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Marine biomarkers deposited on land by the 2011 Tohoku-oki tsunami

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Tsunami deposits, especially sand deposits is generally used for estimating paleotsunami event. Sand deposit is mainly identified as tsunamigenic on the basis of geological, chemical, biological, archaeological, anthropological, geomorphological, and contextual feathers, especially geological and biological features such as lateral changes in thickness and grain size of deposit, presence of marine-origin microfossils and others have been frequently utilized as identifying proxies. However, these characteristics do not always get preserved, in which case it is difficult to identify paleotsunami deposit. If evidence of seawater inundation can be detected, it became a good criterion for marine source of sand deposits. As a proxy of seawater evidence, in this study, we focused on biomarker which is molecular fossils originated from formerly living organisms. Biomarker has two advantages. One is their high preservation potential. It is confirmed to be stable in geological time scale. Another is the obvious difference between terrigenous and marine biomarkers; To take the *n*-alkane, lower *n*-alkane homologs, notably C_{15}, C_{17}, and C_{19} *n*-alkanes, tend to be predominant in many algae whereas higher *n*-alkane homologs, such as C_{27}, C_{29}, and C_{31}, tend to be predominant in leaf waxes of higher plants. To verify whether marine biomarkers are deposit on land by tsunami inundation, samples of the 2011 Tohoku-oki tsunami deposit and underlying soil were collected at Sendai and Odaka, Northeast Japan.

In Sendai, a 3 cm-thick fine sand deposits was formed by the 2011 tsunami at the top of core, and there was paddy soil beneath the sand deposits. Biomarkers were measured at 1 layer in sand deposits and 7 layers in soil deposits. Short-chain *n*-alkanes (C_{16}, C_{17}, C_{18}, and C_{19}) mainly elaborated from algae and fish were occurred only at 5-6 cm depth. It seems that theses short-chain *n*-alkanes were penetrated sandy tsunami deposit and concentrated at 5-6 cm depth. In Odaka, sand deposits were found at 8-15 cm and 18-20 cm depth, and there was paddy soil beneath sand deposits. Organic-rich mud deposits (15-18 cm depth) was intercalated between two sand layers. This mud drape was seems to be formed by first wave together with thin sand layer (18-20 cm depth), and then following waves formed thick sand layer (8-15 cm depth). Biomarkers were measured at 1 layer in surface soil deposits, 8 layers in the 2011 tsunami deposits, and 3 layers in underlying soil deposits. Short-chain *n*-alkanes (C_{16}, C_{17}, C_{18}, and C_{19}), pristane, and phytane were detected only from 20-21 cm deep. Pristane is predominately elaborated from zooplankton, benthos, and fish, while phytane is predominately elaborated from zooplankton or sediment itself by biological activity. Presence of these hydrocarbons suggests a contribution from marine/aquatic, and this characteristic is similar to the results of Sendai.

Marine origin hydrocarbons, such as short-chain *n*-alkanes, pristane, and phytane, were detected at soil layers below sandy tsunami deposits in both sites. Since no marine biomarkers were presented further deep soil layer in both sites and surface soil layer overlying tsunami deposit in Odaka, it is highly possible that these biomarkers were transported by the tsunami. Each sediment samples were collected more than two years after the tsunami, it means marine biomarkers have been preserved at least two years. Our study present the first evidence for the marine biomarkers detected from the modern tsunami event, and we propose possibility of biomarkers as a proxy of paleotsunami identification.

Keywords: biomarker, hydrocarbon, tsunami deposit, 2011 Tohoku-oki tsunami