Supplement to Effectiveness of olivine dissolution for ocean alkalinity enhancement in beach simulations – insights from flow-through experiments

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Supplementary figures

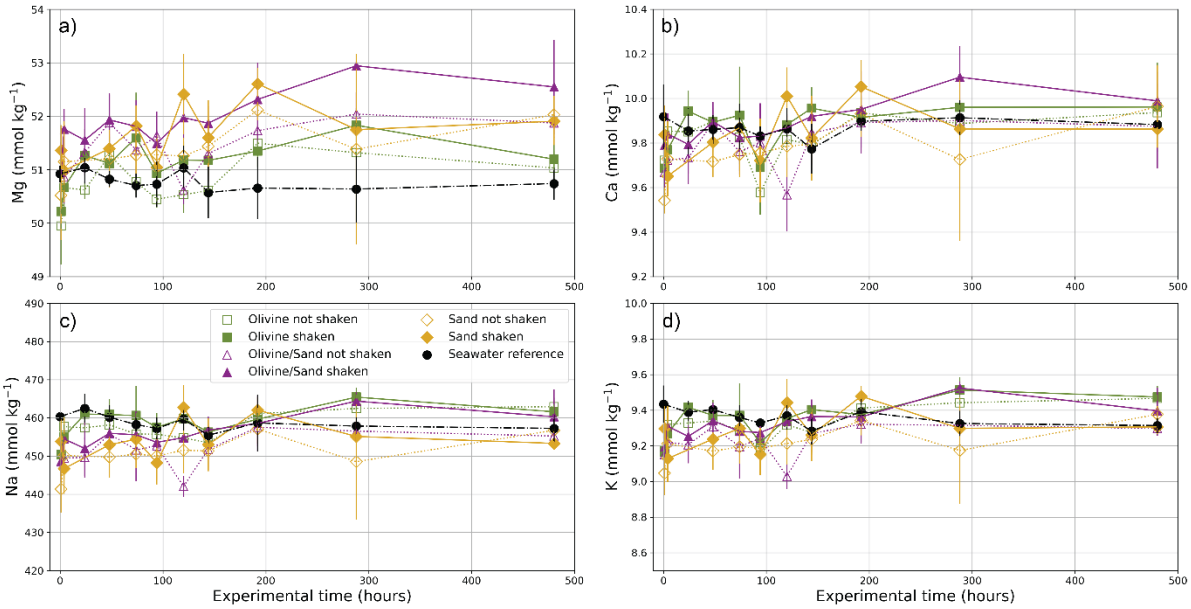

Figure S1: Major element data for the different treatments of the beach simulation experiments, with (a) magnesium (Mg), (b) calcium (Ca), (c) sodium (Na) and (d) and potassium (K). Data points are the average of the three replicates and error indicates 1 SD of the replicates.

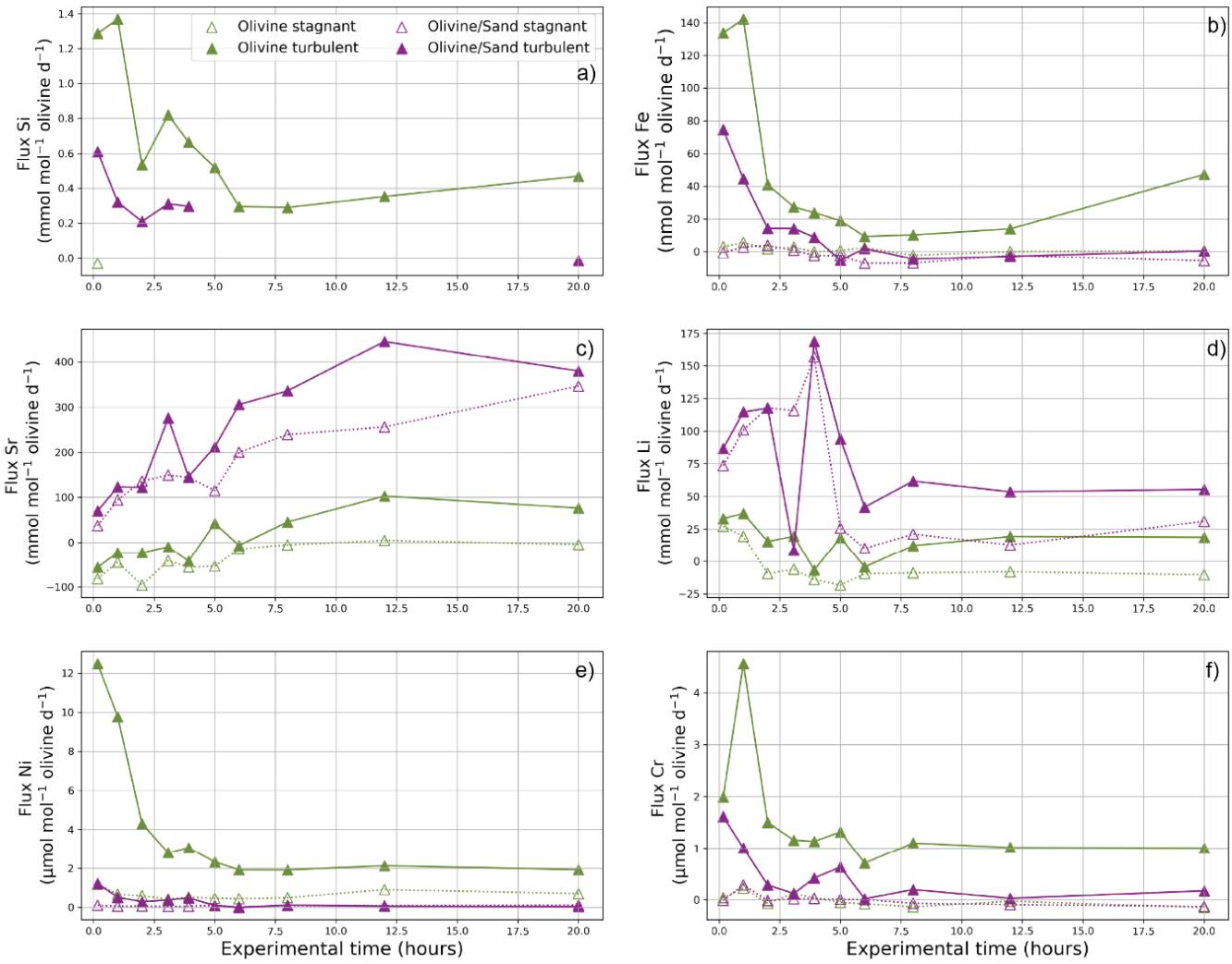

Figure S2: Fluxes for trace elements for the different olivine treatments (pure and olivine/sand mixture), with (a) silicon (Si), (b) iron (Fe), (c) strontium (Sr), (d) lithium (Li), (e) nickel (Ni) and chromium (Cr).

