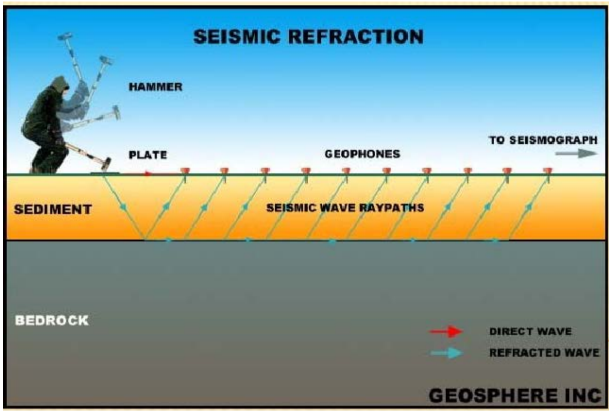
201 GPH
Unit 2 (Review)

Q. What is seismic refraction?

A. Seismic refraction is a geophysical principle governed by Snell's Law. The seismic refraction method utilizes the refraction of seismic waves on geologic layers and rock/soil units in order to characterize the subsurface geologic conditions and geologic structure.



Q. Which exploration techniques are used in seismic refraction?

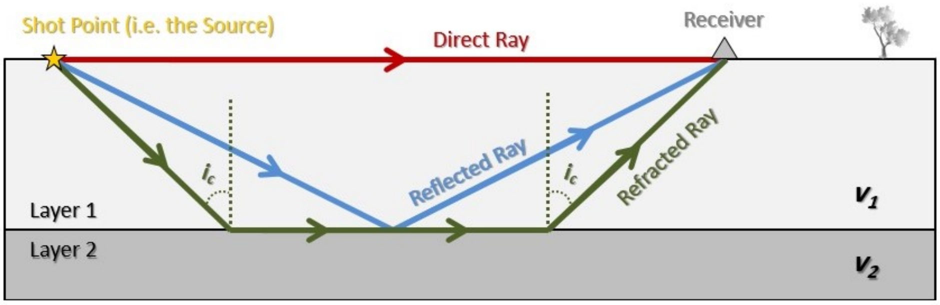
A. Active Methods (Induced Sources): a signal is injected into the earth and then measure how the earth respond to the signal

Q. What are the applications of seismic reflection?

A. They are:
1. Depth to bedrock.
2. Groundwater exploration.
3. Crustal structure and tectonics.

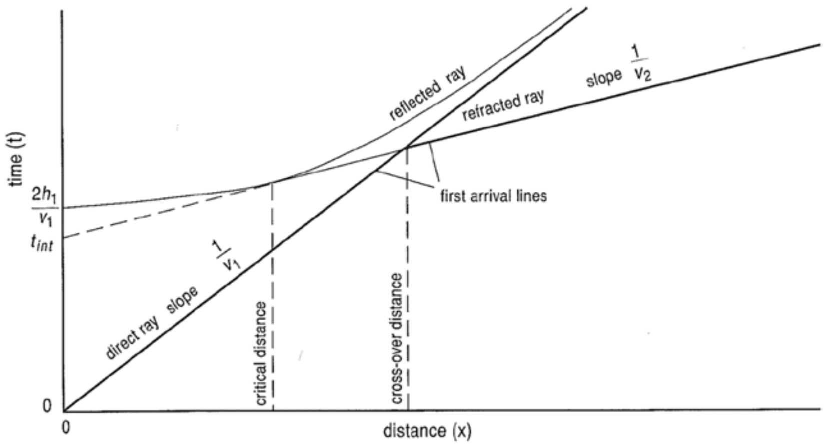
Q. What are the three main rays recorded when doing a seismic refraction survey?

