Determining elastic constants of an orthorhombic material by physical seismic modeling

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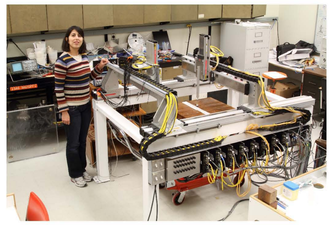
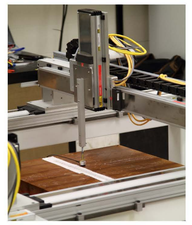
Summary

The CREWES project at the University of Calgary acquired several 3C-2D seismic profiles of a model constructed from phenolic LE material, using a physical modeling instrument. These seismic lines were employed to determine all nine elastic constants of the phenolic model. This poster briefly presents the physical modeling system and a few examples of the acquired 3C-2D seismic gathers to demonstrate the capability of the physical modeling instrument in producing real seismic data on scaled earth models.

Laboratory instruments

Physical modeling equipment: (left Figure below) The physical modeling experiment has a scale (1 : 10000) for distance and scale of (10000 : 1) for frequency. The robotic positioning system guided by computer software accurately positions source and receivers to within 1*mm*. The right Figure shows the arm that positions the receiver transducer. Upon each positioning, one seismic trace is recorded.



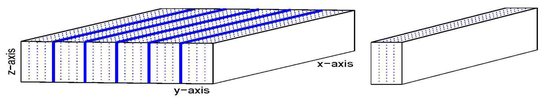


Source and receivers: These are flat-faced piezoelectric cylindrical transducers with the diameter of 13*mm* and central frequency of 1.0*MHZ*.

- The P-transducer, sensitive to normal displacement, acts as a vertical component geophone. The S-transducer, sensitive to tangential displacement, acts as a horizontal component geophone.

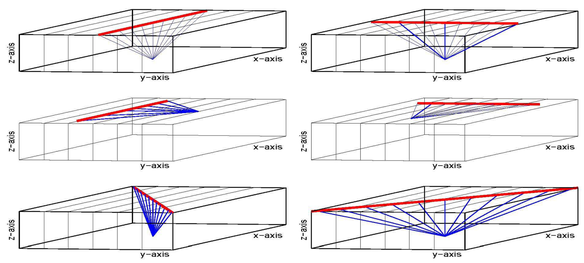
Material: Phenolic LE is composed of laminated sheets of linen fabric, with alternating fabric sheets oriented approximately orthogonal to each other and bonded with phenolic resin. A small block of phenolic material is shown below.

Model: 6 slabs of phenolic material are used to construct the model.



Transmission receiver profiles

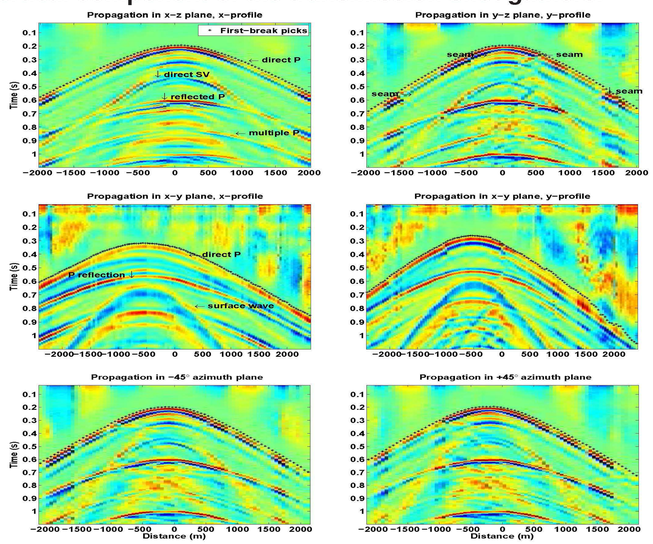
Three component data from six seismic receiver profiles have been acquired and are shown below.



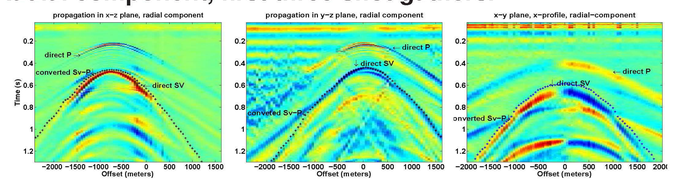
Transmission shot gathers

P-wave group velocities are measured from vertical component data of above transmission receivers profiles; the SV- and SH-wave group velocities are measured from radial and transverse components.

