Fundamentals of Seismic Reflection Surveys

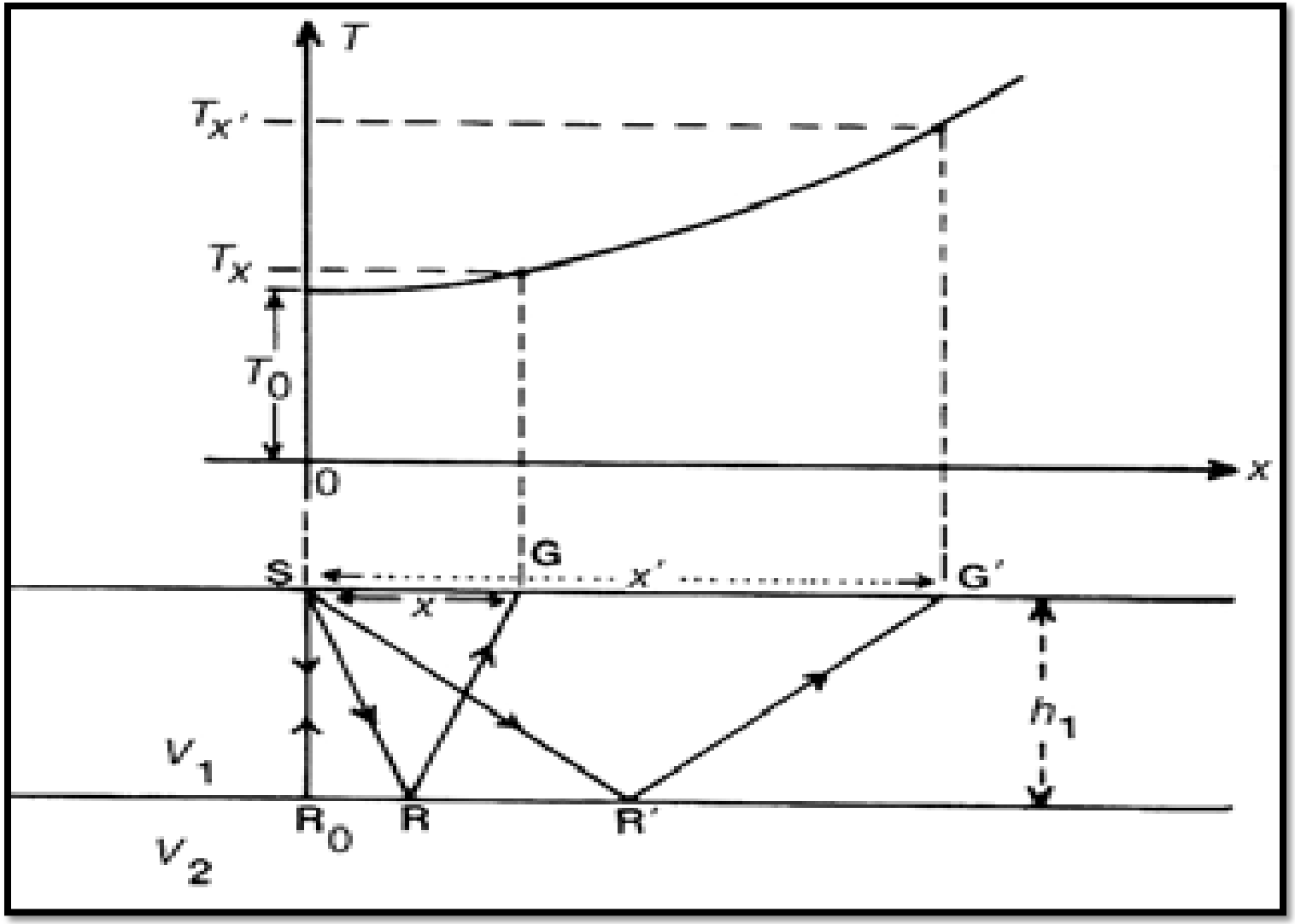
Emad A. Al-Heety
Department of Applied Geology
University of Anbar
Email: emadsalah@ uoanbar.edu.iq

Normal move out (NMO)

- Normal move out refers to the later arrival times of rays reflected of a horizontal interface for receivers offset from the shot point or source.
- Normal move out only applies to horizontal reflectors.
- The later arrival times for reflected rays of any generic interface is called move out.
- Move out patterns vary for reflectors of different geometry.

