Supporting Information

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Table S1. Compiled data for net O_2 production rates measured in situ for diverse benthic microbial ecosystems

Ref.	Benthic environment	Net O_2 (nmol/cm^2/s)	Environment*
1	Submerged Wadden sea intertidal flats	0.077	1
1	Submerged Wadden sea intertidal flats	0.074	1
1	Submerged Wadden sea intertidal flats	0.056	1
1	Submerged Wadden sea intertidal flats	0.054	1
1	Submerged Wadden sea intertidal flats	0.043	1
1	Submerged Wadden sea intertidal flats	0.020	1
1	Submerged Wadden sea intertidal flats	0.019	1
1	Submerged Wadden sea intertidal flats	0.013	1
1	Submerged Wadden sea intertidal flats	0.003	1
2	Cyanobacterial mats, Guerrero Negro (Mexico)	0.267	1
3	Cyanobacterial mats, Ebro delta (Spain)	0.467	1
4	Brackish intertidal sandy microbial mat	0.240	1
5	Cyanobacterial mats, hypersaline Chiprana lake (Spain)	0.133	1
6	Hypersaline desert lake cyanobacterial mat	0.926	1
7	Cyanobacterial mats, tropical lagoon	0.283	1
7	Cyanobacterial mats, tropical lagoon	0.217	1
7	Cyanobacterial mats, tropical lagoon	0.175	1
8	Carbonate sediments, Great Barrier Reef	0.136	1
9	Shallow marine sediments, brackish water, bacteria, and diatoms	0.419	1
9	Shallow marine sediments, brackish water, bacteria, and diatoms	0.281	1
9	Shallow marine sediments, brackish water, bacteria, and diatoms	0.222	1
9	Shallow marine sediments, brackish water, bacteria, and diatoms	0.009	1
10	Hypersaline desert lake cyanobacterial mat	0.275	1
10	Hypersaline desert lake cyanobacterial mat	0.050	1
11	Cyanobacterial mats, Solar lake (Egypt)	0.100	1
12	Cyanobacterial mats, commercial salt pond	0.700	1
12	Cyanobacterial mats, commercial salt pond	0.400	1
12	Cyanobacterial mats, commercial salt pond	0.300	1
12	Cyanobacterial mats, commercial salt pond	0.250	1
13	Hypersaline cyanobacterial saltern crusts (gypsum)	0.057	1
14	Cyanobacterial mats in ponds on McMurdo Ice shelf, Antarctica	1.183	2
14	Cyanobacterial mats in ponds on McMurdo Ice shelf, Antarctica	1.131	2
14	Cyanobacterial mats in ponds on McMurdo Ice shelf, Antarctica	0.717	2
14	Cyanobacterial mats in ponds on McMurdo Ice shelf, Antarctica	0.703	2
14	Cyanobacterial mats in ponds on McMurdo Ice shelf, Antarctica	0.453	2
14	Cyanobacterial mats in ponds on McMurdo Ice shelf, Antarctica	0.408	2
15	Green algal mats in two acidic mining lakes	0.014	2
16	Green algal mat in acidic mining lake	0.098	2
16	Green algal mat in acidic mining lake	0.002	2
17	Diatom mats in acidic mining lake	0.041	2
17	Diatom mats in acidic mining lake	0.029	2
18	Survey of 20 literature studies of freshwater green algal mats	0.291	2
19	Green algal mat in experimentally acidified lake	0.257	2
20	Epilithic cyanobacterial biofilms, wastewater trickling filter	0.249	3
20	Epilithic cyanobacterial biofilms, wastewater trickling filter	0.244	3
20	Epilithic cyanobacterial biofilms, wastewater trickling filter	0.229	3
20	Rapidly flowing freshwater stream, epilithic diatom-dominated mat	0.221	3
20	Rapidly flowing freshwater stream, epilithic diatom-dominated mat	0.194	3
20	Rapidly flowing freshwater stream, epilithic diatom-dominated mat	0.150	3
20	Epilithic cyanobacterial biofilms, wastewater trickling filter	0.144	3
20	Rapidly flowing freshwater stream, epilithic diatom-dominated mat	0.139	3
20	Rapidly flowing freshwater stream, epilithic diatom-dominated mat	0.132	3
20	Epilithic cyanobacterial biofilms, wastewater trickling filter	0.110	3
20	Epilithic cyanobacterial biofilms, wastewater trickling filter	0.106	3
20	Rapidly flowing freshwater stream, epilithic diatom-dominated mat	0.084	3
20	Rapidly flowing freshwater stream, epilithic diatom-dominated mat	0.063	3

Table S1. Cont.

