Physical modelling update

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ABSTRACT

This is a short note on some of the physical models manufactured and analyzed by members of the CREWES Project over the last year.

INTRODUCTION

The models which have been built over the past year are in various stages of analysis. Some, like the glauconitic sand channel have been recycled by adding various layers and structures to create new models. All models are distance scaled 1:10,000 so measurements are in meters, rather than millimeters which are the actual model measurements. The experimental sample rate is 100 nanoseconds which gives us a field sample rate of 1000 micro seconds. The experiments described below do not discuss all the tests done with the various models, only one example.

PHYSICAL MODELS

Velocity gradient model

The velocity gradient model is constructed from five layers of synthetic rock (Gallant et al., 1993) which have *P*-wave velocities from 1903 m/s to 2375 m/s. The synthetic rock was mixed with steel shot to obtain a velocity contrast between the layers. The layers are 100 m thick and have metal rods buried within the model at various depths as shown in Figure 1. Two aluminum rods (V_P=6300 m/s V_S=3200 m/s) of 50 and 60 m in diameter were placed at one end of the model in the second and forth layers. At the other end of the model, four steel rods (V_P=5800 m/s V_S=2600 m/s) of 30 m in diameter were placed in the second to fifth layers. The data from the experiment did not exhibit the turning wave phenomena as expected, due to the high attenuation of the synthetic rock and the low power of the analog pulse generator. The pulse generator has since been upgraded to a digital system and now has a power output of 150 volts DC, an increase of 135 volts DC. Research on the velocity gradient model is ongoing.

Survey geometry: Elastic 2-D line, constant offset, 10 m shot and receiver spacing, 250 shots.

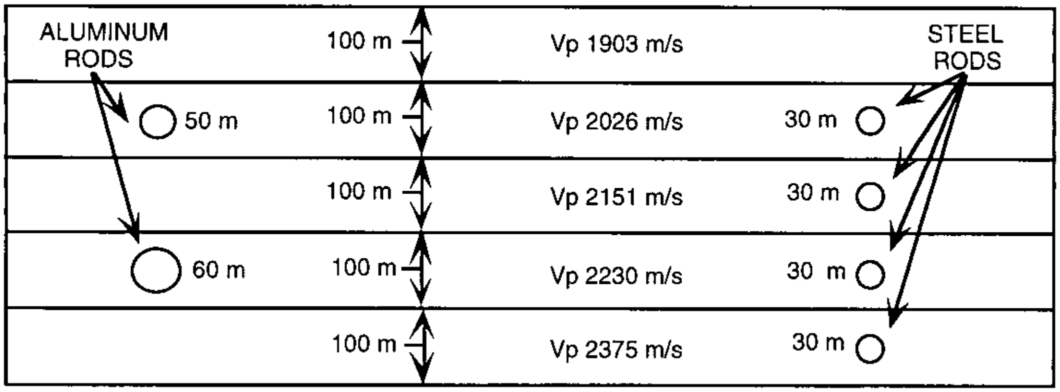


FIG. 1.Schematic diagram of velocity gradient model.

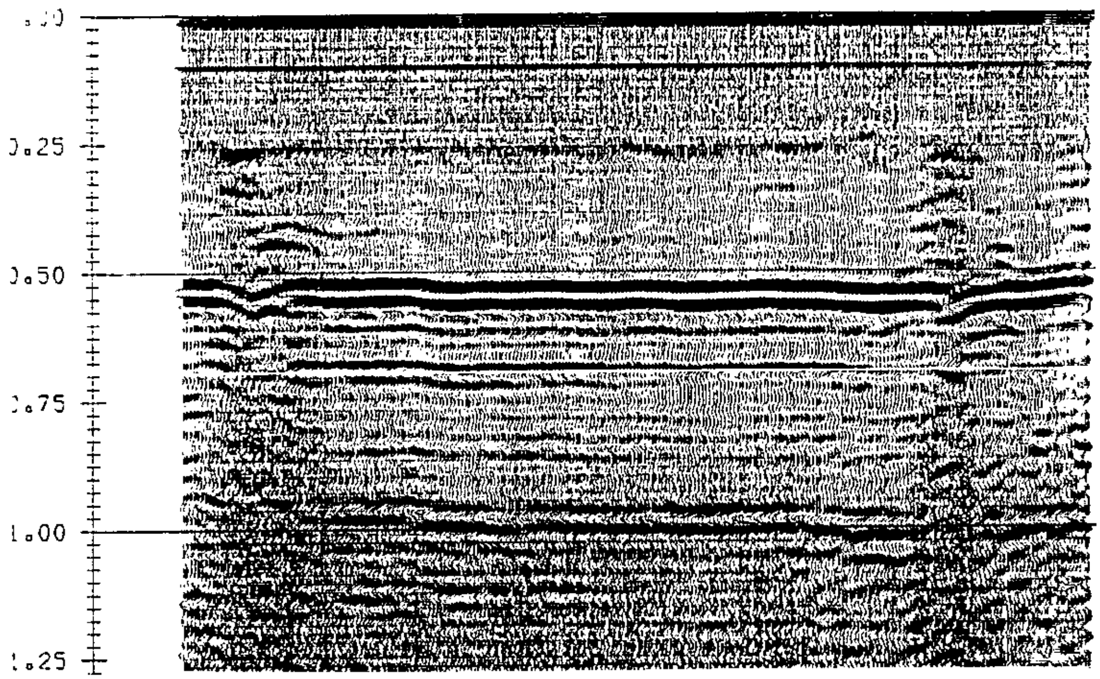
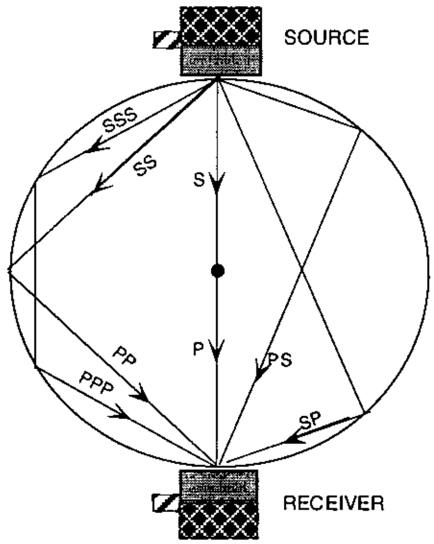


