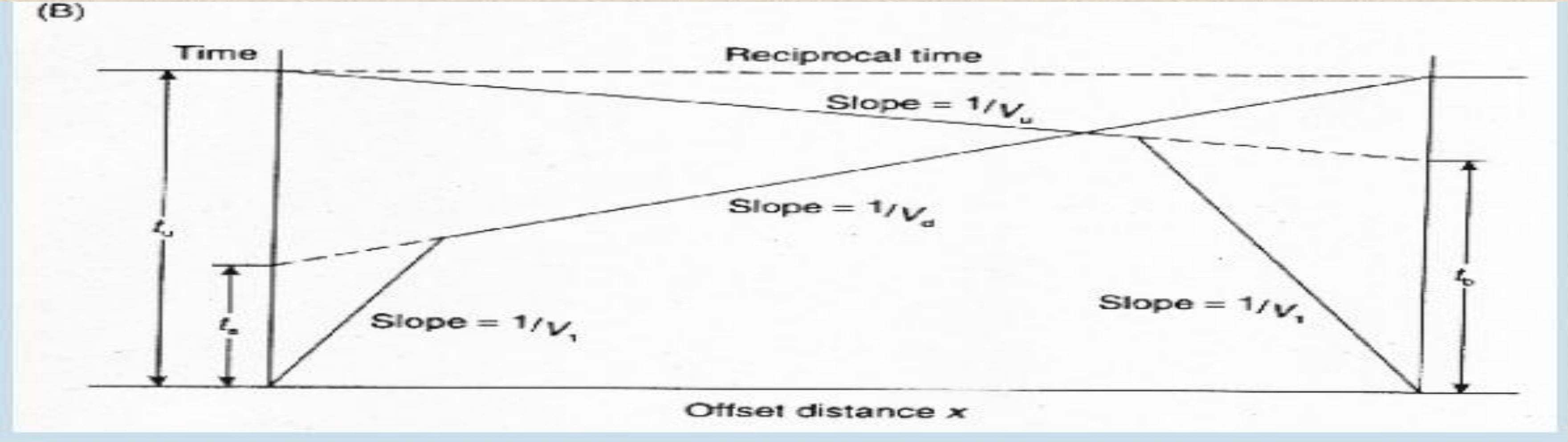
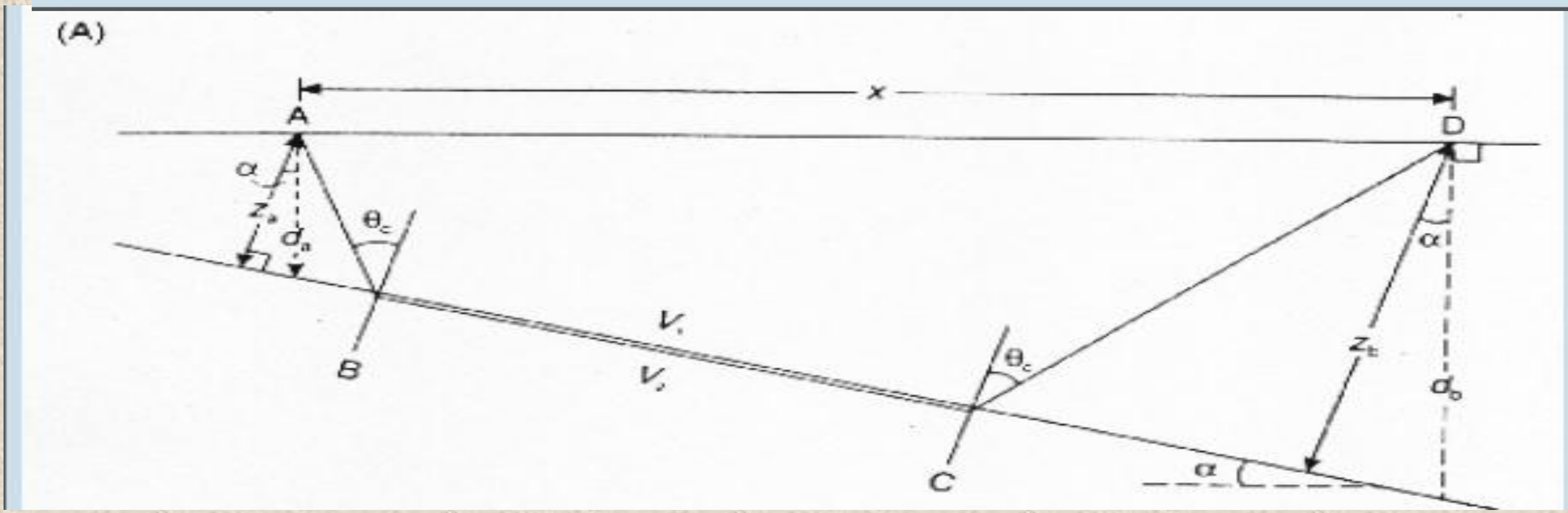
Dipping layer case