A. They are:
1. The direct ray.
2. The reflected ray.
3. The refracted ray.

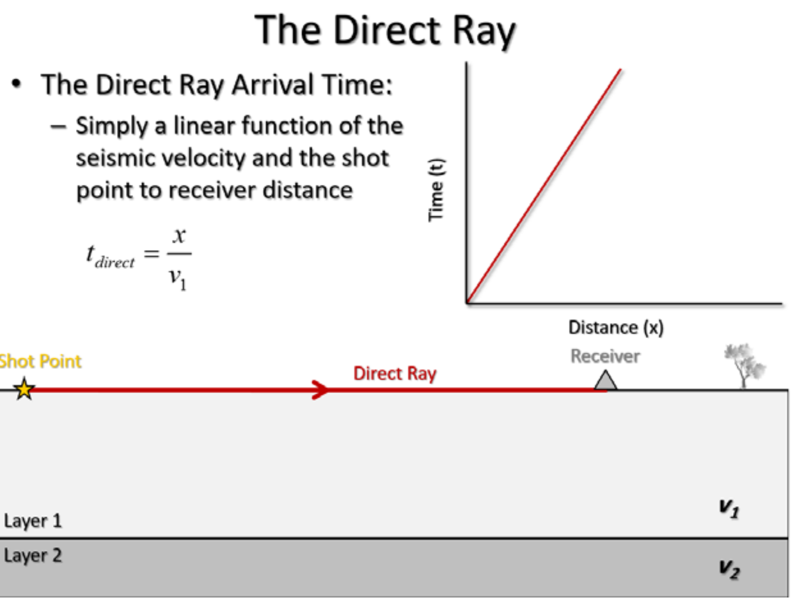


Q. What is time-distance (t-x) diagram?

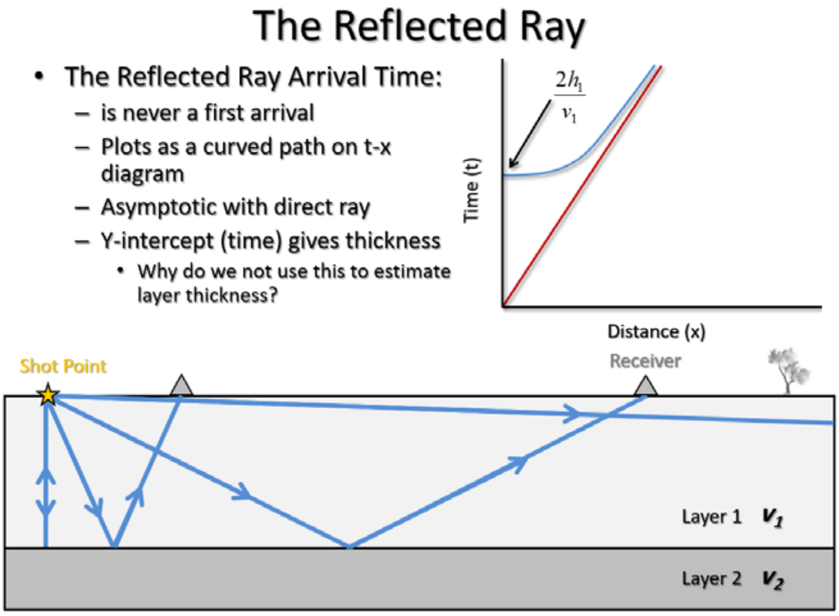
A. Time-distance (t-x) diagram shows the relationship between the travel-time and distance of seismic energy propagating from the source to receivers.



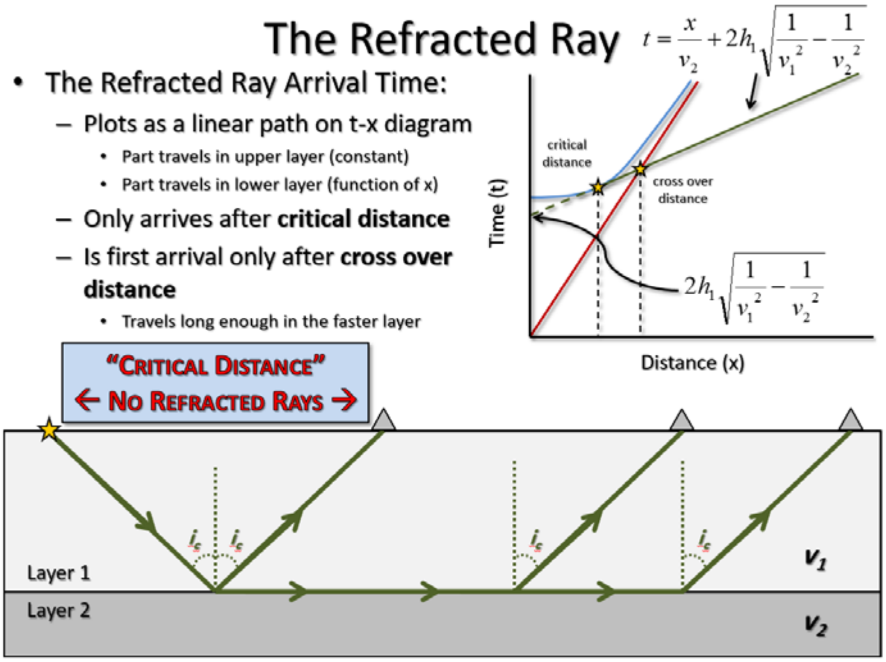
Q. Plot the direct ray on (t-x) diagram?