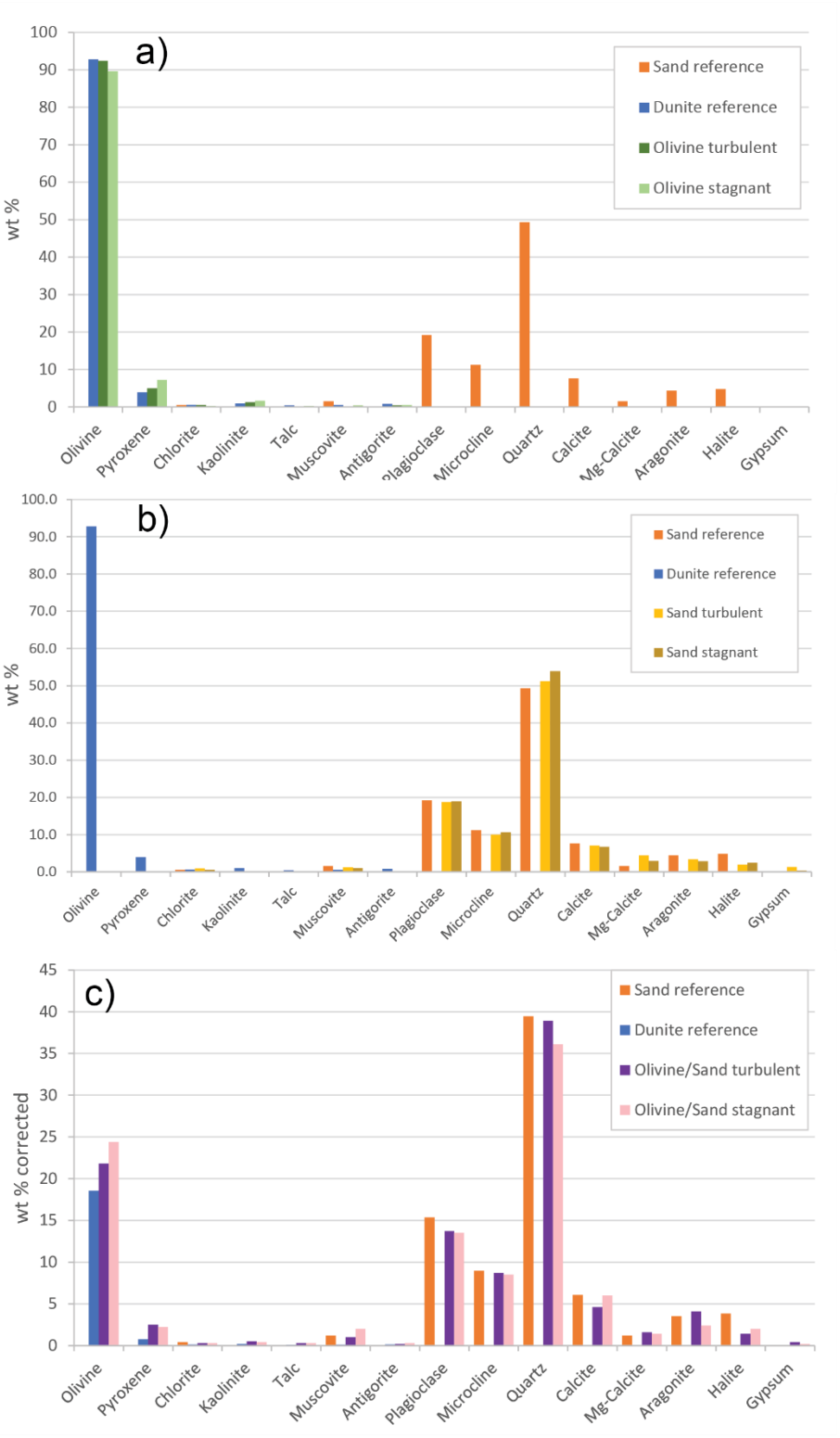

Figure S3: Mineralogical composition in weight percentage (wt%) of stagnant and turbulent.

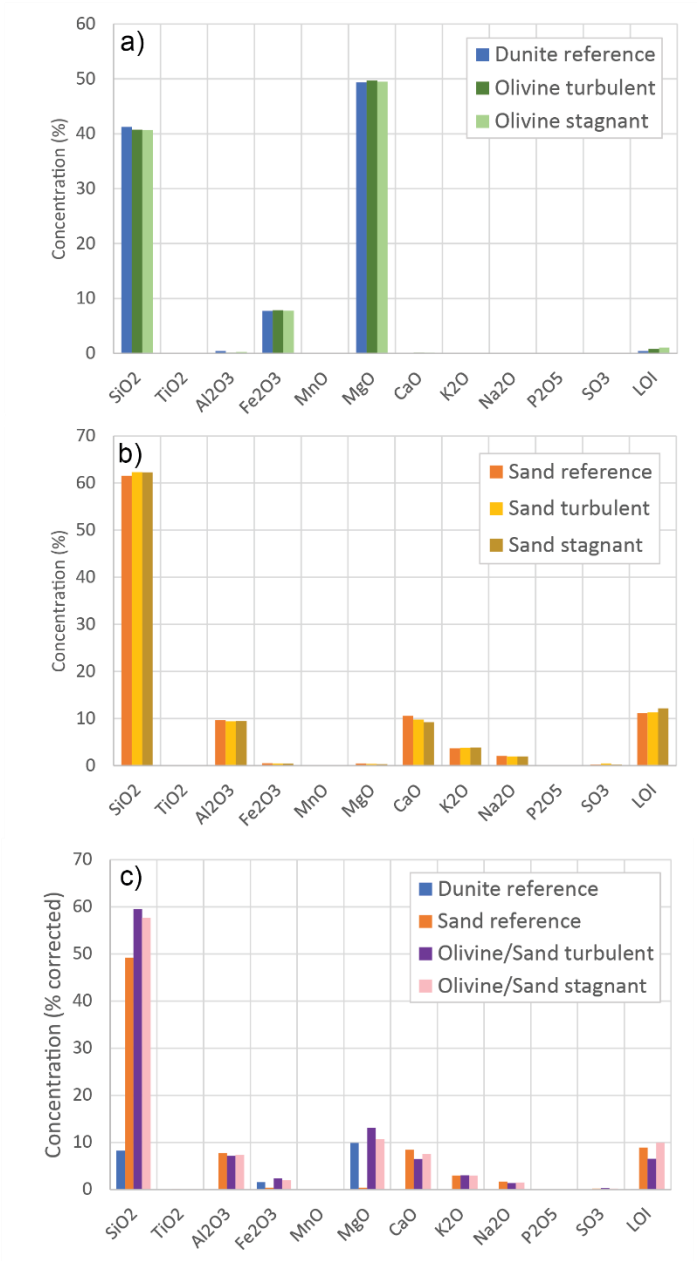

Figure S4: *Elemental oxide percentage across all experimental setups (LOI: loss of ignition).*

