Supporting Online Material for

Determining Chondritic Impactor Size from the Marine Osmium Isotope Record

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Methods

Os, Pt and Ir were preconcentrated from bulk sediment samples from ODP Site 1090 (67) and 1219 (43) using a NiS fire assay. Sample powders (3-10) were spiked with a tracer solution enriched in ^{105}Pd, ^{190}Os, ^{191}Ir and ^{198}Pt prior to fusion for concentration determination by isotope dilution. Isotope ratio measurements were made using a magnetic-sector inductively coupled plasma mass spectrometer (ELEMENT2) (see ref. *1* for the original methods). An in-house standard was analyzed each day to monitor long-term reproducibility. The average $^{187}Os/^{188}Os$ of these standards is 0,1082 ± 0,0025 (2 S.D., n= 60). Seven procedural fusion blanks were as well performed and yielded an average of 0,31 ± 0,02 pg/g for Os and 1,5 ± 0,05 pg/g for Ir. Argon gas blank were performed every set of five Os isotope analyses to monitor any potential carry over between samples.

1. D.R. Hassler, B. Peucker-Ehrenbrink, G.E. Ravizza, *Chemical Geology* **166**, 1–14 (2000).

Note S1: One-box ocean model

We used a simple one-box model to simulate the removal of Os and Ir from the ocean following an impact event.

The differential equation that describes the model is $dN/dt = F_{in} - KN$

Where symbols used in the equations below are defined as follows (units are given in parentheses):

F_{in} = total flux into the box (mass/time)
N = size of the reservoir (mass)
K = first order rate constant for removal from seawater (inverse time)
τ = Residence time of the element or isotope = 1/K

The solution to this differential equation is

$N= F_{in}\,\tau + (N_0 - F_{in}\,\tau)\, e^{-t/\tau}$

Where,

t = 0 is defined as the time immediately after the impact event;

N_0 is this size of the reservoir at t =0

To produce the model curve in Fig. 2A, separate equations were written for ^{187}Os and ^{188}Os. The ratio of $^{187}N_0/^{188}N_0$ was set to 0.28 to match the minimum $^{187}Os/^{188}Os$ ratio in Fig.1 1 at t= 0. The ratio $F(187)_{in}/F(188)_{in}$ was set to 0.42 to match the stable $^{187}Os/^{188}Os$ ratio measured in the youngest samples shown in figure 1 at steady state. The absolute value chosen for $^{188}N_0$ was arbitrary because only ratios are plotted. The value of K was identical for both ^{187}Os and ^{188}Os. K was varied to obtain the best visual fit to the data.

To produce the model curve in Fig. 2B separate equations were written for Os and Ir. The steady state ratio of $^{Os}N_{st.st.}/^{Ir}N_{st.st.}$ was set to 100 to match the value of present day seawater (*31*, *32*). The value of $^{Os}N_0$ was set to 2.5 $^{Os}N_{st.st.}$ to match the estimated increase in the seawater Os inventory immediately following the Late Eocene impact event that was estimated using the sedimentary Os isotope data. Similarly $^{Ir}N_0$ was set to $50^{Ir}N_{st.st.}$ where the factor of 50 was calculated assuming the addition of 2 $X10^{19}$ ng Ir to present day seawater Ir inventory. The value of K_{Os}, the first order rate constant for Os removal, was set to match the best fit residence time for Os obtained in Fig. 2A. This choice also sets the value of $F(Os)_{in}$ and fixes the temporal evolution of seawater Os concentration following the impact event. The value of K_{Ir} , and thus the temporal evolution of seawater Ir concentration, was varied by adjusting $F(Ir)_{in}$ to obtain a visual best fir to the sedimentary Os/Ir ratio record assuming that $(Os/Ir)_{sed} = (Os/Ir)_{sw}/50$, an empirical Os/Ir fractionation determined from modern pelagic carbonates.

Supplemental Data table 1. Results of Os isotope analyses of bulk sediments from ODP 1090 and 1219.