FIG. 2. Constant offset P-P line across velocity gradient model.

2300 m phenolic sphere

A sphere, 2300 m in diameter has been machined from an industrial laminate called Phenolic CE (Brown et al., 1993). The reason for making the sphere is to model shear-wave singularities in an orthorhombic medium. Experiments previous to this one used a much smaller phenolic sphere of 1000 m in diameter in which the traveltime through the model in a transmission experiment made it hard to distinguish separate events due to the traveltimes being so close together, thus a lager sphere of the same material would separate the various events relative to time. The 1-axis has a Vp=3584 m/s, the 2-axis a Vp=3401 m/s, and the 3-axis Vp=2935 m/s.

Survey geometry: antipodal transmission through the sphere, 3-component shot and receiver lines starting 45 degrees before the principal axis, in 1 degree increments. There are 180 shot and receiver locations.



WAVE PHASE	APPROXIMATE TRAVELTIME (s)
P	0.68 - 0.80
PP	0.90 - 1.13
PPP	1.02 - 1.25
S	1.48 - 1.70
PS/SP	1.60 - 1.82
SS	2.04 - 2.27
SSS	2.15 - 2.49

FIG. 3. The diagram on the left shows some of the possible ray paths through the phenolic sphere.The table on the right shows the approximate traveltimes for the various wave phases.

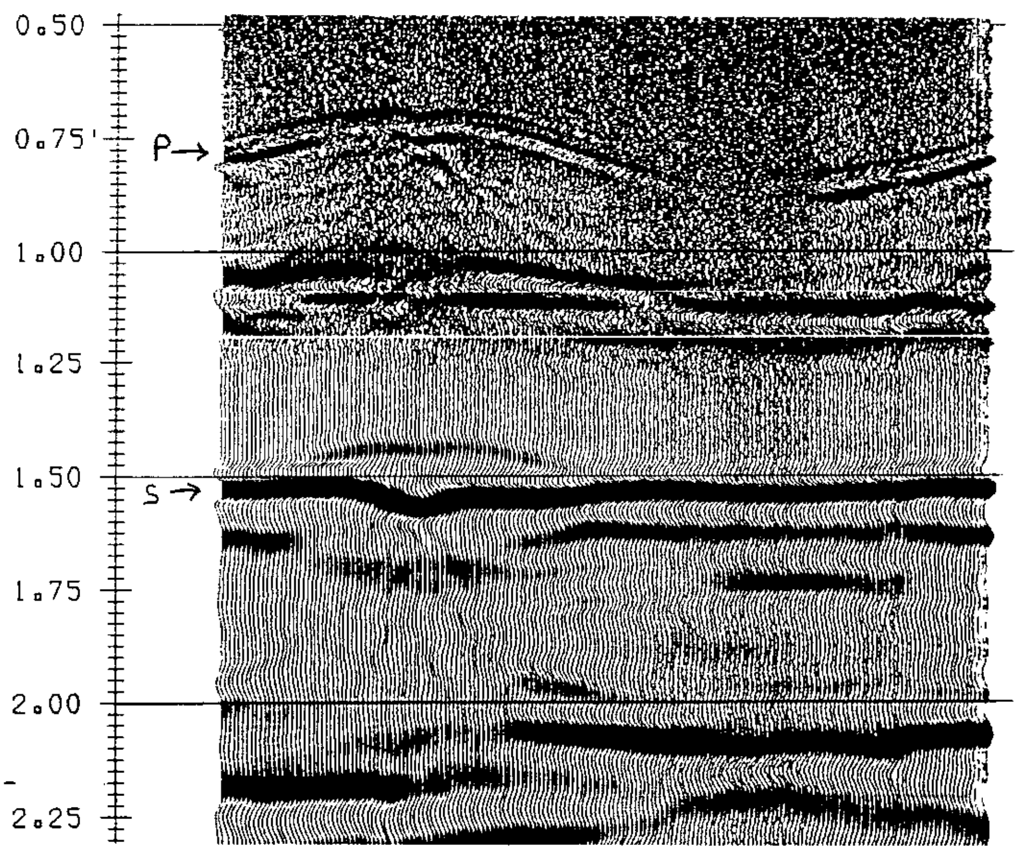


FIG. 4. Data from R-R transmission experiment showing various wave phases.