Normal move out (NMO)

- Importance of NMO
- Having determined the layer velocity, we can use the predicted quadratic shape to identify reflectors.
- Then correct (shift traces) and stack to enhance signal to noise.



$$\Delta_{NMO} = T_x - T_0 \approx X^2 / 2T_0V_1^2$$

Normal move out (NMO)

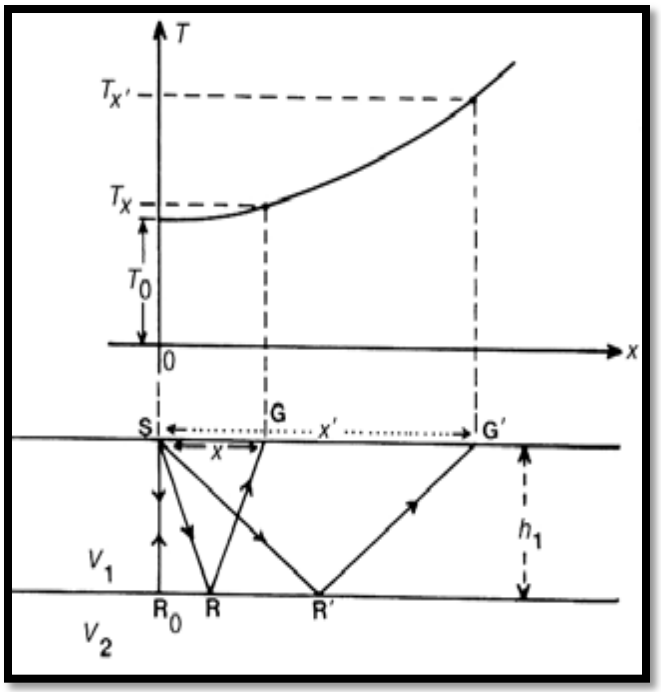
- Reflection from a single horizontal impedance contrast:

Arrival time

$T_x = 2SR/V_1 = 2/V_1 \sqrt{h_1^2 + (x/2)^2}$

or

$T_x^2 = T_0^2 + x^2/V_1$



The arrival time curve is a hyperbola

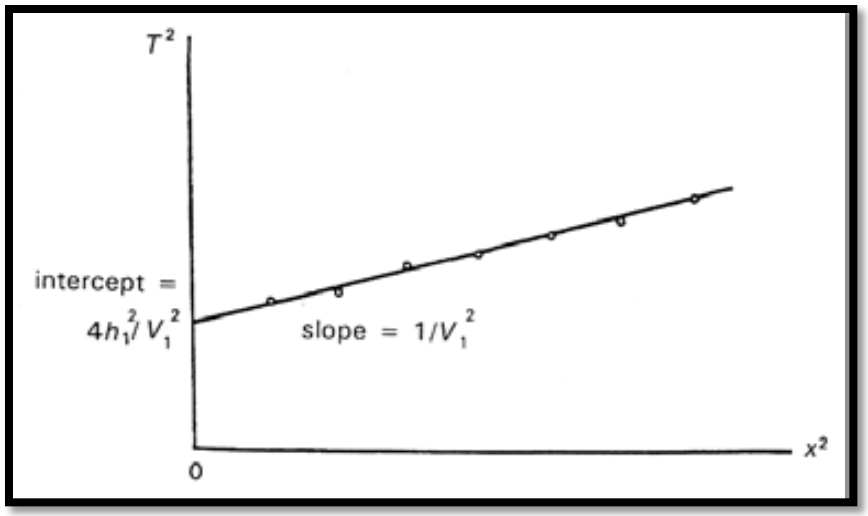
Note: a geophone spread GG' samples RR' of the reflector. RR'=GG'/2.

Normal move out (NMO)

Arrival time curve is quadratic

$T_x^2 = T_0^2 + x^2/V_1^2$

So, if plot T2 vs. x2 we can determine the V1 and h1 from the slope and intercept.

