Physical modeling of microseismics and time reversal

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1. MICROSEISMICS SURVEY

A microseismic survey over the physical model shown on Figure 1.1 acquired data for a hypocentre location problem made difficult by the presence of an HTI layer.

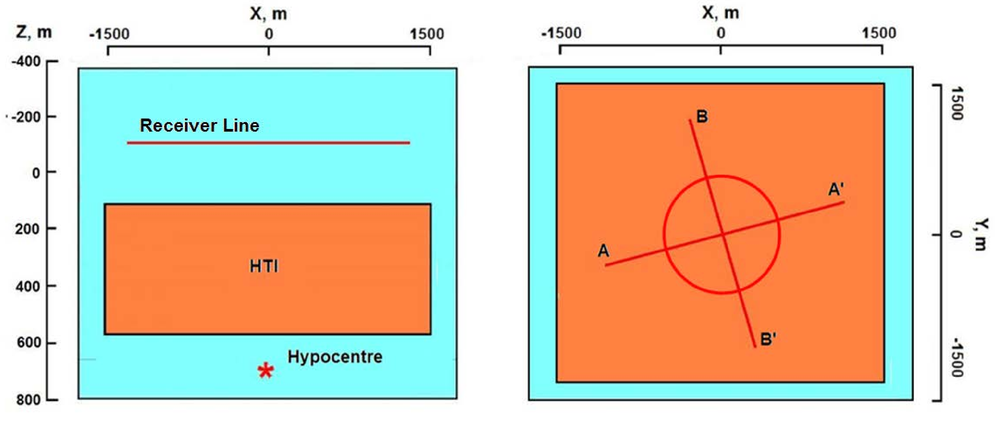

Figure 1.1: Side and plan views of the physical model for microseismic survey. The x-axis is aligned with the fast direction of the HTI layer.

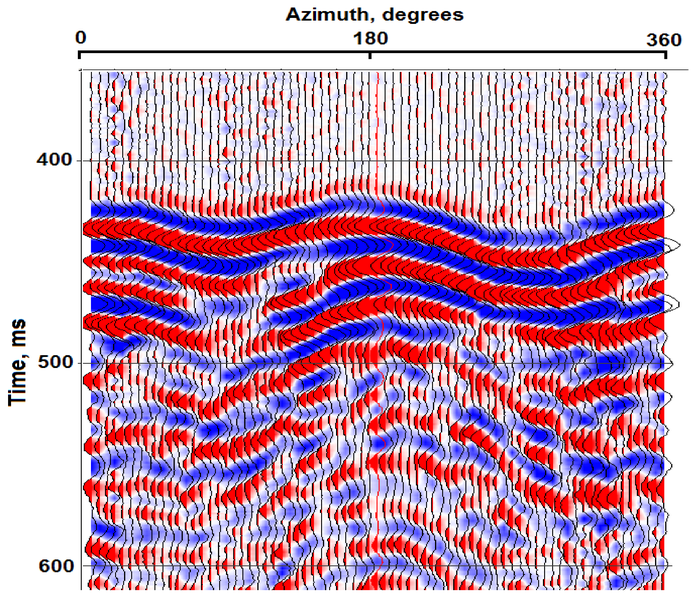

Figure 1.2: Microseismograms recorded on the circular receiver line (radius=500m, angle spacing = 5 degrees).

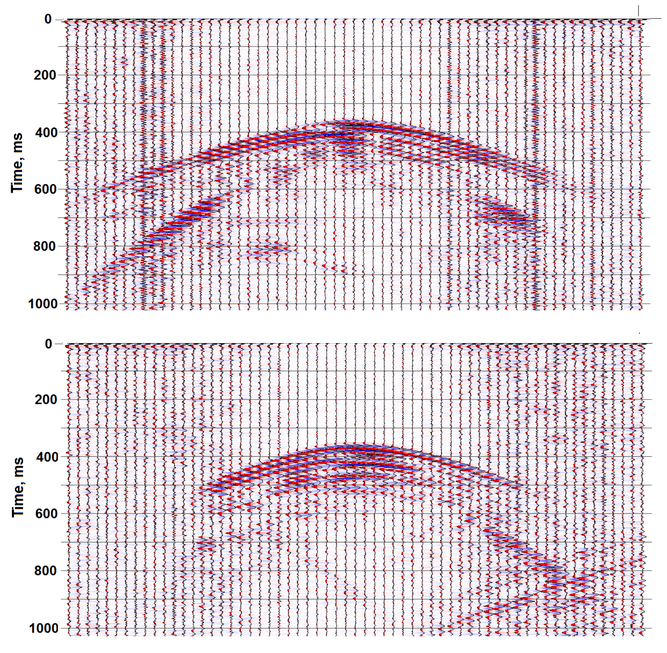

Figure 1.3: Microseismograms recorded on arms AA' and BB' on the crossed array (receiver spacing is 44.7m).

Hypocenter location is normally done using ray tracing to match event arrival times. Refractive ray tracing in 3D through the HTI layer is difficult, and requires formulas that adequately describe the anisotropic velocities of HTI materials (e.g., the Byun equations).

2. TIME-REVERSAL EXPERIMENT

A three-step time-reversal experiment (Landa et al., 2019; Vick, 1994) was conducted over the physical model on Figure 2.1 with an impulsive source function.

Step 1: A forward survey. A single source under a high-velocity body shot to a receiver line above the body. Figure 2.1 displays the resulting seismograms. Figure 2.2 shows windowed and reversed traces for 11 chosen receiver positions.