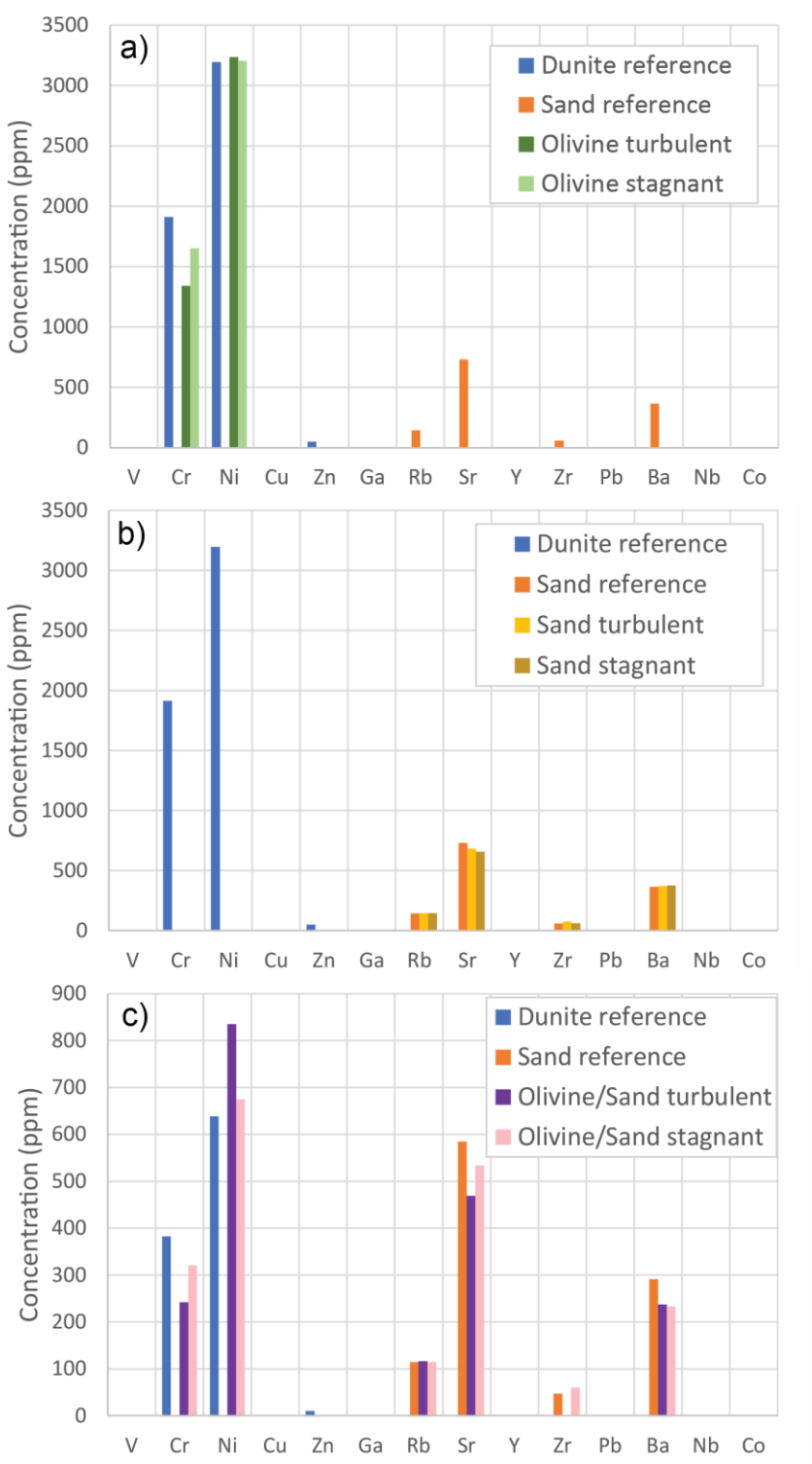

Figure S5: *Trace element concentrations for the different experimental conditions and treatments.*

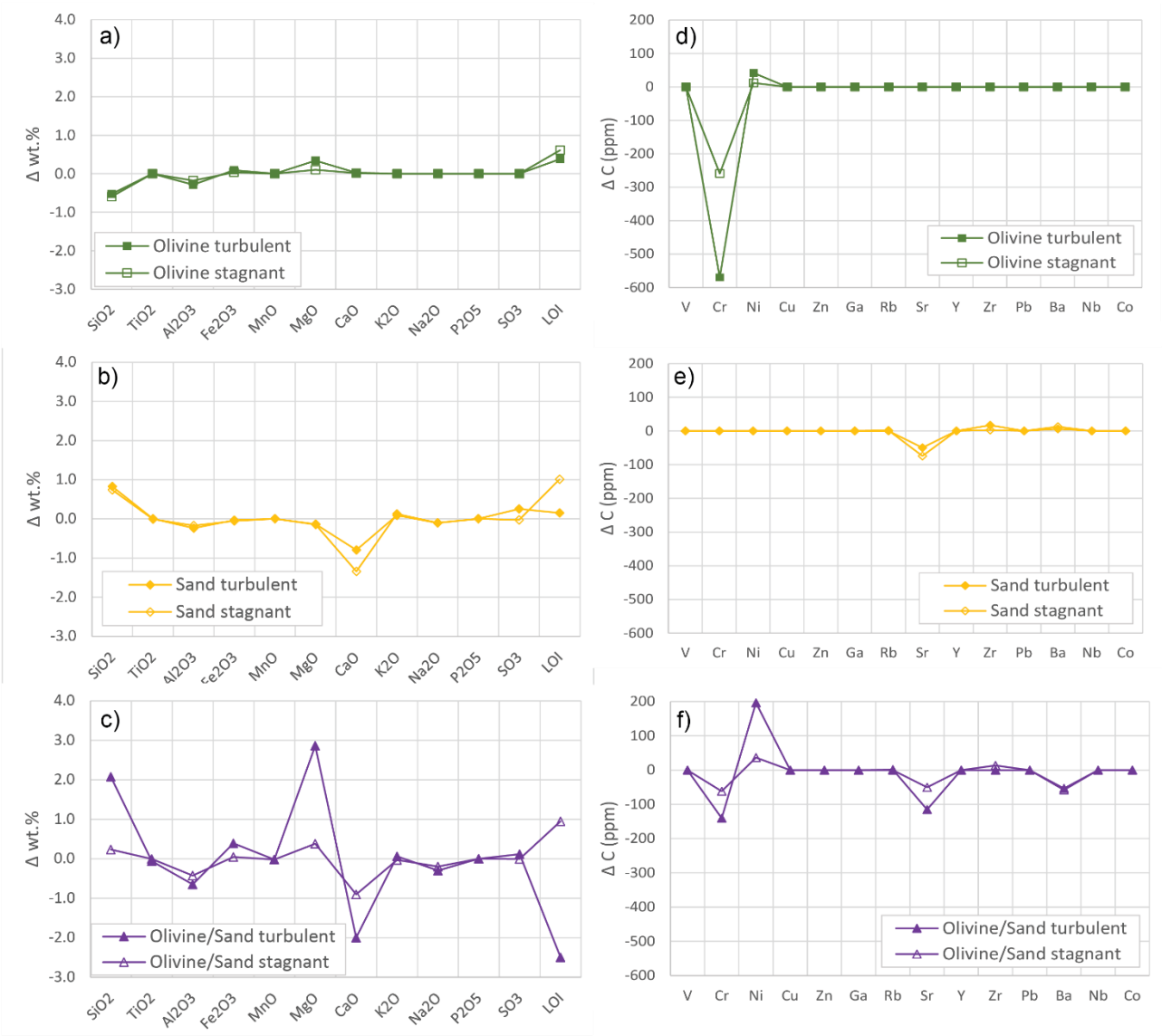

Figure S6: *Variation of major and trace element concentration in wt.% and ppm relative to the starting materials (ΔC; sand and dunite) for the different experimental treatments. For the olivine/sand experiments, the percentage ratio of starting material was considered.*

