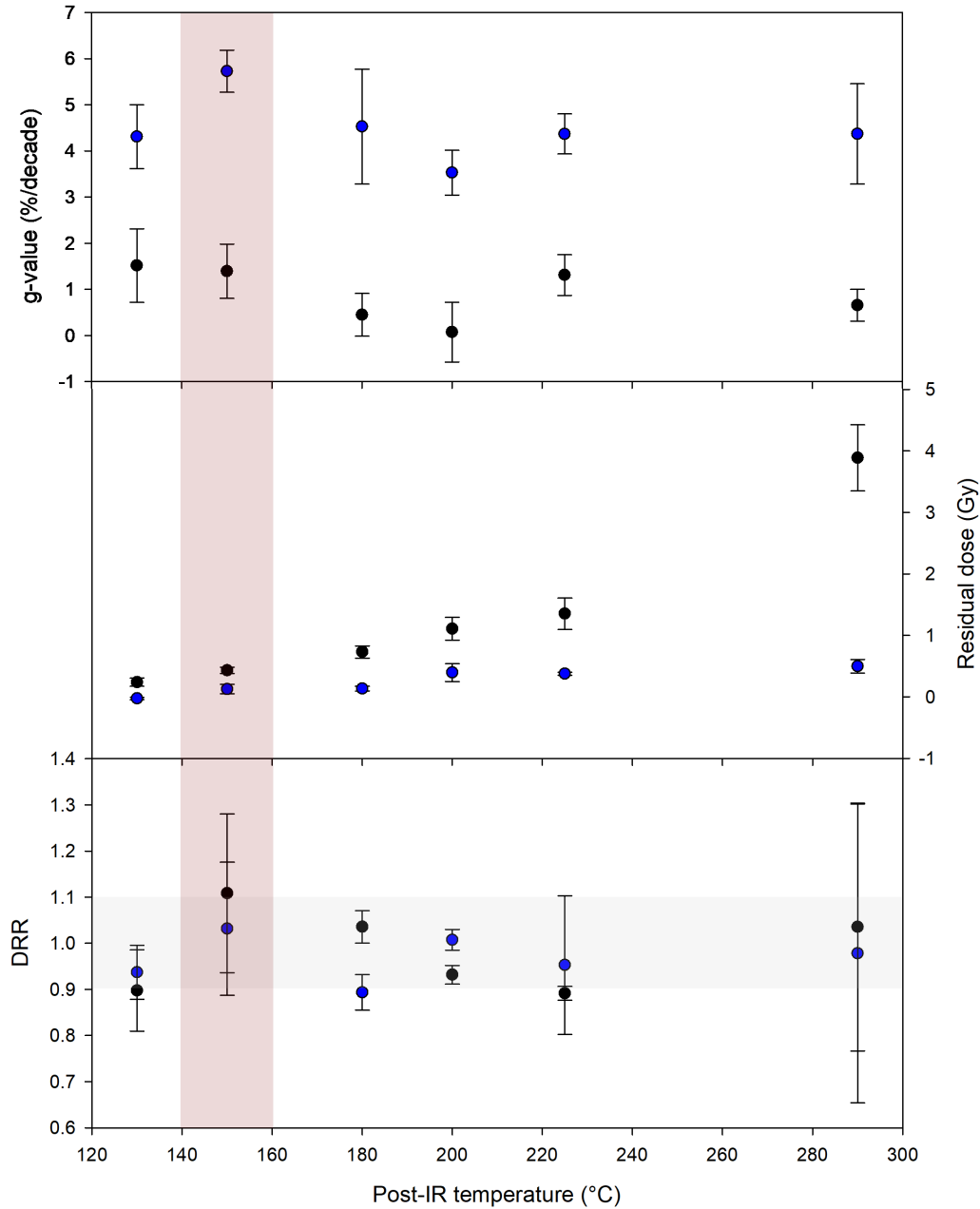
