Global Biogeochemical Cycles

Supporting Information for

Controls on dissolved Cu concentrations and isotopes in the North Atlantic: the importance of continental margins

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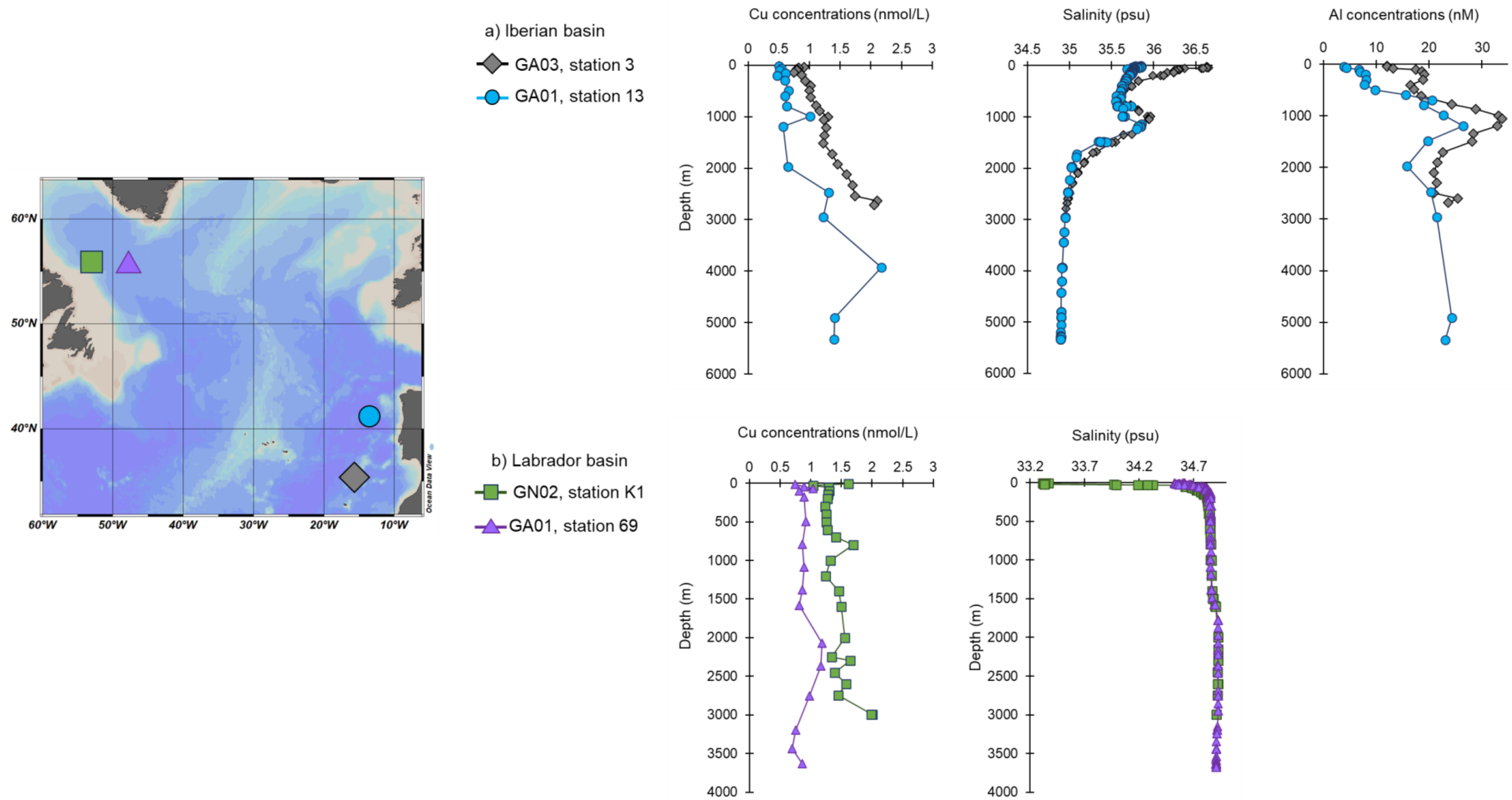

Figure S1. Comparison of Cu concentrations and salinity a) in the Iberian basin between GA01 (GEOVIDE) station 13 and GA03 station 3 (grey diamonds; Roshan & Wu, 2015), and b) in the Labrador basin between GA01 (GEOVIDE) station 69 and GN02 station K1 (green squares; GEOTRACES IDP2021). Aluminium (Al) concentrations are only shown in the Iberian basin (GEOTRACES IDP2021) as they are not available at the GN02 K1 station.