Copper ore nugget

A 3-D acoustic survey over a large native copper ore nugget has been done to test 2-D and 3-D migration algorithms. The nugget is approximately 2300 m long x 1300 m wide x 780 m high and highly convoluted. The copper nugget (Vp=4658 m/s) is immersed in water (Vp=1498 m/s) with a minimum of 300 m of water (Vp=1498 m/s) above the model and rests on a 130 m thick sheet of PVC foam (Vp=984 m/s)

Survey geometry: 3-D 100 lines x 180 receivers, 20 m between shots, 20 m between receivers

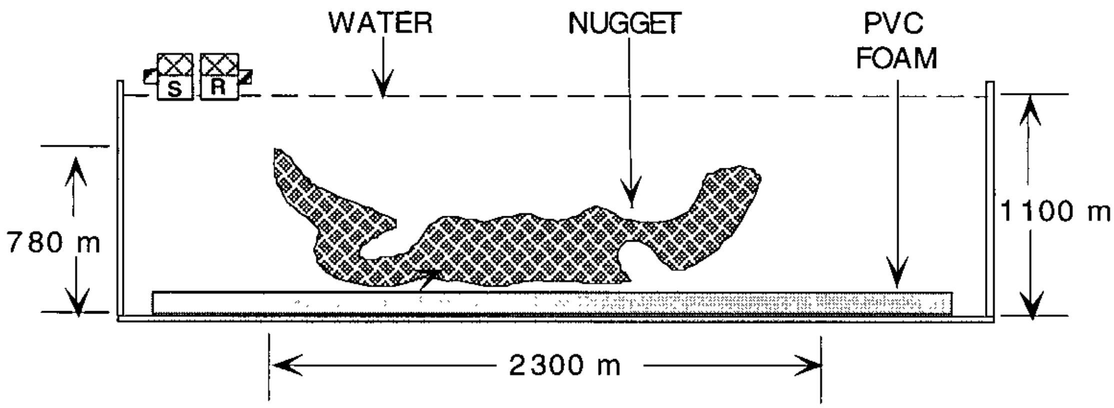


FIG. 5. Schematic showing experimental setup over copper nugget.

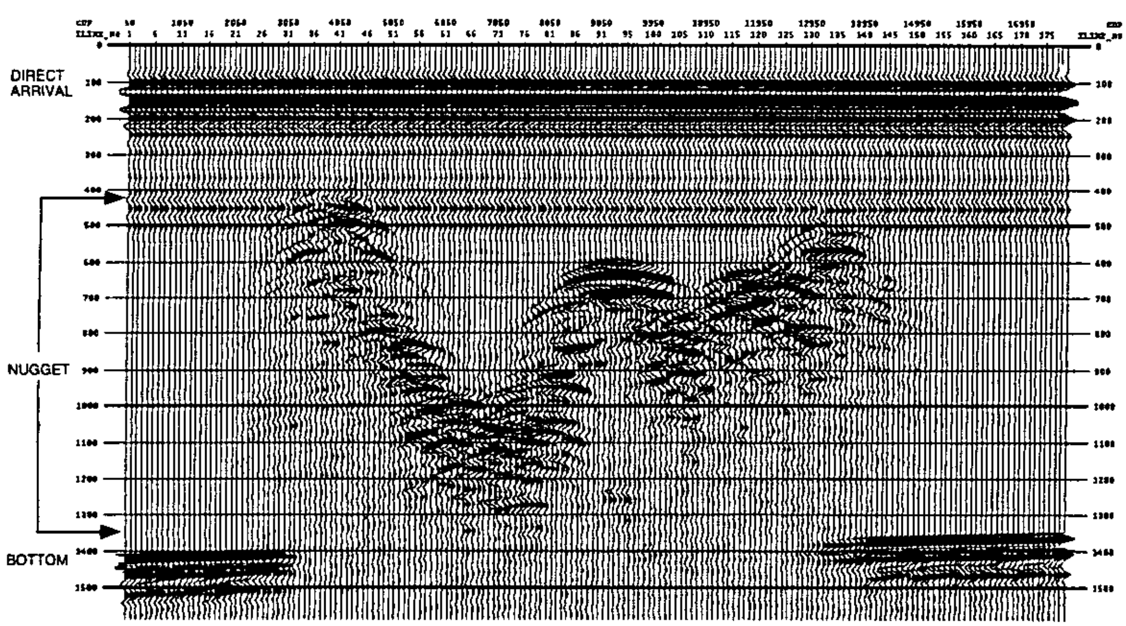


FIG. 6. P-P survey from line 50 over the center of the nugget.

