論文の内容の要旨

Australasian Tektite Event: Identification of the On-land Ejecta Deposit and its Distribution across Eastern Indochina

（　オーストラリア・アジアテクタイトイベント：インドシナ半島東部における陸上イジェクタ層の認定とその分布　）

氏名　多田 賢弘

The Australasian Tektite Event (AATE) occurred ca. 0.8 Ma is the youngest record of a large impact event on the Earth. Based on the wide distribution of the tektite—from Southeast Asia to Antarctica—the magnitude of the impact has been estimated as large enough to create a 30–120 km sized crater. Although it has been estimated that the impact occurred somewhere in eastern Indochina, the crater has never been located definitively despite intensive search efforts, and the nature of the impact, such as the location, magnitude, and target rocks, are not well constrained.

In general, the distribution and composition of the proximal ejecta deposits have information about the location, magnitude, and target rock of the impact. Especially, the distribution of the thickness of an ejecta deposit is important to constrain the location of the impact since the thickness of an ejecta deposit increases toward the impact location. As for the AATE, however, the ejecta deposit proximal to the estimated impact area in eastern Indochina has never been identified.

There are several reports of tektites found within a stratum called the "laterite" layer that is widely distributed in eastern Indochina. It has long been debated whether these tektites are in situ or reworked. This uncertainty is due to the lack of detailed description of the field occurrence

of the tektites and tektite-bearing Quaternary deposits, and the lack of evidence of shock metamorphism (such as shocked minerals) other than the tektites in Indochina.

To identify the proximal ejecta deposit in eastern Indochina and clarify its lithostratigraphy, distribution, and depositional process for a better understanding of the nature of the AATE, field surveys of the Quaternary deposits were conducted at 20 sites across eastern Indochina (northeastern Thailand, Southern Laos, northern Cambodia, and central Vietnam).

The detailed occurrence of tektite fragments found within the "laterite" layer at the HO06 section in Ubon Ratchathani province, northeastern Thailand, was described demonstrating the evidence of the in-situ occurrence of these tektite fragments. At least 331 tektite fragments with a total weight of 713 g were found from a 40 x 30 cm area with 10 cm thickness in the upper part of the "laterite" layer. The very angular shapes and very poorly-sorted nature of the tektite fragments, the similar chemical composition of the fragments, and the restoration of larger tektite fragments into one ellipsoidal tektite mass suggest that these tektite fragments were formed by fragmentation of one large tektite mass. The fact that the fragments were found within the "laterite" layer is inconsistent with the previous interpretation that the upper surface of the "laterite" layer is a paleo-erosional surface, on which the tektites were reworked. The fragments' size distribution is bifractal following two power laws in the range from 10 to 26 mm and 26 to 37 mm, with fractal dimensions (Ds) of 2.2 and 7.5, respectively. The Ds for the coarse fraction of the tektite fragments is larger than the Ds for rock fragments generated by rockfalls and rock avalanches and similar to the Ds for the coarser fraction fragments generated by high-speed impact experiments. This large Ds value suggests that the tektite fragments were formed through intense fragmentation by a relatively high energetic process. The occurrence of the fragments forming a cluster and the distribution of the fragments in sediments revealed by a computer tomography scanning analysis indicate that the fragments were not moved apart significantly after fragmentation and burial. Based on these results, it is concluded that the mass of a tektite was fragmented at the time of the landing on the ground after the ejection from the impact site and has not been disturbed further (i.e., in situ).

In addition to the in-situ occurrence of the tektite fragments, I reported the discovery and occurrence of shocked quartz with planar deformation features (PDFs) from the Quaternary depositional sequence, including the "laterite" layer, at the Huai Om section in Ubon Ratchathani province, northeastern Thailand. Measurements of the orientation of lamellae with a universal stage microscope and observation using scanning electron microscopy and transmission electron microscopy were conducted to confirm the presence of PDFs.

The extensive field survey at 20 sites (including the Huai Om and HO06 sections) across a wide area in eastern Indochina revealed that there are basically the same lithostratigraphic units (Units 1-3 in ascending order) unconformably covering the basement rocks and sediments.

Unit 1 is composed of gravely silt to sand layers or a sandy gravel layer containing materials reworked from the local basement. The thickness of Unit 1 is about 30 cm to 2 m. This unit is not laterally continuous and absent at several localities. Unit 2 is composed of a very poorly sorted breccia corresponding to the "laterite" layer. The thickness of Unit 2 is about 30 cm to more than 9 m. Tektites were found at several sites at the top of or within the upper part of this unit. Unit 3 is composed of a well-sorted silt to fine sand layer. Although the original thickness of this unit is unknown because this unit is truncated and capped by modern soil, the observed thickness of Unit 3 varies from site to site, about 30 cm to 3 m.

Based on the in-situ occurrence of tektites in Unit 2 at HO06 section, the discovery of shocked quartz grains throughout Units 1-3 at Huai Om section, and continuous distribution of Units 2-3 in a wide area, the ejecta-bearing sequence of this region (Units 1-3) was identified as the proximal ejecta deposit of the AATE.

Based on their stratigraphy and lithological and sedimentological evidence, Units 1-3 are considered as deposited by the following process: rework of the local basement rocks by the impact-generated wind loaded with fine ejecta (Unit 1), followed by deposition of the ejecta curtain materials including gravels and tektites (Unit 2), and finally deposition of fallout fine ejecta (Unit 3).

The thickness of Unit 2 becomes thicker toward southwestern Laos. This thickness distribution of Unit 2, as well as the fact that the size of gravels in Unit 2 becomes larger toward southwestern Laos, indicates that the location of the impact is somewhere in southwestern Laos. The regression analysis of the distribution of the thickness of Unit 2, assuming that the log thickness is negatively correlated with log distance from a source area, indicates that the Bolaven Plateau area (15.2°N, 106.1°E) is the most probable impact site of the AATE. The presence of the weathered basalt fragments, sandstone and mudstone fragments, and fragments of rounded quartzite gravels in Unit 2 indicates that the target rock of the AATE includes basalt, Mesozoic sedimentary basement rocks, and possibly Quaternary river gravels. This estimation of the target rocks is consistent with the estimation of the impact site in southwestern Laos, where Neogene to Quaternary basalt lava and Mesozoic sedimentary rocks are widely distributed. The result of the estimation of the impact site strongly supports the hypothesis of Sieh et al. (2019) that the AATE occurred in the basalt field of the Bolaven Plateau, and the crater was buried by younger basalts that erupted after the impact.