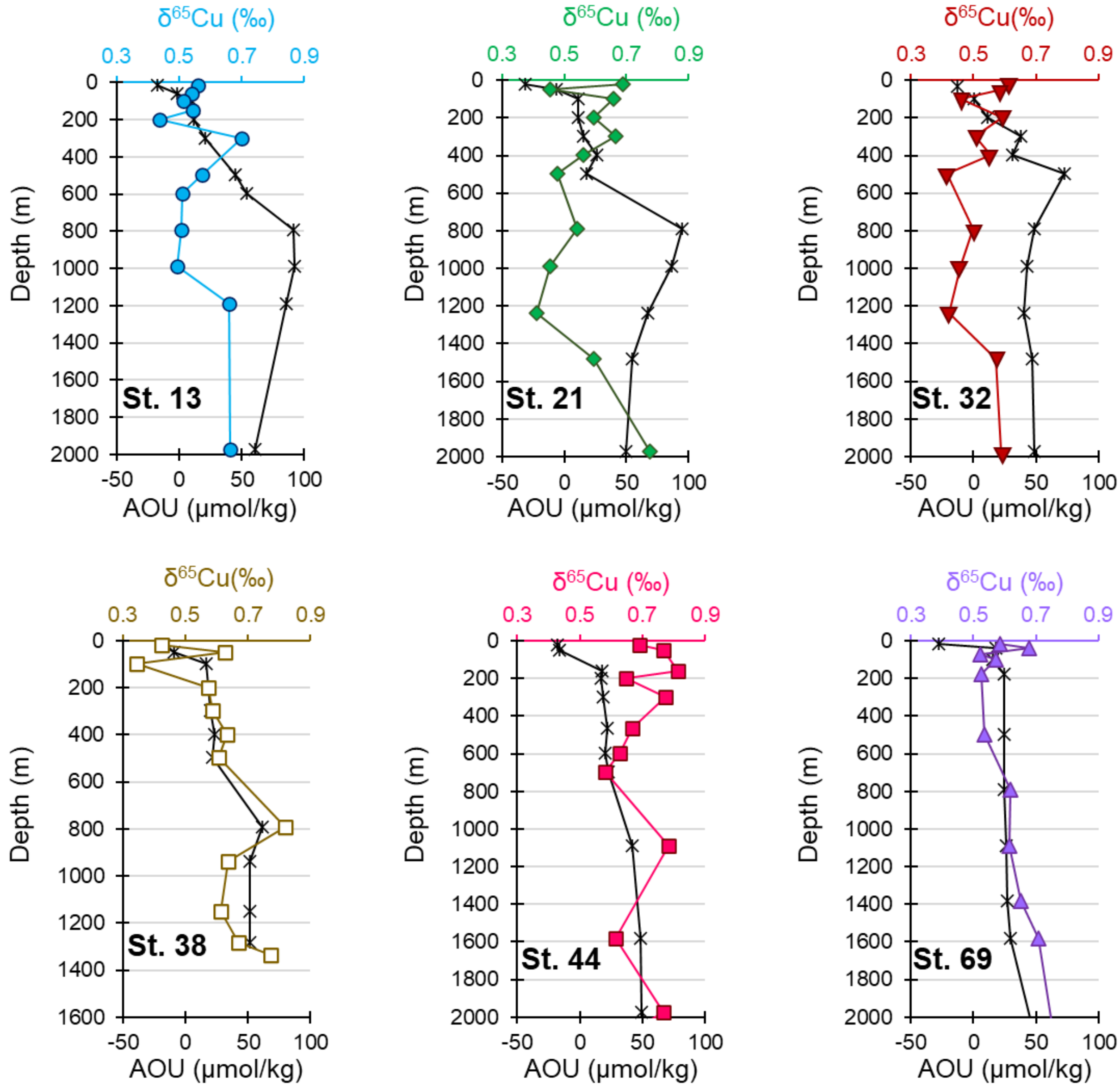

Figure S2. Comparison of Cu isotope compositions ($\delta^{65}Cu$, coloured symbols) and apparent oxygen utilisations (AOU, black crosses) in the upper 2000 m of the GEOVIDE stations.