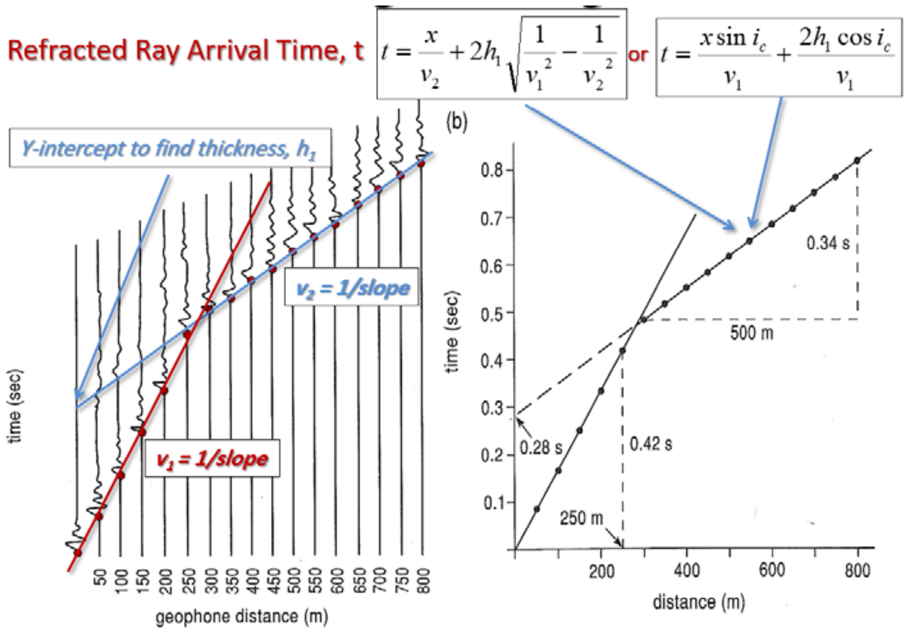
Q. Plot the reflected ray on (t-x) diagram?



Q. Plot the refracted ray on (t-x) diagram?



Q. Write down the equation of the refracted ray arrival time?



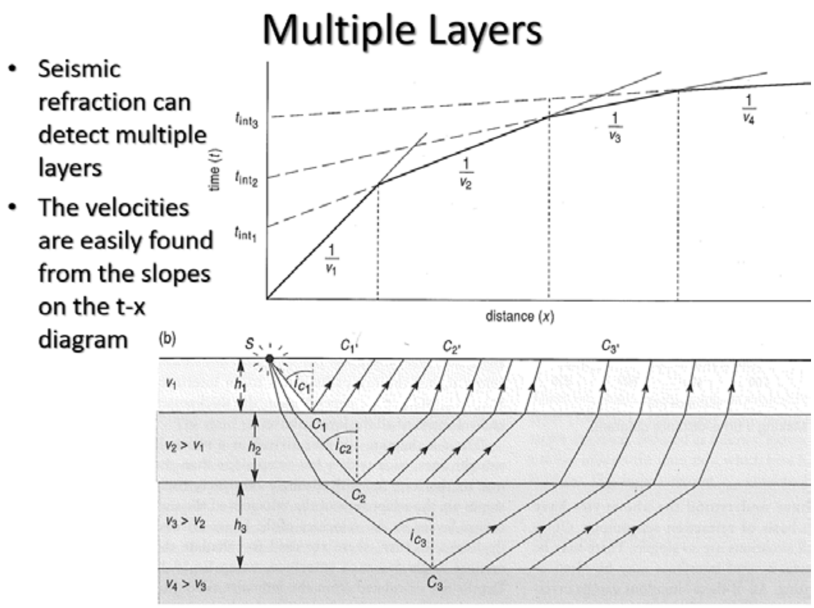
Q. What does seismic refection reveals?