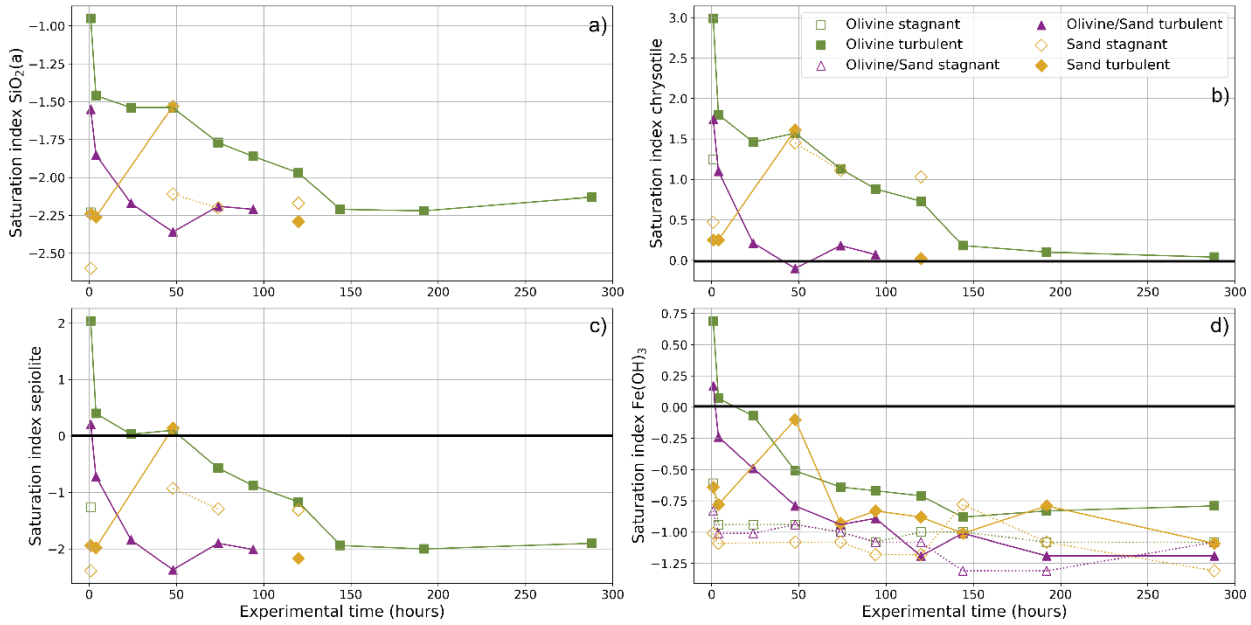

Figure S7: Saturation indices calculated in PHREEQC for (a) amorphous SiO_2 ($SiO_{2(a)}$), (b) chrysotile, (c) sepiolite and (d) $Fe(OH)_3$. Note that $SiO_{2(a)}$ is undersaturated and chrysotile mostly oversaturated (black line, saturation index > 0) throughout the experiment for all treatments where Si was detectable, while sepiolite and $Fe(OH)_3$ are only oversaturated in the first 48 hours of the experiment.

Supplementary tables

Table S1: Experimental results for the carbonate system. Alkalinity and pH are directly measured after sampling, all other parameters calculated using the CO2SYS program. Samples were excluded from the average when the deviation exceeds 5%.

Sample	Experimental time	Alkalinity	SD_{TA}	Alkalinity_ *sw corrected*	Alkalinity_ *sw-cor, olivine normalized*	pH[a]	SD_{pH}	DIC[b]	SD_{DIC}	pCO_2[b]	SD_{pCO2}	$\Omega_{aragonite}$[b]	$SD_{\Omega A}$
	(hours)	(µmol kg^{-1})	(µmol kg^{-1})	(µmol kg^{-1})	(mmol mol^{-1} olivine)			(µmol kg^{-1})	(µmol kg^{-1})	(µatm)	(µatm)		
Olivine stagnant	1	2300	5	-11	-0.14	8.32	0.01	1908	7	177	3	4.1	0.04
	4	2305	1	-6.5	-0.08	8.37	0.03	1882	17	156	12	4.4	0.18
	24	2333	19	7.3	0.09	8.34	0.01	1926	14	171	1	4.2	0.07
	48	2315	12	-0.7	-0.01	8.34	0.00	1912	11	171	1	4.2	0.02
	74	2311	5	-6.3	-0.08	8.28	0.01	1943	9	200	4	3.8	0.04
	94	2307	5	-1.1	-0.01	8.29	0.01	1939	11	198	6	3.8	0.06
	120	2313	14	-7.6	-0.10	8.26	0.01	1960	13	212	4	3.7	0.04
	144	2310	5	-12	-0.15	8.26	0.01	1960	2	214	3	3.7	0.04
	192	2316	4	9.1	0.12	8.27	0.01	1959	5	210	6	3.7	0.07
	288	2318	4	4.6	0.06	8.24	0.01	1976	6	225	3	3.6	0.03
	480	2297	9	-4.9	-0.06	8.02	0.01	2080	14	412	14	2.4	0.05
Olivine turbulent	1	2359	10	47	0.60	8.18	0.01	2054	11	278	8	3.2	0.07
	4	2375	9	64	0.82	8.15	0.02	2082	20	299	20	3.1	0.12
	24	2428	22	102	1.30	8.12	0.02	2152	24	338	18	3.0	0.10
	48	2357	24	41	0.52	8.14	0.03	2074	31	310	24	3.0	0.14
	74	2344	39	27	0.34	8.14	0.03	2065	54	313	36	3.0	0.14
	94	2331	29	23	0.29	8.13	0.03	2053	45	310	33	3.0	0.14
	120	2340	32	19	0.24	8.14	0.02	2056	37	302	17	3.0	0.04
	144	2329	34	6.2	0.08	8.13	0.00	2056	31	315	5	2.9	0.05
	192	2340	8	33	0.42	8.12	0.01	2069	11	322	6	2.9	0.02
	288	2345	16	31	0.39	8.08	0.01	2093	20	357	9	2.7	0.02
	480	2321	5	19	0.24	8.04	0.02	2095	10	402	18	2.5	0.07
Sand stagnant	1	2294	7	-17	N.A.	8.31	0.02	1910	16	182	11	4.0	0.14
	4	2302	6	-9.2	N.A.	8.36	0.04	1884	24	159	19	4.3	0.28
	24	NM	NM	NM	N.A.	8.31	0.01	NM	NM	NM	NM	NM	NM
	48	2314	6	-2.3	N.A.	8.31	0.02	1926	5	183	8	4.0	0.11
	74	2319	8	1.7	N.A.	8.28	0.01	1952	8	202	6	3.8	0.08
	94	2312	8	4.6	N.A.	8.27	0.01	1954	8	208	3	3.7	0.04
	120	2334	15	13	N.A.	8.26	0.01	1983	11	219	5	3.7	0.08
	144	2320	5	-1.9	N.A.	8.25	0.01	1975	3	221	3	3.6	0.04
	192	2315	4	8.1	N.A.	8.26	0.00	1965	5	216	1	3.7	0.01
	288	2319	8	5.3	N.A.	8.23	0.00	1987	5	236	1	3.5	0.02
	480	2307	0	4.8	N.A.	8.02	0.02	2092	9	422	22	2.4	0.09
Sand turbulent	1	2324	3	12	N.A.	8.15	/	2042		298		3.0	
	4	2329	11	18	N.A.	8.16	0.02	2036	2	287	11	3.1	0.11
	24	NM	NM	NM	N.A.	8.14	0.03	NM	NM	NM	NM	NM	NM
	48	2328	12	12	N.A.	8.19	0.07	2016	52	266	50	3.3	0.38
	74	2335	4	18	N.A.	8.13	0.01	2095	74	316	18	3.0	0.08
	94	2333	15	26	N.A.	8.13	0.01	2060	21	316	11	2.9	0.04
	120	2335	6	14	N.A.	8.14	0.01	2055	5	307	8	3.0	0.06
	144	2328	18	6.0	N.A.	8.13	0.01	2053	23	312	13	2.9	0.04
	192	2335	15	28	N.A.	8.12	0.01	2066	20	325	11	2.9	0.05
	288	2329	9	15	N.A.	8.08	0.01	2078	14	355	13	2.7	0.06
	480	2316	2	14	N.A.	8.03	0.01	2093	7	404	13	2.4	0.06
Olivine-sand stagnant	1	2283	26	-28	-0.69	8.27	0.09	1926	33	209	55	3.7	0.58
	4	2301	3	-11	-0.08	8.37	0.03	1873	20	153	15	4.4	0.22
	24	2333	14	6.7	0.57	8.32	0.01	1937	18	180	7	4.1	0.05
	48	2313	5	-3.3	-0.06	8.32	0.02	1918	8	178	8	4.1	0.11
	74	2304	7	-13	-0.70	8.29	0.00	1935	6	197	1	3.8	0.02
	94	2308	1	0.32	-0.27	8.28	0.02	1946	13	204	11	3.8	0.12
	120	2321	6	-0.34	-0.87	8.23	0.02	1987	9	235	14	3.5	0.13
	144	2313	7	-10	-0.49	8.23	0.02	1978	6	232	10	3.5	0.11
	192	2316	3	9.4	0.08	8.24	0.01	1975	1	225	3	3.6	0.03
	288	2324	4	11	0.34	8.21	0.01	2004	5	251	7	3.4	0.05
	480	2292	3	-11	-0.37	8.02	0.01	2057	36	411	17	2.3	0.05
Olivine-sand turbulent	1	2323	8	12	-0.03	8.17	0.02	2074	98	286	29	3.2	0.02
	4	2339	11	28	0.64	8.16	0.02	2045	13	288	13	3.1	0.10
	24	2404	10	78	4.98	8.12	0.02	2130	20	335	18	3.0	0.09
	48	2352	6	36	1.55	8.13	0.02	2076	15	318	16	3.0	0.09
	74	2342	5	25	0.50	8.12	0.01	2072	8	325	9	2.9	0.05
	94	2341	12	33	0.48	8.11	0.01	2074	12	329	6	2.9	0.01
	120	2348	4	27	0.87	8.11	0.01	2081	6	330	5	2.9	0.03
	144	2331	3	8.9	0.19	8.12	0.01	2062	5	321	5	2.9	0.03
	192	2342	7	35	0.42	8.11	0.01	2076	12	332	11	2.9	0.05
	288	2336	3	23	0.48	8.09	0.00	2083	2	353	1	2.7	0.01
	480	2319	11	16	0.16	8.04	0.01	2092	9	398	11	2.5	0.06
Seawater reference	1	2311	6	N.A.	N.A.	8.42	0.02	1854	9	135	7	4.7	0.14
	4	NM	NM	N.A.	N.A.	NM	NM	NM	NM	NM	NM	NM	NM
	24	2326	25	N.A.	N.A.	8.38	/	1892	22	152	2	4.5	0.05
	48	2316	2	N.A.	N.A.	8.32	0.01	1923	4	178	3	4.1	0.04
	74	2317	4	N.A.	N.A.	8.31	/	1933	4	187	0	4.0	0.01
	94	2308	3	N.A.	N.A.	8.25	0.02	1960	11	218	10	3.6	0.09
	120	2321	5	N.A.	N.A.	8.27	0.01	1960	10	208	7	3.8	0.08
	144	2322	5	N.A.	N.A.	8.24	0.01	1979	7	226	4	3.6	0.04
	192	2307	10	N.A.	N.A.	8.24	0.02	1965	13	224	10	3.6	0.09
	288	2313	5	N.A.	N.A.	8.24	0.01	1973	8	229	7	3.6	0.06
	480	2302	11	N.A.	N.A.	8.09	0.01	2051	11	348	10	2.7	0.05

