

Quantifying seawater exchange rates in the Eocene Arctic Basin using osmium isotopes

A.J. Dickson, M. Davies, M.-L. Bagard, A.S. Cohen

Supplementary Information

The Supplementary Information includes:

- Tables S-1 to S-5
- Figure S-1
- Supplementary Information References

Table S-1 New Re-Os data from this study obtained from IODP M0004A.

An Excel version of Table S-1, including an alternate age model, is available for download from the online version of this article at <https://doi.org/10.7185/geochemlet.2239>.

Sample	Metres composite depth	Backman <i>et al.</i> (2008) age (Ma)	Re (pg g ⁻¹)	Os (pg g ⁻¹)	¹⁹² Os (pg g ⁻¹)	¹⁸⁷ Re/ ¹⁸⁸ Os	¹⁸⁷ Os/ ¹⁸⁸ Os	err	¹⁸⁷ Os/ ¹⁸⁸ Osi	Os _i uncertainty
302 2 A 47 4 74-72	205.43	44.702	82504	273	86	1876	2.341	0.001	0.943	0.026
302 2 A 47 CC 2-4	206.76	44.757	76733	205	63	2351	2.468	0.003	0.714	0.020
302 2 A 48 1 22-23	206.86	44.761	50303	240	79	1237	1.851	0.006	0.928	0.025
302 2 A 48 1 62-63	207.26	44.778	86702	224	67	2518	2.801	0.002	0.922	0.025
302 2 A 58 3 78-79	255.21	46.755	23872	200	70	672	1.422	0.001	0.899	0.024
302 4 A 6 4 15-16	278.18	47.702	33648	165	55	1180	1.680	0.004	0.742	0.020
302 4 A 7 1 3-4	278.73	47.725	31260	191	61	975	1.969	0.036	1.193	0.032
302 4 A 7 1 61-62	279.31	47.749	20171	163	55	699	1.449	0.002	0.893	0.024
302 4 A 7 1 117-118	279.87	47.772	5359	245	86	121	1.286	0.001	1.190	0.032
302 4 A 7 2 12-13	280.34	47.791	38288	225	76	975	1.598	0.002	0.821	0.022
302 4 A 7 2 95-96	281.17	47.826	21987	156	52	802	1.511	0.002	0.872	0.024
302 4 A 9 1 16-17	287.46	48.085	32669	190	63	990	1.616	0.004	0.823	0.022
302 4 A 10 2 50-51	293.85	48.348	33205	178	59	1079	1.685	0.002	0.815	0.022
302 4 A 19 1 45-46	320.98	50.252	19331	92	29	1214	1.707	0.020	0.690	0.019
302 4 A 19 1 144-145	321.97	50.330	19360	114	38	953	1.369	0.002	0.570	0.015
302 4 A 19 2 50-51	322.53	50.374	24837	106	34	1378	1.833	0.002	0.677	0.018
302 4 A 19 2 146-147	323.49	50.449	16089	87	28	1082	1.795	0.002	0.885	0.024
302 4 A 20 1 12-13	326.4	50.678	32783	124	41	1555	1.856	0.002	0.542	0.015
302 4 A 20 1 88-89	327.16	50.738	32612	153	50	1253	1.834	0.001	0.775	0.021
302 4 A 20 2 55-56	327.82	50.789	19792	92	30	1251	1.760	0.004	0.701	0.019
302 4 A 21 1 12-13	329.4	50.913	25553	131	43	1146	1.794	0.004	0.821	0.022
302 4 A 21 1 93-94	330.21	50.977	22844	152	51	863	1.600	0.003	0.866	0.023
302 4 A 21 2 9-10	330.9	51.031	29509	155	51	1107	1.709	0.002	0.767	0.021
302 4 A 21 2 97-98	331.78	51.100	29069	113	37	1506	1.745	0.005	0.463	0.012
302 4 A 21 3 22-23	332.5	51.157	32703	172	57	1101	1.686	0.006	0.748	0.020
302 4 A 22 1 13-14	339.13	51.678	21503	94	30	1869	1.908	0.003	0.298	0.008
302 4 A 22 CC 6-7	339.91	51.739	26415	123	40	1276	1.904	0.002	0.803	0.022
302 4 A 23 1 60-61	342.2	51.919	34056	111	35	1841	2.049	0.002	0.456	0.012
302 4 A 23 1 136-137	342.96	51.979	25877	117	39	1290	1.733	0.002	0.616	0.016
302 4 A 23 2 50-51	343.61	52.030	24263	127	43	1098	1.593	0.019	0.641	0.017
302 4 A 23 2 140-141	344.51	52.100	45023	157	50	1743	2.154	0.003	0.641	0.017
302 4 A 23 CC 3-4	345.48	52.177	31567	116	37	1645	2.115	0.004	0.684	0.018



Table S-2 Average $^{187}\text{Os}/^{188}\text{Os}$ for 2-million-year intervals of the Early Eocene. Open ocean seawater values calculated from ferro-manganese crusts and metalliferous sediments (Peucker-Ehrenbrink et al., 1995; Pegram and Turekian, 1999). Arctic Ocean seawater values calculated from this study.