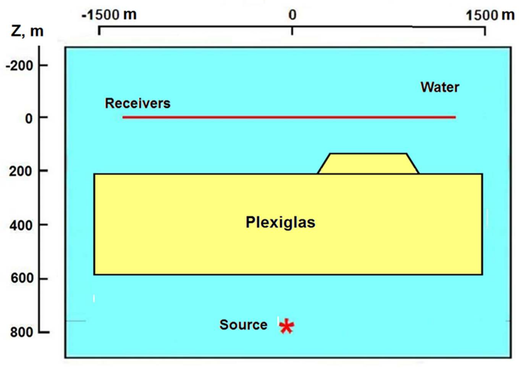

Figure 2.1: The physical model.

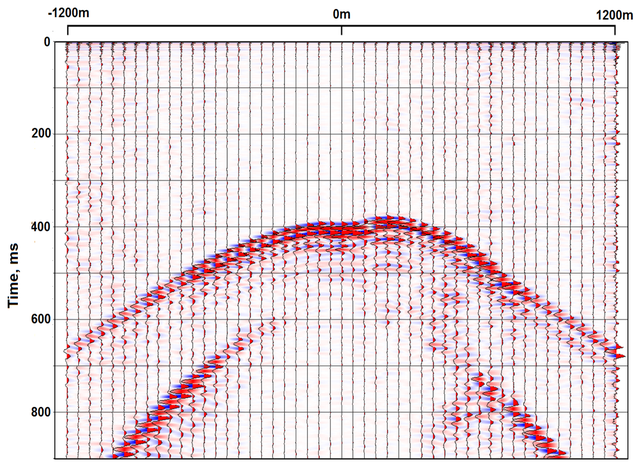

Figure. 2.2: Common-source gather (CSG) of seismograms from the forward survey.

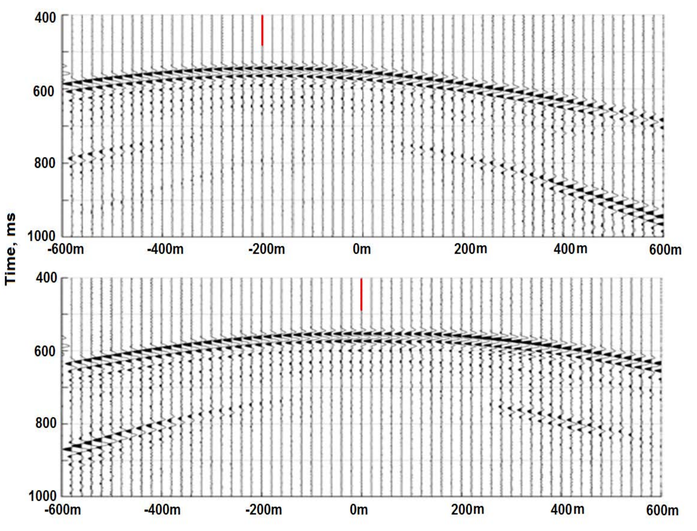

Figure 2.4: Two of 11 CSGs from the reverse survey. Red lines indicate source positions.

Step 2: A reverse survey. Sources at 11 chosen positions above the body shot down to a receiver line through the forward survey source position. resulting in 11 common-source gathers (two are shown on Figure 2.4). Delay times for firing the 11 above-body sources were determined by reversed first-arrival times.

Step 3: Summation. The eleven reverse survey CSGs were added together (Figure 2.5). Properly delayed firing of sources in the reverse survey forced focusing of seismic energy in the sum.

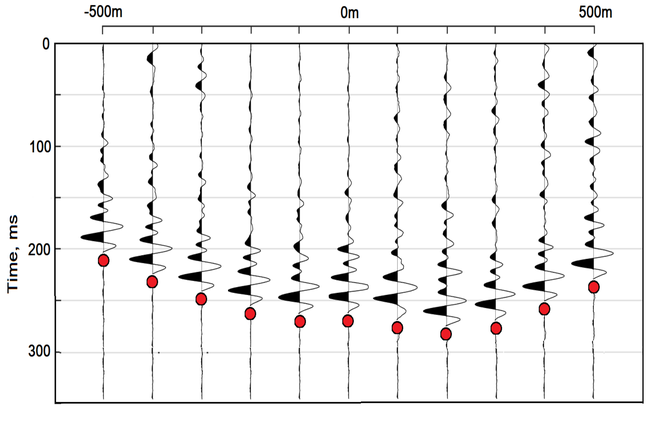

Fig. 2.3: Seismograms and time picks for 11 chosen positions, mirrored and time-reversed.

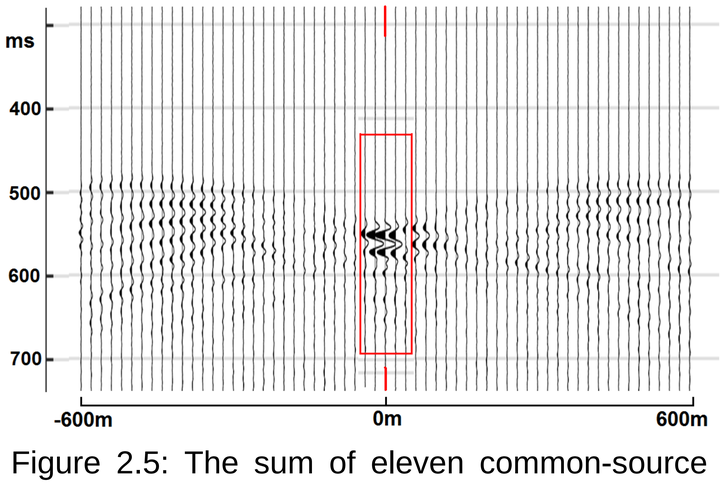

Figure 2.5: The sum of eleven common-source gathers from the reverse survey. Seismic energy is focused at the forward survey source position. [1]

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