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Orbital control on the timing of oceanic anoxia in the Late Cretaceous

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Supplementary Material to *"Orbital control on the timing of oceanic anoxia in the Late Cretaceous"*

Supplementary Table 1: Complete $^{40}Ar/^{39}Ar$ results

Sample 91-O-03, J: 0.0207634 ± 0.0000127 (1σ), D/amu: 1.00 ± 0.0002 (1σ), MSWD = 0.69
Single sanidine fusions, Ages relative to 28.201 Ma Fish Canyon sanidine (Kuiper et al., 2008)

File	^{40}Ar (moles)	^{40}Ar (10^{-15} V)	± 1σ$_{40}$ (10^{-15} V)	^{39}Ar (10^{-15} V)	±1σ$_{39}$ (10^{-15} V)	^{38}Ar (10^{-15} V)	± 1σ$_{38}$ (10^{-15} V)	^{37}Ar (10^{-15} V)	± 1σ$_{37}$ (10^{-15} V)	^{36}Ar (10^{-15} V)	± 1σ$_{36}$ (10^{-15} V)	%$^{40}Ar^*$	$^{40}Ar^*/^{39}Ar_K$ ± 2σ	Age (Ma)	± 2σ (Ma)	K/Ca	Outliers
BG2538	2.688E-15	0.455488	0.000598	0.173046	0.000268	0.002121	0.000020	0.001465	0.000167	0.000017	0.000006	98.87	2.602509	0.02323	96.33	± 0.84	50.8	
BG2540	1.513E-15	0.256400	0.000567	0.098068	0.000224	0.001175	0.000019	0.001086	0.000159	0.000009	0.000006	99.02	2.588839	0.03975	95.84	± 1.43	38.8	
BG2541	3.716E-15	0.629596	0.000618	0.240421	0.000296	0.002879	0.000025	0.001621	0.000183	0.000021	0.000006	98.99	2.592404	0.01653	95.97	± 0.60	63.8	
BG2543	1.923E-15	0.325774	0.000582	0.125257	0.000245	0.001508	0.000022	0.000840	0.000168	0.000019	0.000006	98.24	2.555077	0.03117	94.62	± 1.13	64.1	< 98.5% 40Ar
BG2544	2.152E-15	0.364594	0.000623	0.139133	0.000257	0.001626	0.000020	0.001099	0.000187	0.000010	0.000006	99.15	2.598308	0.02828	96.18	± 1.02	54.4	
BG2546	2.952E-15	0.500217	0.000615	0.191081	0.000240	0.002271	0.000024	0.001465	0.000171	0.000016	0.000006	99.03	2.592507	0.02113	95.97	± 0.76	56.1	
BG2547	1.457E-15	0.246878	0.000561	0.094100	0.000221	0.001160	0.000014	0.000801	0.000172	0.000008	0.000006	99.10	2.599921	0.04078	96.24	± 1.47	50.5	
BG2549	2.939E-15	0.497890	0.000627	0.190952	0.000248	0.002331	0.000020	0.001266	0.000172	0.000007	0.000006	99.61	2.597166	0.02073	96.14	± 0.75	64.9	
BG2550	2.535E-15	0.429545	0.000614	0.163874	0.000244	0.001953	0.000021	0.001768	0.000169	0.000011	0.000006	99.23	2.600931	0.02412	96.28	± 0.87	39.9	
BG2552	1.700E-15	0.288101	0.000584	0.109420	0.000227	0.001293	0.000017	0.001118	0.000190	0.000016	0.000006	98.40	2.590863	0.03509	95.91	± 1.27	42.1	< 98.5% 40Ar
BG2555	2.418E-15	0.409718	0.000592	0.156706	0.000225	0.001849	0.000017	0.001257	0.000153	0.000010	0.000006	99.26	2.595314	0.02439	96.07	± 0.88	53.6	
BG2556	2.673E-15	0.452928	0.000609	0.173626	0.000257	0.002080	0.000025	0.001284	0.000162	0.000007	0.000006	99.55	2.596947	0.02221	96.13	± 0.80	58.2	
BG2558	2.125E-15	0.360015	0.000576	0.136902	0.000237	0.001651	0.000023	0.000973	0.000191	0.000017	0.000006	98.57	2.592119	0.02865	95.96	± 1.03	60.5	
BG2559	2.424E-15	0.410644	0.000637	0.155942	0.000254	0.001895	0.000024	0.001459	0.000172	0.000008	0.000006	99.45	2.618752	0.02516	96.92	± 0.91	46.0	
