Characterization of Cretaceous-Paleogene boundary of marine sediments around Australia

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In this study, we present the recent results of our group's research on the characteristics of osmium (Os) concentrations and its isotopic composition ($^{187}Os/^{188}Os$) in marine sediments that include the Cretaceous-Paleogene boundary (K-Pg) interval around Australia, especially in the Lord Howe Rise and Mentelle Basin. A clear increase in the concentrations of platinum group elements (PGEs) and decrease in the Os isotope ratio at the K-Pg boundary is considered as strong evidence for the Chicxulub impact on the Yucatan Peninsula, Mexico. The circum-Australian basins were located near the antipodal point of the Yucatan Peninsula, and is expected to have deposited sediments in an environment with less affected by the meteoritic impact.

1. Lord Howe Rise Site 208 (Kuroda et al., 2021)

Deep-Sea Drilling Program (DSDP) Leg 13 (1971) drilled to 590 m below the seafloor at Site 207 on the Lord Howe Rise, and recovered Cenozoic and late Cretaceous calcareous chalk-dominated sediments. Kuroda et al. (2021) re-examined the calcareous nanofossils in the Site 208 cores and determined the stratigraphy of the K-Pg boundary by Os isotope ratio, carbonate isotope ratio and paleomagnetic measurements. (2021) re-examined the calcareous nannofossils in the Site 208 core and examined the stratigraphy of the K-Pg boundary using Os isotopic compositions, carbonate carbon isotopic compositions, and paleomagnetic measurements. The K-Pg boundary was found to be located at 576.8 m by the re-examination of calcareous nannofossils. This level represents a clear lithologic shift from Maastrichtian chalk to siliceous mudstone. Above the K-Pg boundary is an interval of ~80 cm of siliceous marl and siliceous mudstone (silicified interval), which contains Danian calcareous nannofossils. The siliceous mudstone that appears to be the K-Pg boundary is located at the base of the silicified interval and has a very low $^{187}Os/^{188}Os$ value of 0.12. Since there is no anomaly in the Os concentration, this level is not a sediment deposited at the K-Pg impact. The impact event deposit may be missing by a hiatus. Nevertheless, the low $^{187}Os/^{188}Os$ value suggest that the sediments were deposited at a time when the Os isotopic ratio of seawater was still low immediately after the impact, suggesting that the hiatus at the K-Pg boundary was short-term. The carbonate carbon isotope ratio also decreased at this level, consistent with the global trend at the K-Pg boundary. On the other hand, paleomagnetism does not agree with this stratigraphic level during the C29R polarity chron, suggesting the possibility of alteration by secondary minerals.

2. Mentelle Basin Site U1514 (Ota et al. 2020)

During the International Ocean Discovery Program (IODP) Exp. 369 (2017), drilling was conducted at Site U1514 on the Mentelle Basin, southwest off Australia, and Cenozoic and Cretaceous sediments were recovered. Onboard stratigraphic examination with calcareous nannofossils and planktonic foraminifera revealed the K-Pg boundary stratum at 393.6 m depth below the seafloor. The K-Pg boundary level is at a lithologic boundary from Maastrichtian chalk to Danian claystone and is heavily bioturbated. At this level, the sediment has low $^{187}Os/^{188}Os$ value of 0.17 and high Os concentration of 1.4 ppb. These features of high Os concentrations and low Os isotopic compositions are evidence of extraterrestrial impact and thus indicate that the sediment deposited at the Chicxulub impact is preserved without any hiatus. Above and below the 393.5 m level, both Os concentrations and Os isotope ratios gradually return to the background values. This is due to vertical mixing caused by bioturbation.

Our study on stratigraphy with Os isotope records shows that the K-Pg impact level is missing in the sediment on the Lord Howe Rise due to a short-term hiatus, while the K-Pg boundary layer is continuously preserved in the sediments on the Mentelle Basin. At both sites the K-Pg boundary intervals are characterized by the lithological change from Maastrichtian chalk to siliceous sediments such as siliceous mudstone and claystone, suggesting the cessation of calcareous nannoplankton production just after the Chicxulub impact. Similar lithological changes are also observed in sections in New Zealand, and appears to have been a widespread feature of Australia-Zealandia.

Kuroda, J., Hagino, K., Usui, Y. et al. (2021) GSA Bull. https://doi.org/10.1130/B36112.1

Ota, H., Kuroda, J., Tejada, M.L.G. et al. (2020) 2020 JPGU-AGU Joint Meeting MIS11–P03.

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