Elastic-wave seismic acquisition systems

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ABSTRACT

CREWES has designed and built an omni-directional geophone and cable set for the University of Calgary's Geometrics Strataview 60 seismograph. This lightweight system has been field-tested and has given good results. Along with this geophone system we have also been testing various plates and blocks for hammer seismic energy sources. These can generate both P-wave and S-wave energy, depending on the design.

A new acoustic modelling tank has been acquired and measuring four feet square and two feet deep. Made of 15mm-thick glass, the depth will eliminate water column multiples and the width will eliminate edge effects from the sides. The glass sides will also aid in the alignment of the models and the sensors. A reusable river channel model has been built to test the acoustic response of various fluids and porous solids. Liquids such as water and oil and porous solids such as sand, steel shot and glass beads will be used for various experiments.

SINGLE CHANNEL OMNI-DIRECTIONAL GEOPHONES

CREWES has recently designed and built a set of 75 omni-directional geophones for use with the Geometrics Strataview 60 seismograph. The omni-directional geophones are intended to be used for channel-limited recording systems, where full vector recording is desired. These geophones have a single Geospace 20DM 28 Hz element, which can maintain manufacturer's output specifications to a tilt of 90 degrees. The geophone case, with a single spike and a levelling bubble, came from the manufacturer designed to hold the geophone element in a horizontal orientation. CREWES adapted these cases to accommodate a second spike on the side of the case, so the geophone element can be oriented vertically (Figure. 1). By using the geophone in the horizontal orientation, both SV- and SH-waves (by rotating the geophone case relative to the line) can be recorded. Removing the spike from the bottom of the geophone case and mounting it on the new side location allows P-waves to be recorded. CREWES also designed and manufactured seismic cables to go with the 75 omni-directional geophones. These cables have 15 takeouts at a 2.5-metre station interval, for a maximum offset of 150 metres, with four cables live (60 channels) and one spare set of geophones and cable leading the spread. This system with light cables and single element geophones is easily portable and can still accomplish 3-C surveys. Samples of data from the omni-directional geophones are shown in Figures 2, 3, and 4. These data sets are from Devon Island, Nunavut, from the Haughton Crater test site. New spikes for the omni-directional geophones were also designed and built. These have a hexagonal shank to keep the geophone from rotating out of azimuth when planted in the horizontal configuration.

FIG. 1 Single-channel omni-directional geophones. The top left geophone is in the vertical position and the top right geophone is in the horizontal position. Note the levelling bubble on the left side of the top of the case. In the foreground is the CREWES designed adapter plate and hex-sided geophone spike. The white plastic bolts on the geophones are to keep the unused threads clean of mud or snow.

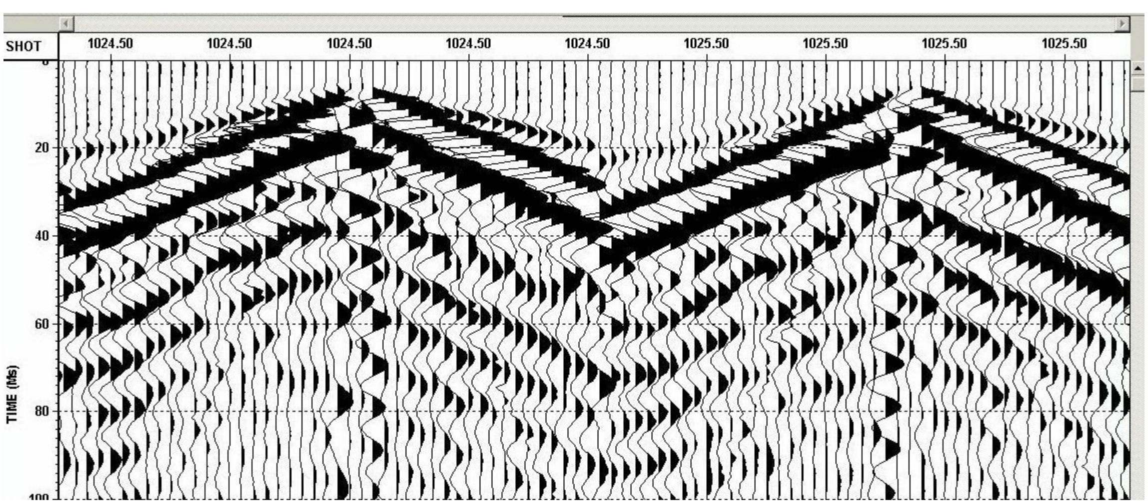

FIG.2. Two consecutive raw shot gathers using vertical oriented geophones and a vertical impact with a hammer. The recording parameters are: .05ms sample rate with traces every 2 metres, with a 200ms AGC.