BG2561	1.965E-15	0.332994	0.000575	0.127580	0.000257	0.001537	0.000027	0.001137	0.000159	0.000000	0.000006	99.96	2.609120	0.03105	96.57	± 1.12	48.2	
BG2562	1.962E-15	0.332400	0.000579	0.127720	0.000243	0.001504	0.000018	0.001202	0.000168	0.000009	0.000006	99.23	2.582635	0.03006	95.62	± 1.08	45.7	
BG2565	2.799E-15	0.474318	0.000595	0.181702	0.000294	0.002173	0.000027	0.001605	0.000166	0.000011	0.000006	99.30	2.592148	0.02166	95.96	± 0.78	48.7	
BG2567	2.447E-15	0.414686	0.000593	0.156068	0.000259	0.001893	0.000022	0.001004	0.000189	0.000023	0.000006	98.38	2.614099	0.02576	96.75	± 0.93	66.9	< 98.5% 40Ar
BG2568	3.073E-15	0.520647	0.000594	0.198725	0.000278	0.002450	0.000026	0.001661	0.000167	0.000006	0.000006	99.66	2.610987	0.02016	96.64	± 0.73	51.4	
BG2570	2.071E-15	0.350955	0.000574	0.134345	0.000246	0.001637	0.000021	0.000813	0.000171	0.000008	0.000006	99.35	2.595250	0.02920	96.07	± 1.05	71.0	
BG2571	2.002E-15	0.339143	0.000577	0.129811	0.000240	0.001553	0.000019	0.000877	0.000149	0.000007	0.000006	99.37	2.596017	0.03003	96.10	± 1.08	63.6	
BG2573	2.735E-15	0.463406	0.000591	0.176698	0.000259	0.002172	0.000025	0.001557	0.000174	0.000010	0.000006	99.37	2.606031	0.02223	96.46	± 0.80	48.8	
BG2574	2.371E-15	0.401755	0.000591	0.153758	0.000245	0.001873	0.000022	0.000927	0.000176	0.000002	0.000006	99.88	2.609848	0.02535	96.60	± 0.91	71.3	
BG2576	2.199E-15	0.372670	0.000581	0.142847	0.000264	0.001763	0.000020	0.001095	0.000168	0.000007	0.000006	99.46	2.594743	0.02714	96.05	± 0.98	56.1	
BG2577	1.935E-15	0.327913	0.000558	0.125206	0.000251	0.001521	0.000019	0.000989	0.000166	0.000002	0.000006	99.83	2.614620	0.03075	96.77	± 1.11	54.4	
BG2579	1.732E-15	0.293406	0.000568	0.112215	0.000214	0.001345	0.000023	0.000902	0.000177	0.000003	0.000006	99.68	2.606365	0.03485	96.47	± 1.26	53.5	
BG2580	1.724E-15	0.292050	0.000569	0.111667	0.000234	0.001335	0.000017	0.000895	0.000165	0.000004	0.000006	99.64	2.605889	0.03511	96.46	± 1.27	53.6	
BG2582	1.892E-15	0.320504	0.000371	0.122576	0.000181	0.001475	0.000016	0.000906	0.000158	0.000001	0.000004	99.90	2.612138	0.02046	96.68	± 0.74	58.2	
BG2585	1.836E-15	0.311041	0.000333	0.118229	0.000217	0.001459	0.000022	0.000872	0.000142	0.000004	0.000004	99.61	2.620656	0.02362	96.99	± 0.85	58.3	
BG2588	1.557E-15	0.263847	0.000344	0.100811	0.000137	0.001190	0.000017	0.000593	0.000144	0.000007	0.000004	99.23	2.597069	0.02743	96.14	± 0.99	73.1	
BG2589	2.238E-15	0.379144	0.000410	0.143448	0.000196	0.001735	0.000020	0.001102	0.000135	0.000020	0.000004	98.42	2.601440	0.01771	96.30	± 0.64	56.0	< 98.5% 40Ar
BG2591	1.347E-15	0.228257	0.000379	0.087467	0.000145	0.001030	0.000013	0.000871	0.000137	0.000014	0.000004	98.21	2.562801	0.02766	94.90	± 1.00	43.2	< 98.5% 40Ar
BG2592	1.699E-15	0.287944	0.000362	0.110065	0.000164	0.001350	0.000017	0.001010	0.000141	0.000007	0.000004	99.27	2.596988	0.02143	96.14	± 0.77	46.8	
BG2594	1.411E-15	0.239135	0.000364	0.091782	0.000126	0.001122	0.000019	0.000817	0.000133	0.000002	0.000004	99.72	2.598287	0.02574	96.18	± 0.93	48.3	
BG2595	1.337E-15	0.226515	0.000347	0.086378	0.000143	0.001056	0.000019	0.000487	0.000142	0.000003	0.000004	99.65	2.613206	0.02703	96.72	± 0.97	76.2	