Sample name	Depth rmcd	Age Ma	$^{187}Os/^{188}Os$	2 SD	Os pg/g	Ir pg/g	Os/Ir
1090B-030X-04W-7/8	288.56	35.25				38.5	
1090B-030X-04W-7/8 Rep	288.56	35.25	0.433	0.006	66.27	33.9	1.95
1090B-030X-04W-15/17	288.64	35.27	0.414	0.006	50.01	36.9	1.36
1090B-030X-04W-24/26	288.73	35.29	0.412	0.011	65.82	42.9	1.54
1090B-030X-04W-34-36	288.83	35.31	0.418	0.009	64.81	32.5	1.99
1090B-030X-04W-44/46	288.93	35.33	0.407	0.007	60.78	38.0	1.60
1090B-030X-04W-56/58	289.05	35.35	0.372	0.006	126.19	33.5	3.77
1090B-030X-04W-56/58 Rep	289.05	35.35	0.417	0.004	119.06	68.2	1.75
1090B-030X-04W-56/58 Rep2	289.05	35.35	0.417	0.008	84.15	49.4	1.70
1090B-030X-04W-65/67	289.14	35.35	0.427	0.004	67.37	45.0	1.50
1090B-030X-04W-76/78	289.25	35.35				43.6	
1090B-030X-04W-76/78 Rep	289.25	35.35	0.425	0.004	74.16		
1090B-030X-04W-84/86	289.33	35.36				48.6	
1090B-030X-04W-84/86 Rep	289.33	35.36	0.408	0.006	69.95	55.7	1.26
1090B-030X-04W-93/95	289.42	35.36	0.422	0.006	72.70	50.0	1.45
1090B-030X-04W-102/105	289.51	35.36	0.415	0.003	122.24	64.9	1.88
1090B-030X-04W-102/105 Rep	289.51	35.36				54.2	
1090B-030X-04W-102/105 Rep2	289.51	35.36	0.415	0.006	112.62	67.7	1.66
1090B-030X-04W-115/117	289.64	35.37	0.392	0.006	96.74	59.5	1.63
1090B-030X-04W-125/127	289.74	35.37	0.384	0.005	135.01	219.5	0.62
1090B-030X-04W-135-137	289.84	35.38	0.413	0.003	191.64	89.0	2.15
1090B-030X-05W-5/7	290.04	35.39				73.3	
1090B-030X-05W-5/7 Rep	290.04	35.39	0.381	0.006	174.79	110.0	1.59
1090B-030X-05W-5/7 Rep2	290.04	35.39	0.374	0.005	150.32	197.9	0.76
1090B-030X-05W-15/17	290.14	35.39	0.360	0.008	97.64	73.9	1.32
1090B-030X-05W-25/27	290.24	35.39	0.356	0.011	86.12	80.3	1.07
1090B-030X-05W-34-36	290.33	35.40	0.370	0.007	79.98	70.9	1.13
1090B-030X-05W-34-36 Rep	290.33	35.40				94.9	
1090B-030X-05W-34-36 Rep2	290.33	35.40	0.371	0.005	143.89	81.2	1.77
1090B-030X-05W-45/47	290.44	35.40	0.340	0.014	69.03	101.1	0.68
1090B-030X-05W-55/57	290.54	35.41	0.331	0.005	68.13	113.9	0.60
1090B-030X-05W-65/67	290.64	35.41				138.9	
1090B-030X-05W-65/67 Rep	290.64	35.41	0.326	0.005	82.46	139.4	0.59
1090B-030X-05W-73.5/75.5	290.725	35.41	0.332	0.006	86.07	150.3	0.57
1090B-030X-05W-85/87	290.84	35.42	0.319	0.004	116.99	233.4	0.50
1090B-030X-05W-85/87 Rep	290.84	35.42	0.336	0.016	96.65	210.3	0.46
1090B-030X-05W-92/94	290.91	35.42	0.299	0.005	141.79	418.7	0.34
1090B-030X-05W-92/94 Rep	290.91	35.42	0.290	0.008	146.83	436.8	0.34
1090B-030X-05W-116-118	291.15	35.43	0.282	0.004	152.83	587.5	0.26
1090B-030X-05W-116-118 Rep	291.15	35.43	0.285	0.006	186.75	618.1	0.30
1090B-030X-05W-124/126	291.23	35.43				272.4	
1090B-030X-05W-124/126 Rep	291.23	35.43	0.371	0.005	115.33	256.4	0.45
1090B-030X-05W-124/126 Rep2	291.23	35.43	0.376	0.007	88.18	249.4	0.35
1090B-030X-05w-136/138	291.35	35.44	0.421	0.005	67.41	97.7	0.69
1090B-030X-05w-136/138 Rep	291.35	35.44	0.431	0.014	62.81	90.1	0.70
1090B-030X-05W-145/147	291.44	35.44	0.417	0.005	75.84	80.0	0.95
1090B-030X-06W-6/8	291.55	35.45	0.450	0.020	70.40	72.2	0.97
1090B-030X-06W-15/17	291.64	35.45	0.460	0.004	58.34	72.2	0.81

