Supplement of Biogeosciences, 21, 261–277, 2024
https://doi.org/10.5194/bg-21-261-2024-supplement

Biogeosciences Open Access EGU

Supplement of

The additionality problem of ocean alkalinity enhancement

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Table S1. Additional information on location and time of beach transects. The coordinates provided here show the exact location of the upper end of the swash zone. Transects extended 150-220 m offshore as shown in Fig. 3 in the main text.

Location	Latitude	Longitude	Sampling time	Low tide	High tide
Clifton South	-42.992299	147.524931	11:30-1:30	0.48 m at 11:02 am	1.08 m at 17:58 pm
Goats	-43.022267	147.500408	10:24-11:40	0.9 m at 13:26 pm	1.02 m at 9:40 am
Clifton North	-42.987078	147.54194	10:16:-11:23	0.51 m at 9:37 am	1.15 m at 16:36 pm
Wedge	-43.033122	147.475549	10:39-11:50	0.55 m at 6:56 am	1.19 m at 13:57 pm

Table S2. Additional information on beach sand and alkalinity source minerals used for the three laboratory experiments. Sampling coordinates for olivine and steel slag are approximate as it was not recorded where exactly in the quarry/deposition site rocks were collected. The range provided for carbonate weights is based on the two most extreme assumptions that all carbonate in beach sand is $MgCO_3$ (lower value) or $CaCO_3$ (upper value).

Mineral	Latitude	Longitude	PIC/POC (mol:mol)	Water content (%)	Carbonate weight (%)
Beach 1	-42.992872	147.52372	1.02	5.9	2.7 - 3.3
Beach 2	-42.991129	147.52686	2.97	13.5	11.9 - 14.2
Beach 3	-42.989084	147.53179	5.21	10.9	12.8 - 15.2
Beach 4	-42.988162	147.53538	16.25	4.3	24.4 - 28..9
Beach 5	-42.992724	147.52394	1.65	14.6	4.9. - 5.9
Olivine	-38.006	142.793	-	-	-
Steel slag	-33.01	137.589	-	-	-

Table S3. Carbonate chemistry data to support understanding of Figs. 5 and 8. DIC additions, pH_T and Ω_{Arg} values as they were determined at the beginning of experiment 2.

Treatment	DIC addition (µmol/kg)	pH_T	Ω_{Ara}	ΔAlkalinity (µmol/kg)	ΔDIC (µmol/kg)	ΔAlkalinity /ΔDIC (mol/mol)
sand-only	0.0	7.92	1.87	-5.0	29.5	-0.2
sand-only	43.6	7.81	1.50	9.5	28.0	0.3
sand-only	75.9	7.72	1.24	18.4	28.9	0.6
sand-only	114.4	7.60	0.96	39.8	32.5	1.2
sand-only	139.8	7.52	0.81	59.2	34.8	1.7
sand-only	164.9	7.44	0.68	86.0	46.0	1.9
sand-only	203.7	7.32	0.52	240.3	185.2	1.3
sand-only	242.8	7.21	0.40	207.4	109.5	1.9
sand-only	292.6	7.08	0.31	288.5	137.5	2.1
sand-only	364.2	6.94	0.22	414.0	200.6	2.1
sand-only	395.5	6.89	0.20	457.2	214.5	2.1
sand-only	436.6	6.83	0.17	537.2	258.4	2.1

eq. NaOH	0.0	7.88	2.09	482.1	53.4	9.0
eq. NaOH	25.5	7.82	1.87	487.8	17.5	27.9
eq. NaOH	50.3	7.76	1.65	495.1	15.8	31.3
eq. NaOH	82.0	7.68	1.40	500.3	10.8	46.2
eq. NaOH	105.6	7.62	1.22	507.0	7.6	67.0
eq. NaOH	126.3	7.57	1.08	511.0	6.2	82.2
eq. NaOH	147.7	7.51	0.95	567.4	86.1	6.6
eq. NaOH	188.0	7.40	0.75	549.3	12.7	43.3
eq. NaOH	210.1	7.34	0.66	577.8	31.8	18.1
eq. NaOH	234.2	7.28	0.58	614.8	50.9	12.1
eq. NaOH	252.2	7.24	0.52	644.1	63.4	10.2
eq. NaOH	252.3	7.24	0.52	626.2	47.3	13.2
eq. NaOH	276.0	7.18	0.46	673.1	72.8	9.2
eq. NaOH	325.0	7.08	0.37	746.9	101.7	7.3
eq. NaOH	403.0	6.95	0.28	888.0	177.0	5.0
eq. NaOH	460.9	6.87	0.23	972.8	212.4	4.6
uneq. NaOH	0.0	8.5776	7.07	343.7	-7.8	-44.0
uneq. NaOH	65.6	8.50	6.37	371.2	8.9	41.7
uneq. NaOH	131.2	8.43	5.67	391.7	15.4	25.4
uneq. NaOH	202.0	8.34	4.92	413.1	13.3	31.0
uneq. NaOH	285.6	8.23	4.05	438.6	15.9	27.5
uneq. NaOH	340.3	8.14	3.48	466.0	86.5	5.4
uneq. NaOH	397.8	8.05	2.90	480.3	91.0	5.3
uneq. NaOH	457.8	7.93	2.32	473.9	12.3	38.7
Slag	0.0	7.92	1.87	521.2	11.7	44.7
Slag	43.6	7.81	1.50	553.0	1.4	400.2
Slag	75.9	7.72	1.24	648.6	1.7	373.0
Slag	114.4	7.60	0.96	656.4	1.7	385.7
Slag	139.8	7.52	0.81	533.5	1.7	308.4
Slag	164.9	7.44	0.68	555.6	5.3	105.4
Slag	203.7	7.32	0.52	773.6	-6.2	-125.4
Slag	242.8	7.21	0.40	621.9	9.1	68.2
Slag	292.6	7.08	0.31	607.8	4.9	123.0
Slag	364.2	6.94	0.22	598.5	19.0	31.5
Slag	395.5	6.89	0.20	925.7	6.1	152.6
Slag	436.6	6.83	0.17	814.3	34.4	23.7
Olivine	0.0	7.92	1.87	257.6	42.7	6.0
Olivine	43.6	7.81	1.50	263.2	40.9	6.4
Olivine	75.9	7.72	1.24	272.9	49.0	5.6
Olivine	114.4	7.60	0.96	284.0	41.8	6.8
Olivine	139.8	7.52	0.81	318.7	47.4	6.7
Olivine	164.9	7.44	0.68	298.5	48.1	6.2