A. It reveal two main pieces of information, they are:

1. Velocity structure (used to infer rock type).
2. Depth to interface (lithology change and water table).

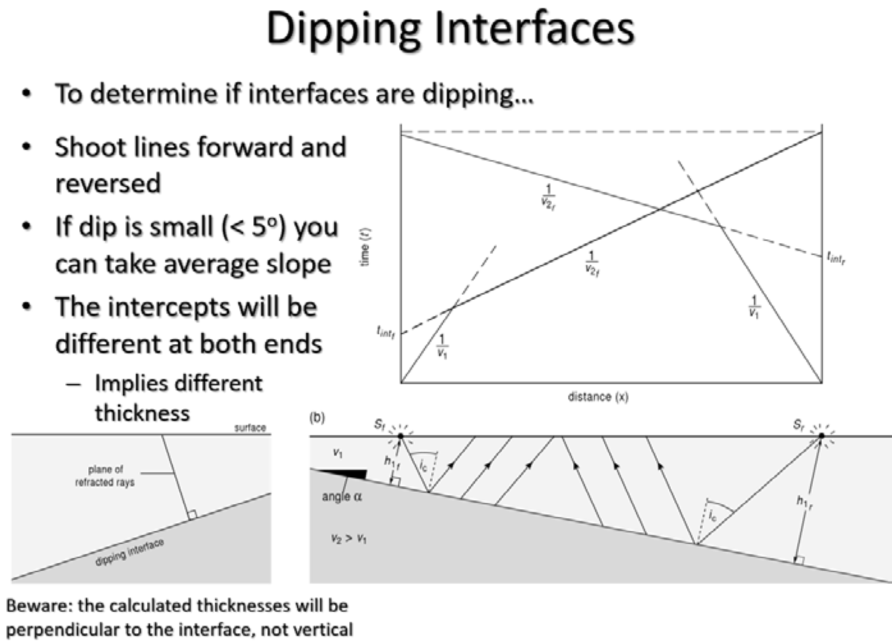
Q. Can seismic refraction detect multiple layers?

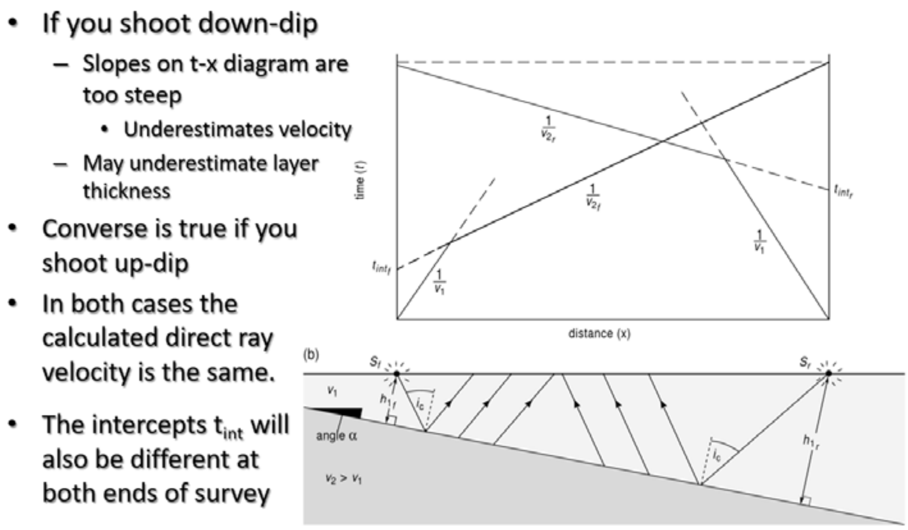
A. Yes, the velocities are easily found from the slopes on the t-x diagram.