Table S1. Comparison of dissolved Cu concentrations and isotope compositions in 3 samples from UK GEOTRACES GA10 section independently processed and analysed during the course of this study (ETH Zurich) and by Little et al. (2018). Uncertainties on Cu concentrations are estimated at ± 20% (e.g., Little et al., 2018).

Sample	Depth (m)	Cu concentration (nmol/L)		$\delta^{65/63}Cu_{SRM976}$ (‰)	
		ETH Zurich	Little et al., 2018	ETH Zurich	Little et al., 2018
1502	2487	1.45 ± 0.29	1.45 ± 0.29	0.61 ± 0.08	0.70 ± 0.06
1547	193	0.36 ± 0.07	0.38 ± 0.08	0.63 ± 0.09	0.67 ± 0.06
1560	16	0.30 ± 0.06	0.27 ± 0.05	0.67 ± 0.10	0.69 ± 0.06

Table S2. Dissolved Cu isotope compositions ($\delta^{65}Cu$) and concentrations (Cu) as well as nitrate (NO_3^-) and silicate ($Si(OH)_4$) concentrations, temperature and salinity for 6 stations across the GEOVIDE transect. There are no PO_4^{3-} concentrations data available for GEOVIDE.

Depth m	$\delta^{65}Cu$ ‰	2SD ‰	Cu nmol/L	NO_3^- µmol/L	$SiOH_4$ µmol/L	Temperature °C	Salinity psu
Station 13: 41.4°N, -13.9°E, Bottom depth 5345m							
15	0.56	0.05	0.50	0.1	0.5	15.46	35.85
60	0.54	0.06	0.54	2.9	0.9	13.27	35.76
99	0.51	0.05	0.51	6.8	1.8	12.88	35.74
149	0.54	0.05	0.61			12.75	35.73
199	0.44	0.03	0.47	7.8	2.3	12.56	35.70
298	0.70	0.04	0.60	10.3	3.1	12.20	35.66
495	0.57	0.05	0.65	11.6	3.7	11.69	35.62
595	0.51	0.05	0.60	13.9	5.0	11.31	35.59
790	0.51	0.06	0.63	18.4	8.7	10.76	35.73
990	0.49	0.04	1.01			9.26	35.64
1187	0.66	0.05	0.57	18.0	10.6	9.30	35.84
1975	0.66	0.05	0.65	19.1	16.3	3.97	35.03
2466	0.71	0.06	1.32	20.2	23.8	3.30	34.98
2952	0.65	0.04	1.22	21.4	33.3	2.85	34.95
3932	0.53	0.03	2.17	23.0	43.4	2.53	34.91
4904	0.77	0.04	1.41	23.3	46.5	2.52	34.90
5330	0.63	0.03	1.40	23.3	47.0	2.57	34.90
Station 21: 46.5°N, -19.7°E, Bottom depth 4518m							
20	0.69	0.05	0.53	4.4	1.6	13.78	35.66
50	0.46	0.03	0.43	4.4	1.6	12.69	35.61
100	0.66	0.06	0.83	8.6	2.9	12.48	35.64
199	0.59	0.04	0.33	9.8	3.4	12.04	35.63
298	0.66	0.05	0.68	10.2	3.6	11.76	35.59
397	0.56	0.04	0.67	12.4	4.5	11.32	35.54
495	0.48	0.07	0.24	11.4	4.1	10.96	35.49
790	0.54	0.08	0.92	17.4	8.0	9.20	35.34
990	0.46	0.07	1.08	19.2	10.8	7.61	35.33
1237	0.41	0.06	1.35	18.8	11.0	5.76	35.15
1483	0.59	0.05	0.69	18.4	10.9	4.52	35.00
1975	0.77	0.17	0.40	18.3	12.2	3.71	34.93
2268	0.73	0.06	0.69	18.3	13.3	3.40	34.92
2759	0.85	0.04	1.11	18.5	15.9	3.07	34.94
2954	0.68	0.04	1.51	19.4	23.8	2.94	34.94
3442	0.78	0.06	1.05	21.8	37.0	2.71	34.93
4415	0.70	0.03	1.42	22.9	43.7	2.56	34.91
4507	0.64	0.08	1.83	23.3	45.6	2.57	34.91