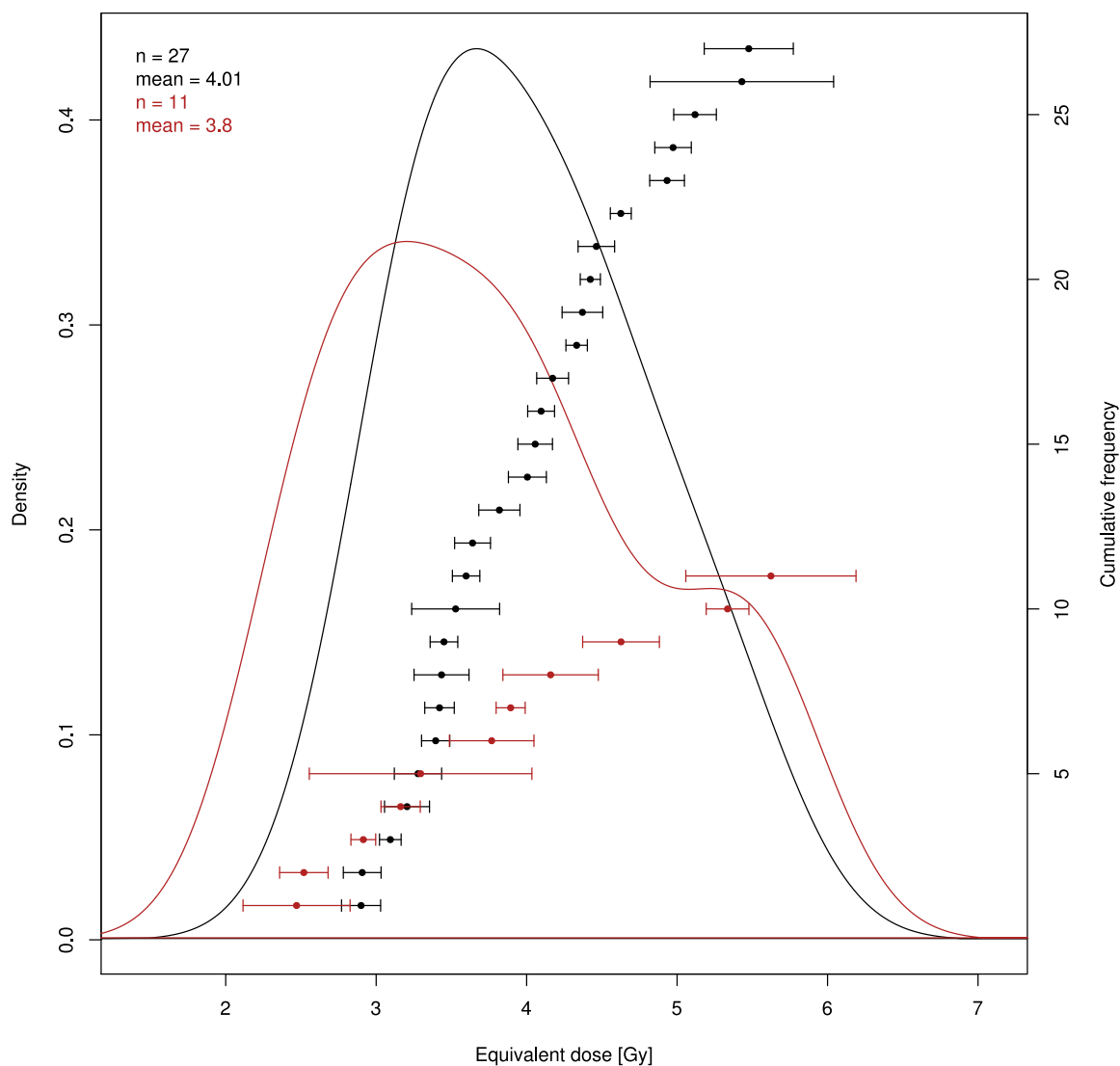