[a]pH data is NBS standard corrected

[b]carbonate system is calculated using CO2SYS

Abbreviations and symbols: NM: not measured; NA = not available; '/' = only one measurement

Table S2: Fluxes for alkalinity and trace elements. Note the different units and that sand treatments are reported in mol day^{-1}, not normalized to the olivine content

Sample	Experimental time (hours)	Alkalinity flux (mmol mol olivine d^{-1})	Si flux (mmol mol olivine d^{-1})	Fe flux (nmol mol olivine d^{-1})	Sr flux (µmol mol olivine d^{-1})	Li flux (µmol mol olivine d^{-1})	Ni flux (µmol mol olivine d^{-1})	Cr flux (µmol mol olivine d^{-1})
Olivine stagnant	1							
	4	0.16	-0.03	3.0	-81	27	1.2	0.0
	24	0.59	/	5.7	-45	19	0.67	0.23
	48	-0.14	/	1.7	-95	-9.4	0.59	-0.06
	74	-0.21	/	2.9	-41	-6.0	0.43	0.13
	94	-0.05	/	-0.09	-55	-14	0.52	0.03
	120	-0.21	/	0.80	-53	-18	0.47	-0.05
	144	-0.37	/	2.4	-14	-9.4	0.44	-0.07
	192	0.29	/	-2.3	-5.3	-8.9	0.49	-0.13
	288	0.14	/	0.07	4.7	-8.0	0.90	-0.02
	480	-0.16	/	0.53	-4.4	-10	0.70	-0.14
Olivine turbulent	1							
	4	3.2	1.29	134	-56	33	12.5	2.0
	24	3.8	1.37	142	-23	37	9.8	4.6
	48	0.80	0.53	41	-23	16	4.3	1.5
	74	0.76	0.82	27	-10	20	2.8	1.2
	94	0.66	0.67	24	-42	-6.6	3.1	1.1
	120	0.60	0.52	19	42	18	2.3	1.3
	144	0.17	0.30	9.3	-6.6	-4.3	1.9	0.7
	192	1.0	0.29	10	46	12	1.9	1.1
	288	1.0	0.35	14	103	19	2.1	1.0
	480	0.56	0.47	47	76	19	1.9	1.0
Olivine-sand stagnant	1							
	4	5.0	/	-0.61	37	73	0.10	-0.01
	24	1.5	/	2.9	94	101	0.06	0.29
	48	-1.2	/	3.9	136	118	0.07	-0.01
	74	-2.5	/	0.86	149	116	0.05	0.02
	94	-0.50	/	-2.4	144	157	0.06	0.03
	120	-2.2	/	-2.4	115	26	0.10	0.01
	144	-1.1	/	-7.1	200	10	0.03	0.01
	192	0.27	/	-6.9	239	21	0.09	-0.06
	288	0.84	/	-2.4	256	13	0.08	-0.09
	480	-2.4	/	-5.5	347	31	0.12	-0.12
Olivine-sand turbulent	1							
	4	5.5	0.61	75	70	87	1.212	1.614
	24	11	0.32	44	123	115	0.516	1.005
	48	2.1	0.21	14	122	118	0.284	0.285
	74	0.86	0.31	14	276	8.6	0.374	0.123
	94	1.1	0.30	8.9	146	169	0.482	0.421
	120	2.2	/	-5.3	212	94	0.098	0.634
	144	0.33	/	1.9	306	42	-0.003	0.022
	192	1.0	/	-4.4	336	62	0.112	0.199
	288	1.2	/	-2.9	446	54	0.061	0.032
	480	0.36	/	0.50	380	55	0.040	0.175
		(mmol d^{-1})	(mmol d^{-1})	(nmol d^{-1})	(µmol d^{-1})	(µmol d^{-1})	(µmol d^{-1})	(µmol d^{-1})
Sand stagnant	1							
	4	0.02	0	-0.20	6.7	6.8	0.05	0.01
	24	/	/	0.80	6.4	7.0	0.04	0
	48	0	0.03	-0.08	7.4	8.0	0.04	0
	74	0.01	0.02	-0.12	18	12	0.04	0
	94	0.01	0	-0.24	10	11	0.03	0.01
	120	0.04	0.03	-0.27	9.1	12	0.04	0
	144	-0.01	/	-0.31	19	2.0	0.02	0
	192	0.02	/	-0.30	23	2.8	0.02	0
	288	0.01	/	-0.19	26	2.7	0.03	0
	480	0.01	/	-0.29	24	2.5	0.02	-0.01
Sand turbulent	1							
	4	0.07	0.02	0.95	2.2	5.5	0.08	-0.01
	24	/	0.11	11	8.2	8.5	0.59	0.13
	48	0.03	0	0.33	9.0	8.3	0.06	0.05
	74	0.04	/	0.90	13	11	0.03	0.01
	94	0.06	0.02	0.57	10	10	0.03	-0.01
	120	0.03	/	0.25	18	15	0.03	0
	144	0.01	/	1.2	18	2.7	0.03	0.19
	192	0.07	/	-0.13	27	4.7	0.02	0
	288	0.04	/	-0.56	24	2.8	0.02	-0.01
	480	0.03	/	-0.06	27	4.0	0.03	0

