Supplementary Information for

CO_2 degassing in the mantle triggers deep earthquakes at the Mid-Atlantic Ridge

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Supplementary Table 1

The maximum depth of earthquakes versus full spreading rates at 25 slow- and ultraslow-spreading Mid-Ocean Ridges. $D1_{max}$ and $D2_{max}$ indicate the maximum depth limited by several earthquakes and one deepest earthquake, respectively. Rainbow Massif (No. 22) is located in an NTD. Magmatism indicates the depths are influenced by strongly magmatic processes, e.g., hotspot and/or focused melting. Lat=Latitude; Lon=Longitude; -1=dead/inactive hydrothermal vent; RTJ=The Rodrigues Triple Junction; OCC=oceanic core complex; DF=detachment fault; TF=transform fault; MAR=Mid-Atlantic Ridge; SWIR=Southwest Indian Ridge; MCSC=Mid-Cayman Spreading Centre.

No.	Name	Ridge center	Area	Lat (°)	Lon (°)	Full rate (mm/yr)	Shallowest (km)	$D1_{max}$ (km)*	$D2_{max}$ (km)*	OCC/DF	Vent	Magmatism	TF
1	Amagmatic SWEAP segment [1]	SWIR	Indian	-52.37	13.30	7.8	13	20	23	Y	N	N	N
2	13°E -14°E (Oblique super-segment) [2]	SWIR	Indian	-52.38	13.50	7.8	1	16	17	N	N	N	N
3	Magmatic SWEAP segment [1]	SWIR	Indian	-52.35	13.60	7.8	10	17	20	Y	N	Y	N
4	85°E Volcanic complex [3]	Gakkel Ridge	Arctic	85.00	85.00	10.0	1	16	23	N	N	Y	N
5	Segment 1 [4]	SWIR	Indian	-25.70	69.80	12.6	0	10	10	n/a	n/a	n/a	RTJ
6	Lena Trough [5]	Fram Strait	Arctic	81.00	-5.00	12.8	N	N	14	N	N	N	N
7	Segment 8 [6]	SWIR	Indian	-27.75	65.80	13.6	0	15	23	n/a	n	Y	N
8	Segment 8 volcano, SWRUM segment [1]	SWIR	Indian	-27.75	65.60	13.6	1	10	13	n/a	Y	Y	N
9	SWRUM segment [1]	SWIR	Indian	-27.75	65.80	13.6	1	17	20	n/a	n/a	N	N
10	Segment 27 [7]	SWIR	Indian	-37.66	50.45	14.2	3	6	8	N	-1	Y	N
11	Segment 7 [8]	SWIR	Indian	-27.58	65.95	14.2	5	12	13	n/a	n/a	N	N
12	SWIR 64°30'E [9]	SWIR	Indian	-27.85	64.50	14.5	0	14	15	Y	-1	N	N
13	Logachev Seamount [6,10,11]	Knipovich Ridge	Arctic	76.50	7.20	14.5	2	6	12	n/a	n/a	Y	N
14	Logachev Seamount-Amagmatic [6,10,11]	Knipovich Ridge	Arctic	76.20	7.20	14.5	7	16.5	20	n/a	n/a	N	N