When a refractor lies at an angle to the horizontal, it is no longer adequate to undertake only one direction of (forward) shooting. It becomes necessary to carry out both forward and reverse shooting in order to determine the parameters.

The refractor velocities determined in the case of dip are referred to as apparent velocities;
V_u: upslope direction
V_d: downslope direction





A. Raypath geometry over a refractor dipping at an angle α, and
B. the respective travel time-distant graph for the forward (down-dip) and reverse (up-dip) shooting directions.

Travel time calculations for a dipping refractor

Total travel time over a refractor dipping at an angle is given by:

$$T_{ABCD} = (x\cos\alpha)/v_2 + [(z_a + z_b)\cos i_c]/v_1 \quad (1)$$

where v_2 is the refractor velocity, and z_a and z_b are the distances perpendicular to the refractor.

The down-dip travel time t_d is given by:

$$t_d = x[\sin(\theta_c + \alpha)]/v_1 + t_a \quad (2)$$

where $t_a = 2z_a(\cos\theta_c)/v_1$.

The up-dip travel time t_u is given by:

$$t_u = x[\sin(\theta_c - \alpha]/v_1 + t_b$$

Where $t_b = 2z_b(\cos\theta_c)/v_1$

Equations (1) and (2) above can be written in terms of the apparent up-dip velocity v_u and down-dip velocity v_d such that:

$$t_d = x/v_d + t_a, \quad \text{where} \quad v_d = v_1/\sin(\theta_c + \alpha)$$

$$t_u = x/v_u + t_b, \quad \text{where} \quad v_u = v_1/\sin(\theta_c - \alpha)$$

An approximate relationship between true and apparent velocities for shallow angles of dip (<10°) is given by:

$$v_2 \approx (v_d + v_u)/2$$

CONCLUSION NOTES ON DIPPING LAYERS

- **Dipping layers can be detected only by conducting both <u>forward and reverse</u> shootings**
- **The <u>intercept times</u> for forward and reverse shooting in case of dipping layers are <u>not equals</u>**
- **In both cases, horizontal and dipping layer cases,:**
  - **the velocity of the first layer is equal in forward and reverse shootings**
  - **the total travel time – reciprocal time – of the refracted wave is equal**

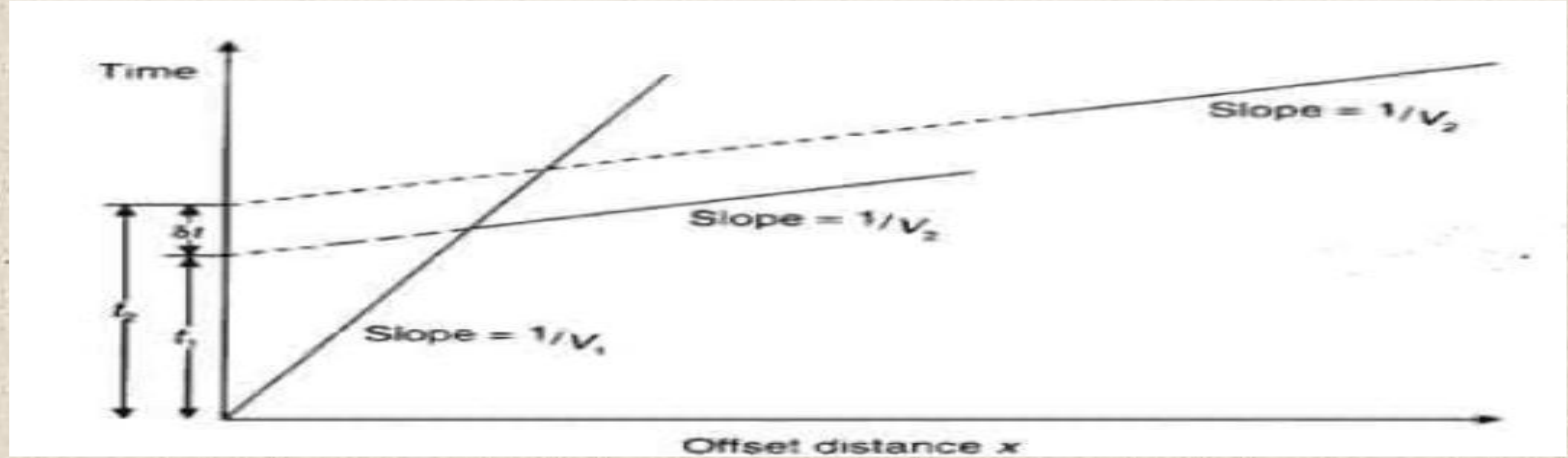
- in dipping layers case, apparent velocities and thicknesses are obtained
- The depths d_a (updip) and d_b (downdip) –both perpendicular to the surface- can be calculated from the following relations:

