Improvement of seismic data quality through low frequency seismic data acquisition and broadband data processing

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Imaging deep structures using land seismic data acquired in complex terrains of Japan often faces problems since the geology is often complex and target is usually deep volcanic. Recently, acquisition of long-offset high density data using combination of cable and cable-free systems in complex terrain is standardized in domestic land acquisition. First Arrival Travel-Time Tomography is applied to such data to estimate subsurface velocity structure where conventional velocity analysis is difficult because of the above mentioned problems, and recently FWI is applied following tomography to estimate detailed velocity structure.

Low frequency components are known to be effective to FWI and other inversion stability. Also, they are known to be effective to deep imaging and enhancing resolution through reducing side lobes of wavelets. Since around mid-2000s, various techniques has been established to acquire low-frequency in both onshore and offshore environments. Especially, land techniques are important to us since those techniques are capable to Japan onshore environment and the low frequency components are expected to be effective to above mentioned domestic situations.

We have been developed such onshore broad band techniques recently. On source side, conventional linear sweep has problem producing effective low frequency energy because there are some limits in vibrator mechanics and hydraulic. However, the low frequency dwelling non-linear sweeps has been developed around 2008 and we have also developed such sweeps especially suited to our vibrators. On receiver side, conventional 10Hz geophone has problem sensing low frequency because the response of geophone below natural frequency usually reduced. But recently, low frequency sensors such as high sensitivity low frequency geophone and MEMS sensor are commercialized and commonly used in seismic acquisition.

We will show some case study of data acquisition using those techniques. The result is verified by comparing with legacy data. In addition to data acquisition techniques, we have applied some data processing techniques which are not used in legacy data. The processing techniques include combination of noise removal techniques, surface consistent deconvolution, accurate velocity estimation and pre-stack imaging. Also we have applied some broad band techniques such as geophone response correction and spectral whitening using wavelet transform. By combined effect of those recently developed techniques, our result show great improvement compared to legacy data.

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