

**Tsunami-induced bedrock erosion and sediment deposition on uplifted coastal bench:  
Cape Todogasaki, eastern Japan**  
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An uplifted coastal bench at an elevation of ca. 20 m a.s.l. is located around Cape Todogasaki of the ria-type rocky coast in Sanriku, northeastern Japan. Tsunami waves induced by the 2011 Tohoku Earthquake were high enough to spread over the 20-m high terrace. To clarify the effects of tsunamis on the terrace surface micromorphology, we performed field measurements of structure-from-motion multi-view stereo (SfM-MVS) photogrammetry using an unmanned aerial system (UAS), composed of a digital camera mounted on a small unmanned aerial vehicle (sUAV), and terrestrial laser scanning (TLS). Global navigation satellite system (GNSS) rover was used to obtain geographical coordinates (centimeter accuracies) of ground control points for the georeferencing of the UAS and TLS data. Using digital elevation models (DEMs) with a 20-cm resolution generated from the point clouds of UAS and TLS, micromorphology of the terrace surface was analyzed. Despite limited basin area draining into the terrace, erosional features in the bedrock were identified. These features appear to be formed by the tsunami flow. Furthermore, sedimentological characteristics of small thin clasts and large (>2 m) boulders located on the terrace were examined in the field, revealing that the sediments are likely dislocated from in-situ bedrock at the terrace edge. Evidences of landward flow were also found from the sediment structure. We conclude that the uplifted terrace surface underwent erosion by not only the 2011 tsunami but also repeated significant tsunamis in the past, some of which could have been much larger than that in 2011.

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