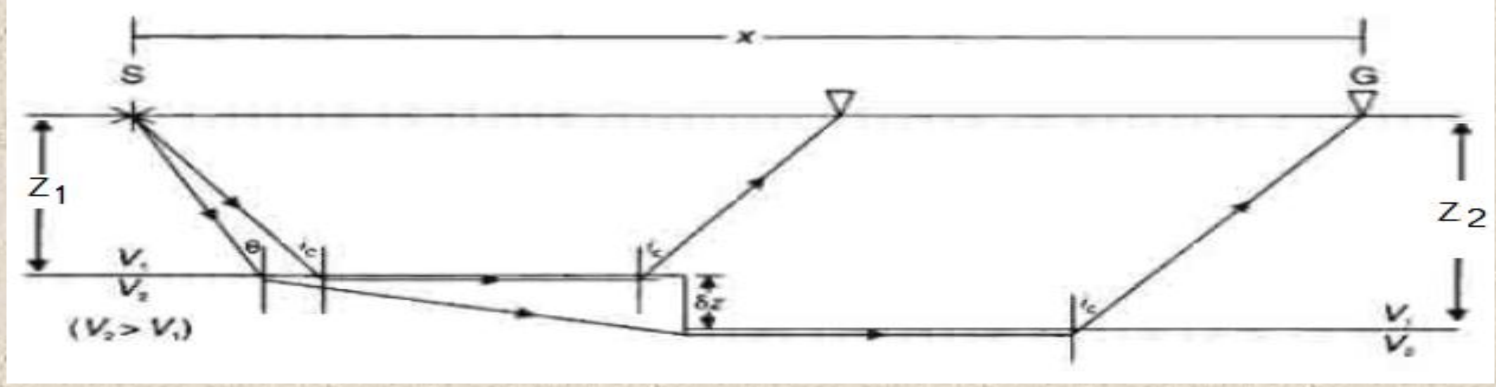
$$d_a = z_a / \cos\alpha$$

$$d_b = z_b / \cos\alpha$$

NORMAL FAULT CASE (Diffraction)

In the presence of a normal fault affected the refractor, there will be a sharp displacement in the travel time curve. See the figure below.





Taking in consideration the profile in the previous figure directed from S (shoot point) to the G (geophone):

The travel time for the refracted wave before arrival to the fault boundary is:

$$t_b = X/V_2 + 2Z_1 \cos i_c / V_1$$

The travel time for the refracted wave after arrival to the fault boundary is:

$$t_a = X/V_2 + (Z_1+Z_2) \cos i_c / V_1$$

The difference in the intercept times for the above two equations is given by:

$\delta_t = \delta z \cos i_c / V_1$. Finally, we obtain:

$$\delta_z = \delta t \, V_1 / \cos i_c,$$

OR:

$$\delta_z = \delta_t \, V_{1*} V_2 / \sqrt{V_2^2 - V_1^2}$$

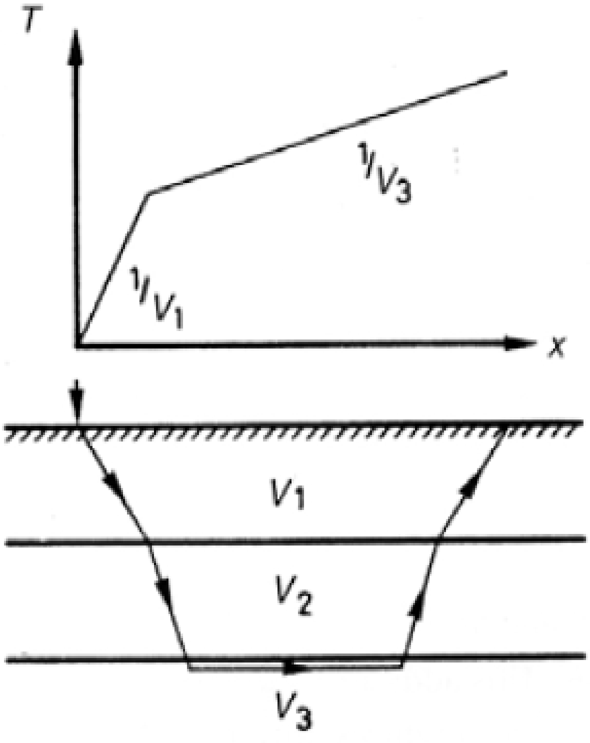
Limitations of Seismic Refraction Method

I. Low Velocity Layers

- **They are completely invisible to the refraction method**
- **They will cause miss-interpretation of the depth of lower lying layers**

  The intercept of the refraction from layer 3 will be dependent on the thickness and velocity in layer 2

- **Lower layers appear deeper than they are**



$V_2 < V_1 < V_3$

How to resolve low velocity layer?

The detection of the presence of a low velocity layer can be done either by:

- direct geological information (such as drilling),

or

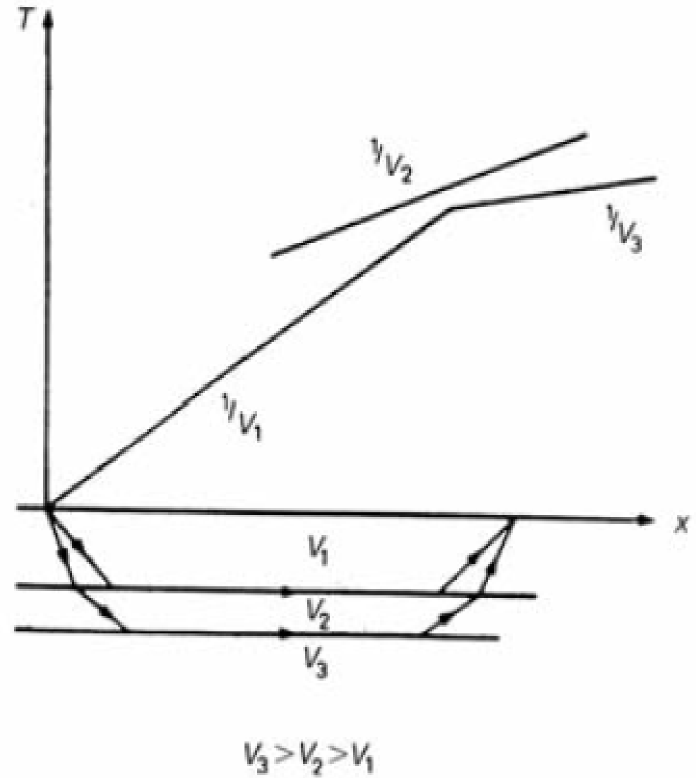
- by using other geophysical exploration methods, such as seismic reflection.

II. Hidden Layers

- **If a layer is thin it may never produce a first arrival**

  Either the direct or refraction from a lower (much higher velocity layer) is always first

- **Lower layers always appear too shallow as a layer has been missed**



<u>How to resolve the hidden layer problem?</u>

It is necessary to drill a test well in areas where the presence of this problem is expected. This way, corrections to depth values obtained by seismic refraction can be made.

Seismic Refraction Field Procedures

➢It means the relative position of the shot point to the geophone.

I. Profile Shooting

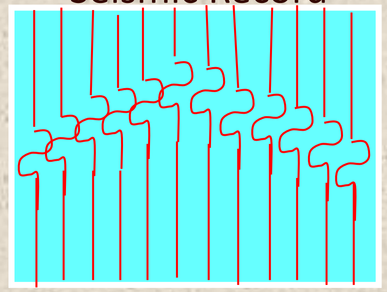
The shotpoint and the receiving geophones are located on one line.