Depth m	$\delta^{65}Cu$ ‰	2SD ‰	Cu nmol/L	NO_3^- µmol/L	$SiOH_4$ µmol/L	Temperature °C	Salinity psu
Station 32: 55.5°N, -26.7°E, Bottom depth 3234m							
30	0.60	0.04	0.75	9.2	2.2	10.34	35.12
50	0.59	0.07	0.80			8.46	35.04
99	0.46	0.03	0.51	9.5	2.0	8.71	35.13
198	0.59	0.04	0.82	13.9	5.8	8.12	35.11
298	0.51	0.03	0.86	15.5	7.5	6.65	34.92
397	0.55	0.04	0.89	16.5	8.4	6.77	35.06
496	0.42	0.03	0.94	19.0	10.8	5.71	34.99
792	0.50	0.09	0.89	17.7	9.8	4.47	34.94
990	0.46	0.03	0.94	17.1	9.6	4.11	34.92
1236	0.42	0.04	0.98	16.9	9.8	3.90	34.91
1482	0.57	0.04	0.84	17.0	10.5	3.78	34.92
1973	0.59	0.03	0.90	17.6	11.9	3.45	34.93
2463	0.56	0.07	1.09	17.5	13.2	3.18	34.94
2953	0.51	0.06	1.24	18.2	22.3	2.90	34.97
3177	0.50	0.07	1.23			2.85	34.99
3218	0.52	0.07	1.08	18.5	25.1	2.86	34.99
Station 38: 58.8°N, -31.3°E, Bottom depth 1341m							
19	0.43	0.03	0.63	7.1	0.5	9.24	35.06
50	0.63	0.03	0.90	8.8	1.2	7.94	35.07
98	0.34	0.04	0.73	14.3	5.9	7.51	35.10
197	0.57	0.03	1.00	14.6	6.4	7.34	35.11
297	0.59	0.04	0.95	14.8	6.6	7.12	35.09
397	0.63	0.03	1.08	15.0	6.6	6.78	35.06
495	0.61	0.05	1.02	16.6	8.3	6.58	35.07
792	0.82	0.04	0.97	17.8	10.3	5.17	35.03
940	0.64	0.04	0.86	17.2	10.3	4.54	34.99
1149	0.61	0.05	1.06			4.03	34.99
1285	0.67	0.04	1.00	16.8	10.6	4.01	34.99
1337	0.77	0.07	0.78	16.7	10.9	4.01	34.99

