Tsunami geochemistry: current situation and issues

*Tetsuya Shinozaki[1]

1. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology

In general, tsunami deposits refer to sand, mud, and gravel that are eroded by the tsunami and transported to other places for re-deposition. In addition to visible sediments, invisible materials such as suspended and dissolved materials are also transported by tsunamis. Tsunami geochemistry is the chemical understanding of such invisible materials transported by tsunamis. Tsunami geochemistry is mainly used as a proxy to identify tsunami deposits. If we can detect inorganic and organic substances in seawater from event layers in terrestrial strata, it is probably that the event layers were deposited by seawater flow. Therefore, it will be possible to conduct paleotsunami surveys in areas that have not been surveyed to avoid confusion between flood and paleotsunami deposits. Furthermore, if we can chemically detect tsunami traces in the areas where tsunami deposits cannot be found, we can reconstruct more detailed tsunami inundation areas and tsunami occurrence intervals, and expect to reconstruct the tsunami history in a specific area with high accuracy.

Geochemical studies of tsunami deposits have been conducted since around 1990s. Especially after the 2004 Indian Ocean tsunami, the 2009 Chilean earthquake tsunami, and the 2011 Tohoku-oki tsunami, their geochemical behavior has been reported. Since then, review papers have been reported irregularly (Chagué-Goff et al., 2017; Shinozaki, 2021), and the characteristics and cautions of each geochemical proxy have been summarized in detail.

In tsunami geochemistry, inorganic geochemistry, organic geochemistry, and isotope geochemistry are mainly applied. Recently, studies using environmental DNA (not strictly geochemistry) have also been reported. Inorganic geochemistry often targets water-leachable ions (e.g., Minoura and Nakaya, 1991), suspended and dissolved light elements in seawater (e.g., Nichol et al., 2007), and heavy metals from the hinterland (e.g., Komai et al., 2012). In recent years, core scanners, which have been mainly used for sea-bottom sediment, have been applied to the tsunami deposit research, enabling non-destructive and rapid acquisition of a large number of data. In isotope geochemistry, $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$, are used to reflect marine sediments and marine organic matter (e.g., Chagué-Goff et al., 2012). In organic geochemistry, biomarkers (e.g., Alpar et al., 2012) and anthropogenic markers (e.g., Bellanova et al., 2020) have been applied to the study of tsunami deposits. Although organic geochemistry has disadvantages in that it requires high expertise and is time-consuming to measure, its strength is that it can capture allochthonous materials somewhat directly. A more direct indicator than organic geochemistry is the study using environmental DNA. The presence of genetic information of marine organisms in terrestrial event sediments can provide significant physical evidence that they were formed by currents from the sea. In addition, the discrimination between tsunami and storm surge sediments is one of the major issues in tsunami deposit research (Morton et al., 2007), and it has been pointed out that environmental DNA may be effective in discriminating between tsunami and storm surge sediments (Yap et al., 2021). Although environmental DNA requires a high level of expertise, as does organic geochemistry, and the number of studies is still limited, it is an extremely reliable approach as a discriminative proxy, and future reports are expected.

It is important to note that these geochemical proxies are not necessarily universal tools for identifying tsunami deposits. Previous studies have shown that chemical features are not always preserved for long periods of time. How long (years, centuries, and millennia) and in what sedimentological environments (wetlands, lakes, and plains) certain proxies persist needs to be closely examined in various combinations. In this presentation, I will integrate the knowledge obtained so far, and introduce the characteristics of each geochemical proxy and points to note when obtaining data. In addition, I will summarize the issues that need to be solved in the future, aiming at the development of tsunami geochemistry.

Keywords: Tsunami, Tsunami deposit, Inorganic geochemistry, Organic geochemistry, Isotope geochemistry, environmental DNA