Test profiles are usually conducted in the study area in order to:

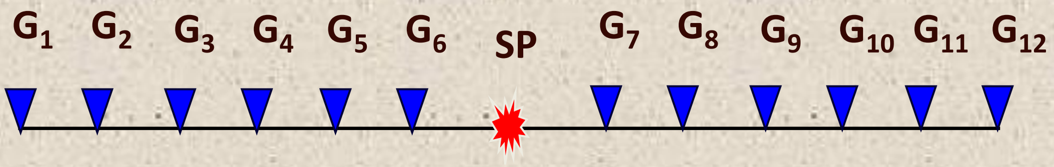
- choose the most adequate distance between the shopoints, and
- determine profile length most adequate for the investigated depth of the target.

There are several configurations for profile shooting:

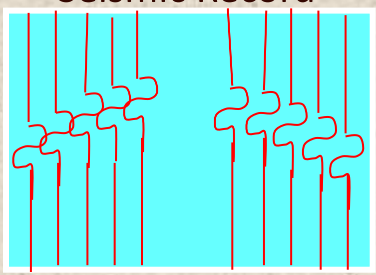
Seismic Record



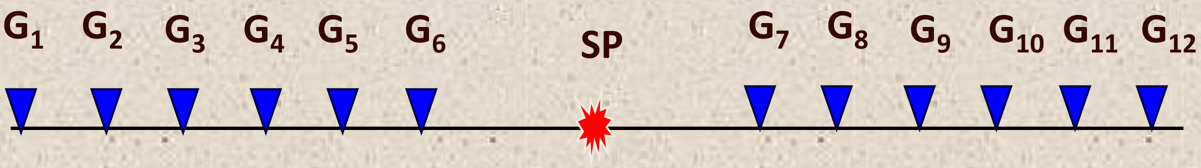
1- Split Spread: (SP) is placed at the center of spread.



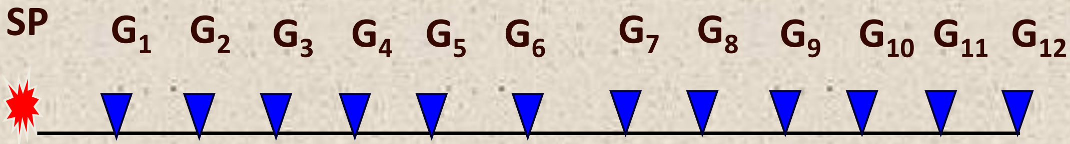
Seismic Record



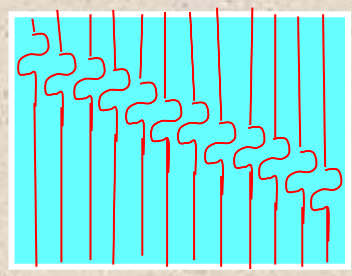
2- Split Spread with a gap: (SP) is placed at the center of spread with plotting a gap.



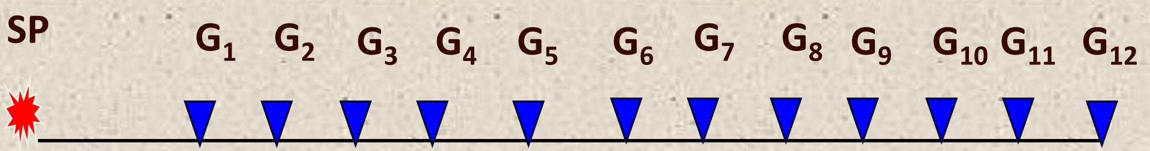
3- End of Spread: (SP) is placed at the end of spread.



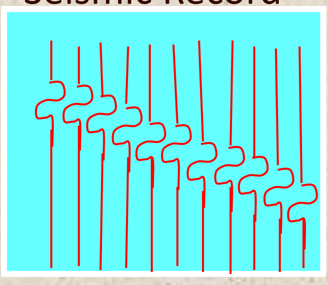
Seismic Record



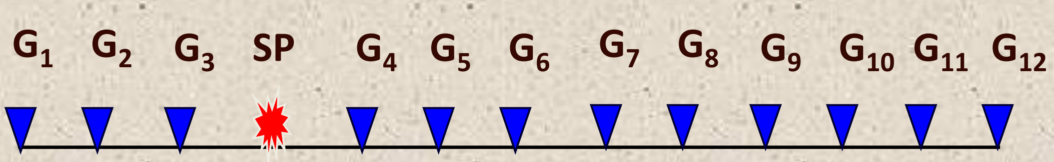
4- End of Spread with a gap: (SP) is placed at the end of spread with plotting a gap.