Symbol explanation: / elemental concentration below detection limit

Table S3: Major and trace element data. Samples were excluded from the average when he deviation exceeds 5%.

Sample	Exp. time (hours)	Ca (mmol L^{-1})	SD_{Ca} (mmol L^{-1})	K (mmol L^{-1})	SD_K (mmol L^{-1})	Mg (mmol L^{-1})	SD_{Mg} (mmol L^{-1})	Na (mmol L^{-1})	SD_K (mmol L^{-1})	Si (µmol L^{-1})	SD_{Si} (µmol L^{-1})	Li (µmol L^{-1})	SD_{Li} (µmol L^{-1})	Sr (µmol L^{-1})	SD_{Sr} (µmol L^{-1})	Cr (nmol L^{-1})	SD_{Cr} (nmol L^{-1})	Fe (nmol L^{-1})	SD_{Fe} (nmol L^{-1})	Ni (nmol L^{-1})	SD_{Ni} (nmol L^{-1})
Olivine stagnant	1	9.7	0.2	9.2	0.12	49.9	0.7	450	5	9.3	/	27.4	0.2	94.6	0.8	50.9	9.0	1.5	0.3	73.3	9.7
	4	9.9	0.1	9.3	0.02	50.7	0.3	458	2	bdl	/	26.8	0.3	94.7	1.4	20.7	7.2	0.7	0.2	42.3	8.7
	24	9.9	0.1	9.3	0.07	50.6	0.2	457	3	bdl	/	26.5	0.4	95.9	0.8	23.4	10.6	0.7	0.1	22.8	5.3
	48	9.9	0.0	9.3	0.06	51.3	0.3	458	4	bdl	/	25.5	0.2	94.3	0.3	14.1	2.8	0.6	0.1	19.9	2.8
	74	9.8	0.15	9.3	0.06	50.8	0.3	456	3	bdl	/	25.6	0.5	96.0	2.3	20.3	7.3	0.6	0.1	14.5	5.3
	94	9.6	0.1	9.2	0.02	50.4	0.2	456	1	bdl	/	25.4	0.1	95.6	0.7	17.2	7.6	0.5	0.1	17.7	7.8
	120	9.8	0.0	9.3	0.06	50.5	0.3	455	4	bdl	/	25.2	0.3	95.7	0.9	14.6	5.1	0.6	0.1	15.9	3.5
	144	9.8	0.16	9.3	0.12	50.6	0.4	453	2	bdl	/	25.5	0.3	96.9	1.2	13.6	1.7	0.6	0.1	15.1	3.6
	192	9.9	0.1	9.4	0.05	51.5	0.2	461	1	bdl	/	25.5	0.3	97.2	0.6	11.8	1.6	0.5	0.2	16.7	4.0
	288	9.9	0.1	9.4	0.02	51.3	0.1	462	3	bdl	/	25.6	0.3	97.6	1.2	15.3	4.4	0.5	0.0	30.2	10.1
	480	9.9	0.0	9.5	0.05	51.0	0.3	463	2	bdl	/	25.5	0.2	97.3	0.5	11.4	5.3	0.6	0.1	23.6	5.7
Olivine turbulent	1	9.7	0.1	9.2	0.04	50.2	0.4	450	3	178.6	38.3	28.1	0.4	93.3	0.7	896.2	67.6	29.5	6.9	1632.0	450
	4	9.8	0.1	9.3	0.12	50.7	0.4	455	5	55.0	31.0	27.0	0.2	95.4	0.3	158.2	76.3	7.2	4.4	524.7	245
	24	9.9	0.1	9.4	0.03	51.3	0.2	461	1	45.0	15.0	27.0	0.6	96.6	1.7	165.2	29.0	5.2	1.3	324.0	80.4
	48	9.9	0.1	9.4	0.09	51.1	0.3	461	4	17.7	2.3	26.3	0.1	96.7	0.2	66.1	11.9	1.9	0.7	143.1	29.7
	74	9.9	0.2	9.4	0.18	51.6	0.8	461	8	26.8	/	26.5	0.2	97.1	0.4	54.1	38.6	1.4	1.0	92.7	66.1
	94	9.7	0.1	9.2	0.10	50.9	0.3	458	4	21.8	18.1	25.6	0.2	96.0	0.5	53.3	31.2	1.3	0.7	100.7	72.1
	120	9.9	0.02	9.4	0.002	51.2	0.3	460	1	17.0	10.8	26.4	0.3	98.8	1.1	59.2	21.4	1.2	0.7	76.8	39.0
	144	10.0	0.1	9.4	0.03	51.2	0.1	456	2	9.7	1.0	25.7	0.3	97.2	1.9	39.4	9.9	0.8	0.3	63.6	5.6
	192	9.9	0.1	9.4	0.09	51.3	0.3	460	4	9.5	1.7	26.2	0.3	98.9	1.6	52.2	6.4	0.9	0.1	63.3	16.1
	288	10.0	0.0	9.5	0.07	51.8	0.3	465	2	11.5	4.7	26.5	0.9	101	3.1	49.4	31.1	1.0	0.4	70.3	34.3
	480	10.0	0.2	9.5	0.06	51.2	0.4	462	4	15.3	6.7	26.4	0.8	100	2.9	49.0	13.0	2.1	1.7	63.6	15.3
Sand stagnant	1	9.5	0.1	9.0	0.12	50.5	0.8	441	6	4.0	/	28.1	0.6	97.2	2.2	29.0	21.9	0.6	0.2	26.0	6.3
	4	9.7	0.2	9.2	0.22	51.1	0.8	450	10	bdl	/	28.6	0.7	100	2.6	21.2	5.4	0.5	0.1	23.4	3.2
	24	9.8	0.1	9.3	0.10	51.2	0.7	451	3	bdl	/	28.7	0.2	100	1.1	15.0	5.5	0.9	0.6	18.9	9.5
	48	9.7	0.1	9.2	0.11	51.2	0.5	450	5	12.2	/	29.1	0.2	100	0.9	15.5	5.2	0.5	0.04	16.0	2.5
	74	9.7	0.1	9.2	0.10	51.3	0.7	451	4	10.1	/	30.8	1.4	105	5.3	17.4	8.1	0.5	0.1	16.8	1.4
	94	9.8	0.1	9.2	0.12	51.3	0.4	450	6	bdl	/	30.5	0.3	102	0.6	19.3	4.6	0.4	0.1	15.1	5.6
	120	9.8	0.1	9.2	0.12	51.3	0.3	452	6	10.6	/	30.9	0.2	101	0.7	16.5	1.6	0.4	0.1	15.9	4.4
	144	9.8	0.1	9.2	0.09	51.4	0.7	451	4	bdl	/	26.7	0.7	105	3.0	16.4	6.3	0.4	0.1	9.6	4.1
	192	9.9	0.1	9.3	0.08	52.1	0.2	457	4	bdl	/	27.0	0.8	107	2.8	14.1	2.9	0.4	0.1	10.4	6.3
	288	9.7	0.4	9.2	0.30	51.4	1.8	449	15	bdl	/	26.9	0.3	108	1.7	14.0	2.5	0.5	0.2	14.2	1.2
	480	10.0	0.2	9.4	0.05	52.0	0.4	457	3	bdl	/	26.9	0.2	107	1.2	13.9	2.4	0.4	0.0	11.0	5.5
Sand turbulent	1	9.8	0.1	9.3	0.13	51.4	0.5	454	6	9.1	0.8	28.6	0.3	98.1	0.5	28.6	11.7	1.4	0.3	29.2	14.5
	4	9.7	0.1	9.1	0.08	51.0	0.4	447	3	8.6	/	28.2	0.4	98.3	0.6	15.3	5.4	1.0	0.4	32.0	12.2