3-C 3-D reverse VSP

A 3-C 3-D reverse vertical seismic profile model was constructed utilizing a previously built model of a glauconitic sand channel. A 500 m sheet of acrylic (V_P= 2750 m/s,V_S=1375 m/s) was glued to the top of the sand channel model. At a location above the point bar (V_P=2175 m/s, V_S=1389 m/s)on the sand channel (V_P=2885

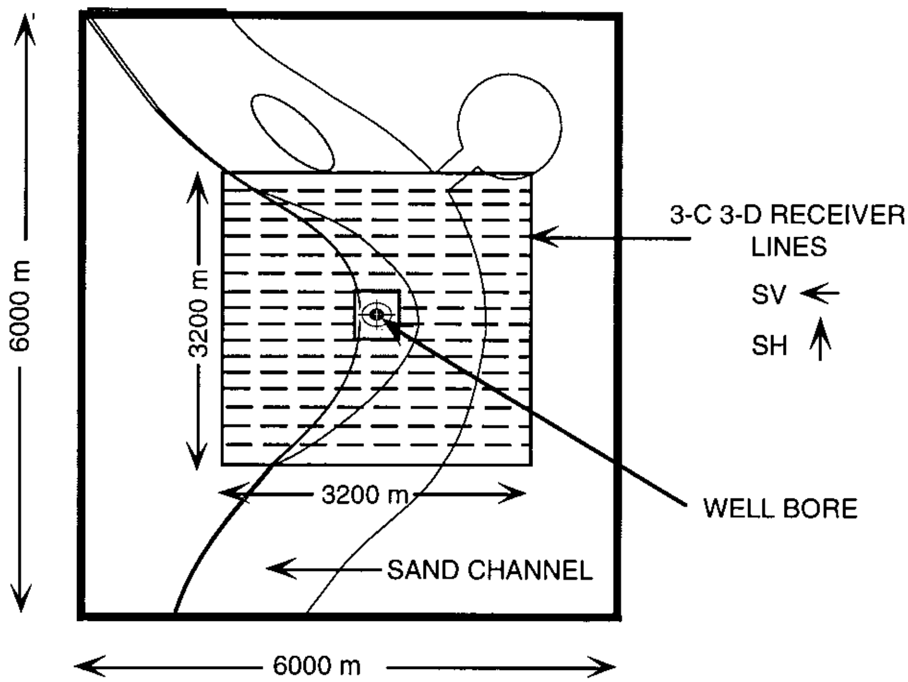


FIG. 7. Schematic diagram showing the 16 receiver lines, the inline and cross line polarizations as well as the well bore.

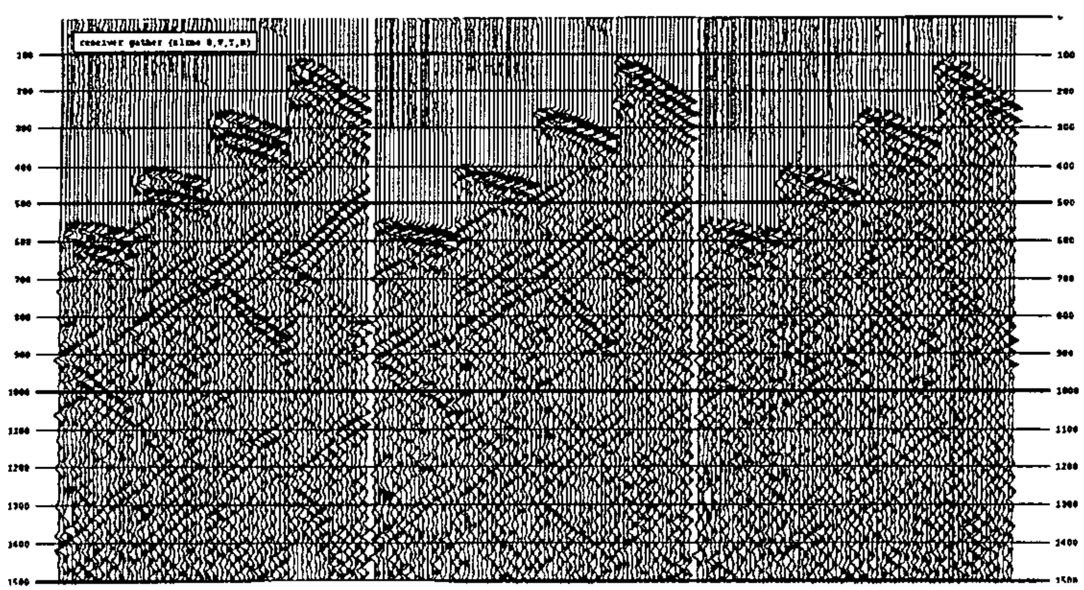


FIG. 8 Figure showing data from 3-C 3-D RVSP experiment. The first pannel is V-V, the second panel is V-T, and the third pannel is V-R from the shot at the 241 m level.

m/s, V_S =1538 m/s) a source was fired at 30 m intervals from the 500 m level to the surface of the model. The 3-C receiver patch was 3200 m x 3200 m centered on the well bore or shot location. Figure 7.