Figure S26. Preheat experiment for selecting suitable post-IRSL-IRSL protocol for the ISM samples. For post-IRSL temperatures of 130, 150, 180, 200, 225 and 290 °C batches of 3 aliquots (2 mm diameter) each were measured to determine temperature-dependent dose recovery ratios (DRR; note: for DRR of post-IRSL signals residuals have been subtracted), residual doses and g-values. IRSL signals within the different post-IRSL protocols are shown with blue, post-IRSL signals with black symbols. The post-IRSL protocol measured at 150 °C (post-IRSL₁₅₀), that was selected for further measurements, is highlighted in red.

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223 **Figure S27.** Equivalent dose distribution of IRSL signals from sample ISM 5B. Shape of the
224 distributions (~normal distribution) and agreement between 1-mm aliquots (red) and 2-mm aliquots
225 (black) indicates complete luminescence signal.

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Supplementary tables

Table S1. Samples collected for dating in each ridge. The coordinates, depth and type of dating applied to each sample are shown.

<i>Ridge</i>	<i>Sample</i>	<i>X</i>	<i>Y</i>	<i>Sample depth (m)</i>	<i>OSL (yrs)</i>	<i>OSL error (yrs)</i>	<i>C14 (yr BP)</i>	<i>C14 error (yrs)</i>	<i>IRSL (yrs)</i>	<i>IRSL error (yrs)</i>	<i>pIRIR (yrs)</i>	<i>pIRIR error (yrs)</i>
24	24	632306	5899961	1.6			4415	28	4540	320	5200	400
23	23	632373	5900074	1.3					4500	330	5600	350
22	22	632058	5900470	0.75								
21	21	632101	5900549	0.5	2500	300			3660	220	4000	250
20	-	-	-	-								
19	19	632107	5900714	0.55					2670	170	2800	200
18	18	632150	5900799	0.8								
17	17	632155	5900863	0.75			2773	34	2650	200	2900	250
16	16	632195	5900901	0.7								
15	15	632000	5901244	0.7								
14	14	632109	5901212	0.8					2680	170	3000	210
13	13	632123	5901233	0.8								
12	12	632113	5901380	0.57								
11	11A/1 front	632168	5901409	0.7					2540	160		
	11A/2 front	632168	5901409	2.1					2520	180		
	11B top	632163	5901401	0.8	2100	140	2887	35	2480	160	2900	200
	11C/1 back	632152	5901392	0.6					2570	190		
	11C/2 back	632152	5901392	1.3					3000	190		
10	10	632171	5901455	0.55								
9	9	632231	5901520	0.65								
8	8	632276	5901578	0.65								
7	7	632286	5901619	0.7								
6	6	632354	5901618	0.7	1900	130			1880	120	2300	230
5	5	632362	5901656	0.7					1800	130	1720	140
4	-	-	-	0.8								
3	-	-	-	1.1								
2	2	631556	5902764	1.1					900	70	1300	90
1	-	-	-	-								
Dune1	D1	632010	5902726	0.4					170	15	440	50
Dune2	D2	632061	5902778	0.1					150	10	450	110

Table S2. Summary of dose information for luminescence dating of quartz and feldspar (IRSL and pIR150). OD – over-dispersion, Age unc. – age not corrected for fading, Age cor. – Age corrected for fading using a mean g-value of 4.2 ± 0.1 %/decade. IRSL-based luminescence ages used for chronological interpretations are highlighted.