Q. What if the critically refracted interface is not horizontal? What to do?

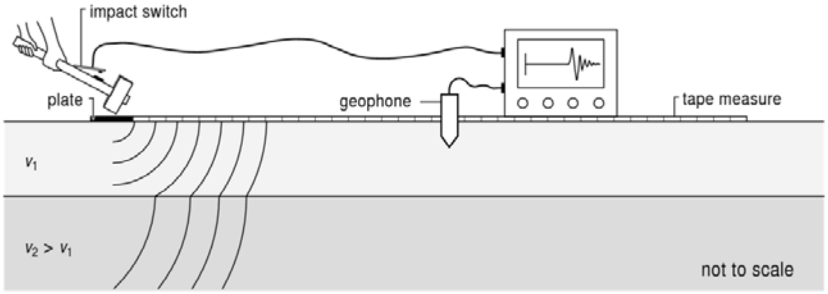
A. A dipping interface produces a pattern that looks just like a horizontal interface. Velocities are called “apparent velocities”.



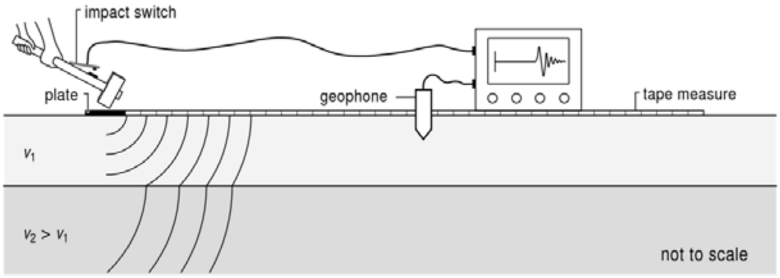


Q. What is the simplest and cheapest type of survey?

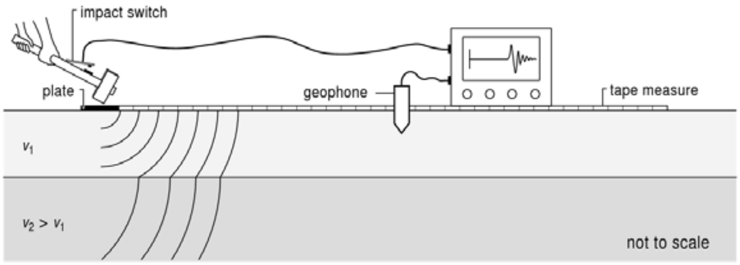
- The simplest (and cheapest) type of survey is called a hammer seismic survey
  - A sledgehammer is whacked into a steel plate
  - Impact switch tells time=0
  - First arrivals are read digitally or inferred from seismogram
  - Because swinging a hammer is free, only one geophone is needed
    - More can be used, but single geophones must be along a linear transect



- The maximum workable distance depends on:
  - The sensitivity of the system
  - The strength of the sledgehammer whacks
  - The amount of noise
    - Wind shakes trees, etc...
    - Cars, footsteps, HVAC, traffic, etc...
    - Surveys may be done at night to minimize noise



- Often the signal to noise ratio is very poor:
  - Stacking is often used to help delineate first arrivals
- General rule of thumb:
  - Geophone array should be about 10x the depth to interface
  - 100 meters is the typical upper limit on length of hammer seismic transect
    - So hammer seismics are best for shallow interfaces (< 10 m)