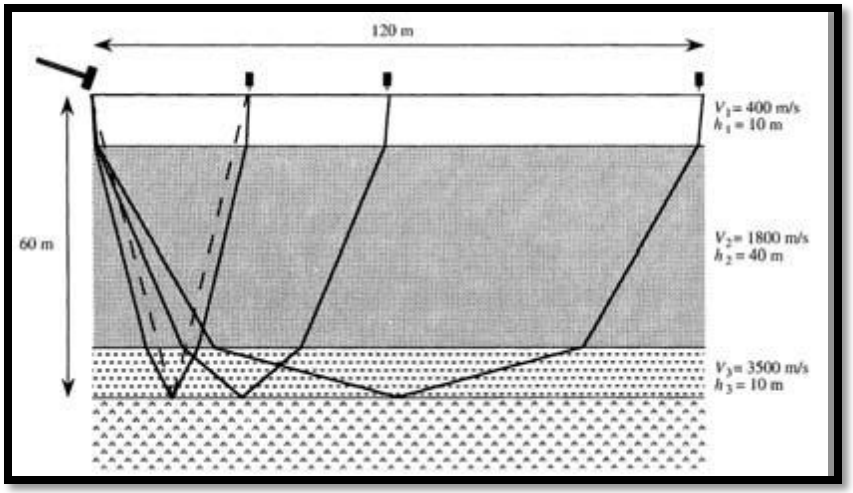


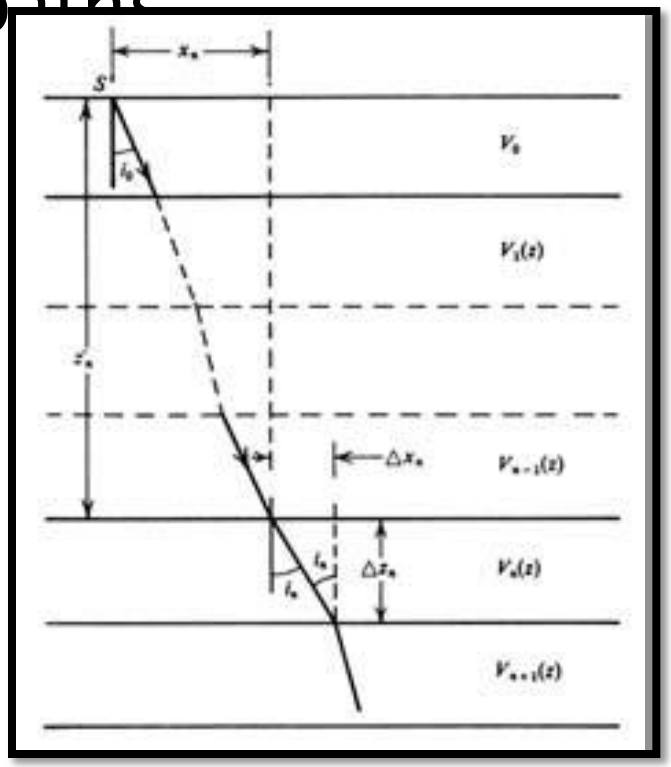
Normal move out (NMO)

= p

- **Multiple layers**

Use Snell's Law to trace ray paths





At each interface

$$Sin\ i_p/V_{p1} = Sin\ r_p/V_{p2} = P$$

Seismic Energy Sources

- In order to select the seismic energy source, we consider the following:

1. Energy input
2. Repeatability
3. Cost
4. Convenience

Types of seismic sources

I. Rifles and guns

- Cheap
- Repeatable – fire into water filled hole
- Shallow targets 0–50m

II. Sledge hammer

- Cheap
- Repeatable once plate is stable (and with training!)
- Targets 15–50m

Rifle

Sledge hammer

Types of seismic sources

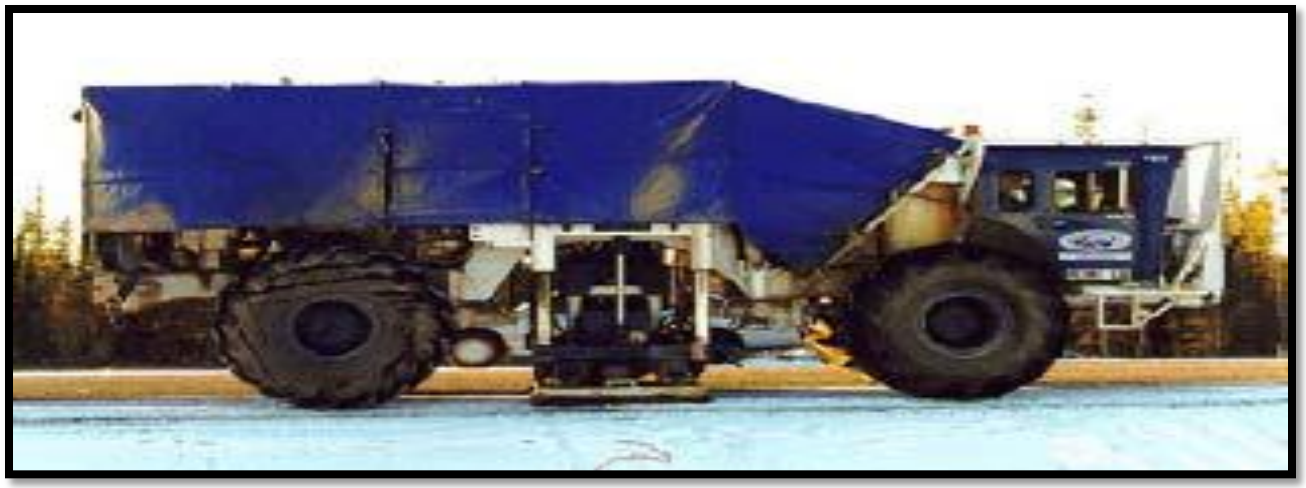
III. Weight drops

- Cheap
- Repeatable – automated
- Targets > 50m

Types of seismic sources

IV. Vibroseis

- No pulse, frequency sweep
- Significant signal with stacking/deconvolution



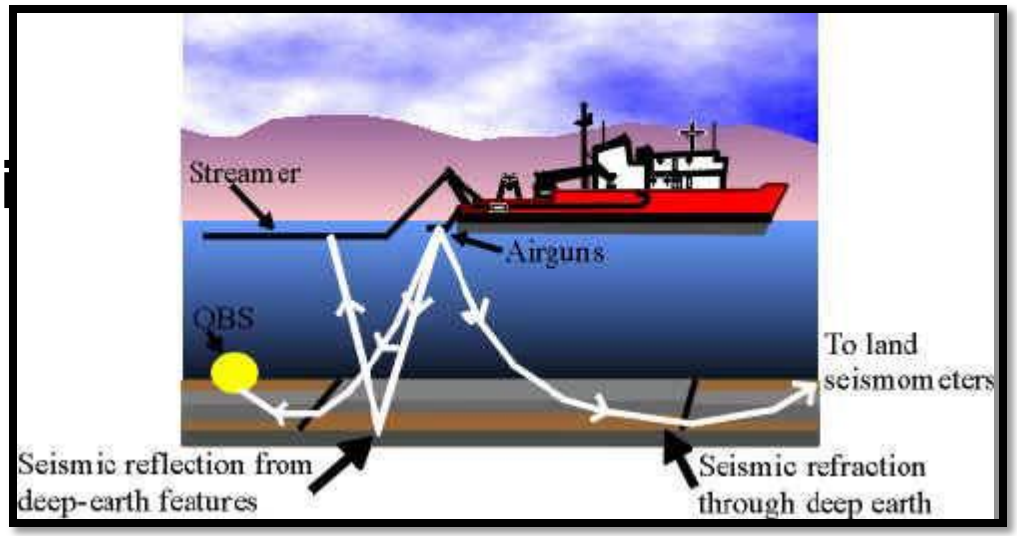
Types of seismic sources

V. Explosives

- Various sizes – target depth
- Safety and expense can be an issue.

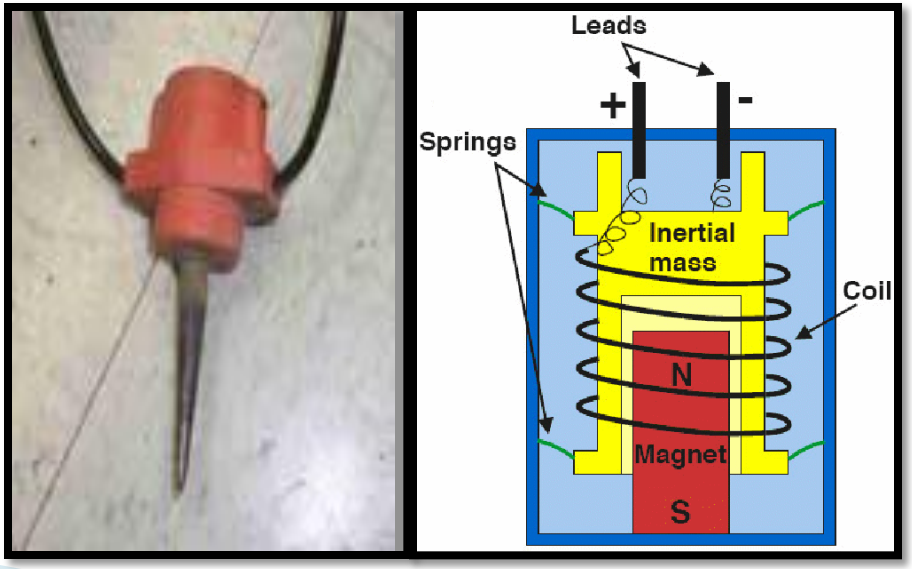
VI. Air guns

- At sea
- Very repeatable
- Large array for big si



Seismic receivers

- **Geophone**
- Cylindrical coil suspended in a magnetic field
- The inertia of the coil causes motion relative to the magnet generating a electrical signal.
- Geophones are sensitive to velocity



