

Advanced Seismic Depth Imaging of the Tsunamigenic Fault in the 2024 Noto (M7.6) Earthquake Rupture Area

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On January 1st, 2024, at 7:10:22.5 UTC, a M7.6 earthquake struck the Noto Peninsula, Japan, causing a series of severe effects, including strong ground shaking, landslides, liquefaction, and tsunami across the eastern coast of the Japan Sea. The initial assessments by the Japan Meteorological Agency (JMA) identified the activation of a reverse fault with the hypocentral parameters of (37°29.7' N, 137°16.2' E, 16 km) and a compressional axis oriented NW-SE. The extension of the causative fault, were later estimated from the aftershock distribution (Japan Meteorological Agency, 2024), evidently posing a total length of approximately 150 km, originating from the west coast of the Noto Peninsula to the northeast offshore area of the peninsula. It is inferred that part of the 150-km-long fault, as an active submarine fault, could serve as the source of the tsunami in the northeast offshore Noto Peninsula. However, the detailed structure and physical properties of tsunamigenic faults remained unexplored. To shed more light into the mechanisms of the tsunamigenic faults, we conducted a multi-channel seismic (MCS) reflection survey in March 4-16, 2024, comprising 14 2D lines offshore of the northeast coast of the Noto Peninsula, using the R/V Hakuho-maru cruise. The MCS data was recorded with a recording length of 5 or 6 seconds and a sampling interval of 2 milliseconds, using a 1200 m long streamer cable with 48 channels at 25 m group spacings.

The data was processed at the Atmosphere and Ocean Research Institute, The University of Tokyo, for advanced depth imaging. Initially, a workflow was applied that included the UKOOA P1/90 navigation application, followed by a series of conventional processing steps such as trace editing, de-ghosting, surface-related multiple attenuation (SRMA), predictive deconvolution for multiple suppression, stacking velocity analysis, normal moveout correction, common midpoint (CMP) stacking, and Kirchhoff post-stack time migration. The region's complex geological structure, characterized by intense lateral and vertical velocity variations and rapidly changing seafloor depths (ranging from just a few tens of meters to nearly 2 km in some areas), posed significant challenges in processing the recorded dataset, hindering conventional imaging workflows from producing clear depth images. Accordingly, an optimized processing workflow was devised at some steps to tackle these issues. Specifically, after applying SRMA, an optimal predictive deconvolution method was applied in the CMP domain to suppress the remaining multiple reflections. The operator window for this process was designed by incorporating the seafloor reflection time on the stack sections. Additionally, to update the interval velocity section for pre-stack depth migration (PSDM), the absence of a sharp continuous reflector limited the effectiveness of layer-stripping method. To overcome this challenge, a grid-based tomography method was applied, enhancing the continuity of reflections identified by automated continuity attributes while effectively distinguishing between primaries and multiples in the migrated gathers by analyzing their dips. In this talk, we will present the implemented imaging workflow and provide PSDM depth sections of the MCS study, focusing on the active faults.