Early Paleocene Os isotope stratigraphy within the Chicxulub impact basin

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Abstract

The impact event at the Cretaceous-Paleogene (K-Pg) boundary, ~66 million years ago, formed ~200-km diameter Chicxulub impact structure on the Yucatán Peninsula of the Gulf of Mexico (1). The asteroid impact delivered osmium (Os) into the ocean, which records globally as a negative Os isotope ($^{187}Os/^{188}Os$) shift in the pelagic carbonate sequences for ~200 thousand years (kyr) after the impact (2). This impact-induced changes in ocean chemistry provides a unique means of constraining the time scale of recovery after the environmental perturbation (3). However, this approach has been established with the data from only three pelagic sites among the many reported the K-Pg boundary sections. Here we report new record of $^{187}Os/^{188}Os$ ratios and concentrations of highly siderophile elements (HSEs: Os, Ir, Ru, Pt, Pd, Re) in the earliest to middle Paleocene limestone deposited on top of the Chicxulub impact structure recovered during the IODP-ICDP Expedition 364 (4). The HSE concentrations throughout the earliest to middle Paleocene limestone show remarkably lower than those in the gray-green marlstone, which contains evidence for asteroid/chondritic material (5). The CI-chondrite normalized HSE patterns in the Paleocene limestone exhibit concentrations and signatures typical for the crustal materials, following a tilted pattern with low Os-Ir-Ru and higher Pt-Pd-Re concentrations.

Age-corrected $^{187}Os/^{188}Os$ ratios are low in the earliest Paleocene limestone (~0.19) and then increase gradually. Subsequently, $^{187}Os/^{188}Os$ ratios recovered to steady state (~0.45) around ~2.5 million years (myr) after the impact. The $^{187}Os/^{188}Os$ ratios of the limestone within the Chicxulub impact basin are consistent with the values previously reported from the pelagic sites in that the ratios recover from low (~0.17 to 0.2) to steady state (~0.4) after the K-Pg impact (2). However, the recovery time for Os isotope ratios is quite different, $^{187}Os/^{188}Os$ profile recorded in the impact basin remain lower than the expected values compared to those of the pelagic sites for at least the first ~1 myr of the Paleocene (2).

Our results suggest that the Paleocene limestone accumulated in the Chicxulub impact structure recorded continuous but unique temporal evolution of seawater Os isotopic composition after the K-Pg impact. A possible mechanism to achieve the delayed recovery of

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187Os/188Os values within the impact basin demands (1) only small influx of radiogenic Os in global seawater, and (2) a large input of unradiogenic Os from impact ejecta deposited in the Gulf of Mexico and on Yucatán Peninsula, or (3) input from the impact melt sheet underneath the central basin via venting of hydrothermal fluids (6).

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