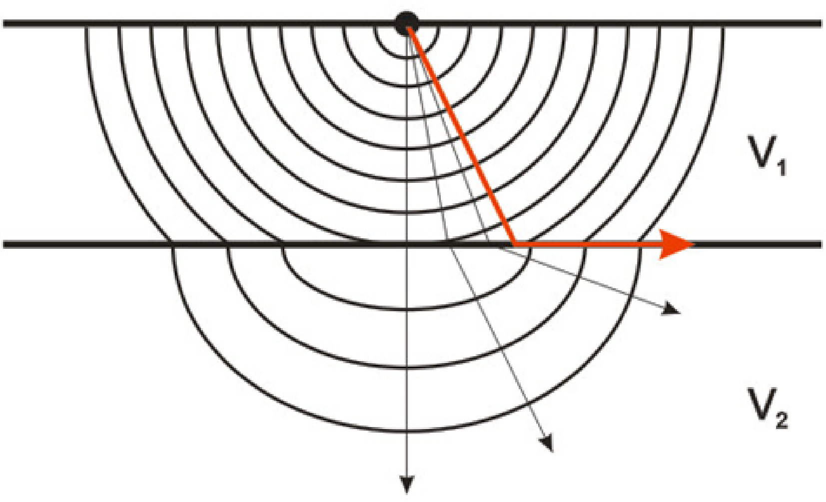


Q. What are other survey types?

- Explosion seismics
  - Offers a much stronger signal
    - Can detect deeper features
    - Often involves water explosions (much cheaper)
    - Geophones / Seismometers are often linked wirelessly (RF / radio waves)
- Marine Surveys
  - Sometimes use explosives, compressed air, high voltage charges, or many other types.
  - Usually use hydrophones
    - Respond to pressure changes (p-waves)
    - Surveying is often done while the ship is moving, so very long transects can be done at a lower cost

Q. What is critical refraction?

At Critical Angle of incidence i_c, angle of refraction $r = 90°$

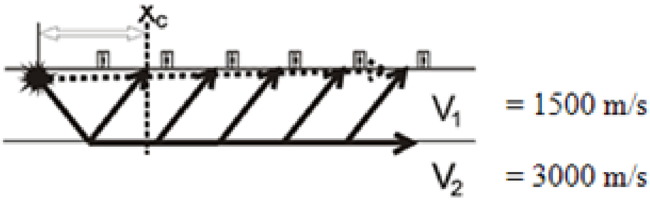


Q. Calculate the crossover distance from the below figure?

The crossover distance (Xcr) can be computed from the following equation:

$$X_{cr} = 2h\sqrt{\frac{V_2 + V_1}{V_2 - V_1}}$$

where:



h= 100 m

V_1= 1500 m/s

V_2= 3000 m/s

$$X_{cr} = 2(100)\sqrt{\frac{3000 + 1500}{3000 - 1500}}$$

$$X_{cr} = 200\sqrt{\frac{4500}{1500}}$$

Therefore: **Xcr= 346.410 meters**

Q. Using Snell's law, calculate the reflected angle if V_1= 4 km/s, V_2= 6 km/s, and i= 30°?

$$\frac{V_i}{\sin i} = \frac{V_r}{\sin r}$$

$$\frac{4}{\sin 30^0} = \frac{6}{\sin r}$$

$$r = \sin^{-1}\langle\frac{\sin 30^0(6)}{4}\rangle$$

$$r \approx 49^0$$

Q. An incident P-wave strikes an interface between two different rock types. The upper layer has a P-wave velocity of 1500 m/s, and the lower layer has a P-wave velocity of 3900 m/s. The incident angle is 19 degrees:

a. Calculate the angles of refraction for P-wave.

b. Calculate the angles of refraction for S-wave

a. The angle of refraction for P-wave can be calculated from Snell's law:

$$\sin \theta_i / Vp_1 = \sin \theta_{rfrct} / Vp_2$$

Where:

$Vp_1 = 1500$ m/s, $Vp_2 = 3900$ m/s, and $\theta_i = 19°$

$$\sin (19)/1500 = \sin \theta_{rfrct}/3900$$

$$0.325/1500 = \sin \theta_{rfrct}/3900$$

$$\theta_{rfrct} = \sin^{-1} (0.325)(3900)/1500$$

$$\theta_{rfrct} = 57.67°$$

b. The angle of refraction for S-wave can be calculated from Snell's law:

$$\sin \theta_i / Vp_1 = \sin \theta_{rfrct} / Vs_2$$

Where:

$Vp_1 = 1500$ m/s

$Vs_2 = Vp_2 / (1.732) = (3900) / (1.732) = 2251.73$ m/s, and $\theta i = 19°$

$$\sin (19)/1500 = \sin \theta_{rfrct}/2251.73$$

$$0.325/1500 = \sin \theta_{rfrct}/2251.73$$

$$\theta_{rfrct} = \sin^{-1} (0.325)(2251.73)/1500$$

$$\theta_{rfrct} = 29.20°$$