Depositional mechanism of the Penalver Formation: The K/T boundary deep-sea tsunami deposit in northwestern Cuba

Kazuhisa Goto[1], Eiichi Tajika[2], Ryuji Tada[3], Manuel A. Iturralde-Vinent[4], Shoichi Kiyokawa[5], Yoichiro Nakano[6], Shinji Yamamoto[1], Tatsuo Oji[7], Hideo Takayama[8], Takafumi Matsui[9]

[1] Earth and Planetary Sci., Tokyo Univ, [2] Dept. Earth Planet. Sci., Univ. of Tokyo, [3] DEPS, Univ. Tokyo, [4] Museo Nacional de Historia Natural, [5] Earth & Planetary Sci., Kyushu Univ., [6] Dept. of Earth and Planetary Sci., Univ. of Tokyo, [7] Geological Institute, Univ. of Tokyo, [8] NHK Nagoya, [9] Dept. of Earth and Planetary Phys., Univ. of Tokyo

Alvarez et al. (1980) proposed that the Cretaceous-Tertiary (K/T) boundary mass extinction, some 65 million years ago, was resulted from the impact on Earth of a large (approximately 10km in diameter) asteroid or comet. This hypothesis becomes well accepted based on the discovery of high Ir concentration in the K/T boundary clay layer worldwide and identification of approximately 180 km diameter circular subsurface structure (the Chicxulub crater) in the northwestern part of the Yucatan Peninsula. Since the bolide hit into the shallow sea, it has been considered that the large tsunamis were generated, and, in fact, a lot of shallow sea tsunami deposits have been reported around coastal area of the Gulf of Mexico. However, because information from the deep-sea deposits of the proto-Caribbean Sea was very poor, magnitude and influence of impact generated tsunamis have not been well known.

Since 1997, we organized Japan-Cuban joint research group and investigated the Penalver Formation in northwestern Cuba, which is one of the closest outcrop from the Chicxulub crater and was deposited at the deep-sea area 600-2000 m depth of the proto-Caribbean sea. The thickness of the Penalver Formation is more than 180 m and monotonous upward fining from calcirudite to calcilutite. It is composed of a lower gravity flow unit and an upper homogenite unit, the latter being interpreted as a deep-sea tsunami deposit (Takayama et al., 2000). According to our previous study at the type locality, the upper homogenite unit has homogeneous appearance, and neither erosional nor current structures are observed (Takayama et al., 2000). However, our recent study revealed slight compositional oscillations characterized by variation in serpentine lithic content within the upper homogenite unit, which is repeated more than 6 times. These oscillations are associated with variation in coarse fraction content within insoluble residues. Based on the thin section observation, compositional oscillations suggest mixing of two end members characterized by serpentine lithics and micritic limestone lithics. Serpentine lithic content negatively correlates with abundance of micritic limestone lithics and their maximum grain size and also with abundance of volcanic lithics of Cretaceous Cuban island Arc origin. This feature indicates that sediments of Cretaceous Cuban island Arc origin might have been supplied into the dense sediment suspended cloud with serpentine lithics of probable Northern Ophiolite origin.

Then, how the sediments were transported and what was the trigger? Lateral supply of clastic sediments as sediment suspended cloud caused by repeated tsunami waves are difficult to explain the slight compositional oscillation, because tsunamis can transport sediments only 10 km even if we assume the maximum wave height and period suggested by numerical simulation of the K/T impact tsunamis (Matsui et al., in press). Thus, the repetition of gravity flows of Cretaceous Cuban island Arc origin were plausible mechanism to produce the compositional oscillation. When we assume the depositional depth of the type locality was 2000 m and shocked quartz grains fell through the atmosphere and ocean, the depositional time of each unit can be estimated from vertical grain size variation of shocked quartz grains. At the base of the upper homogenite unit, shocked quartz of 250 micron in size is observed, which suggests that the upper homogenite unit deposited at more than 18 hours after the impact. To take into account the variation of grain size of the shocked quartz, secondary gravity flows could have been triggered by the repetition of tsunamis hitting the Cretaceous Cuban island Arc, because the impact-generated tsunamis may have still repeated more than 18 hours after the impact (Matsui et al., in press).