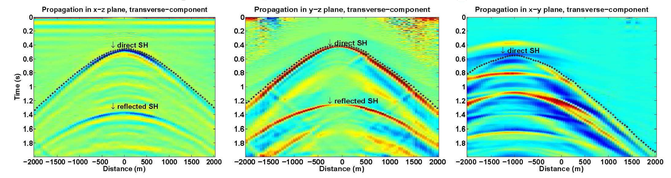
Vertical component of the transmission shot gathers.



Radial component, first three shot gathers.

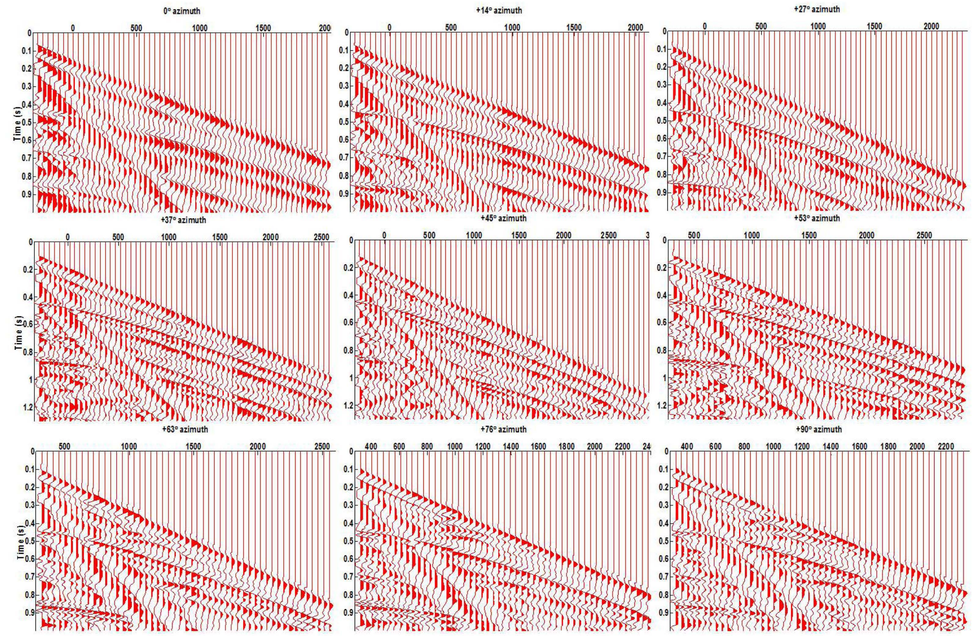


Transverse component, first three shot gathers.



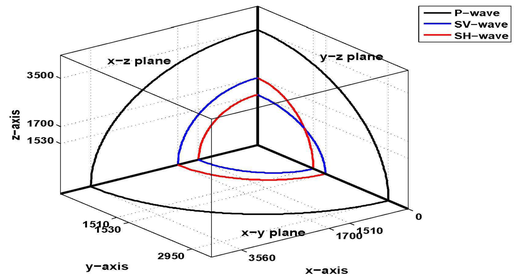
Reflection azimuth data

To obtain velocity in different directions in the x-y plane, seventeen reflection shot-gathers between -90° to $+90^\circ$ azimuths were acquired with the source and receivers at the top face of our model. In each azimuth reflection data, the dip of the firstbreak event gives the group velocity along that azimuth.



Group velocity surfaces

The P- and S-waves velocity surfaces for the principal planes of x-z, y-z, and x-y of phenolic model are illustrated.



Elastic constants

The calculated density normalized elastic constants of the phenolic LE model are presented. They have the units of $(km/s)^2$.

$$\begin{pmatrix} 12.67 \pm 0.006 & 6.13 \pm 0.003 & 6.68 \pm 0.003 & 0 & 0 & 0 \\ & 8.70 \pm 0.006 & 5.79 \pm 0.003 & 0 & 0 & 0 \\ & & 12.25 \pm 0.006 & 0 & 0 & 0 \\ & & & 2.34 \pm 0.001 & 0 & 0 \\ & & & & 2.89 \pm 0.001 & 0 \\ & & & & & 2.28 \pm 0.001 \end{pmatrix}$$

Acknowledgement

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