Seismic receivers

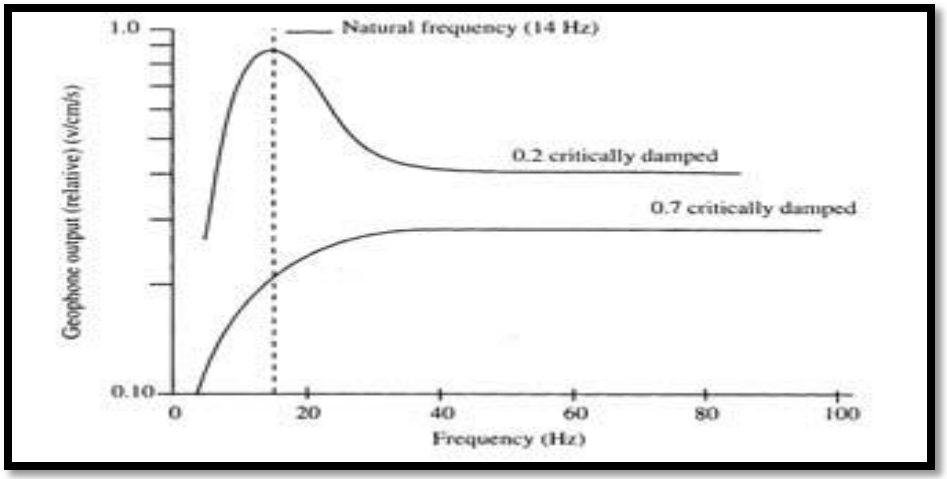
- Hydrophones
- Used at sea
- Use piezoelectric minerals to sense pressure variations.

Seismic receivers

- **Instrument response**
- The relation between the input ground motion and the output electrical signal.
- Natural Frequency
- The frequency which produces the maximum amplitude output.

Seismic receivers

- **Damping**
- Reduces the amplitude of the natural frequency response and prevents infinite oscillations
- Want a flat response



Deployment

- **Important considerations**
- Need good coupling to the ground – spike
- Mini-arrays to reduce surface wave noise
- **Offset of geophones**
- Small offsets
- Near-vertical incidence retains P-energy
- High resolution of subsurface reflectors

→ **Seismic reflection analysis**

Deployment

- Large offsets
- Improves velocity sensitivity
- Provides horizontal averages only

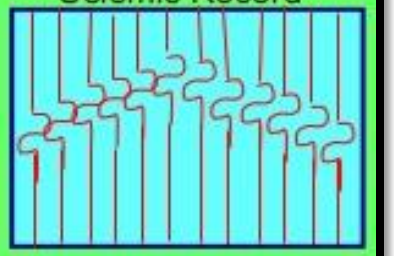
  → **Seismic refraction analysis**

- **Types of geophones spread**

  It means the relative position of the shot point to the geophone. The following figure shows the different geophones spread:

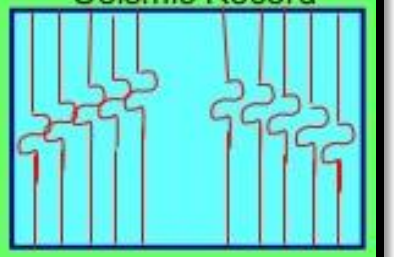
1- Split Spread: (SP) is placed at the center of spread.

Seismic Record



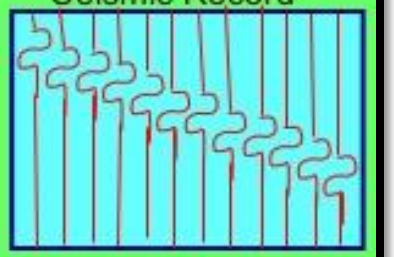
2- Split Spread with a gap: (SP) is placed at the center of spread With plotting a gap.

Seismic Record



3- End of Spread: (SP) is placed at the end of spread.

Seismic Record



Textbook

Alsadi, H.N. (2017) Seismic Hydrocarbon Exploration: 2D and 3D Techniques. Springer International Publishing, Switzerland, 331p.