Survey geometry: 3-C 3-D survey, shot spacing 30 m, receiver spacing 200 m, receiver line separation 200 m, 16 receiver lines x 16 3-C receivers.

Rugose model

The rugose model was constructed using the same glauconitic sand channel as in the above experiment. An acrylic sheet 500 m in thickness was glued to the surface of the sand channel model. The acrylic (V_P=2750 m/s, V_S=1389 m/s) sheet was cut to exhibit various extremes of rugosity (Figure 9) from 10 m to 20 m deep in area #1, to 150 m deep in the center area of channel #2. The acrylic was then covered with Silastic *J* (V_P=915 m/s, V_S=307 m/s), a silicone-based rubber approximately 20 m thick. A 3-C 3-D survey was then conducted over the model.

Survey geometry: 6 shots per shot line, shooting into a patch of 36 3-C receivers, 14 patches per receiver line. Shot spacing 200 m, receiver spacing 100 m.

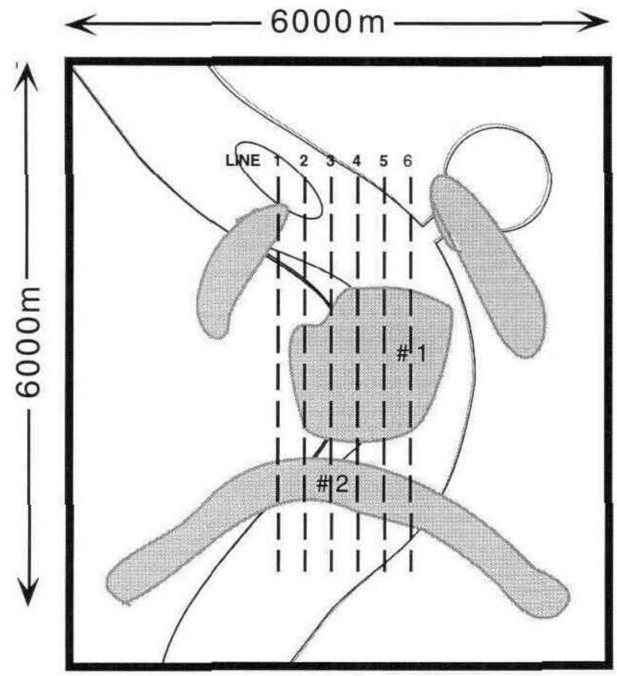


FIG. 9. Schematic diagram of the rugose model with shaded areas indicating rugosity. Area #1 is 10 m to 20 m deep and area #2 is 150 m deep.

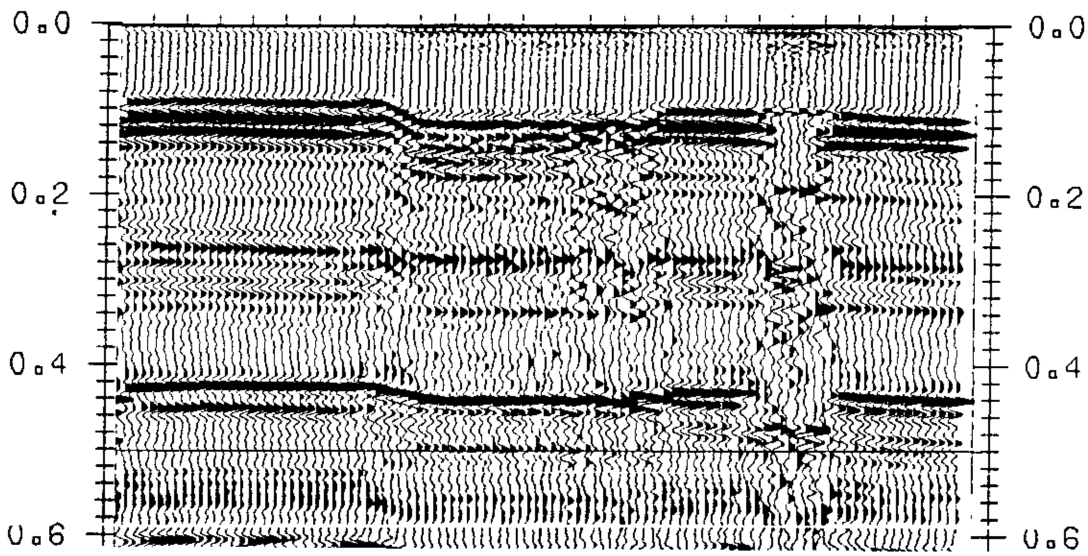


FIG. 10. Rugose model data showing a P-SV survey of line 5.

Weathering layer model

The weathering layer model was constructed to evaluate the time difference delay in static corrections. The model consists of two layers as per Figure 7. The top layer is Silastic J (Vp=915 m/s) a silicone based rubber material. The bottom layer is PVC (Vp=2350 m/s).

Survey geometry: 3-D survey, 9 patches , 7 shot lines, 7 receiver lines, receiver space 100 m, receiver line space 100 m, shot space 100 m, shot line space 200 m.