Sample	Ridge	Lab-ID	Signal	Size (mm)	N	OD (%)	Dose (Gy)	Age unc. (ka)	g-value (%/dec)	Age cor. (ka)
ISM 2	2	C-L4853	IRSL	2	20	18.8±3.8	1.36±0.07	0.637±0.048	4.6±0.4	0.89±0.073
			pIR150	2	15	8.3±3.4	2.74±0.1	1.283±0.085	-0.3±0.1	-
ISM 5	5	C-L4837	IRSL	2	20	16.1±2.9	2.76±0.11	1.274±0.087	4.3±0.3	1.79±0.13
			pIR150	2	7	11.7±5.9	3.73±0.23	1.722±0.143	1.2±0.1	-
ISM 6	6	C-L4836	Quartz	8	14	19±4.6	2.98±0.17	1.875±0.132	-	-
			IRSL	2	20	11.3±2.2	2.94±0.08	1.326±0.081	3.2±0.5	1.88±0.12
			pIR150	2	14	29.5±6.3	5.01±0.42	2.26±0.226	0.4±0.6	-
ISM 11A1	11	C-L4830	IRSL	2	21	12.6±2.2	3.91±0.12	1.783±0.112	4.3±0.2	2.54±0.158
			pIR150	2	19	20.1±3.9	6.85±0.35	3.123±0.234	-2±1.2	-
ISM 11A2	11	C-L4831	IRSL	2	21	14.8±2.6	3.82±0.13	1.768±0.115	4.4±0.2	2.52±0.18
			pIR150	2	15	8.9±2.3	6.24±0.18	2.888±0.18	-0.6±1.5	-
ISM 11B	11	C-L4832	Quartz	8	22	24.6±4	3.27±0.18	2.095±0.144	-	-
			IRSL	2	27	15.6±2.5	3.94±0.13	1.737±0.112	4.5±0.4	2.48±0.164
			pIR150	2	21	13.7±3.1	6.5±0.24	2.912±0.191	1.4±0.6	-
ISM 11C1	11	C-L4833	IRSL	2	18	17.5±3.4	3.96±0.18	1.8±0.128	4.2±0.4	2.57±0.19
			pIR150	2	15	31.9±6.6	5.36±0.47	2.436±0.252	0.4±0.6	-
ISM 11C2	11	C-L4834	IRSL	2	20	9.6±1.7	4.55±0.1	2.09±0.124	4.7±0.3	2.99±0.19
			pIR150	2	15	8.3±2	6.78±0.16	3.115±0.186	3.1±1.3	-
ISM 14	14	C-L4847	IRSL	2	19	10.3±2.1	4.25±0.11	1.882±0.113	4.6±0.4	2.68±0.166
			pIR150	2	18	16.7±3.5	6.73±0.3	2.981±0.209	2.7±0.6	-
ISM 17	17	C-L4844	IRSL	2	17	15.2±3	4.04±0.16	1.862±0.126	4.7±0.5	2.65±0.195
			pIR150	2	15	21.7±4.8	6.18±0.38	2.849±0.235	4.8±1.4	-
ISM 19	19	C-L4840	IRSL	2	19	12.1±2.3	4.34±0.13	1.866±0.114	3.9±0.6	2.67±0.17
			pIR150	2	11	14±4.4	6.53±0.34	2.807±0.209	1.6±0.8	-
ISM 21	21	C-L4839	Quartz	8	14	47.4±9	3.91±0.5	2.524±0.339	-	-
			IRSL	2	19	8.5±1.8	5.55±0.13	2.546±0.152	2.7±0.2	3.66±0.218
			pIR150	2	11	4.7±4.1	8.66±0.26	3.969±0.248	0.2±0.6	-
ISM 23	23	C-L4841	IRSL	2	22	14.7±2.5	6.28±0.21	3.097±0.205	4.5±0.5	4.48±0.327
			pIR150	2	14	5.2±4	11.43±0.35	5.637±0.365	0.9±0.8	-
ISM 24	24	C-L4842	IRSL	2	19	15.8±2.8	6.76±0.26	3.139±0.212	3.7±0.7	4.54±0.316
			pIR150	2	8	15.4±4.7	11.14±0.67	5.172±0.423	0.3±0.9	-
ISM D1	Dune/1	C-L4849	Quartz	8	17	23.8±6.3	0.46±0.03	0.292±0.023	-	-
			IRSL	2	17	24.9±7.2	0.29±0.02	0.132±0.012	4.3±0.4	0.174±0.014
			pIR150	2	15	32.2±7.3	0.96±0.09	0.436±0.047	2.1±0.5	-
ISM B1	Beach	C-L4850	Quartz	8	15	19.5±4	1.04±0.06	0.607±0.043	-	-
			IRSL	2	20	58.6±16.6	0.15±0.02	0.064±0.009	4.5±0.3	0.079±0.014
			pIR150	2	13	33±8.6	0.77±0.08	0.329±0.038	-0.7±1.2	-
ISM B2	Beach	C-L4851	IRSL	2	19	46.1±9.6	0.18±0.02	0.081±0.01	4.5±0.5	0.106±0.014
			pIR150	2	16	46.6±10.5	0.7±0.09	0.315±0.044	1.9±0.1	-
ISM D2	Dune/2	C-L4852	IRSL	2	20	35.6±9	0.26±0.03	0.113±0.014	3.4±0.7	0.148±0.014
			pIR150	2	7	57.2±17.1	1.04±0.24	0.451±0.107	1.8±0.5	-

Table S3. Protocols for quartz (a) and feldspar (b) dose determination. R1-x = regeneration doses, RR = recycling dose, DR = depletion ratio, R0 = zero dose (recuperation).

