Geophysical Research Abstracts
Vol. 16, EGU2014-4338-1, 2014
EGU General Assembly 2014

Development and testing of a two-dimensional ultrasonic laboratory model system for seismic imaging of heterogeneous structures

Yike Mo, Hakki Karaman, and Stewart Greenhalgh
Institute of Geophysics, ETH Zürich, Zurich, Switzerland (yimo@student.ethz.ch)

To tackle the challenges and imaging problems of complex structures, we have recently assembled within the Wave Propagation Lab at ETH Zürich a simple 2D ultrasonic model facility in which the simulated geological structures are constructed from thin (2 mm thickness) metal and plastic sheets, cut and bonded together. The models were used, in full recognition of the similitude relations, to investigate reflections from beneath a low velocity distorting overburden. Besides uniform and irregular near surface layers, flat and dipping interfaces as well as rectangular high and low velocity block inserts were investigated. The experiments entailed the use of a piezoelectric source driven by a pulse amplifier at ultrasonic frequencies (20–300 kHz) to generate Lamb waves in the plate, which are detected by piezoelectric receivers and recorded digitally on a National Instruments recording system, under SignalExpress software control.

In the lab system, a single cycle sinusoidal pulse with a negative onset (5 μs pulse width and 600 V pulse voltage) was selected as the optimized source pulse. Transducers can be placed along the thin edges of the plate in reflection mode (same edge) or transmission mode (opposite edges, or perpendicular edges). Alternatively they can be mounted on the flat planar surface of the plate to simulate a crosshole survey. Data were originally collected in all different recording geometries over a homogenous aluminium model for calibration purposes and to examine wave modes and propagation characteristics. The two dominant Lamb waves recorded are the fundamental symmetric mode (non-dispersive) and the fundamental antisymmetric (flexural) dispersive mode, which is normally absent when the source transducer is located on a model edge but dominant when it is on the flat planar surface of the plate. Only the symmetric Lamb mode can be used as a proxy for 2D propagation in an extended medium (the field situation). Experimental group and phase velocity dispersion curves were experimentally determined for both modes in aluminium, brass and perspex plates.

For the heterogeneous models, we collected reflection data for various source positions and applied various processing techniques such as AGC, filtering, deconvolution, and pre-stack Kirchhoff migration. Some muting and pre-processing was necessary to attenuate the refractions, guided waves and surface waves produced by the low velocity near surface layer (perspex) which has a large impedance contrast with the host rock (aluminium). Pre-stack migration was able to resolve the two main buried interfaces when the surface layer was flat but for the variable thickness irregular surface layer the interfaces could not be properly imaged. First-arrival tomography was implemented to the crosshole seismic data set and yielded the correct velocity distribution. Unfortunately, the presence of anti-symmetric Lamb waves in this data precluded the application of 2D full waveform inversion. The VSP data enhanced the imaging of the near-surface layer as well as providing additional control for the reflection experiments.