Age range (Ma)	Open ocean $^{187}\text{Os}/^{188}\text{Os}$	Arctic $^{187}\text{Os}/^{188}\text{Os}$
44–46	0.564	0.836
46–48	0.501	0.915
48–50	0.559	0.819
50–52	0.413	0.667
52–54	0.484	0.605
54–56	0.460	0.444

Table S-3 Calculated seawater exchange rates and salinities for different Os burial fluxes. Arctic rivers held at $^{187}\text{Os}/^{188}\text{Os} = 1.4$ and $[\text{Os}] = 8 \text{ pg g}^{-1}$; open seawater held at $[\text{Os}] = 11 \text{ pg g}^{-1}$

Age range (Ma)	Arctic basin salinity (PSU)	Burial flux = $5.5125 \times 10^{16} \text{ pg yr}^{-1}$	Burial flux = $3.675 \times 10^{16} \text{ pg yr}^{-1}$	Burial flux = $1.8375 \times 10^{16} \text{ pg yr}^{-1}$
		Open ocean exchange (Sv)	Open ocean exchange (Sv)	Open ocean exchange (Sv)
44–46	21.3	0.00034	0.000225	0.00011
46–48	16.1	0.00019	0.000124	0.00006
48–50	21.6	0.00035	0.000236	0.00012
50–52	24.0	0.00048	0.000318	0.00016
52–54	29.0	0.00106	0.000709	0.00035
54–56	35.0	0.15875	0.105834	0.05292

Table S-4 Calculated seawater exchange rates and salinities for different Arctic river $^{187}\text{Os}/^{188}\text{Os}$. Burial fluxes held constant at $3.675 \times 10^{16} \text{ pg yr}^{-1}$ (Os burial across ~50% of the Arctic seafloor); Arctic rivers held at $[\text{Os}] = 8 \text{ pg g}^{-1}$; open seawater held at $[\text{Os}] = 11 \text{ pg g}^{-1}$

Age range (Ma)	$^{187}\text{Os}/^{188}\text{Os}_{\text{riv}} = 1.2$		$^{187}\text{Os}/^{188}\text{Os}_{\text{riv}} = 1.4$		$^{187}\text{Os}/^{188}\text{Os}_{\text{riv}} = 1.6$	
	Salinity (PSU)	Open ocean exchange (Sv)	Salinity (PSU)	Open ocean exchange (Sv)	Salinity (PSU)	Open ocean exchange (Sv)
44–46	17.4	0.00014	21.1	0.000220	23.6	0.00030
46–48	11.8	0.00007	16.1	0.000124	19.1	0.00018
48–50	18.1	0.00016	21.8	0.000241	24.0	0.00032
50–52	21.3	0.00022	23.8	0.000310	25.4	0.00039
52–54	27.3	0.00052	29.0	0.000709	29.9	0.00086
54–56	35.0	0.10583	35.0	0.105834	35.0	0.10583



Table S-5 Calculated seawater exchange rates and salinities for different open ocean and Arctic river Os concentrations. Burial fluxes held constant at 3.675×10^{16} pg yr⁻¹ (Os burial across ~50% of the Arctic seafloor); Arctic rivers held at $^{187}\text{Os}/^{188}\text{Os} = 1.4$.

Age range (Ma)	River [Os] = 4 pg g ⁻¹ , Ocean [Os] = 16.5 pg g ⁻¹		River [Os] = 8 pg g ⁻¹ , Ocean [Os] = 11 pg g ⁻¹		River [Os] = 12 pg g ⁻¹ , Ocean [Os] = 5.5 pg g ⁻¹	
	Salinity (PSU)	Open ocean exchange (Sv)	Salinity (PSU)	Open ocean exchange (Sv)	Salinity (PSU)	Open ocean exchange (Sv)
44–46	11.9	0.00015	21.3	0.00023	28.8	0.00045
46–48	7.8	0.00008	16.1	0.00012	25.2	0.00025
48–50	12.3	0.00015	21.6	0.00024	29.0	0.00047
50–52	14.7	0.00021	24.0	0.00032	30.4	0.00064
52–54	21.7	0.00047	29.0	0.00071	32.8	0.00142
54–56	34.9	0.07056	35.0	0.10583	35.0	0.21167