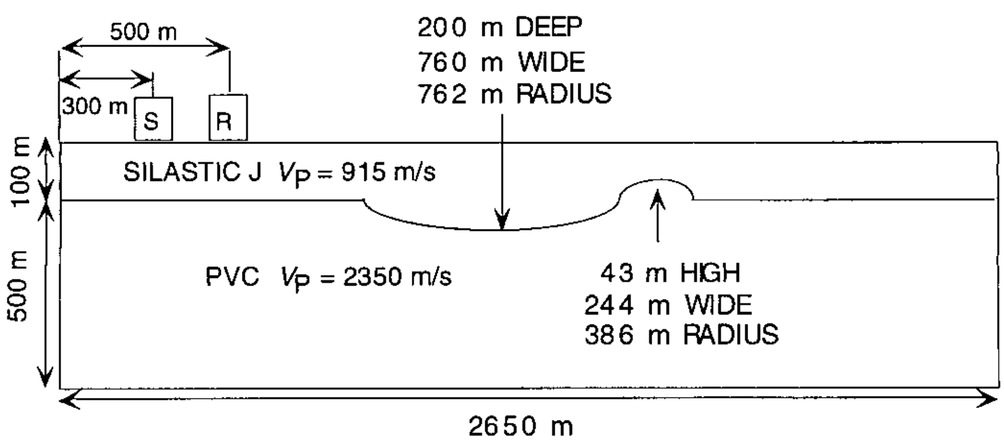


FIG. 11. Schematic diagram showing the two-layer weathering layer model.

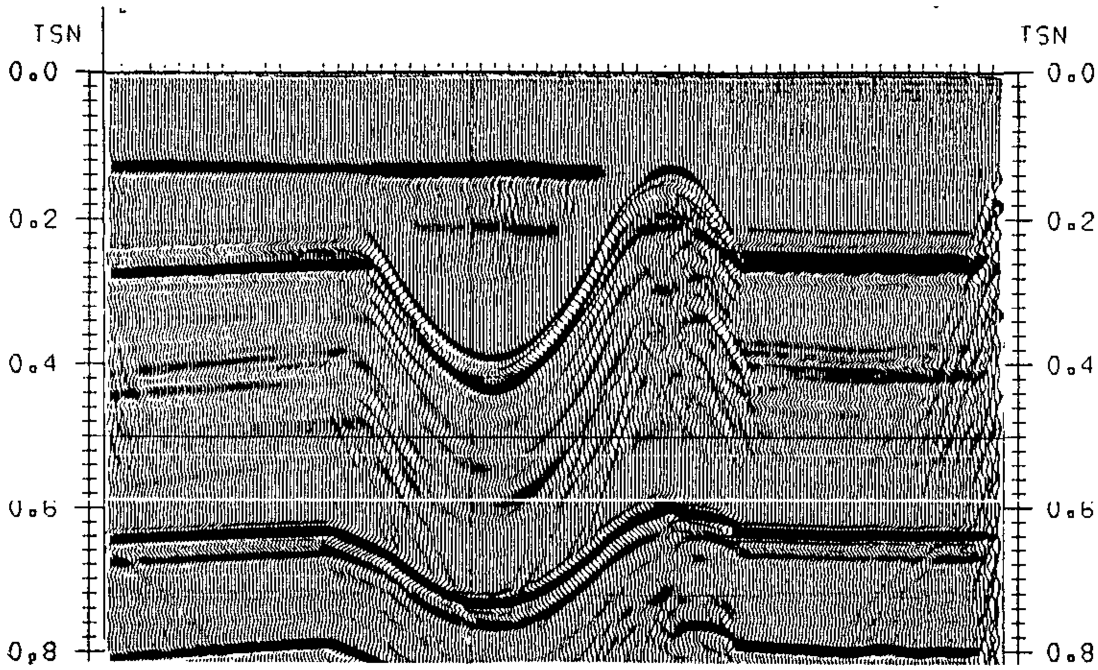


FIG. 12. Constant offset P-P record over the model.

Azimuthal anisotropy model experiment

This 3-C elastic experiment uses another industrial laminate called Phenolic LEB. The velocity in the 1-axis is Vp=3584 m/s, 2-axis Vp=3401 m/s and 3-axis Vp=2935 m/s.The model was cut perpendicular to the horizontal laminations along the 3 axis. The phenolic sheet was cut twice and the three pieces were turned 90 degrees and glued together to simulate a model with vertical fractures and displaying azimuthal anisotropy. The model dimensions are 3000 m x 3300 m x 990 m thick (Figure.14).

Survey geometry: 3-C transmission experiment, 1 shot per line, 20 receivers per line, 50 m receiver spacing, 9 receiver lines, 9 shot positions at 0, 15, 35, 45, 55, 65, 75, and 90 degrees.