10910B-030X-06W-25/27	291.74	35.45	0.477	0.004	44.18	63.2	0.70
1090B-030X-06W-36/38	291.85	35.46	0.475	0.009	83.04	80.4	1.03
1090B-030X-06W-45/47	291.94	35.46	0.480	0.005	54.16	62.2	0.87
1090B-030X-06W-56/58	292.05	35.47	0.474	0.003	72.43	79.6	0.91
1090B-030X-06W-64/66	292.13	35.47	0.483	0.005	55.99	71.3	0.79
1090B-030X-06W-75/77	292.24	35.47	0.505	0.006	52.63	57.5	0.92
1090B-030X-06W-82/84	292.31	35.48	0.503	0.005	58.09	57.5	1.01
1090B-030X-06W-85/87	292.34	35.48	0.490	0.007	50.78	68.1	0.75
1090B-030-06W-95/97	292.44	35.48	0.506	0.013	48.38		
1090B-030X-06W-105/107	292.54	35.49	0.505	0.004	47.46	44.7	1.06
1090B-030-06W-116/118	292.64	35.49	0.495	0.005	61.86		
1090B-030X-06W-121/123	292.7	35.49	0.427	0.033	55.14		
1090B-030X-06W-136/138	292.85	35.50	0.535	0.007	33.96	46.8	0.73
1090B-030-06W-146/148	292.95	35.50	0.540	0.003	66.42		
1090B-030-07W-7/9	293.06	35.51	0.542	0.007	63.76		
1090B-030-07W-7/9 Rep	293.06	35.51	0.535	0.006	61.36		
1090B-030X-07W-13/15	293.12	35.51	0.536	0.003	44.73	48.5	0.92
1090B-030X-07W-13/15 Rep	293.12	35.51	0.475	0.003	55.64		
1090B-030X-07W-18/20	293.17	35.51	0.547	0.011	43.55	39.5	1.10
1090B-030X-07W-18/20 Rep	293.17	35.51	0.553	0.003	39.86		
1090B-030X-07W-22/24	293.21	35.51	0.483	0.004	44.50	38.5	1.16
1090B-030-07W-34-36	293.32	35.48	0.552	0.039	42.17		
1090B-030X-07W-43/45	293.42	35.52	0.464	0.008	38.06	42.6	0.89
1090B-030-ccw-5/7	294.53	35.59	0.547	0.007	34.29		
1090B-030X-ccw-12/14	293.59	35.53	0.544	0.006	41.98	41.8	1.00
1090B-031X-01W-10/13	293.805	35.55	0.507	0.005	46.45	56.4	0.82
1090B-031X-01W-23/25	293.84	35.55	0.563	0.005	40.15	33.1	1.21
1090B-031X-01W-35.5/37.5	293.965	35.56	0.585	0.007	23.81	27.4	0.87
1090B-031X-01W-48/50	294.09	35.56	0.538	0.014	20.27	24.3	0.84
1090B-031X01W-58/60	294.19	35.57	0.602	0.012	24.06	35.0	0.69
1090B-031X-01W-71/73	294.32	35.58	0.589	0.012	29.66	29.4	1.01
1090B-031X-01W-83/85	294.44	35.59	0.573	0.007	72.89	33.7	2.16
1090B-031X-01W-93/95	294.54	35.59	0.576	0.006	90.01	44.5	2.02
1090B-031X-01W-107/109	294.68	35.60	0.577	0.009	48.33	32.4	1.49
1090B-031X-01W-119-121	294.8	35.61	0.576	0.009	25.45	30.8	0.83
1090B-031X-01W-132/134	294.93	35.62	0.508	0.008	36.40	32.1	1.13
1090B-031X-01W-146.5/148.5	295.075	35.63				29.4	
1090B-031X-02W-6/8	295.16	35.63	0.581	0.005	31.21	31.2	1.00
1090B-031X-02W-16/19	295.275	35.64	0.539	0.010	35.50	40.4	0.88