15	Segment 28 [12]	SWIR	Indian	-37.72	49.70	14.6	2	13	15	Y	Y	N	N
16	Segment 28 [7]	SWIR	Indian	-37.72	49.70	14.6	0	16	20	Y	Y	N	N
17	Mount Dent [2]	MCSC	Caribbean	18.40	-81.75	15.0	1	7.5	9.5	Y	Y	N	Y
18	Reykjanes Ridge [13]	MAR-Iceland	Atlantic	62.45	-25.80	20.0	0	7.5	12.5	n/a	n/a	Y	N
19	Lucky strike [14]	MAR	Atlantic	37.33	-32.30	20.3	1.5	3	3.3	n/a	Y	Y	N
20	Lucky strike [15]	MAR	Atlantic	37.33	-32.30	20.3	1.5	6	6.5	n/a	Y	Y	N
21	35°N-West [16]	MAR	Atlantic	35.20	-36.50	20.6	0	4	4.5	n/a	n/a	N	Y
22	Rainbow Massif [17]	MAR	Atlantic	36.20	-33.90	21.5	0	7.5	8	-1	Y	N	NTD
23	35°N-East [18]	MAR	Atlantic	35.10	-35.20	22.2	1	9	14	N	N	N	Y
24	29°N [19]	MAR	Atlantic	29.20	-43.20	22.8	2.5	7.5	8	n/a	Y	Y	N
25	23°N [20,21]	MAR	Atlantic	23.50	-45.00	23.0	0.9	8	8	n/a	n/a	N	N
26	Logatchev Massif [22]	MAR	Atlantic	14.45	-45.00	24.0	1.5	5.5	7	Y	Y	N	Y
27	26°N TAG [23]	MAR	Atlantic	26.10	44.85	24.2	0	7	8	Y	Y	N	N
28	26°N TAG [24]	MAR	Atlantic	26.10	44.85	24.2	2	7	8	Y	Y	N	N
29	13°20′N OCC [25,26]	MAR	Atlantic	13.33	-44.90	25.4	3	12	15	Y	Y	N	N
30	13°30′N OCC [25,26]	MAR	Atlantic	13.50	-44.85	25.4	4	10	12	Y	Y	N	N
31	5°S [27]	MAR	Atlantic	-5.20	-11.65	32.0	0	7	8	N	n/a	N	Y
32	0°6′S, this study	MAR	Atlantic	-0.15	-16.45	32.0	1.5	16	18.5	N	N	N	Y
33	7°12′S [22]	MAR	Atlantic	-7.20	-13.20	32.0	3	6	7	N	N	N	Y
34	7°56′S [22]	MAR	Atlantic	-7.80	-13.40	32.0	2	4	7	N	N	N	Y

Supplementary Table 2

Average location parameters for earthquakes located with the different 1-D velocity models. For each model, an earthquake was counted when it has an RMS residual of ≤0.3 s, a horizontal uncertainty of ≤10 km, a vertical uncertainty of ≤10 km, a station primary gap of <270°, and phases participated in the computation of >5. Model 5 (bold) was selected as the best fitting 1-D velocity model, and 516 events are well located, of which two events were removed because they are out of the observation network.

Velocity model	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Number of located events	502	505	508	509	**516**
Mean RMS residual (s)	0.0832	0.0908	0.0860	0.0982	**0.0851**
Mean horizontal uncertainty (km)	2.62	2.71	2.70	2.96	**2.76**
Mean vertical uncertainty (km)	2.96	3.07	3.01	3.00	**2.93**
Mean focal depth below seafloor (km)	9.21	13.22	11.49	15.79	**11.64**
Mean number of phases used in the computation	13.47	13.55	13.51	13.55	**13.45**
Mean station primary gap	152.24	152.62	152.82	153.29	**152.4**

Supplementary Table 3

Earthquake locations dependent on three velocity models shown in Supplementary Fig. 7b.

Only earthquakes with depth errors of ≤5 km are included in the computation of these average values.

Velocity model	Number of located earthquakes (depth error ≤10 km)	Number of located earthquakes (depth error ≤5 km)	Mean depth (km)	Mean depth error (km)	Mean horizontal error (km)	Mean RMS (s)
-0.1 km/s	511	412	12.45	1.86	2.49	0.0915
Final	516	418	11.63	1.89	2.45	0.0884
+0.1 km/s	507	407	10.10	1.84	2.43	0.0851

Supplementary Table 4

The calculated focal mechanism solutions. S1-S3 are three previous solutions for earthquake swarms from ref.[28].

No.	Longitude (°)	Latitude (°)	Depth (km)	Mechanism solution			RMS uncertainty		Number of P first motion polarities	Misfit of first motions weighted	Mechanism probability	Station distribution ratio (%)
				strike	dip	rake	fault plane	auxiliary plane				
S1	-17.1485	0.0268	11.6430	280	48	-144	30	36	13	0	63	41
S2	-17.4826	-0.0395	21.6340	121	44	-111	22	33	15	17	78	44
S3	-17.5224	-0.0468	20.8370	96	39	-153	21	33	14	13	72	46
4	-17.1022	0.0891	11.4750	257	41	-163	28	41	10	3	78	43
5	-16.8813	0.0896	6.0015	193	87	169	43	44	9	12	60	60
6	-16.8046	0.1327	6.5790	72	56	152	39	44	9	18	65	59

Supplementary Table 5

Geochemical analysis results: values for the Ba, Nb, and Rb for three different samples.

Samples	Latitude	Longitude	Ba (ppm)	Nb (ppm)	Rb (ppm)
SMA1974-278	0.04°S	16.46°W	334.21	48.48	25.27
SMA1974-279	0.04°S	16.46°W	329.96	46.94	19.52
13-12 49A[29]	0.08°S	16.38°W	561.00	79.60	42.90

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