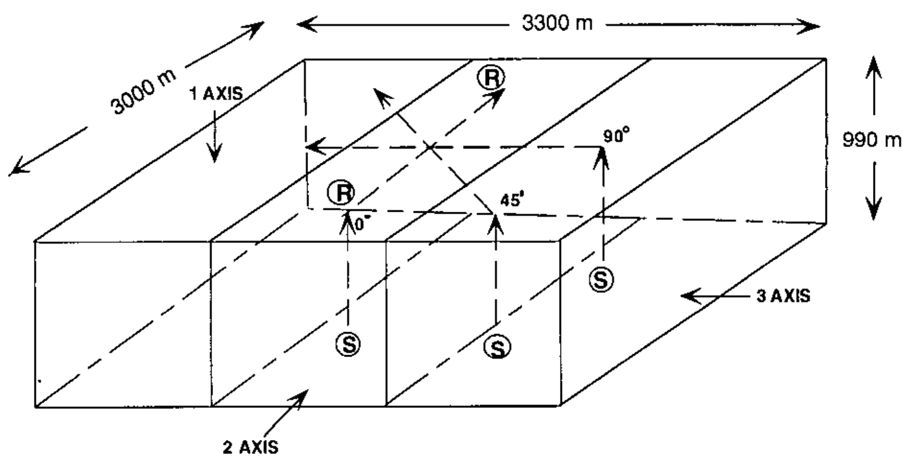


FIG. 13. Diagram of the azimuthal anisotropic model showing the experimental setup .

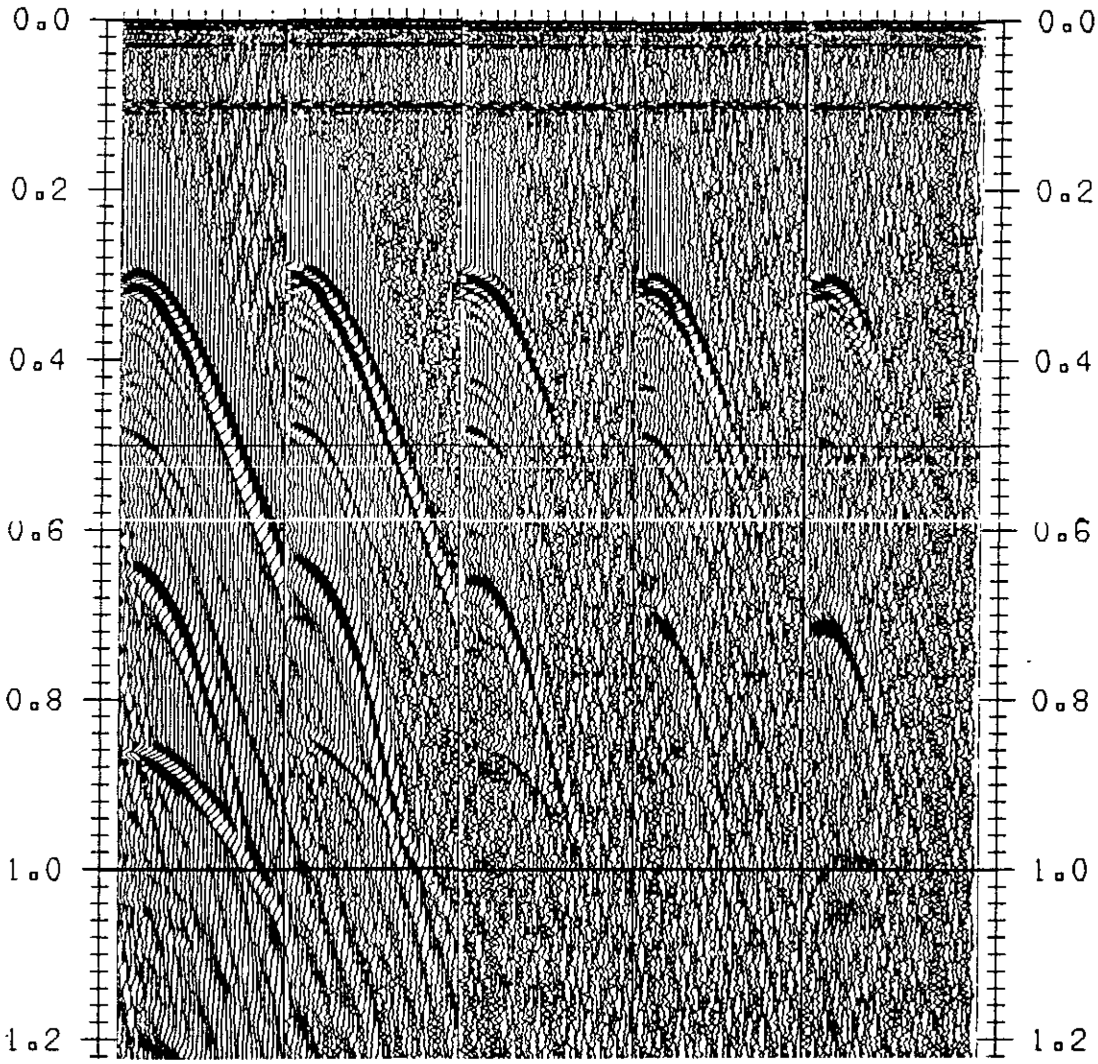


FIG. 14. P-SV data from shot gathers at 0, 25, 45, 75, and 90 degrees.

Aluminum rod experiment

This acoustic experiment utilizes solid aluminum rods (Vp=6300 m/s) in a water tank (Vp=1450 m/s). The rods are 190 m, 130 m, 95 m, 64 m and 47 m in diameter.

