

OSMIUM-ISOTOPE AND PLATINUM-GROUP-ELEMENT SYSTEMATICS OF IMPACT-MELT ROCKS, CHESAPEAKE BAY IMPACT STRUCTURE, VIRGINIA, USA. Seung Ryeol Lee¹, J. Wright Horton, Jr.², and Richard J. Walker¹, ¹Dept. of Geology, University of Maryland, College Park, MD 20742 (leesr@geol.umd.edu, rjwalker@geol.umd.edu), ²U.S. Geological Survey, 926A National Center, 12201 Sunrise Valley Drive, Reston, VA 20192 (whorton@usgs.gov).

Introduction: Osmium (Os) isotopes and platinum-group elements (PGEs) are useful for geochemically identifying a meteoritic component within impact structures, because meteorites are typically characterized by low $^{187}\text{Os}/^{188}\text{Os}$ ratios and high PGE concentrations. In contrast, most types of crustal target rocks have high radiogenic Os and very low PGE concentrations [1]. We have examined Os isotope and PGE systematics of impact-melt rocks and pre-impact target rocks from a 2004 test hole in the late Eocene Chesapeake Bay impact structure [2] and from nearby core-holes. Our goal is to determine the proportion of the projectile component in the melt rocks.

Analytical Methods: All analyses were done by isotope dilution. Finely ground aliquots of 0.5 to 2 g were dissolved in quartz Carius tubes using *aqua regia*. Osmium was purified by solvent extraction. All other elements were purified using 2-stage anion exchange chromatography. Osmium was analyzed by negative thermal ionization mass spectrometry. Rhenium (Re) and PGEs were analyzed using a *Nu Plasma* multi-collector ICP-MS. Signals were quantified in a static mode using multiple multiplier arrangements. Additional details regarding the chemical separations and mass spectrometry can be found in [3]. Blanks for Re, Os, Ir, Ru, Pt, Pd averaged 3, 2, 3, 25, 26, 35 pg, respectively.

Results: Re and Os concentrations in the impact-melt rocks range from 0.127 to 1.09 ng/g and 0.058 to 0.928 ng/g, respectively (Table 1). In two of three pre-impact target rocks and a reworked impact-melt clast, Re and Os concentrations range from 0.008 to 0.30 and 0.004 to 0.012 ng/g, respectively. Pre-impact target rock JA2 is a glauconite-bearing sand from upper Paleocene strata. Its Re (3.04 ng/g) and Os (0.248 ng/g) concentrations are high relative to average upper continental crust (UCC) [4].

The $^{187}\text{Re}/^{188}\text{Os}$ ratios of all the analyzed rocks are highly variable, ranging from 1.2 to 328. Age corrections for 36 Ma of ^{187}Os ingrowth vary from 0.4 to 9% of the $^{187}\text{Os}/^{188}\text{Os}$ ratio. All samples can be divided into low Re/Os and high Re/Os groups (Fig. 1). Most impact-melt rock samples belong to the low Re/Os group, whereas target rock JA2 and a reworked impact-melt rock belong to the high Re/Os group. Two breccias with some impact melt also belong to the high Re/Os group. The low Re/Os group has consistently

lower $^{187}\text{Os}/^{188}\text{Os}$ ratios of 0.152 to 0.223, whereas the high Re/Os group has variable but generally higher $^{187}\text{Os}/^{188}\text{Os}$ ratios of 0.188 to 4.67 (Table 1). Thus, samples in the low Re/Os group suggest more influence of a projectile component.

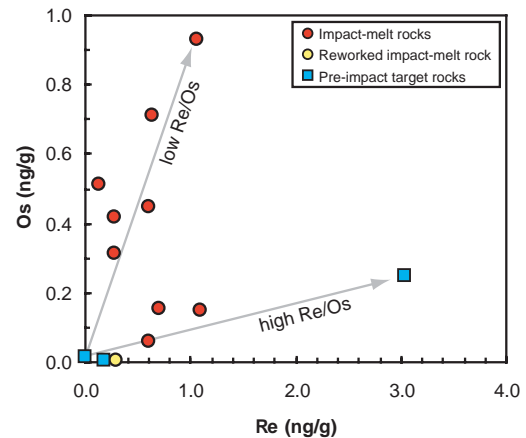


Fig. 1. Concentrations of Re and Os (in ng/g) for impact-melt rocks, a reworked impact-melt rock, and pre-impact target rocks.

Chondrite-normalized Re-PGE patterns for the impact-melt rocks are variably enriched in Re and PGE, but generally are similar to average UCC [4] (Fig. 2).

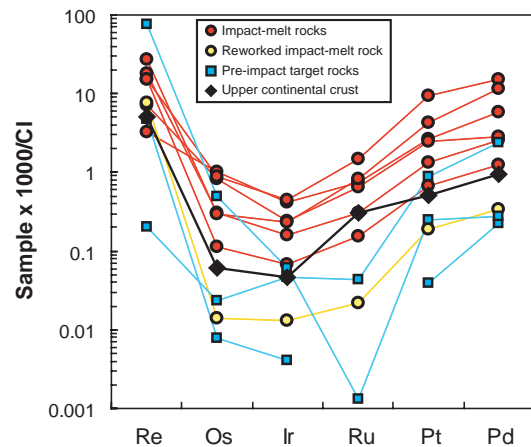


Fig. 2. CI-chondrite-normalized abundances of Re-PGEs for impact-melt rocks, a reworked impact-melt rock, and pre-impact target rocks.

Table 1. Re-Os isotopic and PGE data for rocks from the Chesapeake Bay impact structure.