a) Quartz SAR protocol

Step	Treatment	Signal
1	Preheat (180 °C for 10 s)	
2	Blue LEDs (40 s @ 125 °C)	Lx (OSL)
3	Test dose	
4	Cutheat (160 °C)	
5	Blue LEDs (40 s @ 125 °C)	Tx (OSL)
6	Dose (R1-R4, R0, RR, DR)	
7	Return to step 1	

b) pIRIR150 protocol for potassium feldspar

Step	Treatment	Signal
1	Preheat (180 °C for 60 s)	
2	IR LEDs (200 s @ 50 °C) for SA	Lx (IR ₅₀)
3	IR LEDs (200 s @ 150 °C) for SA	Lx (pIRIR ₁₅₀)
4	Test dose	
5	Preheat (180 °C for 60 s)	
6	IR LEDs (200 s @ 50 °C) for SA	Tx (IR ₅₀)
7	IR LEDs (200 s @ 150 °C) for SA	Tx (pIRIR ₁₅₀)
8	IR LEDs (100 s @ 200 °C)	
9	Dose (R1-R4, R0, RR)	
10	Return to step 1	

Table S4. Summary of dose rate (DR) information for IRSL luminescence dating.

Sample	Lab-ID	U (ppm)	Th (ppm)	K (%)	Water (mass-%)	Cosmic DR (Gy/ka)	Internal DR (Gy/ka)	External DR (Gy/ka)	Total DR (Gy/ka)
ISM 2	C-L4853	0.9±0.05	3.07±0.19	0.96±0.01	5±22	0.18±0.02	0.54±0.1	1.6±0.07	2.14±0.12
ISM 5	C-L4837	0.91±0.06	3.48±0.22	0.95±0.01	5±11	0.19±0.02	0.54±0.1	1.63±0.07	2.17±0.12
ISM 6	C-L4836	0.89±0.06	3.32±0.21	1.02±0.01	5±10	0.19±0.02	0.54±0.1	1.68±0.07	2.22±0.12
ISM 11A1	C-L4830	0.91±0.06	3.36±0.21	1±0.01	5±5	0.19±0.02	0.54±0.1	1.67±0.07	2.21±0.12
ISM 11A2	C-L4831	0.92±0.06	3.33±0.21	1.12±0.01	5±6	0.15±0.02	0.54±0.1	1.75±0.08	2.29±0.12
ISM 11B	C-L4832	0.89±0.06	3.27±0.21	1±0.01	5±7	0.18±0.02	0.54±0.1	1.65±0.07	2.19±0.12
ISM 11C1	C-L4833	0.93±0.06	3.39±0.21	1.09±0.01	5±8	0.19±0.02	0.54±0.1	1.77±0.08	2.31±0.12
ISM 11C2	C-L4834	0.94±0.06	3.51±0.22	1.12±0.01	5±9	0.17±0.02	0.54±0.1	1.79±0.08	2.33±0.12
ISM 14	C-L4847	0.94±0.06	3.46±0.22	1.04±0.01	5±17	0.18±0.02	0.54±0.1	1.72±0.08	2.26±0.12
ISM 17	C-L4844	0.88±0.06	3.28±0.21	0.98±0.01	5±16	0.18±0.02	0.54±0.1	1.63±0.07	2.17±0.12
ISM 19	C-L4840	0.95±0.06	3.63±0.23	1.08±0.01	5±13	0.2±0.02	0.54±0.1	1.79±0.08	2.33±0.12
ISM 21	C-L4839	0.91±0.06	3.48±0.22	0.95±0.01	5±12	0.2±0.02	0.54±0.1	1.64±0.07	2.18±0.12
ISM 23	C-L4841	0.89±0.05	3.09±0.19	0.86±0.01	5±14	0.17±0.02	0.54±0.1	1.49±0.07	2.03±0.12
ISM 24	C-L4842	0.97±0.06	3.5±0.22	0.94±0.01	5±15	0.16±0.02	0.54±0.1	1.62±0.07	2.15±0.12
ISM D1	C-L4849	0.86±0.06	3.01±0.19	1.05±0.01	5±18	0.17±0.02	0.54±0.1	1.66±0.07	2.2±0.12
ISM B1	C-L4850	0.92±0.06	2.97±0.19	1.15±0.01	5±19	0.21±0.02	0.54±0.1	1.81±0.08	2.34±0.12
ISM B2	C-L4851	0.86±0.06	3.01±0.19	1.05±0.01	5±20	0.25±0.03	0.54±0.1	1.69±0.07	2.23±0.12
ISM D2	C-L4852	0.91±0.06	3.22±0.2	1.13±0.01	5±21	0.17±0.02	0.54±0.1	1.77±0.08	2.31±0.12

Table S5. Radiocarbon data of *polychaete* tubes collected.