Ref.	Benthic environment	Net O_2 (nmol/cm^2/s)	Environment*
20	Rapidly flowing freshwater stream, epilithic diatom-dominated mat	0.043	3
21	Epilithic cyanobacterial biofilms, wastewater trickling filter	0.282	3
21	Epilithic cyanobacterial biofilms, wastewater trickling filter	0.262	3
21	Epilithic cyanobacterial biofilms, wastewater trickling filter	0.260	3
21	Epilithic cyanobacterial biofilms, wastewater trickling filter	0.217	3
21	Epilithic cyanobacterial biofilms, wastewater trickling filter	0.139	3
21	Epilithic cyanobacterial biofilms, wastewater trickling filter	0.121	3
21	Epilithic cyanobacterial biofilms, wastewater trickling filter	0.111	3
22	Stream sediment	0.367	3
23	Green algal mat in Alaskan tundra stream	0.004	3
24	Cyanobacterial mats, Antarctic dry valley streambeds	0.597	3
24	Cyanobacterial mats, Antarctic dry valley streambeds	0.458	3
24	Cyanobacterial mats, Antarctic dry valley streambeds	0.411	3
24	Cyanobacterial mats, Antarctic dry valley streambeds	0.392	3
24	Cyanobacterial mats, Antarctic dry valley streambeds	0.369	3
24	Cyanobacterial mats, Antarctic dry valley streambeds	0.253	3
24	Cyanobacterial mats, Antarctic dry valley streambeds	0.244	3
24	Cyanobacterial mats, Antarctic dry valley streambeds	0.169	3
24	Cyanobacterial mats, Antarctic dry valley streambeds	0.108	3
24	Cyanobacterial mats, Antarctic dry valley streambeds	0.086	3
25	Endolithic cyanobacterial in sandstone	0.200	4
26	Cyanobacterial desert crust	0.117	4
26	Cyanobacterial desert crust	0.041	4
27	Cyanobacterial mats under ice covered Lake Hoare, Antarctica	0.015	5
27	Cyanobacterial mats under ice covered Lake Hoare, Antarctica	0.015	5
28	Benthic brown algae (pennate diatoms) under sea ice	0.116	5
29	Cyanobacterial mats under ice covered Lake Hoare, Antarctica	0.014	5
29	Cyanobacterial mats under ice covered Lake Hoare, Antarctica	0.003	5

*Environments: 1-coastal or hypersaline; 2-lacustrine; 3-river/stream; 4-BSC or endolithic; 5-under ice.

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Table S2. Compilation of annual O_2 source and sink fluxes (in terms of O_2 equivalents) contributing to Earth's surface redox balance, with additional values relevant to Precambrian redox evolution

Ref.	Process	Annual flux O_2 equivalents* (Tmol/y)
1	Modern global primary production	8,734
2, 3	Estimated Archean global primary production (∼1/10 modern)	800
4	Upper estimate for Archean CH_4 flux	400†
5	Modern CH_4 flux	60†
6	Modern organic carbon burial	+18.4
6	Modern oxidative weathering and volcanism	−17.9
7	Fe(III) burial ca. 2.5 Ga	−0.5
8	Sulfate flux from continents at present	−3.500
8	Sulfate flux from continents 2.5–1 Ga	−2.275
8	Sulfate flux from continents 2.8–2.5 Ga	−0.9625
8	Sulfate flux from continents 3.3–2.8 Ga	−0.0963
9	Archean atmospheric H_2O_2 rainout	+0.00004

Many are as compiled by Claire et al. (4) however primary references are provided where possible; see also Kastings (10) and Catling (11) for detailed treatments.

*Fluxes directly determining global redox balance are denoted as sources (+) or sinks (-); values not noted as such do not directly determine global redox balance and/or are included simply for comparison. O_2 equivalents were calculated from sulfate fluxes conservatively assuming the pyrite oxidation reaction $FeS_2 + 3.5O_2 + H_2O \rightarrow Fe^{2+} + 2SO_4^{2-} + 2H^+$.

†Methane production has an indirect positive contribution to atmospheric oxidation by its promotion of hydrogen escape, which itself is dependent on atmospheric CH_4 concentrations [see discussion by Claire et al. (4)]. It is thus included for comparison only.

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