Sample	Depth (ft)	Re ¹	Os	Ir	Ru	Pt	Pd	¹⁸⁷ Re/ ¹⁸⁸ Os	¹⁸⁷ Os/ ¹⁸⁸ Os	¹⁸⁷ Os/ ¹⁸⁸ Os _T ²
<i>Target rocks</i>										
JA2	243	3.04	0.248	0.029	0.001	0.241	0.155	61.8	0.4690	0.432
WSR674.1	674	0.008	0.012	0.023	0.030	0.857	1.31	3.28	0.9846	0.983
ST2672.3C	2672	0.186	0.004	0.002	b.d. ³	0.038	0.123	328	4.669	4.47
<i>Reworked impact-melt clast</i>										
UN749.4	749	0.300	0.007	0.006	0.015	0.186	0.187	248	1.662	1.51
<i>Impact-melt rocks</i>										
ST2440.8C	2441	1.07	0.928	n.d. ⁴	n.d.	n.d.	n.d.	5.57	0.1521	0.149
ST2453.3C	2454	0.643	0.711	n.d.	n.d.	n.d.	n.d.	4.37	0.1554	0.153
ST2470.6C	2471	0.127	0.514	0.197	0.502	2.57	3.19	1.20	0.1634	0.163
ST2562.8C*	2563	0.706	0.156	0.077	0.205	1.32	1.42	22.4	0.3451	0.332
ST2565.0C	2565	0.610	0.058	0.033	0.105	0.667	0.695	52.7	0.5181	0.486
ST2567.6C	2568	0.283	0.419	0.115	0.449	2.42	1.57	3.28	0.2035	0.202
ST2570.0C	2570	0.278	0.312	n.d.	n.d.	n.d.	n.d.	4.34	0.2234	0.221
ST2570.9C*	2571	1.09	0.149	0.113	0.565	4.24	6.52	36.4	0.4190	0.397
ST2582.1C	2582	0.606	0.445	0.216	1.02	9.14	8.43	6.61	0.1879	0.184

*Breccias that contain some impact melt. ¹All concentrations are in ng/g (ppb). T is calculated for 36 Ma as per [5].

³b.d. = below detection limit. ⁴n.d. = not determined.

In contrast, the pre-impact target rocks are generally similar to, or lower than UCC in Re and PGE content. Ruthenium depletion is prominent in samples JA2 and ST2672.3C (Fig. 2).

Discussion: We performed mixing calculations to constrain the proportions of the projectile component contained in the rocks. The mixing parameters for the target components were derived from target rocks ST2672.3, WSR674.1 and JA2. The projectile is assumed to be similar to that of the carbonaceous chondrite Allende: 573 ng/g Os, ¹⁸⁷Os/¹⁸⁸Os = 0.126 [3].

Samples of impact-melt rock plot between mixing curves with end members defined by the hypothetical projectile and by target rocks ST2672.3, WSR674.1, and JA2 (Fig. 3). The maximum proportion of the projectile contained in the target rocks permitted by the mixing models is ~ 0.1 to 0.2%, corresponding to as much as 60% of the Os being derived from the impactor.

Samples from the high Re/Os group (ST2562.8C and ST2570.9C) are closest to the mixing curve defined by sample JA2, suggesting that some variability in Os isotopic ratios and PGE concentrations in this group reflects modest incorporation of glauconite-bearing sand such as sample JA2. Thus, the results suggest that melt components were derived from multiple target materials.

At present, the chemical nature of the projectile cannot be constrained. The relative proportions of most PGEs are dominated by the indigenous compositions of the target rocks. Nevertheless, low ¹⁸⁷Os/¹⁸⁸Os ratios and enriched PGE concentrations, especially in the impact-melt rocks of the low Re/Os group clearly confirm the presence of an extraterrestrial component in the Chesapeake Bay impact structure.

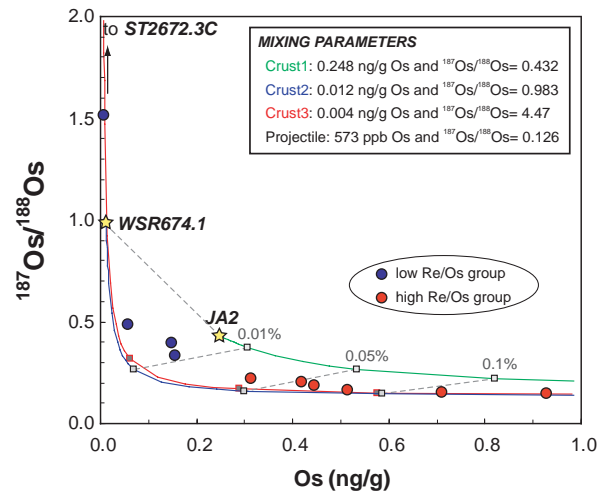


Fig. 3. Plot of ¹⁸⁷Os/¹⁸⁸Os versus Os concentration (in ng/g). The curves show mixing between 3 pre-impact target rock samples (ST2672.3, WSR674.1 and JA2) and a projectile with a carbonaceous chondrite composition (Os = 573 ng/g, ¹⁸⁷Os/¹⁸⁸Os = 0.126).

References: [1] Koeberl C. and Shirey S. B. (1997) *PPP*, 132, 25-46. [2] Sanford et al. (2004) *EOS*, 85, 369-371. [3] Walker R. J. et al. (2002) *GCA*, 66, 4187-4201. [4] Peucker-Ehrenbrink and Jahn (2001) *G3*, 2001GC000172. [5] Shirey S. B. and Walker R. J. (1988) *ARE&P*, 26, 423-500.

This work was supported by NASA Grant NNG04GK52G (to RJW).