

Reflection seismic 1 script

Educational Material

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Reflected, Refracted and Diffracted waves

- Reflected wave from a horizontal layer
- Reflected wave from a dipping layer
- Refracted wave from a horizontal layer
- Refracted wave from a dipping layer
- Diffracted waves

Applications for shallow high resolution Reflection seismic

- Hydrogeological studies of aquifers
- Engineering geology
- Shallow faults
- Mapping Quaternary deposits
- Preconstruction ground investigation for pipe, cable and sewerage tunnel schemes

Applications for Refraction seismic

- Depth of groundwater level
- Depth and location of hardrock
- Elastic medium parameters
- Permafrost
- Glaciology
- Lower layer has higher velocity than upper layer

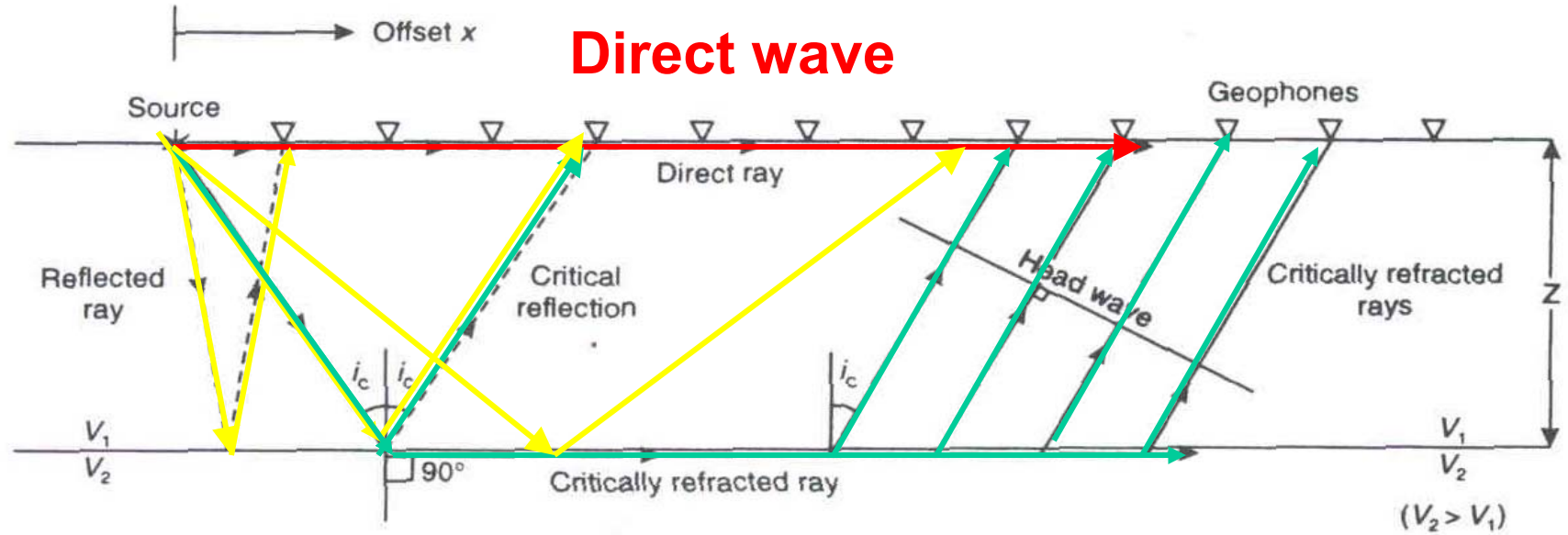
Refraction seismic

- Refracted Waves
- Mainly horizontal Wave propagation
- Only refracted waves are used.
- *Distribution of velocity as well as the depth and orientation of interfaces between layers*

Reflection seismic

- Reflected Waves (“Echo lot principal”)
- Mainly vertical wave propagation
- Complete seismic recording is used
- *Distribution of the velocity variation*