Survey geometry : Acoustic 2-D line, 400 shot locations, 400 receiver locations, shots at every 10 m. The source and receiver are at a constant offset of 300 m apart in a crossline mode, 420 m above the top aluminum rods. The survey starts 550 m from the center of the largest rod (190 m), and continues on toward the smallest rod (47 m). The rods are on 75 m centers (Figure.16).

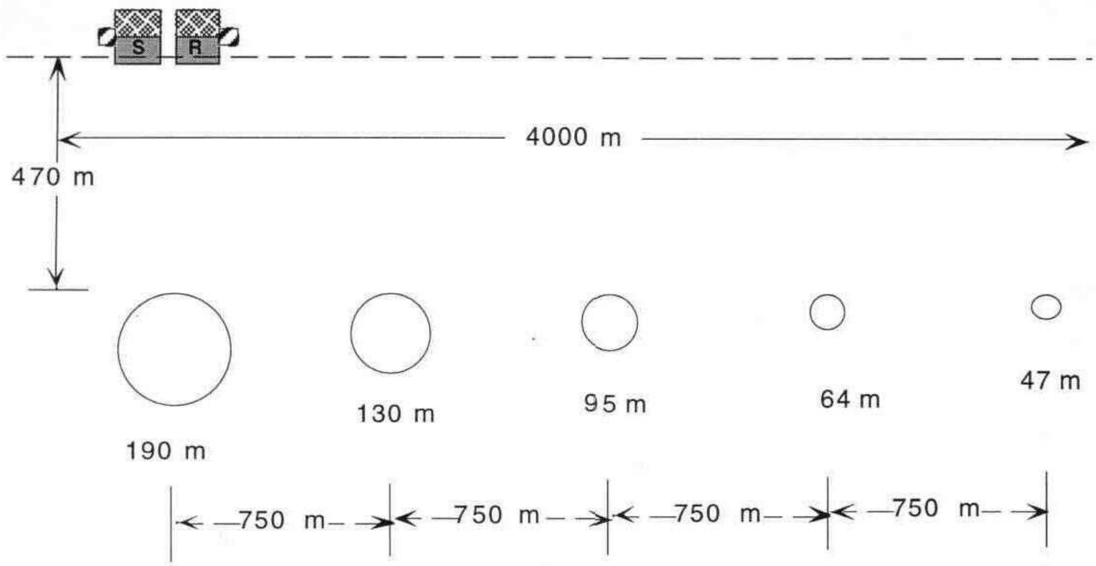


FIG. 15. Schematic diagram of aluminum rod experiment showing the survey geometry.

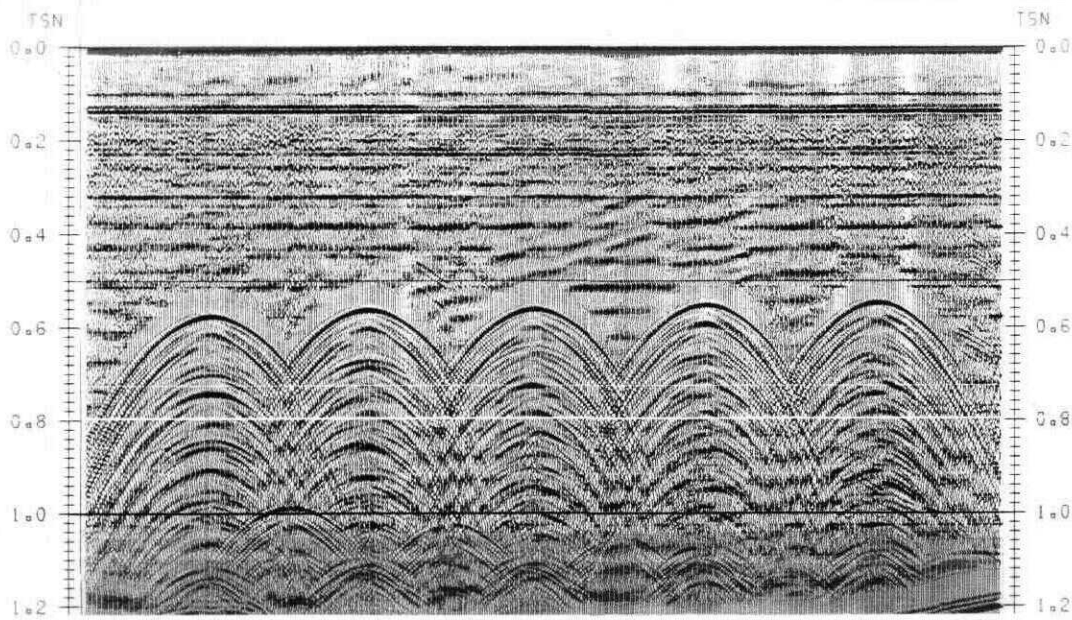


FIG. 16 Data from a constant offset P-P survey across the aluminum rods.

Work in progress

At the present time the CREWES Project is doing research on multicomponent subsea seismic, although data is unavailable for this report at time of printing.

Acknowledgments

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