Depth m	$\delta^{65}Cu$ ‰	2SD ‰	Cu nmol/L	NO_3^- µmol/L	$SiOH_4$ µmol/L	Temperature °C	Salinity psu
Station 44: 59.6°N, -38.9°E, Bottom depth 2928m							
20	0.69	0.03	1.02	16.5	8.1	6.79	34.85
50	0.77	0.03	0.92			4.97	34.86
159	0.81	0.04	1.01	16.4	8.0	4.14	34.90
199	0.65	0.03	1.05	16.5	8.2	4.06	34.90
297	0.77	0.05	1.02	16.3	8.1	3.97	34.90
466	0.67	0.05	1.01	16.3	8.3	3.86	34.89
595	0.63	0.04	1.01	16.4	8.4	3.68	34.87
694	0.58	0.05	0.99	16.4	8.4	3.62	34.87
1087	0.78	0.05	1.02	17.3	10.6	3.73	34.90
1580	0.61	0.04	1.20		11.5	3.54	34.93
1973	0.77	0.05	1.11	17.0	12.7	3.23	34.93
2217	0.52	0.05	1.22	16.9	13.6	3.04	34.93
2561	0.54	0.04	1.19	14.1	7.6	2.65	34.91
2851	0.62	0.04	1.30	13.8	7.4	1.34	34.88
2916	0.51	0.04	1.25	13.8	7.4	1.29	34.89
Station 69: 55.8°N, -48.1°E, Bottom depth 3692m							
15	0.58	0.04	0.74	0.1	3.6	6.22	34.62
41	0.68	0.05	0.90	11.8	7.0	3.60	34.74
70	0.52	0.04	1.04	15.4	7.4	3.89	34.82
100	0.57	0.04	0.81	15.4	7.4	3.87	34.83
178	0.52	0.06	0.89	15.9	8.0	3.71	34.85
496	0.54	0.05	0.92	16.0	8.1	3.49	34.85
792	0.62	0.07	0.86	16.2	8.2	3.48	34.85
1087	0.62	0.08	0.89	16.2	8.3	3.46	34.85
1383	0.65	0.09	0.86	16.1	8.8	3.51	34.86
1580	0.71	0.07	0.81	16.8	9.1	3.62	34.89
2071	0.75	0.05	1.18	17.1	10.8	3.45	34.92
2364	0.67	0.05	1.17	17.2	11.6	3.22	34.92
2756	0.59	0.06	0.98	16.8	12.5	2.93	34.92
3196	0.65	0.05	0.75	16.4	14.0	2.48	34.91
3439	0.63	0.06	0.70	15.4	11.5	2.00	34.90
3635	0.42	0.04	0.87			1.68	34.90

Table S3. Comparison of copper isotope compositions ($\delta^{65}Cu$) and carbon (C) uptake rates at different depths along the GEOVIDE transect. Carbon uptake rates were determined by spiking incubation experiments with $^{13}C\text{-}HCO_3^-$. This ^{13}C-labelled dissolved inorganic carbon spike allows sufficient tracer enrichment for a sensitive detection in the particulate organic carbon pool as a result of biological assimilation. More details of the sampling and analysis procedures can be found in Fonseca-Batista (2017) and Fonseca-Batista et al. (2019). The base of the primary production zone (where in-situ fluorescence is 10% of its maximum value; Owens et al., 2014) is indicated for each station (Lemaitre et al., 2018).

	Copper isotopes				Carbon uptake rates			
	Depth m	$\delta^{65}Cu$ ‰	2SD ‰	Cu nmol/L	PAR %	Depth m	C uptake rate µmol/m³/d	SD µmol/m³/d
Station 13 PPZ = 82 m	15	0.56	0.05	0.50	54%	15	1671	242
					25%	30	403	124
					13%	43	911	131
	60	0.54	0.06	0.54	3%	58	790	103
					1%	75	338	60
	99	0.51	0.05	0.51	0%	116	23	16
Station 21 PPZ = 82 m					54%	10	2825	408
	20	0.69	0.05	0.53	25%	18	3444	434
					13%	25	3500	393
					3%	40	1155	141
	50	0.46	0.03	0.43	1%	60	394	62
	100	0.66	0.06	0.83	0%	91	74	21
Station 32 PPZ = 75 m					54%	10	2141	408
	30	0.60	0.04	0.75	25%	30	24	54
	50	0.59	0.07	0.80	13%	45	2117	413
					3%	55	868	168
					1%	80	800	152
	99	0.46	0.03	0.51	0%	100	242	63
Station 44 PPZ = 37 m					54%	10	4603	535
	20	0.69	0.03	1.02	25%	20	4505	506
					13%	30	1880	263
					3%	40	196	58
	50	0.77	0.03	0.92	1%	50	149	47
					0%	60	72	52
Station 69 PPZ = 35 m					54%	10	404	140
	15	0.58	0.04	0.74	13%	22	1227	233
	41	0.68	0.05	0.90	3%	40	151	105
	70	0.52	0.04	1.04	0%	70	24	41