Seismic Acquisition

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AUSTRALIAN EARTH SCIENCE EDUCATION

Seismic Acquisition – Teacher Resource

Powering Careers in Energy Link:

Unit 2: Demonstrate an understanding of the importance of science in LNG operations.

Background Information:

Seismic reflection surveys are one of the main methods used in exploration for oil and gas reservoirs. To complete these surveys you need a source to generate sound waves and equipment to record the reflected waves. The waves are reflected off stratigraphic horizons (boundaries between rock layers) and structures, due to density contrasts, and their travel time back to the surface is recorded. This is known as the two-way travel time (TWT). The denser the rock, the faster the sound waves travel. Seismic surveys can be done on land or at sea.

Land seismic acquisition generally uses a Vibroseis truck, with a large metal pad, which sends shock waves into the earth. Historically, dynamite was used, but this was replaced for environmental reasons. In land seismic surveys, the recording equipment used is a series of geophones. These are arranged in a line and record the TWTs from each reflected horizon. This information is relayed to a recording truck, building up a picture of the subsurface (Figure 1).

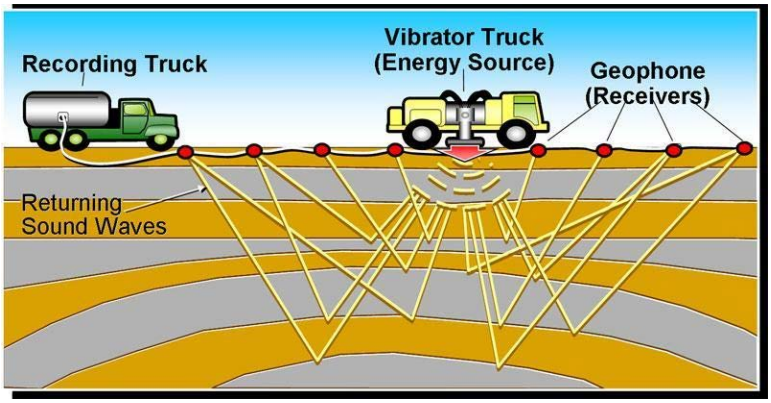


Figure 1: Land Seismic Acquisition (from geologylearn.blogspot.com)

Offshore seismic acquisition uses an adapted marine vessel. At the back of the boat, an air gun sends sound waves into the subsurface. These are reflected off stratigraphic horizons and the wavelets are recorded by hydrophones, which are towed behind the vessel on streamers. The TWTs are recorded and relayed to the boat, where initial processing of the data occurs, building up a picture of the subsurface (Figure 2).

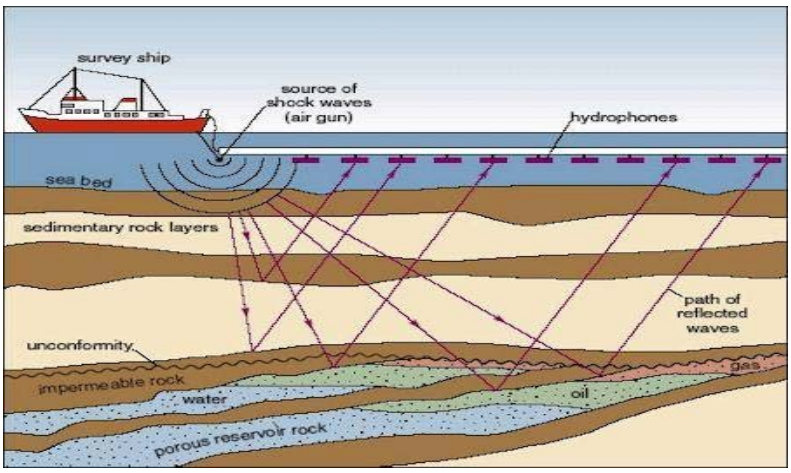


Figure 2: Marine Seismic Acquisition (from geologylearn.blogspot.com)

Aim

To determine what seismic reflection survey waves are, how they travel through the subsurface and are recorded.

Materials

- Slinky
- Metre rule or measuring tape
- Timer

Safety Notes:

Students should be careful not to pinch themselves with the slinky.

Method:

Students should form teams of three. Two students should stretch the slinky to two metres (use the metre ruler or measuring tape) with each holding an end. One student will be the source of seismic energy (will pull the slinky back a little and push it to create a wave, this should 'bump on') the other will be the stratigraphic horizon, which the wave bounces off. The third will be timing how long it takes for a wave to travel from the source (student 1) to the horizon (student 2) and back again = the two-way travel time (TWT). Students should practice creating and measuring these waves until they are comfortable they have the methodology right. They should then take recordings for three waves.