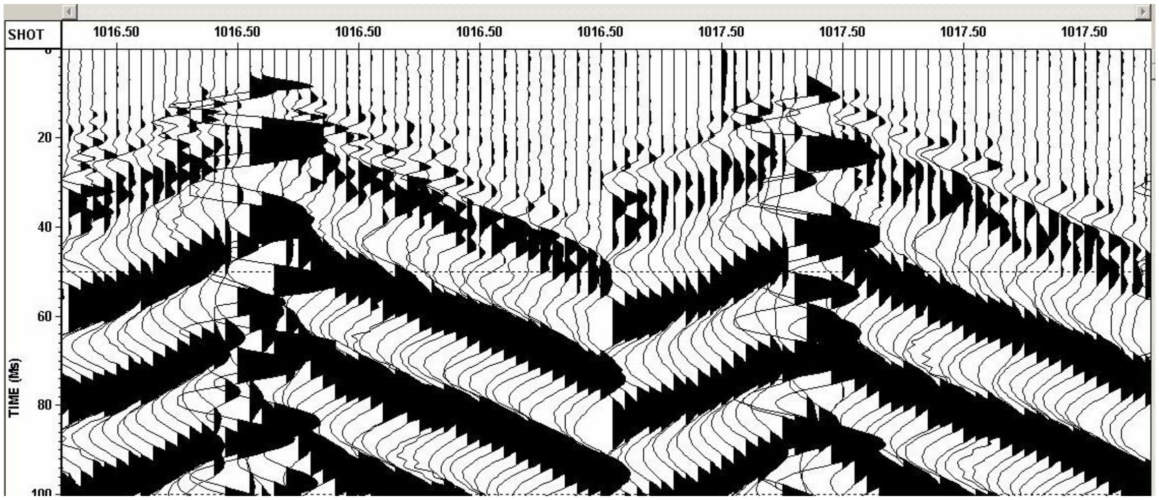

FIG.3. Two consecutive raw shot gathers using transverse oriented, horizontal geophones, with impact towards the west. The recording parameters: .5ms sample rate with traces every 2 metres.

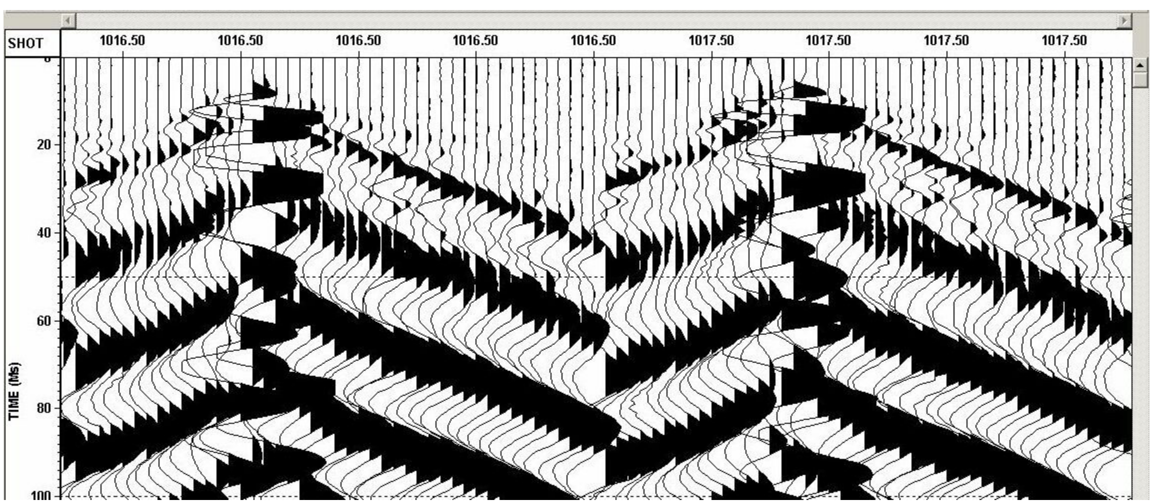

FIG.4. Two consecutive raw shot gathers using transverse oriented, horizontal geophones, with impact towards the east. Recording parameters: .5ms sample rate with traces at every 2 metres.