Sample name	**rmcd**	**Age Ma**	**$^{187}Os/^{188}Os$**	**2sd**	**Os pg/g**	**Ir pg/g**	**Os/Ir**
1219A 017H 07W 136/138	180.23	34.78	0.458	0.003	191.14	153.4	1.25
1219A 017H 08W 18/20	180.47	34.90	0.463	0.004	142.56	170.2	0.84
1219A 017H 08W 30/32	180.58	34.96	0.478	0.007	118.97	163.9	0.73
1219A 018H 01W 30-34	181.81	35.43	0.305	0.007	256.71	1596.8	0.16
1219A 18H 1W 35-39	181.86	35.44	0.366	0.000	105.00	917.2	0.11
1219A 18H 1W 40/42	181.9	35.44	0.380	0.006	512.74	758.2	0.68
1219A 18H 1W 42/46	181.93	35.45	0.404	0.004	133.34	612.9	0.22
1219A 18H 01W 50/54	182.01	35.46	0.454	0.010	116.57	312.4	0.37
1219A 18H 01W 58-62	182.09	35.47	0.459	0.008	129.20	217.7	0.59
1219A 18H 1W 65-69	182.16	35.48	0.475	0.000	128.00	225.3	0.57
1219A 018H 01W 72/74	182.22	35.48	0.489	0.004	215.47	202.9	1.06
1219A 018H 01W 72/74 Rep	182.22	35.48	0.502	0.004	92.27	202.9	0.45

1219A 018H 01W 78/80	182.28	35.49	0.494	0.004	242.32	174.5	1.39
1219A 018H 01W 78/80 Rep	182.28	35.49	0.503	0.003	187.34	170.8	1.10
1219A 018H 01W 84/86	182.34	35.50	0.661	0.004	41.45	37.7	1.10
1219A 018H 01W 90/92	182.4	35.51	0.486	0.010	118.11	157.3	0.75
1219A 018H 01W 95/97	182.45	35.51	0.444	0.005	300.48	289.0	1.04
1219A 018H 01W 95/97 Rep	182.45	35.51	0.459	0.004	121.67	274.1	0.44
1219A 18H 1W 95/99	182.46	35.51	0.342	0.004	786.46	528.3	1.49
1219A 018H 01W 104/106	182.54	35.52	0.425	0.004	72.68	148.9	0.49
1219A 018H 01W 108/110	182.58	35.53	0.594	0.006	100.02	130.7	0.77
1219A 018H 01W 110/112	182.6	35.54	0.478	0.004	193.40	126.0	1.53
1219A 018H 01W 116/118	182.66	35.57	0.480	0.004	158.94	112.0	1.42
1219A 018H 01W 122/124	182.72	35.59	0.501	0.004	87.03	108.5	0.80
1219A 018H 01W 125/127	182.75	35.60	0.451	0.004	156.38	101.7	1.54
1219A 018H 01W 125/127	182.75	35.60	0.461	0.004	289.86		
1219A 18H 1W 125-129	182.76	35.61	0.512	0.000	84.00	103.1	0.81
1219A 018H 01W 135/137	182.85	35.64	0.505	0.005	68.03	109.6	0.62
1219A 018H 01W 135/137 Rep	182.85	35.64	0.505	0.005	77.55	103.5	0.75
1219A 018H 01W 142/144	182.92	35.67	0.510	0.004	171.44	99.9	1.72
1219A 018H 01W 147/149	182.96	35.69				102.3	
1219A 018H 01W 147/149	182.96	35.69	0.518	0.014	105.99		
1219A 018H 02W 4/6	183.04	35.70	0.495	0.006	128.78	114.3	1.13
1219A 018H 02W 9/11	183.09	35.70	0.515	0.005	74.23	92.1	0.81
1219A 018H 02W 9/11 Rep	183.09	35.70	0.509	0.004	128.81	93.9	1.37
1219A 018H 02W 15/17	183.15	35.71	0.535	0.003	57.96	109.6	0.53
1219A 018H 02W 29/31	183.29	35.73	0.634	0.004	69.79	98.3	0.71
1219A 018H 02W 37/39	183.37	35.75	0.515	0.006	86.08	96.8	0.89
1219A 018H 02W 46/48	183.46	35.76	0.515	0.003	99.31	92.4	1.07
1219A 018H 02W 55/57	183.55	35.77	0.504	0.003	254.13	98.4	2.58
1219A 018H 02W 65/67	183.65	35.79	0.506	0.003	83.16	105.6	0.79
1219A 018H 02W 75/77	183.75	35.80	0.511	0.007	509.44	205.9	2.47
1219A 018H 02W 75/77 Rep	183.75	35.80	0.509	0.005	257.81	98.8	2.61
1219A 018H 02W 83/85	183.83	35.81	0.504	0.004	139.84	109.0	1.28
1219A 18H 02W 100/102	184	35.84	0.504	0.008	183.51	106.4	1.73