Results:

Students should record the two way travel time for three tests. From this they can work out the velocity of each wave.

Discussion:

1. What was the average velocity of the waves you generated?
   Velocities for this activity generally sit in the 0.8m/s to 3m/s range, depending on the type of surface, force of wave generation, springiness of the slinky etc.
2. Describe how your wave travelled. What type of wave was it?
   The wave travelled as a 'bump on' along the slinky. They are sound waves and therefore longitudinal (motion of the particles is parallel (and anti-parallel) to the direction of the energy transport).
3. If your wave travelled quickly what would that tell you about the subsurface?
   It could be that the stratigraphic horizon the wave was reflected off was close to the surface or that the rocks are quite dense.

Evaluation:

1. Was this a fair representation of seismic waves?
   Yes the type of motion is correct.
2. How could you improve this investigation?
   Students might suggest ways to monitor the force the wave is sent with, having a wall/other as a horizon (instead of person 2), more accurate measuring systems, etc.

Extension:

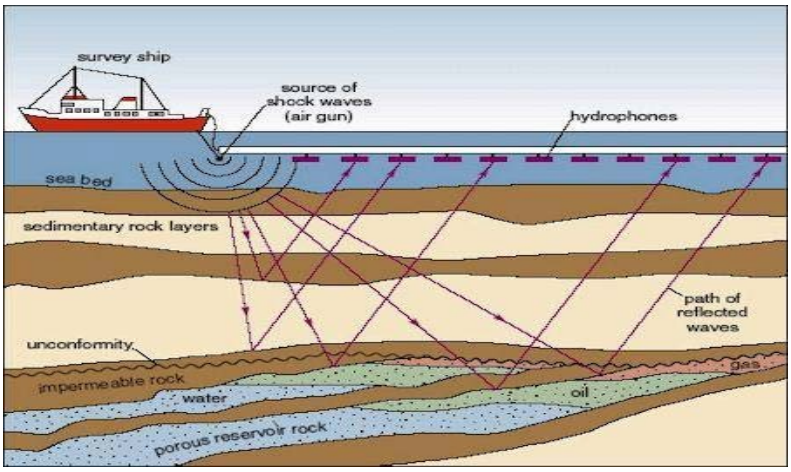
- Students could stretch the slinky further to investigate the impact on results (we would expect velocities to decrease – representing waves travelling more slowly through less dense rocks/materials).
- Students could explore the velocity of waves across different surfaces and how differences relate to what we know (surfaces with lower friction would have faster velocities representing denser rock material).
- Students could measure the two-way travel time across a number of distances and graph these results to discover a formula for the area they are working with. This could be used to calculate the distance to stratigraphic horizons given a known two-way travel time (note: this would only be applicable for their area of work – others may be using different surfaces, this would result in different velocities).

REFERENCES:

Figure 1 and 2: Learning Geology (2015). Accessed at http://geologylearn.blogspot.com.au/2015/06/marine-and-land-seismic-aquisition.html

Worksheet: Seismic Acquisition

Seismic reflection surveys are one of the main methods used in exploration for oil and gas reservoirs, using an adapted marine vessel. At the back of the boat, an air gun sends sound waves into the subsurface. These are reflected off stratigraphic horizons (changes in rock type) and the wavelets are recorded by hydrophones, which are towed behind the vessel on streamers. The two-way travel times (the time it takes for waves to be generated, hit a stratigraphic horizon and be received by a hydrophone) are recorded and relayed to the boat, where initial processing of the data occurs, building up a picture of the subsurface.



Marine Seismic Acquisition

Aim

To determine what seismic reflection survey waves are, how they travel through the subsurface and are recorded.

Materials

- Slinky
- Metre rule or measuring tape
- Timer

Safety Notes:

Be careful not to pinch yourself with the slinky.

Method:

1. Form a team of 3 and take a slinky.
2. Begin by stretching the slinky two meters between two of the group. One person will hold each end.
3. Practice first by pulling the slinky toward you a bit and then pushing it away. Notice that a wave travels along the slinky from you to your partner.
4. The third person should practice timing how long it takes for a wave to travel from the source (person 1), to the stratigraphic horizon (person 2) and back again.
5. Once you are confident with this method pull the slinky back 3 times and make recordings.
6. Document the two-way travel times in the table below. Calculate velocities for each wave.

Results:

	Wave 1	Wave 2	Wave 3
Two Way Travel Time (s)			
Velocity (m/s)			

Discussion:

1. What was the average velocity of the waves you generated (show your calculation/s)?

_____

2. Describe how your wave travelled. What type of wave was it?

_____

3. If your wave travelled quickly what would that tell you about the subsurface?

_____

Evaluation:

Was this a fair representation of seismic waves?

_____

How could you improve this investigation?

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