	24	9.8	0.1	9.3	0.10	51.9	0.2	455	6	46.0	20.4	29.3	0.3	101	0.2	71.0	51.3	4.9	4.3	244.0	232
	48	9.8	0.04	9.2	0.03	51.4	0.3	453	1	bdl	/	29.3	0.3	101	1.1	36.0	35.4	0.7	0.3	26.8	8.4
	74	9.9	0.04	9.3	0.04	51.8	0.4	454	1	bdl	/	30.5	0.0	103	0.5	20.0	2.7	0.9	0.5	14.8	4.0
	94	9.7	0.2	9.2	0.12	51.0	0.0	448	6	8.1	/	30.1	0.3	102	0.6	12.1	3.7	0.8	0.4	15.0	5.0
	120	10.0	0.1	9.4	0.13	52.4	0.8	463	6	bdl	/	32.2	0.9	105	3.2	17.4	6.0	0.6	0.1	14.5	2.0
	144	9.8	0.2	9.3	0.15	51.6	0.7	453	7	bdl	/	27.0	0.5	105	1.3	93.3	127.3	1.0	0.9	12.9	4.8
	192	10.1	0.1	9.5	0.06	52.6	0.3	462	3	bdl	/	27.8	0.5	109	2.2	15.0	2.0	0.5	0.1	9.6	1.6
	288	9.9	0.0	9.3	0.02	51.7	0.1	455	1	bdl	/	27.0	0.0	107	0.5	12.9	5.1	0.3	0.03	10.0	1.8
	480	9.9	0.0	9.3	0.04	51.9	0.4	453	2	bdl	/	27.5	1.1	109	2.8	15.9	5.6	0.5	0.04	12.7	9.5
Olivine-sand stagnant	1	9.7	0.1	9.2	0.11	51.0	0.6	448	5	bdl	/	28.1	0.2	98.1	0.2	27.2	5.0	0.9	0.2	56.6	28.1
	4	9.7	0.05	9.2	0.02	50.9	0.5	450	1	bdl	/	28.2	0.2	98.6	1.1	16.8	3.2	0.6	0.1	23.7	6.3
	24	9.7	0.1	9.2	0.10	51.3	0.4	450	5	bdl	/	29.1	0.2	100	0.7	25.3	13.5	0.6	0.1	25.9	2.6
	48	9.9	0.1	9.3	0.07	51.9	0.5	456	4	bdl	/	29.7	0.1	102	0.4	15.8	1.3	0.7	0.2	15.7	2.8
	74	9.8	0.1	9.2	0.18	51.4	0.5	452	8	bdl	/	29.6	0.1	102	0.5	16.8	1.8	0.6	0.1	18.6	2.3
	94	9.8	0.2	9.2	0.05	51.6	0.1	453	2	bdl	/	31.0	0.3	102	2.2	17.0	2.4	0.5	/	16.9	2.5
	120	9.6	0.2	9.0	0.07	50.6	0.3	442	3	bdl	/	26.7	0.3	101	2.0	16.5	4.2	0.5	0.1	14.5	3.8
	144	9.8	0.1	9.3	0.10	51.3	0.5	452	5	bdl	/	26.2	0.3	104	1.0	16.3	5.5	0.3	0.2	6.1	1.6
	192	9.9	0.1	9.3	0.11	51.7	0.2	458	5	bdl	/	26.5	0.3	105	1.0	14.0	1.4	0.3	0.0	11.2	3.6
	288	9.9	0.04	9.3	0.05	52.0	0.4	457	3	bdl	/	26.2	0.2	106	1.0	13.1	5.8	0.5	0.1	12.8	3.3
	480	9.9	0.2	9.3	0.04	51.9	0.3	455	2	bdl	/	26.8	0.6	109	2.5	12.0	1.7	0.4	0.0	10.1	4.5
Olivine-sand turbulent	1	9.8	0.1	9.2	0.06	51.0	0.1	449	2	44.6	26.5	28.7	0.3	100	0.6	171	58.9	8.9	5.9	359	211
	4	9.8	0.1	9.3	0.05	51.8	0.4	454	3	22.3	10.9	28.7	0.1	100	0.4	78.5	34.9	3.5	1.7	157	56.4
	24	9.8	0.1	9.3	0.15	51.6	0.6	452	7	10.7	2.9	29.6	0.4	101	1.5	49.5	15.6	2.0	0.8	73.7	18.1
	48	9.9	0.1	9.3	0.10	51.9	0.5	456	4	6.9	0.3	29.7	0.2	101	0.5	25.6	6.9	1.0	0.2	40.4	10.0
	74	9.8	0.11	9.3	0.11	51.8	0.5	456	6	10.2	0.1	17.4	15.1	70.9	61.5	13.4	11.7	0.7	0.6	27.5	25.5
	94	9.8	0.01	9.3	0.06	51.5	0.6	454	3	9.7	/	31.3	0.5	102	0.8	29.8	8.9	0.8	0.1	36.3	16.3
	120	9.9	0.1	9.3	0.03	52.0	0.4	455	0	bdl	/	28.9	1.1	104	1.6	36.8	18.6	0.4	0.2	23.8	3.8
	144	9.9	0.1	9.4	0.10	51.9	0.3	457	3	bdl	/	27.2	0.7	107	3.1	16.8	2.3	0.6	0.1	19.3	0.5
	192	10.0	0.2	9.4	0.14	52.3	0.7	459	7	bdl	/	27.8	0.6	108	2.6	22.6	6.3	0.4	0.0	18.0	4.2
	288	10.1	0.1	9.5	0.04	52.9	0.1	464	2	bdl	/	27.6	0.5	112	2.2	17.1	6.0	0.4	0.1	17.4	2.6
	480	10.0	0.1	9.4	0.13	52.5	0.9	460	7	bdl	/	27.6	0.1	110	1.6	21.8	7.8	0.6	0.2	18.7	1.9
Seawater reference	1	9.9	0.1	9.4	0.11	50.9	0.2	460	1.0	bdl	/	25.1	0.3	95.5	0.4	16.7	7.1	0.6	0.1	19.9	1.5
	4									bdl	/										
	24	9.9	0.1	9.4	0.06	51.0	0.3	463	3.8	bdl	/	25.3	0.3	96.2	1.1	13.9	1.0	0.7	0.1	17.6	5.0
	48	9.9	0.1	9.4	0.01	50.8	0.1	460	3.1	bdl	/	26.1	0.2	97.4	0.6	21.6	21.1	0.5	0.3	28.1	16.4
	74	9.9	0.1	9.4	0.07	50.7	0.2	458	1.9	bdl	/	25.4	0.1	96.2	0.8	11.3	2.0	0.6	0.1	16.0	1.6
	94	9.8	0.04	9.3	0.02	50.7	0.4	457	2.9	bdl	/	25.3	0.0	96.2	0.5	17.4	2.7	0.5	0.2	15.5	1.7
	120	9.9	0.1	9.4	0.08	51.0	0.4	460	3.0	bdl	/	25.7	0.1	96.4	0.5	11.0	2.2	0.5	0.2	13.0	3.5
	144	9.8	0.1	9.3	0.08	50.6	0.5	455	2.1	bdl	/	26.2	0.1	97.4	1.0	15.0	6.4	0.6	0.2	12.3	2.5
	192	9.9	0.04	9.4	0.08	50.7	0.6	459	7.4	bdl	/	26.3	0.2	98.8	1.3	15.3	3.5	0.4	0.1	18.4	6.5
	288	9.9	0.1	9.3	0.07	50.6	0.6	458	2.4	bdl	/	26.6	0.3	100	1.5	19.2	8.7	0.5	0.1	15.6	2.9
	480	9.9	0.01	9.3	0.04	50.7	0.3	457	3.6	bdl	/	26.3	0.6	99.4	2.8	19.5	14.1	0.5	0.1	15.9	2.0