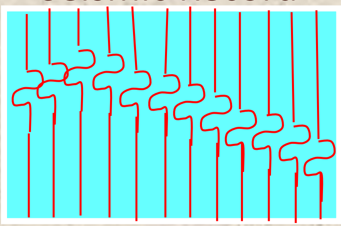
Seismic Record



5- Unbalanced Spread : (SP) is not placed at the center



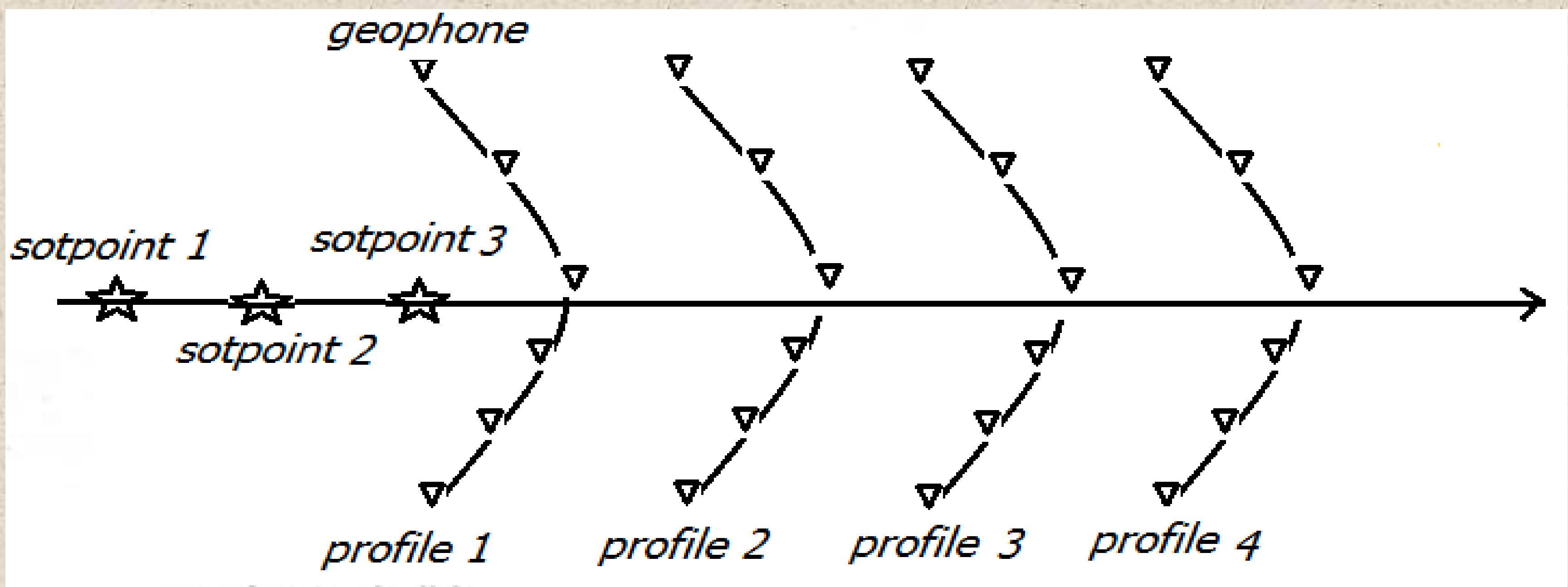
Seismic Record



II. Arc Shooting

In this arrangement, the shotpoints represent the centers of arcs along which the geophones are planted.

The arc shooting arrangement is used for the purpose of mapping lateral variations in the subsurface.



III. Fan Shooting

This is the first field arrangement used in the early seismic exploration words. In this arrangement, the geophones are placed along circles with shotpoints at the centre of the related circles.

In particular, the arrangement was effective in detecting salt domes:

In the absence of salt domes, the arrival times for the seismic wave will be the same for all geophones. While, in the presence of salt dome, the arrival times for the waves that cross the salt dome will be shorter (the wave travels faster) than other arrivals.

Therefore, by plotting first arrivals (the faster waves), it will be possible to locate the anomalous zone.