Perturbation process of the ocean by an extraterrestrial impact at the Cretaceous-Tertiary boundary

Kazuhisa Goto[1]; Ryuji Tada[2]; Eiichi Tajika[3]; Takafumi Matsui[4]

[1] Earth and Planetary Sci., Univ. Tokyo; [2] DEPS, Univ. Tokyo; [3] Dept. Earth Planet. Sci., Univ. of Tokyo; [4] Grad. Sch. of Frontier Sci., Univ. of Tokyo

Impacts of extraterrestrial objects on the earth are universal events in the history of the earth. A great number of impact events should have occurred in the ocean because the ocean covers approximately 70 % of the surface of the earth. Thus, it is important to understand the impact process and environmental perturbation due to the impact into the ocean (oceanic impact event). However, oceanic impact events are difficult to identify and influence of the oceanic impact such as impact tsunami has not been understood well.

Alvarez et al. (1980) proposed that the Cretaceous-Tertiary (K/T) boundary mass extinction, 65 million years ago, was resulted from the impact of a large asteroid or comet on the earth. Large tsunami is one of the major consequences of the K/T boundary impact, because the impact site was in the shallow ocean. In fact, several probable tsunami deposits have been reported from proximal impact sites. Therefore, the K/T boundary impact event provides a rare opportunity for the investigation of the tsunami induced by the oceanic impact. However, ultimate cause of tsunami at the K/T boundary is still controversial and their magnitude and generation mechanism are unknown. Therefore, we investigated influence of the tsunami around the proximal impact sites and its generation mechanism based on field survey in Cuba and analyses of the collected samples and samples obtained from DSDP and ICDP.

Lateral lithological, compositional, and grain size variations of the Penalver Formation in northwestern Cuba, which is a K/T boundary deposit accumulated on the northwestern slope of the Cretaceous Cuban arc, are examined in order to investigate the influence of tsunami to the deep-sea bottom around the proximal impact sites. The lower part of the Penalver Formation is interpreted as debris flows triggered by the impact seismic wave. On the other hand, the upper part is interpreted as having been formed under the influence of tsunami, judging from the regional homogeneity of source materials of pelagic to hemipelagic origin and existence of serpentine lithics that were probably transported from eastern Cuba as suspension by westward water mass movement. Furthermore, compositional and grain size oscillations that repeated 6 to 10 times are observed in the upper part, which probably reflects repeated lateral injection of the sediments eroded from the shelf to the upper slope of the depositional basin by backwashes of subsequent tsunami into the dense sediment suspended cloud that was formed by the first tsunami.

Paleo-current analyses at the Penalver Formation indicate westward (crater-ward) first tsunami wave at the proto-Caribbean sea, suggesting that tsunami was probably formed by the movement of ocean water that filled and then flowed out of the crater cavity. However, no direct evidence of ocean water invasion into the crater has been presented yet. Therefore, the possibility of ocean water invasion was investigated based on the examination of the impactite in the YAX-1 core drilled within the crater. Presence of cross lamination and abundant occurrence of reworked nannofossils of late Campanian to early Maastrichtian age in the impactite, which were probably derived from outside the crater during ocean water invasion, suggest that ocean water invasion into the crater occurred immediately after the impact. Oscillations of chemical composition and grain size that repeated 10 times are also observed. These oscillations were formed probably by repeated lateral injection of the coarse sediments from outside of the crater through the repeated ocean water invasion. Evidence of ocean water invasion into the crater and similarity of number of repeated tsunami between inside and outside the crater support that tsunami was generated by repeated ocean water invasion and affected the sedimentation of the K/T boundary deposits around the proximal impact site.