[a]pH data is TRIS standard corrected

bdl: below detection limit; in cases when no Si-SD is indicated (/), only one data point from one reactor was available

Table S4: Mineralogical composition of the starting materials dunite (olivine) and sand as well as the different experimental treatments after the experiment.

Sample	Olivine wt.%	Pyroxene wt.%	Chlorite wt.%	Kaolinite wt.%	Talc wt.%	Muscovite wt.%	Antigorite wt.%	Plagioclase wt.%	Microcline wt.%	Quartz wt.%	Calcite wt.%	Mg-Calcite wt.%	Aragonite wt.%	Halite wt.%	Gypsum wt.%	Sum wt.%	Rwp -
Olivine - turbulent	92	5.0	0.5	1.3	0.2	0.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	3.43
Olivine - stagnant	90	7.2	0.3	1.7	0.3	0.4	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	3.58
Sand - turbulent	0.0	0.0	0.9	0.0	0.0	1.2	0.0	19	10	51	7.0	4.4	3.4	1.9	1.3	100.0	4.68
Sand - stagnant	0.0	0.0	0.5	0.0	0.0	1.0	0.0	19	11	54	6.7	2.9	2.8	2.4	0.3	100.0	4.85
Olivine/Sand - turbulent	22	2.5	0.3	0.5	0.3	1.0	0.2	14	9	39	4.6	1.6	4.1	1.4	0.4	100.0	4.09
Olivine/Sand - stagnant	24	2.2	0.3	0.4	0.3	2.0	0.3	14	9	36	6.0	1.4	2.4	2.0	0.2	100.0	4.45
Sand starting material	0.0	0.0	0.5	0.0	0.0	1.5	0.0	19	11	49	7.6	1.5	4.4	4.8	0.0	100.0	4.56
Dunite starting material	93	3.9	0.6	1.0	0.4	0.5	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	3.42

Table S5: Major and trace element composition of the starting materials dunite (olivine) and sand as well as the different experimental treatments after the experiment.

Oxide		Dunite starting material	Sand starting material	Olivine - turbulent	Olivine - stagnant	Sand - turbulent	Sand - stagnant	Olivine/Sand - turbulent	Olivine/Sand - stagnant
SiO2	wt.%	41.25	61.49	40.73	40.66	62.32	62.23	59.52	57.67
TiO2	wt.%	<0.05	0.07	<0.05	<0.05	0.08	0.07	<0.05	0.05
Al2O3	wt.%	0.43	9.64	0.14	0.25	9.40	9.47	7.15	7.37
Fe2O3	wt.%	7.75	0.48	7.84	7.78	0.45	0.43	2.33	1.98
MnO	wt.%	0.10	<0.05	0.10	0.10	<0.05	<0.05	<0.05	<0.05
MgO	wt.%	49.38	0.48	49.72	49.49	0.34	0.33	13.12	10.64
CaO	wt.%	0.09	10.55	0.11	0.10	9.75	9.20	6.45	7.55
K2O	wt.%	<0.05	3.70	<0.05	<0.05	3.79	3.82	3.02	2.93
Na2O	wt.%	<0.1	2.06	<0.1	<0.1	1.95	1.96	1.35	1.45
P2O5	wt.%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
SO3	wt.%	<0.05	0.22	<0.05	<0.05	0.47	0.19	0.29	0.17
LOI	wt.%	0.44	11.14	0.82	1.05	11.29	12.15	6.50	9.95
Sum	wt.%	99.48	99.86	99.53	99.50	99.86	99.87	99.80	99.80
Traces									
V	ppm	<50	<50	<50	<50	<50	<50	<50	<50
Cr	ppm	1912	<50	1342	1653	<50	<50	242	321
Ni	ppm	3193	<50	3235	3205	<50	<50	835	675
Cu	ppm	<50	<50	<50	<50	<50	<50	<50	<50
Zn	ppm	51	<50	<50	<50	<50	<50	<50	<50
Ga	ppm	<50	<50	<50	<50	<50	<50	<50	<50
Rb	ppm	<50	143	<50	<50	143	145	116	114
Sr	ppm	<50	730	<50	<50	681	656	469	534
Y	ppm	<50	<50	<50	<50	<50	<50	<50	<50
Zr	ppm	<50	59	<50	<50	76	62	<50	60
Pb	ppm	<50	<50	<50	<50	<50	<50	<50	<50
Ba	ppm	<50	364	<50	<50	370	377	238	233
Nb	ppm	<50	<50	<50	<50	<50	<50	<50	<50
Co	ppm	<50	<50	<50	<50	<50	<50	<50	<50
Sum	ppm	5228	1407	4702	4986	1374	1341	2030	2022