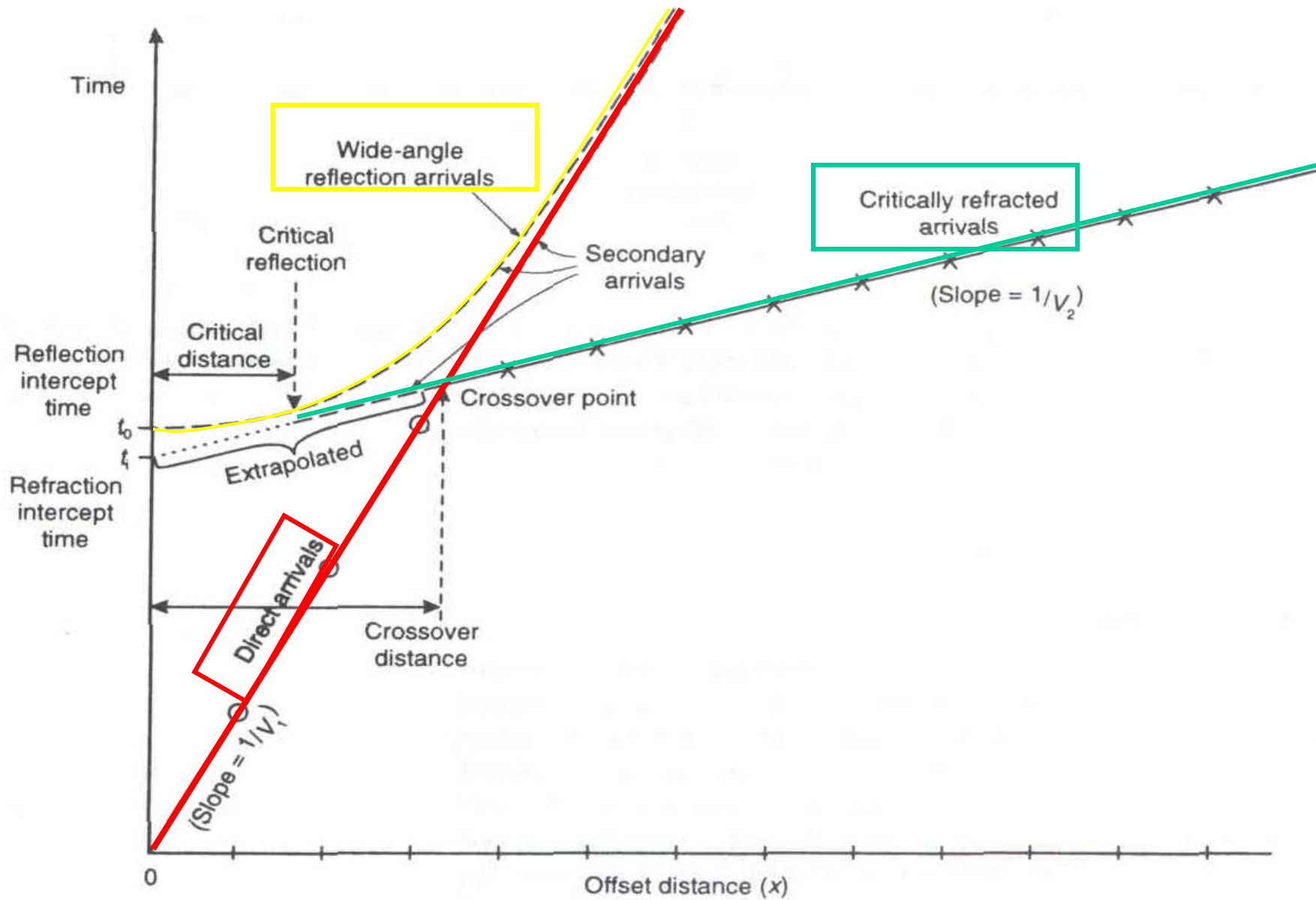
Geometrical situation



Reflected wave

Refracted wave

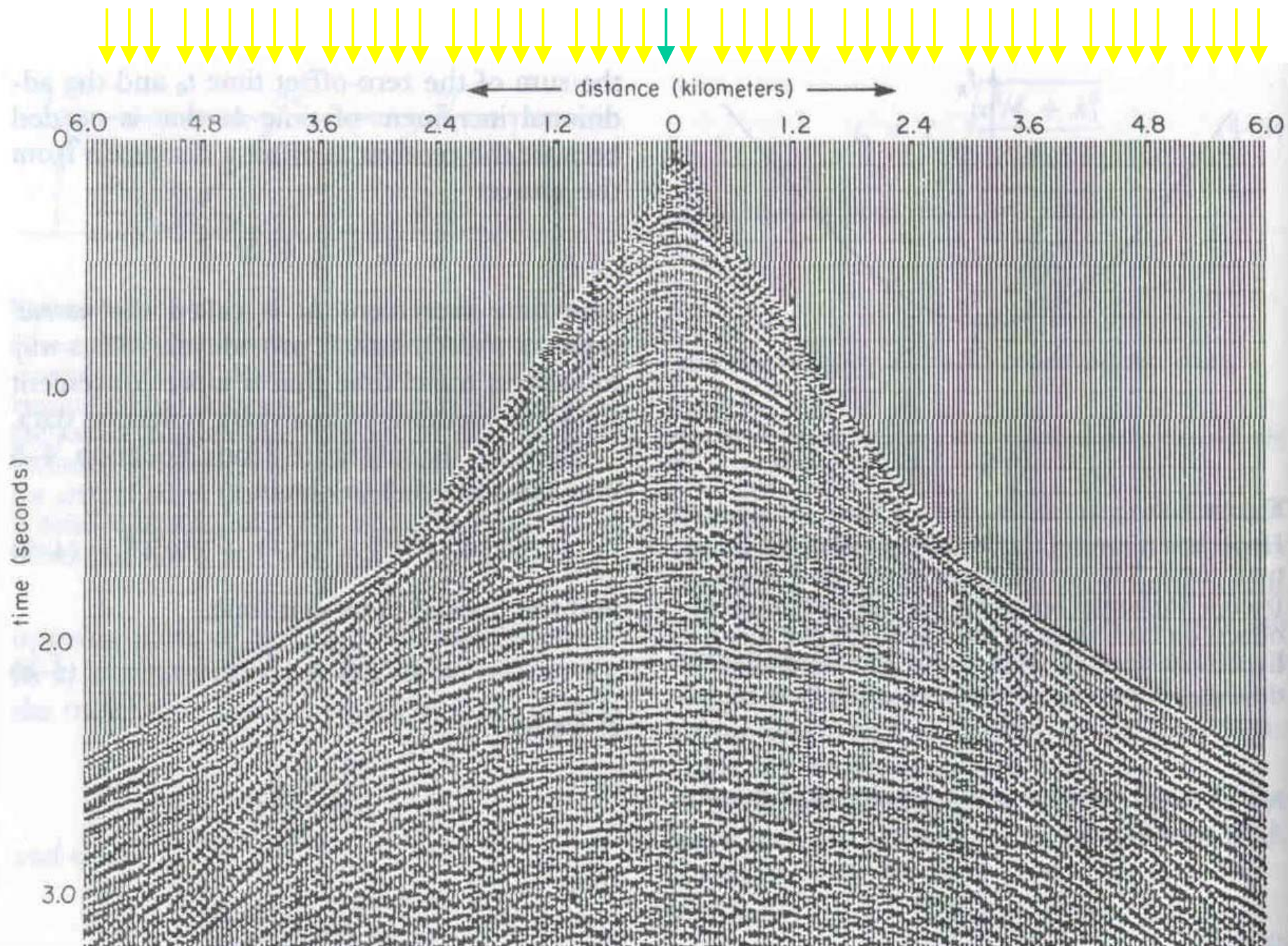
Traveltime curve



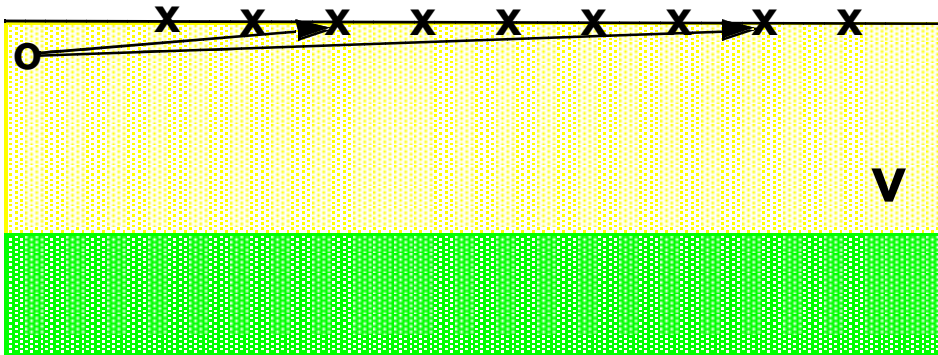
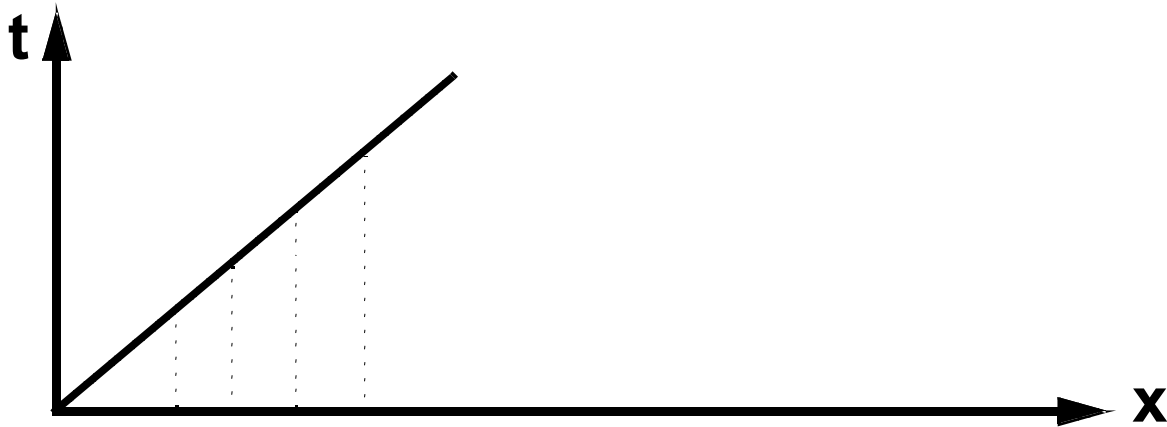
Receivers

