Applications of ITRAX XRF core scanning and PCA in palaeotsunami research

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Following the devastating 2011 Tohoku-oki tsunami in Japan, much research has been carried out to identify its precursors and any other events that have impacted the country. While it is important to gain a better understanding of recurrence intervals, identifying the limit of inundation of these events is crucial in order to be able to estimate their magnitude and thereby improve hazard mitigation measures for the future. However, researchers generally rely on the presence of anomalous coarse layers (mostly sand) to identify tsunami deposits. Estimating the limit of inundation beyond the extent of the sand has proven more difficult and can be very time consuming with commonly used methods, such as grain size and microfossil analyses and/or even conventional geochemical techniques.

Here we present the results of a study, where we used an ITRAX XRF core scanner, a rapid and non-destructive technique, which provides continuous high resolution elemental profiles, magnetic susceptibility, as well as an optical and a radiographic image. Sedimentary sequences collected along a shore-perpendicular transect on the Sendai Plain, include the 869 AD Jogan sandy tsunami deposit within paddy field soil, which is overlain by the Towada-a tephra, as well as possible older tsunami and flood deposits in the lower part of the cores. Further inland, the Jogan deposit becomes discontinuous and is replaced by mud, as also reported for the 2011 Tohoku-oki tsunami deposit on the Sendai Plain. The X-radiographic image allows the identification of thin mud units within the paddy field soil, which were not clearly visible to the naked eye. Analysis with the ITRAX core scanner reveals subtle geochemical differences between the mud unit attributed to the Jogan tsunami, the paddy soil and other mud units. ITRAX data were also processed by principal component analysis (PCA), allowing the distinction of various units and their possible origin, despite the semi-quantitative nature of the elemental data. In this study we could distinguish the marine-sourced units from their terrestrial counterparts, based on their geochemical characteristics.

This study shows that high resolution geochemistry using core scanners can provide a means to identify the limit of inundation of palaeotsunamis beyond the extent of the visible sand deposits, even when units are not clearly visible to the naked eye. These data can be used to draw more accurate palaeotsunami inundation maps, thereby improving hazard management measures for the future.

Keywords: tsunami, geochemistry, ITRAX XRF core scanning, PCA, mud, inundation limit

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