HAMMER PLATES AND BLOCKS

Various hammer source blocks and plates have been built and tested by CREWES. Aluminum is used for these because it does not ring after being struck as does steel. Some of the plate designs tried are shown in Figure 5. a plate with spikes and a cylinder for vertical point sources, and a tapered block and a flat top pyramid (Figure 6) for both P-wave and S-wave generation. The tapered block and the pyramid have changeable teeth for use in hard consolidated ground or loose sand/gravel ground covers.

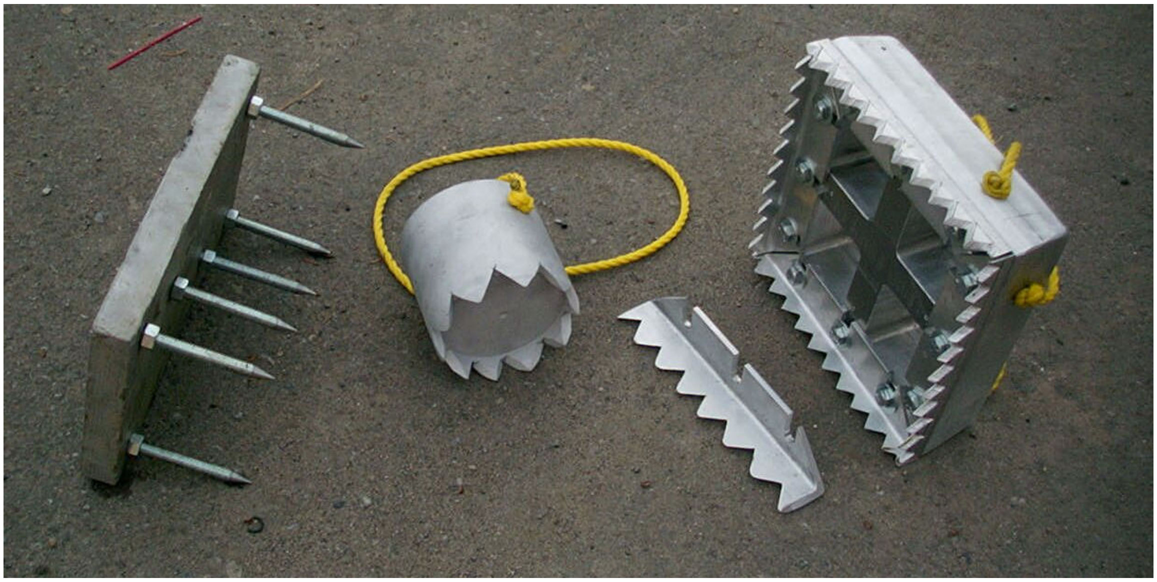

FIG. 5. Hammer seismic plates and blocks. On the left is a flat plate with geophone-like spikes and to its right is a cylinder. Both of these are vertical point sources. On the far right is the tapered block which can generate both P-wave and S-wave energy.

FIG. 6. Flat top pyramid for generating both P-wave and S-wave beside a three pound sledge hammer.

MODELLING TANK UPGRADE

The acoustic modelling tank has been replaced by a four foot square by two foot deep glass aquarium. The existing acoustic tank worked for most surveys, but we could not provide the depth of water for thicker models required to eliminate water column multiples. The new tank holds 900 litres of water with a weight of about 900 kilograms. Because it is built of glass, it is easy to see into the tank for alignment of the models and sensors.

FIG. 7. A very complex fold-thrust model from the C-CORE Laboratory, Memorial University, in Saint John's, Newfoundland. The model, which is 650mm long x 100mm wide and 120mm high at the highest point, is made from silicone putty and plastercine.