Olivine	203.7	7.32	0.52	304.8	51.3	5.9
Olivine	242.8	7.21	0.40	313.1	49.0	6.4
Olivine	292.6	7.08	0.31	356.9	50.7	7.0
Olivine	364.2	6.94	0.22	387.7	66.5	5.8
Olivine	395.5	6.89	0.20	409.7	69.9	5.9
Olivine	436.6	6.83	0.17	453.3	95.3	4.8

Figure S1. The plankton wheel used for experiments 1, 2, and 3. The picture shows the plankton wheel with incubation bottles mounted on it.

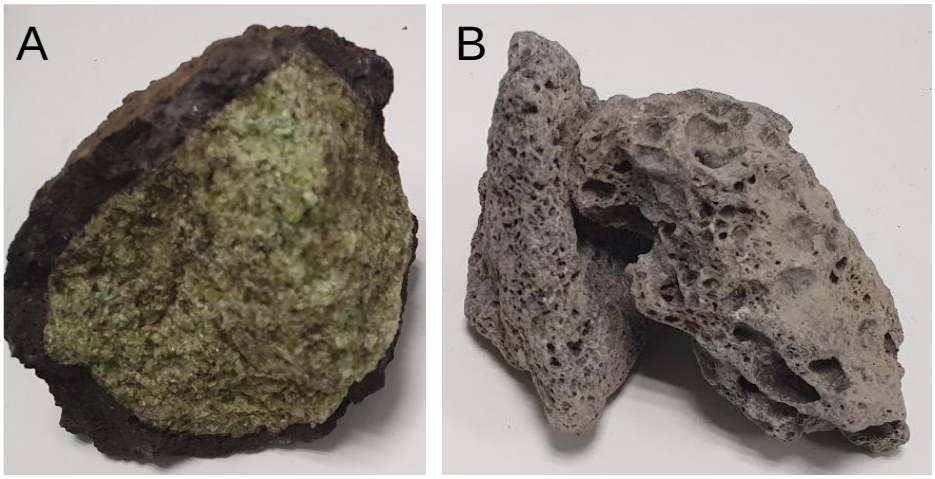

Figure S2. Raw material of olivine from Mortlake, Victoria, Australia (A) and steel slag from Whyalla, South Australia, Australia (B) before they were crushed to powder.

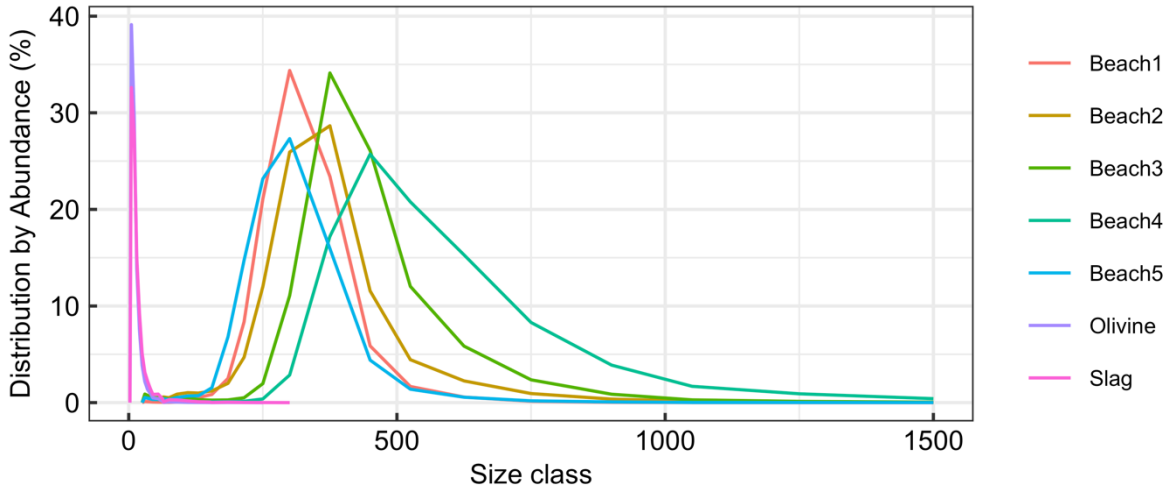

Figure S3. Size distribution of particles in beach sand and ground olivine/slag mineral used for incubations. Please note that distribution by abundance shows in which size class most of the particles occur but does not reflect the size class in which most of the mass is accumulated.