Source

Receivers



Direct wave

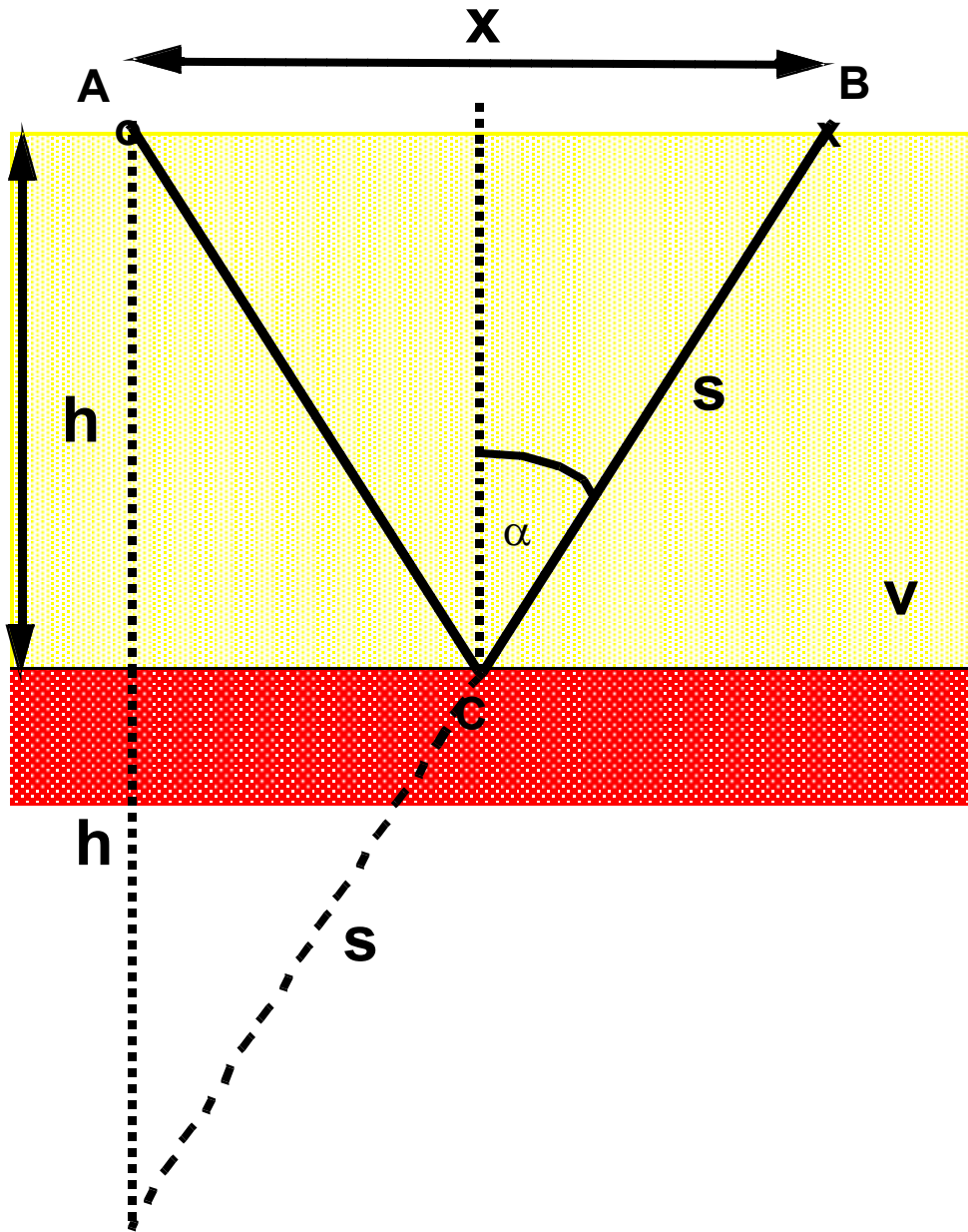


$$t = \frac{1}{v}x$$

$$v = \frac{x}{t}$$

Velocity of direct wave is derived from the distance and travel time

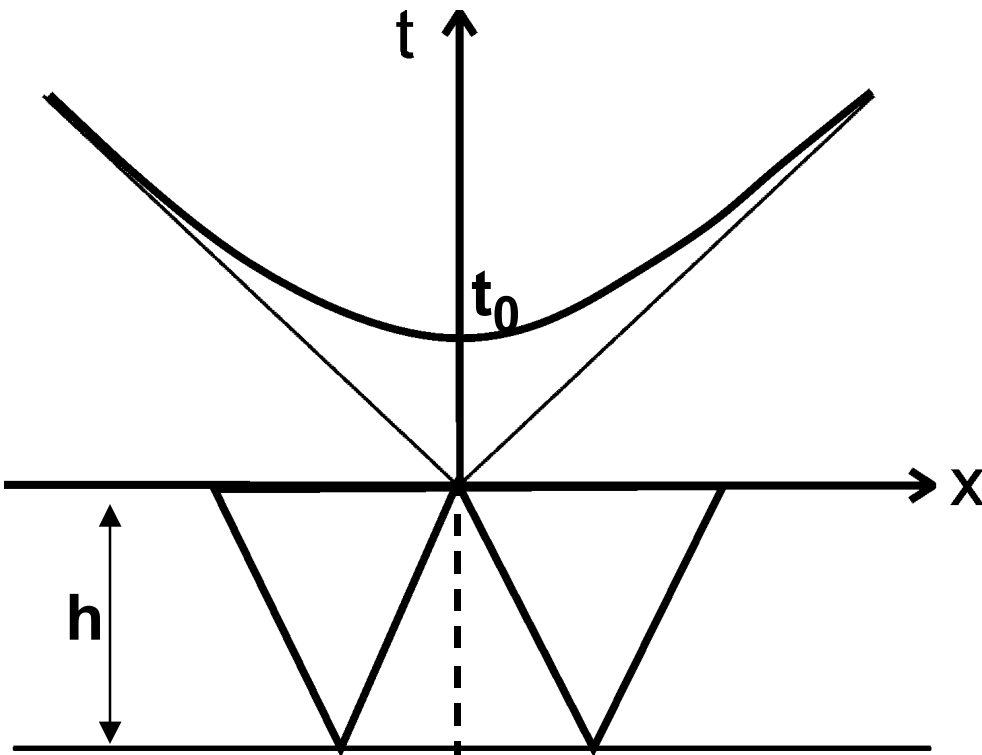
Reflection: Horizontal reflector



$$4S^2 = 4h^2 + x^2 = t^2 v^2$$

$$t^2 = (4h^2 + x^2) / v^2$$

Reflection: Horizontal reflector



for $x=0$:

$$t^2 v^2 = 4h^2$$

$$t_{(x=0)} = t_0 = 2h/v$$

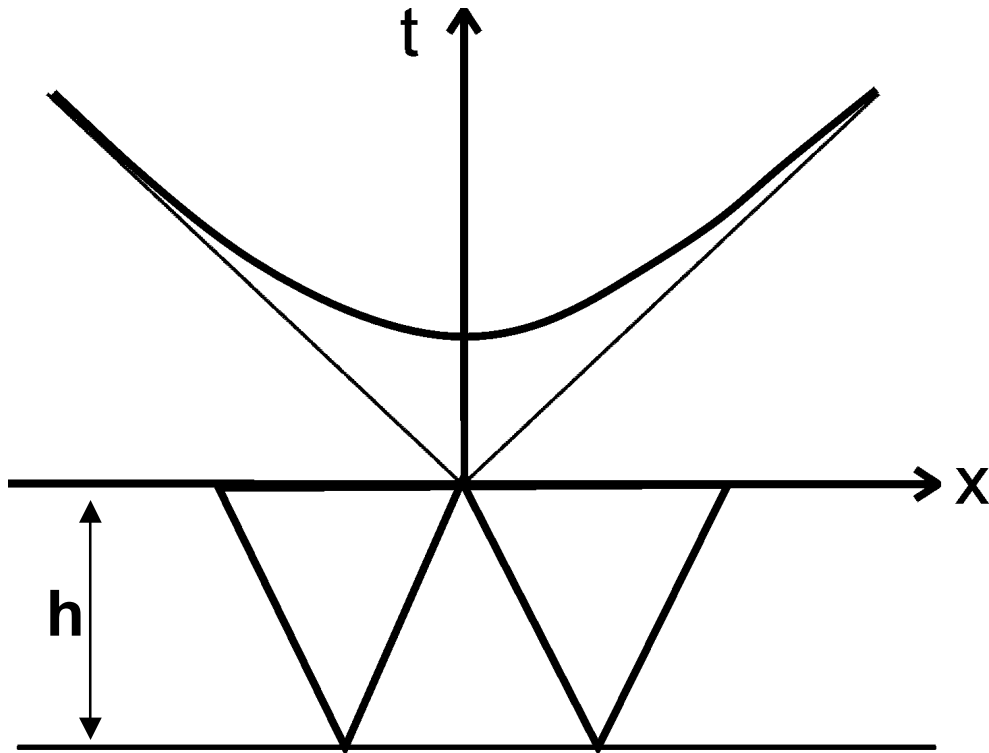
or

$$h = t_0 v / 2$$

$$t^2 v^2 = 4h^2 + x^2$$

$$t^2 = x^2 / v^2 + t_0^2$$

Reflection: horizontal reflector



$$t^2 v^2 = 4h^2 + x^2$$

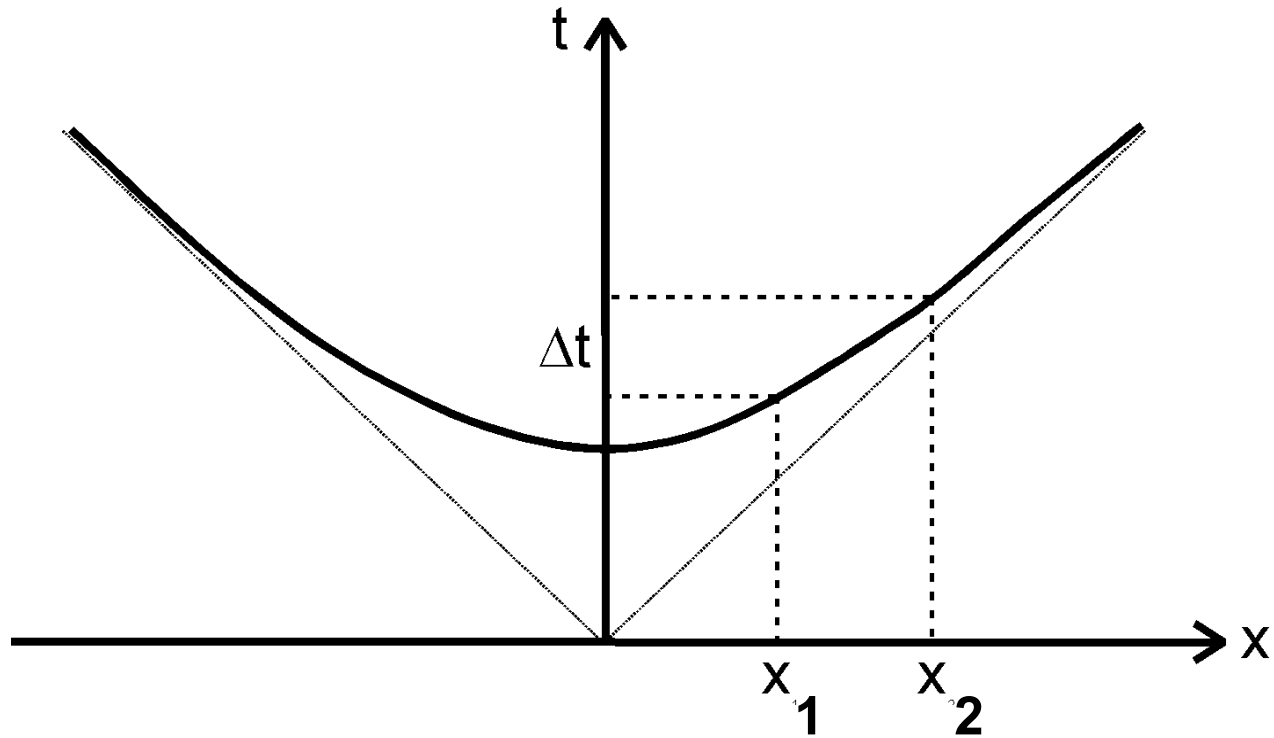
$$t^2 v^2 - x^2 = 4h^2$$

$$\frac{t^2 v^2}{4h^2} - \frac{x^2}{4h^2} = 1$$

Hyperbola

$$x \gg h \Rightarrow t = \frac{x}{v}$$

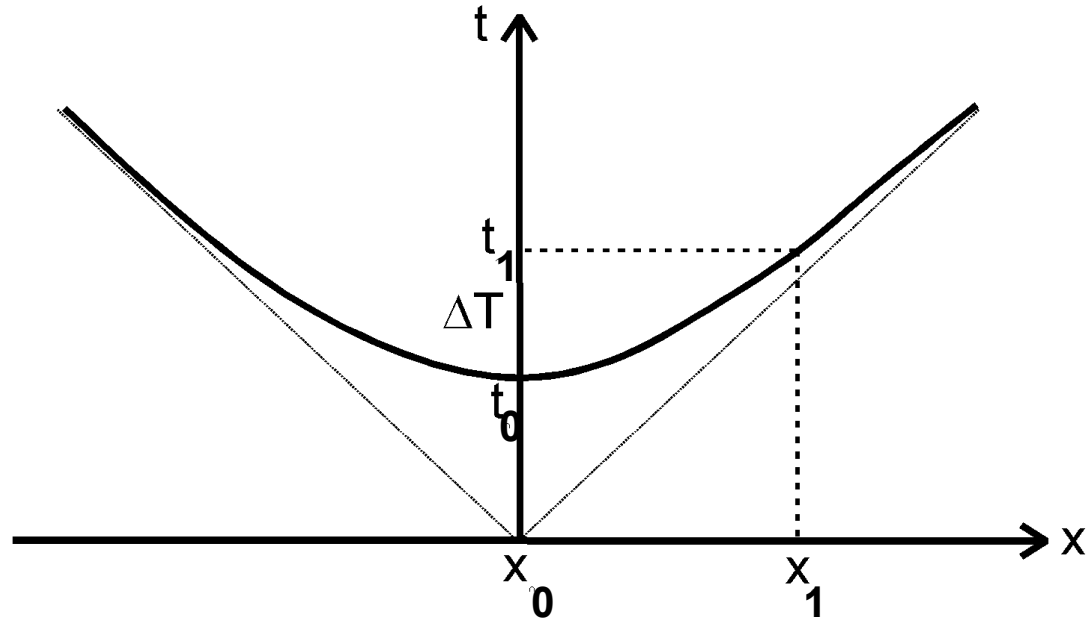
Moveout



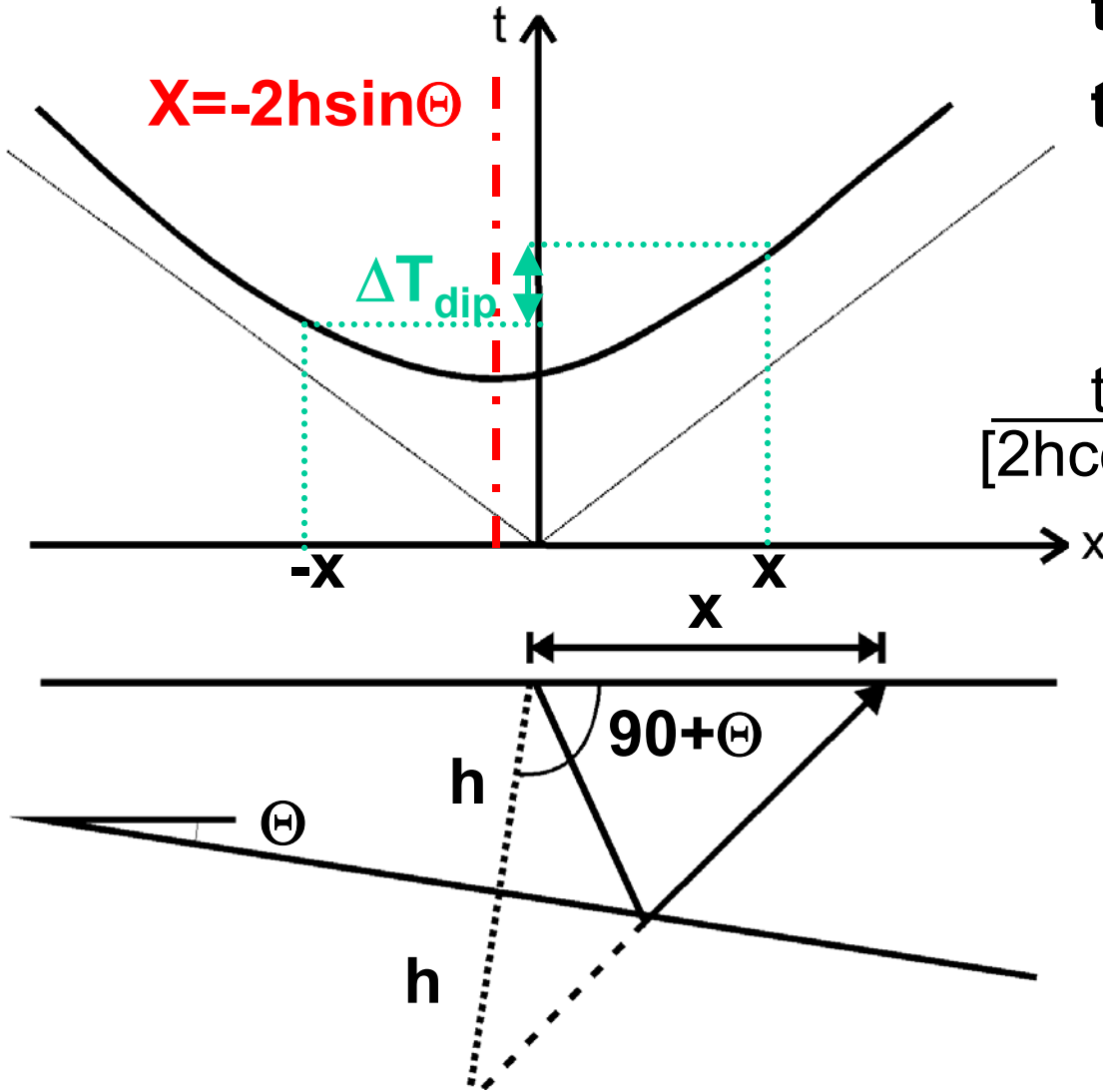
Difference in travel time $t(x_1)$ und $t(x_2)$:

$$t_2 - t_1 \approx \frac{x_2^2 - x_1^2}{2v^2 t_0}$$

Normal Moveout



Difference in traveltimes t_0 and $t(x)$:
$$\Delta T = t_1 - t_0 \approx \frac{x_1^2}{2v^2 t_0}$$



$$t^2 v^2 = 4h^2 + x^2 - 4hx \cos(90 + \Theta)$$

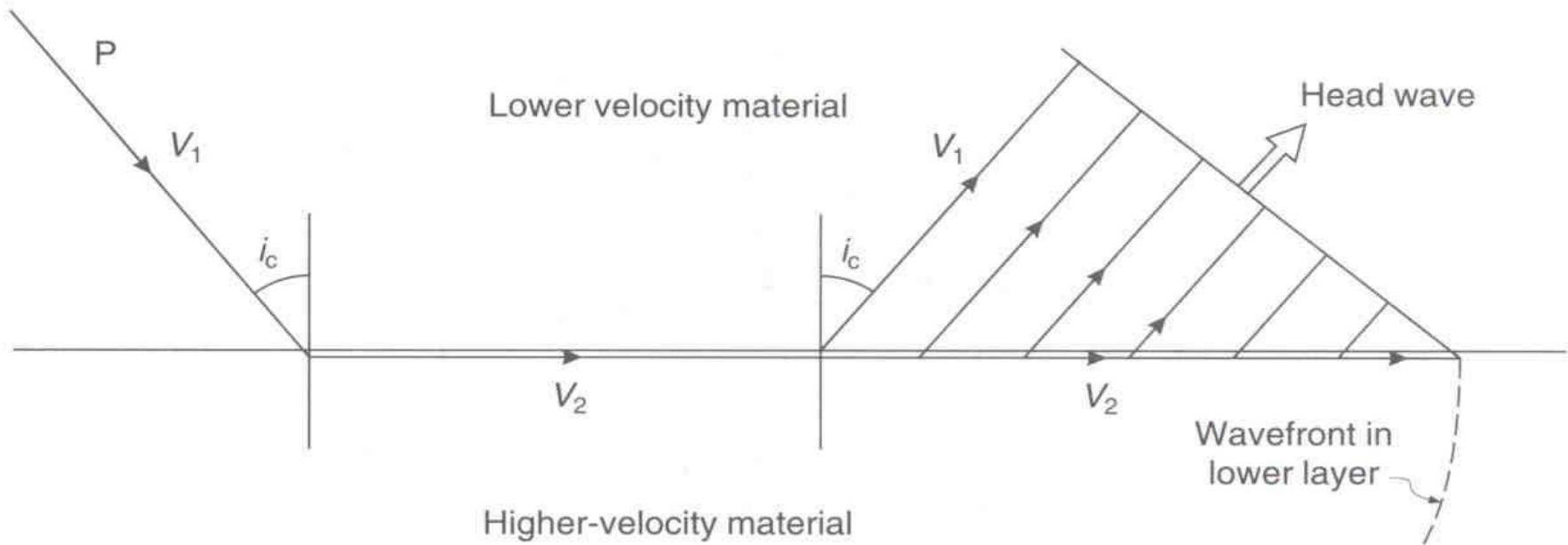
$$t^2 v^2 = 4h^2 + x^2 + 4hx \sin(\Theta)$$

Hyperbola:

$$\frac{t^2 v^2}{[2h \cos(\Theta)]^2} - \frac{[x + 2h \sin(\Theta)]^2}{[2h \cos(\Theta)]^2} = 1$$

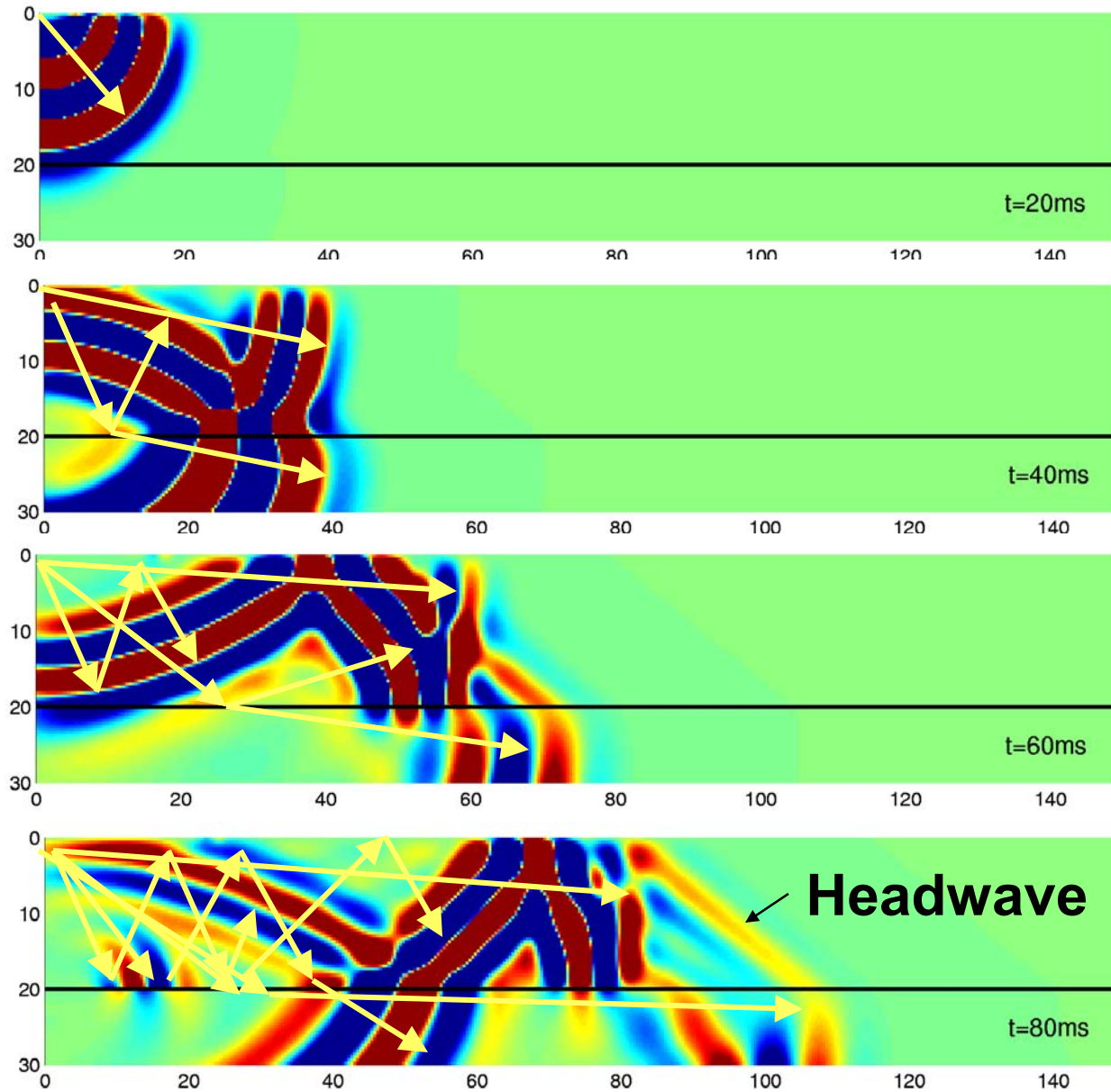
$$\Delta T_{\text{dip}} = t_x - t_{-x} = \frac{2x \sin \Theta}{v}$$