Field number	Ridge number	Laboratory code	Coordinates (UTM)	Material	Sample Deep (m)	δ13C	¹⁴ C age and error (¹⁴ C yr BP)	Delta R and error (yr)	Age Cal yr BP (1σ)
F-5c	11	D-AMS 036521	632152-5901392	<i>Polychaete</i> tubes	1.30	-10.6	2887 ± 35	43 ± 52	2210 - 2668
F-2-3	17	D-AMS 036520	631664-5902406	<i>Polychaete</i> tubes	1.5	-17.4	2773 ± 34	43 ± 52	2046 – 2489*
F-13	24	D-AMS 036523	632305-5899963	<i>Polychaete</i> tubes	1.5 – 1.6	-13.7	4415 ± 28	43 ± 52	4092 - 4530

*Excluded from the model

Table S6. Average uplift rate calculated for ridges with absolute ages. Indicative meaning (IM) and modeled relative sea level (ICE6G) are also shown.

<i>Ridge</i>	IRSL (yrs BP)	IRSL error (yrs BP)	Modeled age (yrs BP)	Modeled age sigma (yrs BP)	Elevation (m)	Elevation – tilt (m)	IM (m)	ICE6G (m)	ICE6G Uplift rate (m/kyr)
24	4400	400	4399	254	6.48±0.17	4.84±0.20	2.2 ± 0.1	1.82 ± 0.20	0.19 ± 0.07
23	4500	300	4215	131	6.71±0.15	5.13±0.20	2.2 ± 0.1	1.71 ± 0.17	0.29 ± 0.07
21	3500	300	3377	225	5.47±0.23	3.95±0.23	2.2 ± 0.1	1.34 ± 0.28	0.12 ± 0.1
19	2600	240	3032	286	5.06±0.26	3.62±0.35	2.2 ± 0.1	0.99 ± 0.18	0.14 ± 0.13
17	2600	300	2773	105	5.43±0.15	4.23±0.19	2.2 ± 0.1	0.86 ± 0.18	0.42 ± 0.1
14	2680	170	2589	93	5.98±0.26	4.50±0.33	2.2 ± 0.1	0.80 ± 0.15	0.58 ± 0.15
11	2480	160	2401	79	6.03±0.26	4.86±0.38	2.2 ± 0.1	0.76 ± 0.16	0.79 ± 0.18
6	1800	180	1853	111	5.07±0.15	4.23±0.18	2.2 ± 0.1	0.53 ± 0.10	0.81 ± 0.13
5	1800	130	1733	99	3.85±0.20	3.40±0.46	2.2 ± 0.1	0.48 ± 0.08	0.42 ± 0.28
2	900	70	970	169	3.20±0.10	2.92±0.16	2.2 ± 0.1	0.23 ± 0.10	0.51 ± 0.24

Table S7. Average uplift rate calculated for swales with dating. Indicative meaning (IM) and modeled relative sea level (ICE6G) are also shown.

<i>Swale</i>	IRSL (yrs BP)	IRSL error (yrs BP)	Modeled age (yrs BP)	Modeled age sigma (yrs BP)	Elevation (m)	Elevation - tilt (m)	IM (m)	ICE6G (m)	ICE6G Uplift rate (m/kyr)
24	4400	400	4399	254	5.64±0.15	3.98±0.22	1.3 ± 0.1	1.82 ± 0.20	0.20 ± 0.07
23	4500	300	4215	131	5.93±0.18	4.29±0.20	1.3 ± 0.1	1.71 ± 0.17	0.30 ± 0.07
21	3500	300	3377	225	5.37±0.10	3.95±0.14	1.3 ± 0.1	1.34 ± 0.28	0.39 ± 0.09
19	2600	240	3032	286	5.27±0.22	3.64±0.28	1.3 ± 0.1	0.99 ± 0.18	0.45 ± 0.12
17	2600	300	2773	105	5.19±0.15	3.77±0.17	1.3 ± 0.1	0.86 ± 0.18	0.58 ± 0.1
14	2680	170	2589	93	5.88±0.15	4.49±0.17	1.3 ± 0.1	0.80 ± 0.15	0.92 ± 0.1
11	2480	160	2401	79	4.85±0.06	3.68±0.08	1.3 ± 0.1	0.76 ± 0.16	0.67 ± 0.09
6	1800	180	1853	111	4.72±0.15	3.72±0.34	1.3 ± 0.1	0.53 ± 0.10	1.02 ± 0.21
5	1800	130	1733	99	3.64±0.23	3.14±0.32	1.3 ± 0.1	0.48 ± 0.08	0.78 ± 0.20
2	900	70	970	169	2.95±0.10	2.67±0.12	1.3 ± 0.1	0.23 ± 0.10	1.46 ± 0.32