BG2597	1.697E-15	0.287521	0.000348	0.109701	0.000161	0.001331	0.000021	0.000811	0.000139	0.000019	0.000003	98.05	2.569814	0.02111	95.16	± 0.76	58.2	< 98.5% 40Ar
BG2598	1.764E-15	0.298867	0.000385	0.114184	0.000151	0.001370	0.000020	0.000656	0.000158	0.000011	0.000004	98.93	2.589375	0.02192	95.86	± 0.79	74.9	
BG2600	1.410E-15	0.238883	0.000350	0.090732	0.000121	0.001113	0.000018	0.000970	0.000158	0.000021	0.000004	97.39	2.564202	0.02644	94.95	± 0.95	40.2	< 98.5% 40Ar
BG2601	1.063E-15	0.180108	0.000332	0.068258	0.000134	0.000847	0.000016	0.000327	0.000144	0.000015	0.000004	97.50	2.572580	0.03526	95.25	± 1.27	89.6	< 98.5% 40Ar
BG2926	3.465E-15	0.587096	0.000442	0.224134	0.000225	0.002679	0.000023	0.001883	0.000210	0.000019	0.000003	99.04	2.594313	0.01123	96.04	± 0.41	51.2	
BG2928	3.049E-15	0.516641	0.000417	0.198197	0.000226	0.002344	0.000030	0.001483	0.000186	0.000009	0.000003	99.48	2.593281	0.01231	96.00	± 0.44	57.5	
BG2929	3.308E-15	0.560569	0.000469	0.210814	0.000212	0.002477	0.000027	0.001500	0.000180	0.000055	0.000004	97.09	2.581662	0.01281	95.58	± 0.46	60.4	< 98.5% 40Ar
BG2931	3.553E-15	0.601924	0.000568	0.230144	0.000284	0.002794	0.000026	0.001907	0.000188	0.000006	0.000004	99.72	2.608160	0.01313	96.54	± 0.47	51.9	
BG2932	2.471E-15	0.418739	0.000497	0.158816	0.000236	0.001889	0.000022	0.001746	0.000196	0.000015	0.000004	98.99	2.609934	0.01890	96.60	± 0.68	39.1	
BG2934	2.576E-15	0.436471	0.000538	0.167862	0.000238	0.002053	0.000018	0.001028	0.000178	0.000007	0.000004	99.55	2.588466	0.01789	95.83	± 0.65	70.2	
BG2935	3.511E-15	0.594817	0.000540	0.215834	0.000254	0.002616	0.000025	0.001278	0.000184	0.000016	0.000005	99.18	2.733345	0.01695	101.05	± 0.61	72.6	xenocryst
BG2937	2.357E-15	0.399345	0.000473	0.152211	0.000260	0.001789	0.000025	0.001554	0.000187	0.000023	0.000004	98.27	2.578292	0.01978	95.46	± 0.71	42.1	< 98.5% 40Ar
BG2938	2.430E-15	0.411701	0.000530	0.158137	0.000285	0.001904	0.000020	0.001058	0.000186	0.000022	0.000004	98.42	2.562437	0.01885	94.89	± 0.68	64.3	< 98.5% 40Ar
BG2940	2.695E-15	0.456622	0.000522	0.176042	0.000231	0.002112	0.000021	0.001030	0.000179	0.000006	0.000004	99.61	2.583644	0.01585	95.65	± 0.57	73.5	
BG2941	2.960E-15	0.501440	0.000575	0.192708	0.000218	0.002276	0.000018	0.001395	0.000170	0.000003	0.000004	99.85	2.598098	0.01501	96.18	± 0.54	59.4	
BG2943	3.064E-15	0.519164	0.000535	0.198481	0.000251	0.002418	0.000027	0.001542	0.000197	0.000010	0.000004	99.44	2.600966	0.01495	96.28	± 0.54	55.4	
BG2946	2.542E-15	0.430646	0.000530	0.164530	0.000226	0.001992	0.000021	0.001714	0.000188	0.000009	0.000004	99.40	2.601626	0.01785	96.30	± 0.64	41.3	
BG2947	3.105E-15	0.526018	0.000568	0.201033	0.000225	0.002425	0.000030	0.001689	0.000208	0.000012	0.000004	99.35	2.599547	0.01549	96.23	± 0.56	51.2	
Weighted mean age (41 of 53):															96.21	0.11	analytical uncert. only	
															96.21	**±0.16**	analytical uncert. with J error	
															96.21	0.36	total uncertainty	

