能登半島地震震源域陸域におけるS波スプリッティングと地震波速度構造

Shear wave splitting and seismic velocity structure in the onshore focal area of the 2024 Noto Peninsula earthquake, central Japan

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Introduction

The M7.6 Noto Peninsula earthquake occurred on 1 January 2024 in the Noto region of Ishikawa Prefecture. Seismic activity in the area has increased since around August 2020. Possible causes of the increased seismic activity include stress changes due to crustal deformation sources and increased fluid pressure. In this study, following the analysis in the seismic swarm area northeast of the Noto Peninsula (Okada et al., https://doi.org/10.1186/s40623-024-01974-0, 2024a), S-wave splitting using temporary and permanent stations in the epicentral area was investigated. Seismic wave velocity tomography analysis was also conducted to investigate the seismic wave velocity structure in the onshore source region.

Data and methods

Waveform data were collected from temporary stations in the source region from the end of June 2022 (Sakai et al., https://doi.org/10.5281/ZENODO.6767362, 2022; Okada et al., https://doi.org/10.5281/zenodo.10939231, 2024b) and from permanent stations. Seismographs were short-period (natural frequency: 1 Hz or 2 Hz) or broadband. Sampling frequencies are 100 Hz or 250 Hz.For S-wave splitting, this study uses MFAST (Savage et al., 2010), based on Silver and Chan (1991), which performs a cluster analysis of the results of analyses with time windows of various locations and lengths. This is expected to provide a stable and fast estimation of S-wave anisotropy.The double-difference tomography method is used for the seismic wave velocity structure (Zhang and Thurber, 2003, 2006); 8766 earthquakes from February 2020 to April 2024 were used in the analysis.

Results

Spatial distribution of S-wave polarization anisotropy

The predominant direction of anisotropy throughout the peninsula was NE-SW. This direction generally coincides with the strike direction of faults and folds and may be due to anisotropy caused by their tectonic properties. In addition, NW-SE anisotropy, which generally coincides with the direction of the axis of maximum horizontal compression (e.g., Terakawa and Matsu’ura, 2010; Tagami and Okada, 2024), and north-south anisotropy were also observed in some areas.

Seismic wave velocity structure

A low Vs and high Vp/Vs region was identified in the hypocentral area at a depth of 18 km. Slightly larger P-wave velocities were obtained in this region compared to the surrounding area. The Tertiary igneous rocks are distributed in the target area, suggesting that the low Vs and high Vp/Vs region may represent an old magma reservoir and that fluids released from/through it are involved in the 2024 Noto Peninsula earthquake and proceeding swarmseismic activity that happened before the 2024 earthquake.In the shallow crust, the hanging wall of the fault has low velocities. This existence of a shallow low-velocity zone may be interpreted as the structure of a normal fault that once formed in this region.

Discussion

The low velocity in the shallow part of the hanging wall side of the fault and the anisotropy due to structural properties indicate a complex structure in which the structure of normal faults that developed in this region coexists with a compressional structure due to the present stress field. On the other hand, a region of low Vs and high Vp/Vs was identified deep in the epicentral area, suggesting a relationship with fluids.