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```

387 Supplementary Code
388
389 Oxcal Code:
390
391 Options()
392 {
393     SD1=TRUE;
394 };
395 Plot()
396 {
397     Curve("Marine20","marine20.14c");
398     Delta_R(43,52);
399     Sequence("ISM")
400     {
401         Boundary("S24")
402         {
403         };
404         Phase("R24")
405         {
406             R_Date(4415,28);
407             Date(N(2019-4540,316));
408             Interval("I24");
409         };
410         Boundary("S23")
411         {
412         };
413         Phase("R23")
414         {
415             Date(N(2019-4400,400));
416             Interval("Ridge 23");
417         };
418         Boundary("S22")
419         {
420         };
421         Phase("R22")
422         {
423             Interval("I22");
424         };
425         Boundary("S21")
426         {
427         };
428         Phase("R21")
429         {
430             Date(N(2019-3660,218));
431             Interval("I21");
432         };
433         Boundary("S20")
434         {
435         };
436         Phase("R20")
437         {
438             Interval("I20");
439         };
440         Boundary("S19")
441         {
442         };

```

```
443 Phase("R19")
444 {
445   Date(N(2019-2670,170));
446   Interval("I19");
447 };
448 Boundary("S18")
449 {
450 };
451 Phase("R18")
452 {
453   Interval("I18");
454 };
455 Boundary("S17")
456 {
457 };
458 Phase("R17")
459 {
460   Date(N(2019-2650,195));
461   Interval("I17");
462 };
463 Boundary("S16")
464 {
465 };
466 Phase("R16")
467 {
468   Interval(I16);
469 };
470 Boundary("S15")
471 {
472 };
473 Phase("R15")
474 {
475   Interval("I15");
476 };
477 Boundary("S14")
478 {
479 };
480 Phase("R14")
481 {
482   Date(N(2019-2680,166));
483   Interval("I14");
484 };
485 Boundary("S13")
486 {
487 };
488 Phase("R13")
489 {
490   Interval("I13");
491 };
492 Boundary("S12")
493 {
494 };
495 Phase("R12")
496 {
497   Interval("I12");
498 };
```



```
499 Boundary("S11")
500 {
501 };
502 Phase("R11")
503 {
504 R_Date(2887,35);
505 Date(N(2019-2480,164));
506 Interval("I11");
507 };
508 Boundary("S10")
509 {
510 };
511 Phase("R10")
512 {
513 Interval();
514 };
515 Boundary("S9")
516 {
517 };
518 Phase("R9")
519 {
520 Interval("I9");
521 };
522 Boundary("S8")
523 {
524 };
525 Phase("R8")
526 {
527 Interval("I8");
528 };
529 Boundary("S7")
530 {
531 };
532 Phase("R7")
533 {
534 Interval("I7");
535 };
536 Boundary("S6")
537 {
538 };
539 Phase("R6")
540 {
541 Date(N(2019-1880,120));
542 Interval("I6");
543 };
544 Boundary("S5")
545 {
546 };
547 Phase("R5")
548 {
549 Date(N(2019-1790,130));
550 Interval("I5");
551 };
552 Boundary("S4")
553 {
554 };
```

```
555     Phase("R4")
556     {
557         Interval("I4");
558     };
559     Boundary("S3")
560     {
561     };
562     Phase("R3")
563     {
564         Interval("I3");
565     };
566     Boundary("S2")
567     {
568     };
569     Phase("R2")
570     {
571         Date(N(2019-890,73));
572         Interval("I2");
573     };
574     Boundary("S1")
575     {
576     };
577     Phase("R1")
578     {
579         Interval("I1");
580     };
581     Boundary("EQ",2019-449);
582 };
583 };
584
```