Data from neutron fluence montor crystals of Fish Canyon Sanidine (FCs)
Mass discrimination D/amu: 1.001 ± 0.0002 (1σ), MSWD = 0.54

File	^{40}Ar (moles)	^{40}Ar (Volts)	± 1σ$_{40}$ (Volts)	^{39}Ar (Volts)	±1σ$_{39}$ (Volts)	^{38}Ar (Volts)	± 1σ$_{38}$ (Volts)	^{37}Ar (Volts)	± 1σ$_{37}$ (Volts)	^{36}Ar (Volts)	± 1σ$_{36}$ (Volts)	%$^{40}Ar^*$	$^{40}Ar^*/^{39}Ar_K$ ± 1σ	J	± 2σ	K/Ca	Outliers
BF9104	2.076E-14	3.516720	0.035443	4.506578	0.007733	0.054688	0.000146	0.047081	0.000361	0.000534	0.000010	95.55	0.745621	0.00368	0.0208222	± 0.000103	41.2	
BF9105	3.523E-14	5.969541	0.065522	7.937673	0.007861	0.095540	0.000194	0.052232	0.000355	0.000098	0.000011	99.51	0.748368	0.00217	0.0207458	± 0.000060	65.3	
BF9107	1.589E-14	2.692941	0.009360	3.501108	0.007627	0.042670	0.000133	0.025957	0.000213	0.000186	0.000009	97.96	0.753503	0.00470	0.0206044	± 0.000128	58.0	X
BF9108	1.992E-14	3.374348	0.010170	4.352846	0.007726	0.053111	0.000156	0.030149	0.000246	0.000403	0.000011	96.48	0.747884	0.00388	0.0207592	± 0.000108	62.1	
BF9110	3.659E-14	6.200087	0.023474	7.815288	0.007829	0.096371	0.000197	0.053106	0.000371	0.001171	0.000018	94.42	0.749049	0.00246	0.0207269	± 0.000068	63.3	
BF9111	3.092E-14	5.239527	0.022662	6.879092	0.007779	0.083495	0.000171	0.052370	0.000376	0.000305	0.000009	98.29	0.748620	0.00243	0.0207388	± 0.000067	56.5	
BF9113	4.077E-14	6.908084	0.031763	9.150692	0.007918	0.110224	0.000199	0.061748	0.000436	0.000243	0.000011	98.96	0.747067	0.00189	0.0207819	± 0.000053	63.7	
BF9114	1.539E-14	2.607770	0.010494	3.410169	0.007620	0.041550	0.000130	0.023712	0.000198	0.000203	0.000012	97.70	0.747091	0.00500	0.0207813	± 0.000139	61.8	
BF9116	3.215E-14	5.446513	0.006841	7.137932	0.007863	0.086544	0.000190	0.049738	0.000378	0.000388	0.000011	97.89	0.746976	0.00241	0.0207845	± 0.000067	61.7	
BF9117	1.006E-14	1.704794	0.001443	2.201945	0.007545	0.026468	0.000122	0.028470	0.000207	0.000206	0.000010	96.49	0.747027	0.00742	0.0207830	± 0.000206	33.3	
Weighted mean (9 of 10):															0.0207634 ± 0.000025			

The values in this table represent blank, discrimination, and decay (^{37}Ar and ^{39}Ar) corrected values.

Atmospheric argon ratios		
$^{40}Ar/^{36}Ar$	295.5 ± 0.5	Steiger & Jäger (1977)
$^{38}Ar/^{36}Ar$	0.1880 ± 0.0003	Nier (1950)

Interfering isotope production ratios		
$(^{40}Ar/^{39}Ar)_K$	$(5.4 \pm 1.4) \times 10^{-4}$	Jicha and Brown (2013)
$(^{38}Ar/^{39}Ar)_K$	$(1.210 \pm 0.002) \times 10^{-2}$	Jicha and Brown (2013)
$(^{39}Ar/^{37}Ar)_{Ca}$	$(6.95 \pm 0.09) \times 10^{-4}$	Renne et al. (2013)
$(^{38}Ar/^{37}Ar)_{Ca}$	$(1.96 \pm 0.08) \times 10^{-5}$	Renne et al. (2013)
$(^{36}Ar/^{37}Ar)_{Ca}$	$(2.65 \pm 0.022) \times 10^{-4}$	Renne et al. (2013)

Decay constants		
l_{40Ar}	$(0.580 \pm 0.014) \times 10^{-10}$ a^{-1}	Min et al. (2000)
l_B-	$(4.884 \pm 0.099) \times 10^{-10}$ a^{-1}	Min et al. (2000)
^{39}Ar	$(2.58 \pm 0.03) \times 10^{-3}$ a^{-1}	Stoenner et al. (1965)
^{37}Ar	$(5.4300 \pm 0.0063) \times 10^{-2}$ a^{-1}	Renne & Norman (2001)
^{36}Cl l_B	$(2.35 \pm 0.02) \times 10^{-6}$ a^{-1}	Endt (1998)

All lithologic, geophysical, and stable isotope data will be made available in the Pangaea database (http://www.pangaea.de/).