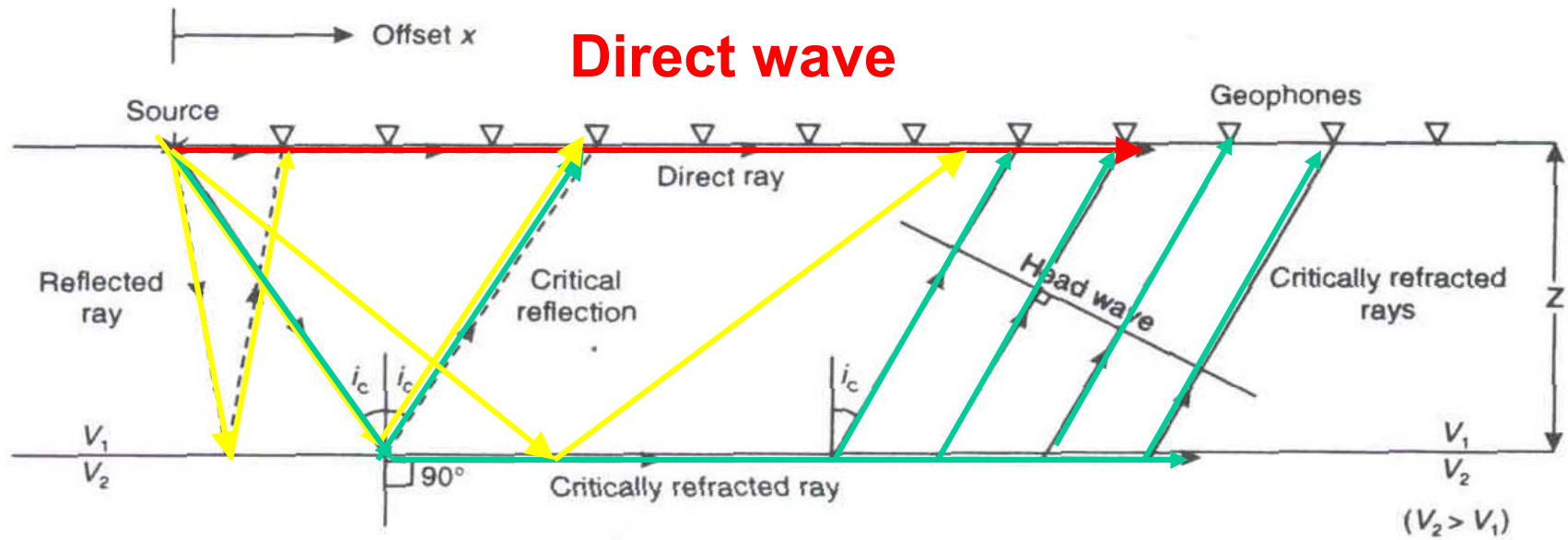
Refraction seismic



$$\frac{\sin i_c}{\sin 90} = \frac{v_1}{v_2} \Leftrightarrow \sin i_c = \frac{v_1}{v_2}$$