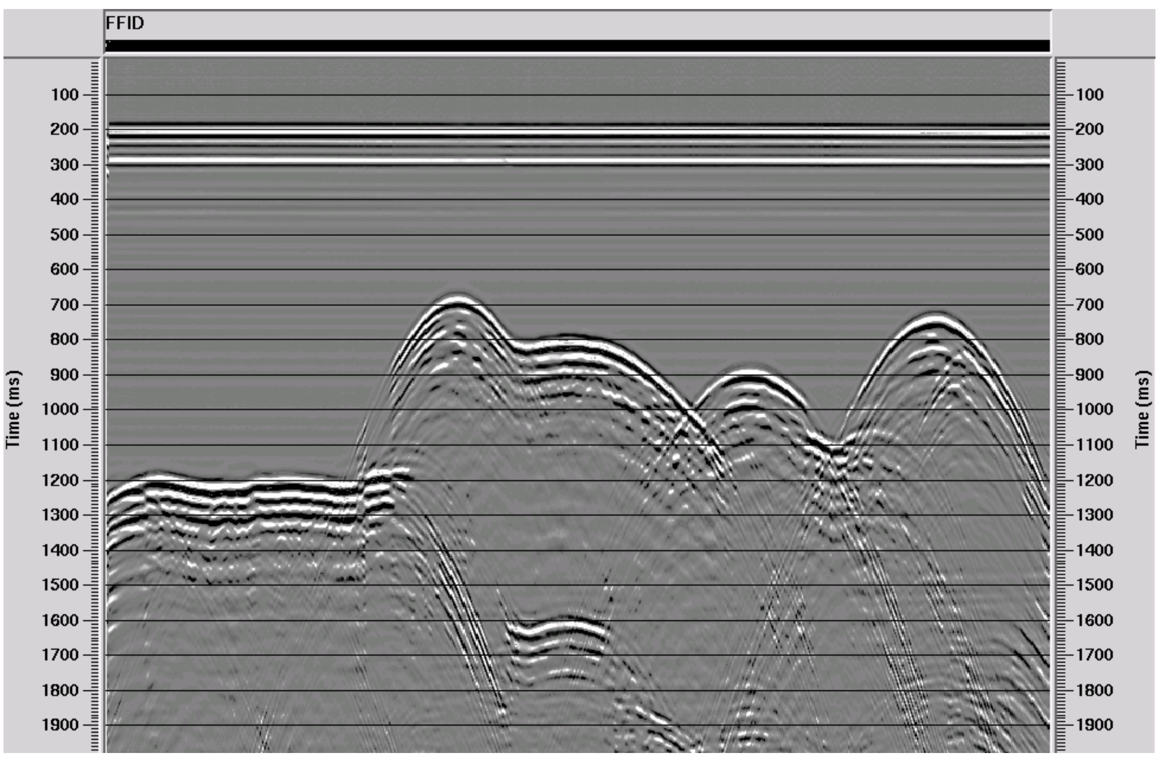

FIG. 8. Fixed offset physical modelling acoustic data from the fold-thrust model in Figure 7. Source/receiver offset 15mm, shot interval 1mm, 720 traces with 1000ms AGC.

PHYSICAL MODELLING

A reusable river channel model (Figure 9) has been built. The 600mm x 600mm x 100mm thick model is constructed of cast acrylic (Vp = 2750ms and Vs = 1375ms). Made of two 50mm layers of acrylic, the model has a hollow meandering channel 45mm wide x 10mm deep cut from edge to edge into one of the 50mm thick layers. This channel has a secondary deeper channel 15mm deep and 10mm wide, which meanders across the 45mm width of the main channel. A series of experiments is planned that will use different channel fills that can be repeated over time. Using various fluids such as water and oil, and porous solids such as sand, steel shot or glass beads, we will be able to measure the effects of changing velocity, density and porosity.

