Advanced surface-wave analysis to detect localized heterogeneity in shallow geological formation

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In the CO_2 geological storage, one of the most important tasks is monitoring injected CO_2 behavior. Understanding field-scale heterogeneity in reservoir is essential to accurately monitor injected CO_2 flow. Because seismic exploration methods can be used to estimate heterogeneous physical properties under the ground, they are effective in reservoir characterization and monitoring injected CO_2 behavior in field-scale. In this study, we present the advanced surface-wave analysis for characterizing heterogeneous structures in shallow formation.

Surface waves are defined as guided waves propagating along the different media (i.e., the earth and the air). In the conventional surface-wave analysis, subsurface S-wave velocity structures are estimated from experimental phase velocity. In our approach, we further utilize attenuation coefficients of surface waves for characterization of subsurface heterogeneities.

We extracted local phase velocities and attenuation coefficients from field seismic data acquired in the fracture-developed zone. We observe lateral variation of the estimated attenuation coefficients near the localized fracture, whereas no lateral variation is detected in the estimated phase velocities. This result can be explained by the different sensitivity of attenuation coefficients and phase velocities to the localized fractures. We also applied the proposed surface-wave analysis for seismic data acquired in the CO2 storage site. Our results indicate that parallel interpretation of spatial variation of attenuation coefficients and phase velocities can detect localized fractures in shallow formation. In the CO_2 geological storage, detecting subsurface fractures is important because such fractures can be leakage paths of injected CO_2. The estimated heterogeneous structure by surface-wave analysis can be further used for estimating the lithology strength or reservoir simulation to estimate future CO_2 distribution.