Propagation of seismic waves

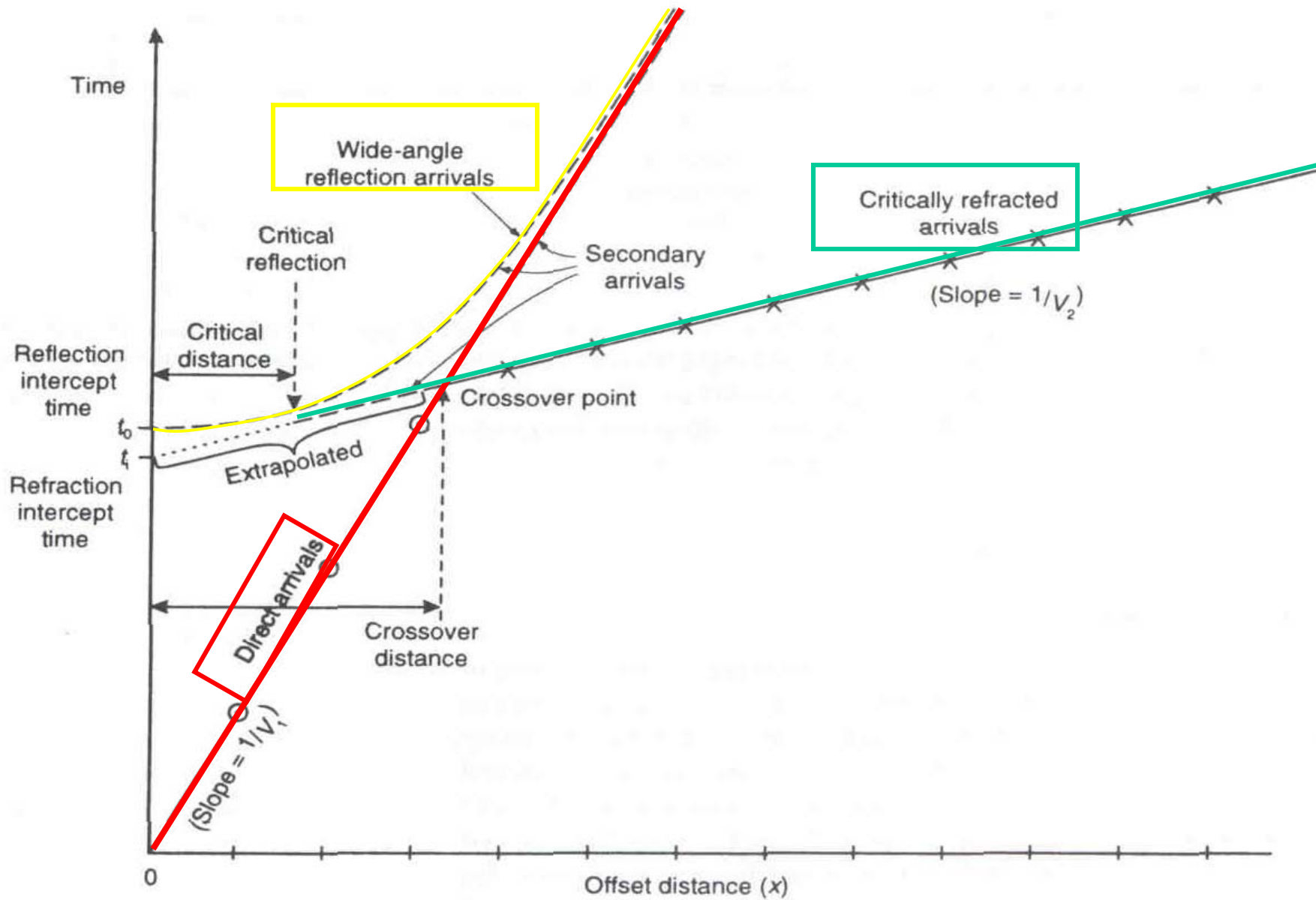


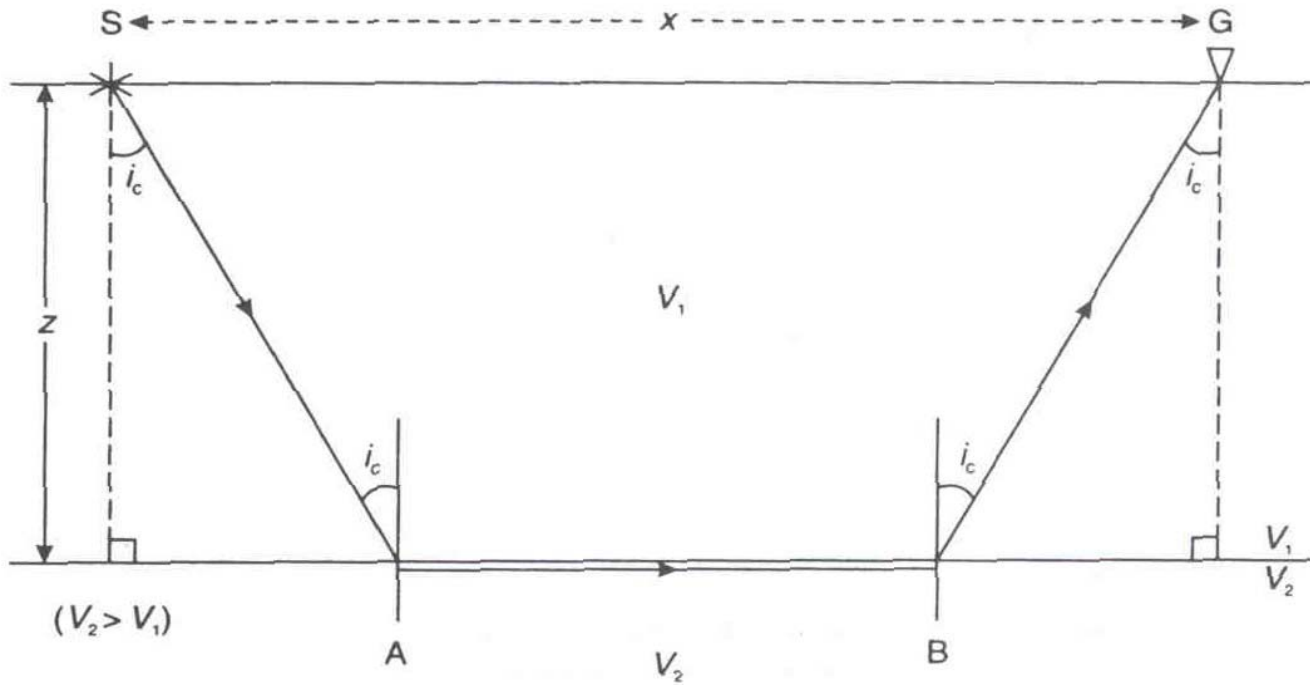


Reflected wave

Refracted wave

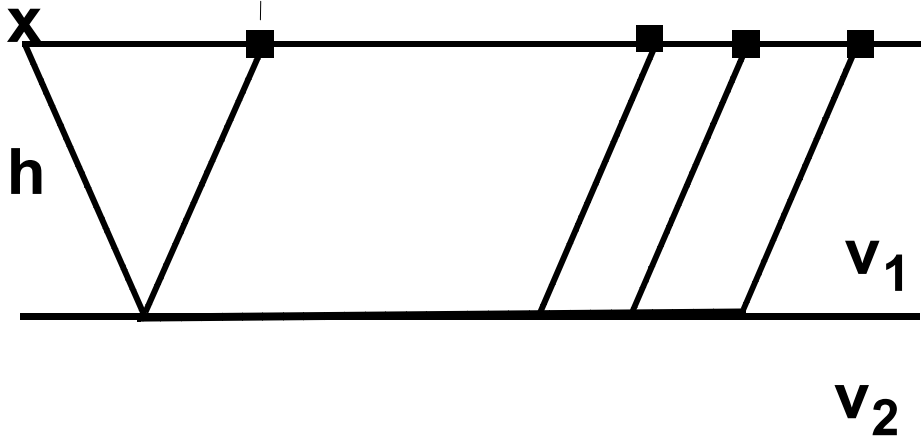
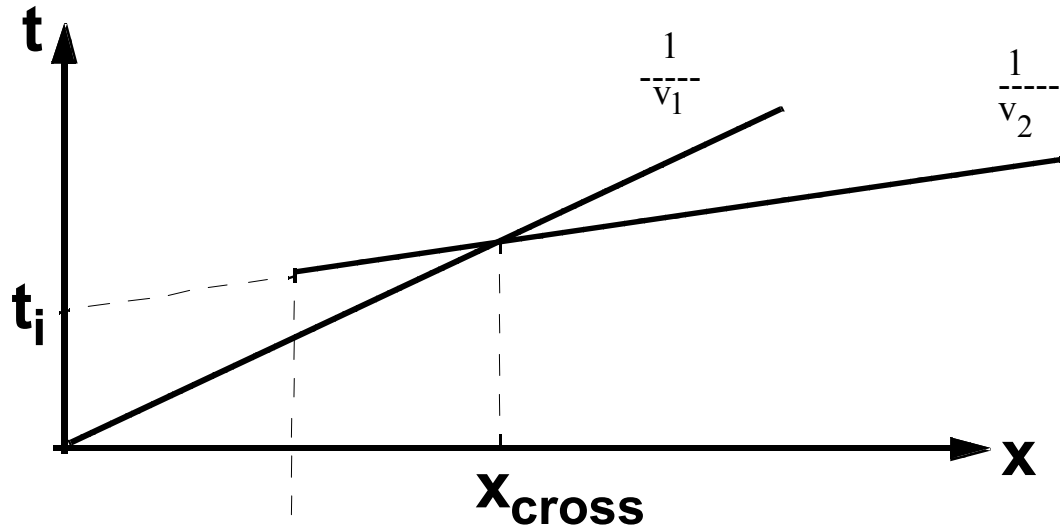
Traveltime curve





$$\begin{aligned}
 T_{SG} &= T_{SA} + T_{AB} + T_{BG} = 2T_{SA} + T_{AB} \\
 &= 2 \frac{z}{v_1 \cos i_c} + \frac{(x - 2z \tan i_c)}{v_2} \\
 &= \frac{x}{v_2} + \frac{2z \cos i_c}{v_1}
 \end{aligned}$$