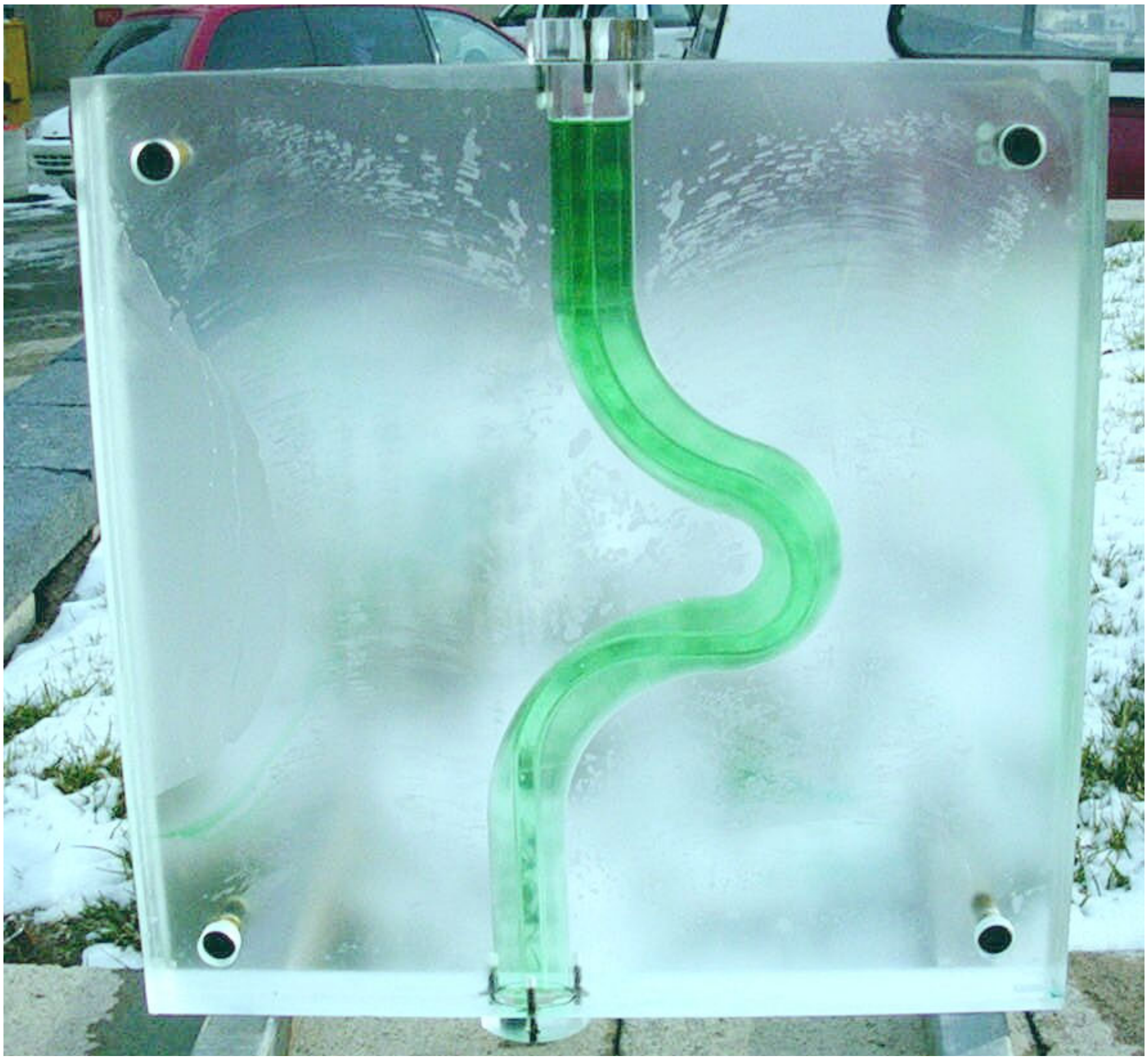

FIG.9. The reusable river channel model. Made of cast acrylic the dimensions are 600mm x 600mm x 100mm thick. The width of the channel is 45mm.

CONCLUSIONS

Good quality P-wave and S-wave data have been recorded on Devon Island and elsewhere using the new omni-directional geophones in vertical and horizontal orientations. We have constructed hammer seismic plates and blocks that have proven successful in the field.

A new river channel model has been built that will give us measurements of changing seismic response with variations in channel fill. The model will be used for 3D multicomponent surveys and time lapse imaging.

ACKNOWLEDGMENTS

The authors would like to acknowledge Andy Read and the staff of the Faculty of Science Workshop, at The University of Calgary for the manufacture and help in the design of the omni-directional geophone, the hammer seismic sources and the reusable river channel model, which was machined using a CNC milling machine.

The authors would like also acknowledge the Foothills Research Project and the Center for Cold Ocean Research and Engineering (C-CORE), Memorial University, St John’s, Newfoundland, for the use of their fold-thrust model.

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