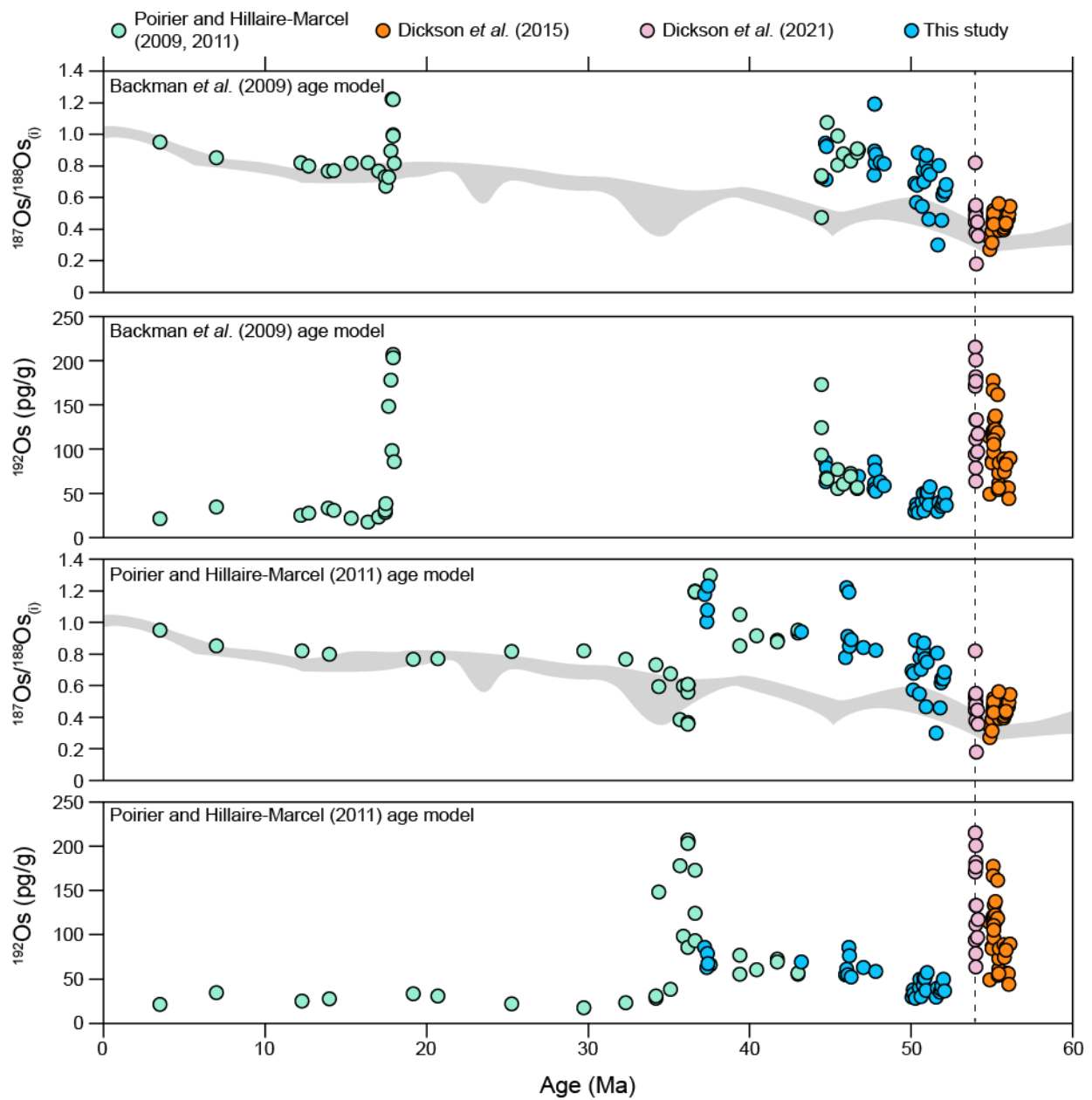


Figure S-1 Osmium isotope data for IODP Expedition 302 Site M0004 plotted against the Backman *et al.* (2008) age model and the Poirier and Hillaire-Marcel (2011) age model. The grey band is the open-ocean $^{187}\text{Os}/^{188}\text{Os}$ trend.

Supplementary Information References

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