

Multi-component reflection survey with MEMS accelerometer for deep seismic profiling across the Kitakami Lowland, Northeast Japan

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The geometry of geological structure and the velocity distribution in sedimentary layers are very important information for the earthquake disaster prevention. The S wave velocity in sedimentary layers is fundamental to estimate strong ground motions which likely damage the human activity. The reflection seismic survey using the PS converted wave is one of exploration methods to estimate V_p/V_s ratio and S wave velocity structures. It is being popular in the oil and gas exploration field, because multi-component survey can give more information about rock properties and occasionally better subsurface images than conventional one-component P wave reflection survey.

In this study, we applied PS imaging to the three-component data and estimate the V_p/V_s ratio and V_s structure of sedimentary layers across the Kitakami Lowland, northeast Japan. The Kitakami Lowland is located at the eastern edge of the Miocene rift system of northern Honshu Island. The western marginal faults are commonly recognized as active reverse faults re-activated after crustal stretching during Miocene back arc spreading and subsequent lithospheric cooling. The multi-component data were acquired on a 20 km-long seismic survey line across the Kitakami Lowland with 800 three-component MEMS accelerometers with 25 m spacing, and 175 vibrator shots.

In data processing, the vertical component is used for the conventional PP processing, and the radial component from each shot point after azimuth rotation is used for the PS processing. There are some difficulties in the PS processing. Because the incident P wave and the converted reflection S wave propagate asymmetrically, the PS imaging is implemented on common conversion point instead of common mid point in the PP imaging. For the static correction the shot statics and receiver statics are independently applied. For velocity analysis and normal moveout correction of the PS converted wave need higher-order term for better moveout correction. The V_p/V_s ratio is estimated by direct event matching between two time sections from PP processing and PS processing. Furthermore, the S wave velocity can be calculated from the P wave velocity model and the estimated V_p/V_s ratio.

The obtained PS section clearly shows the structure from the sedimentary layers to the basement and the form of west dipping listric faults, and it is compatible with the result from the PP processing using a vertical component. In addition, the V_p/V_s ratio and the S wave structure are reasonably estimated in sedimentary layers across the Kitakami Lowland. These results represent that the multi-component reflection survey can play an important role in the deep reflection profiling for the earthquake disaster prevention.