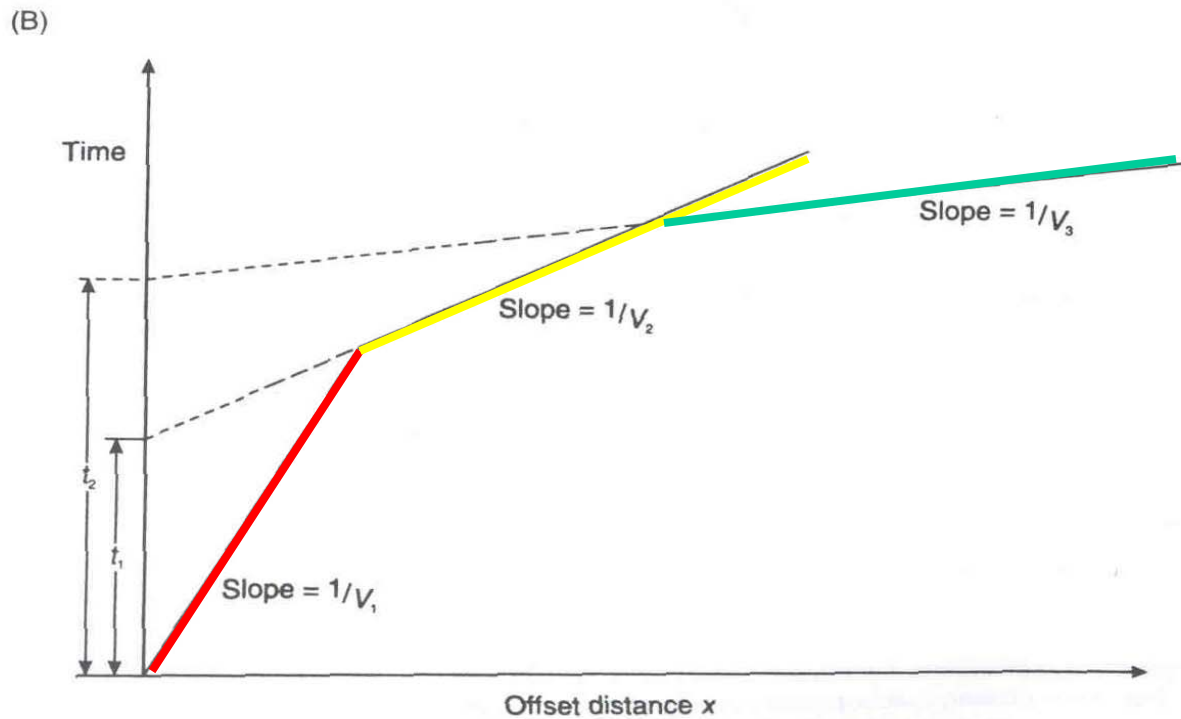
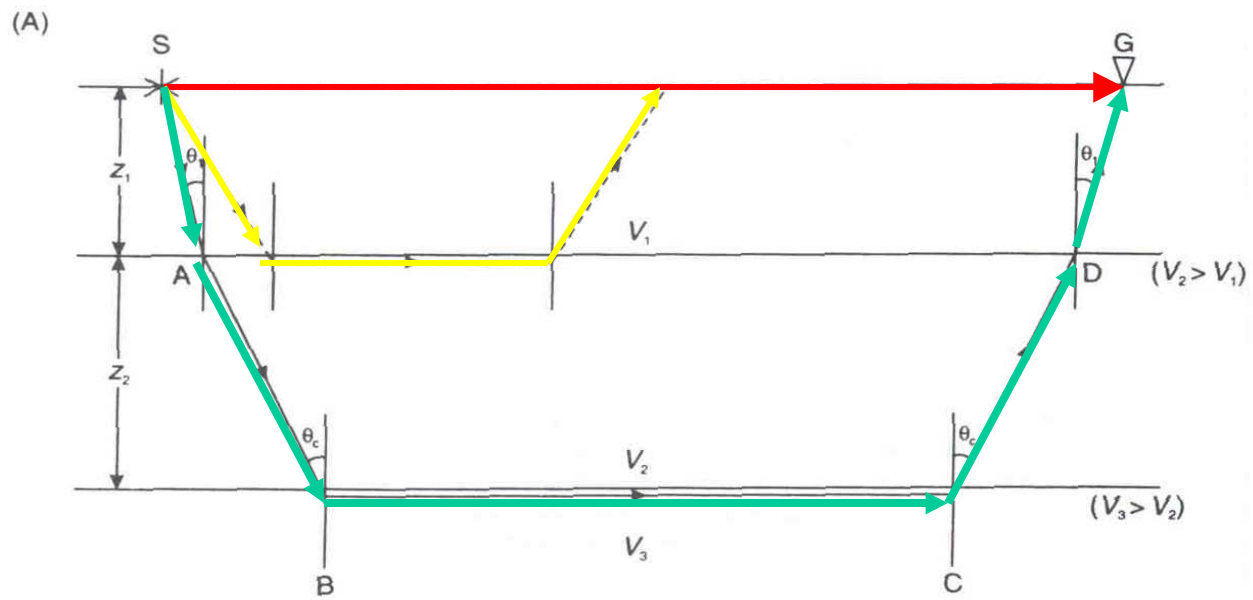
Refraction: horizontal reflector

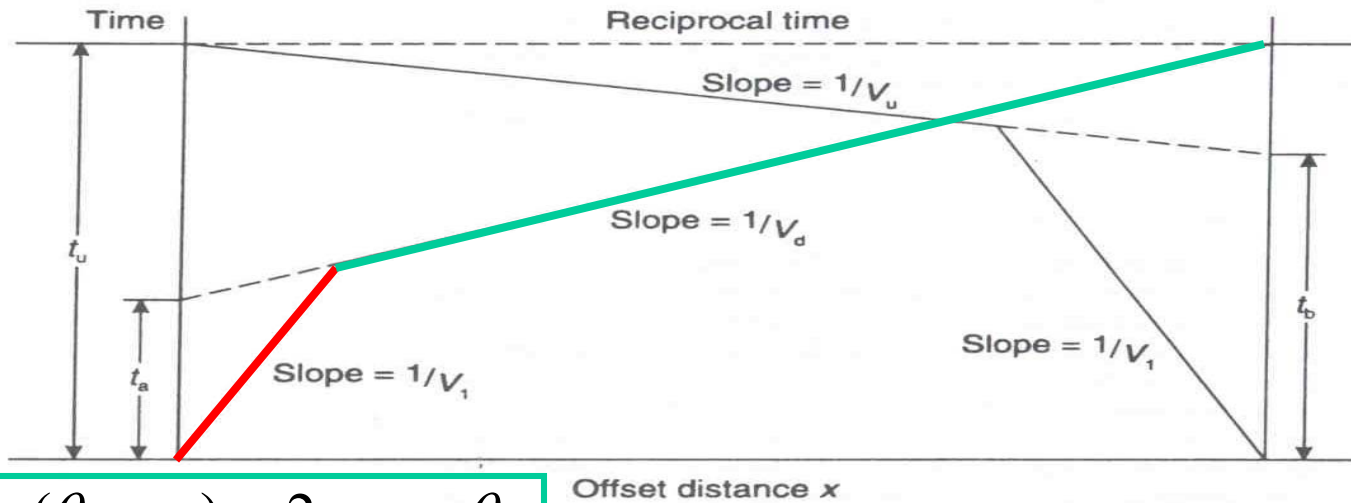
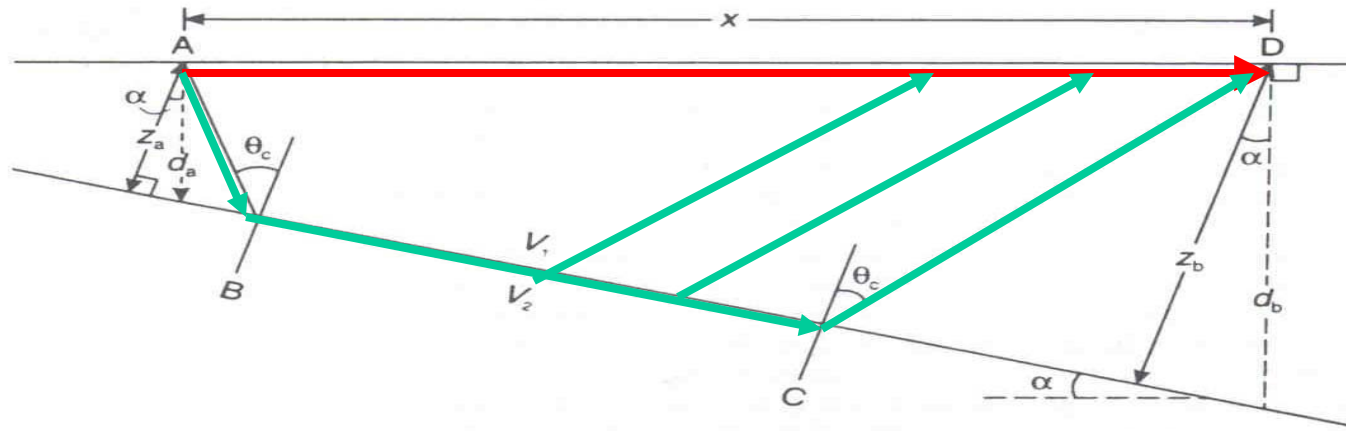


$$t = \frac{x}{v_2} + \frac{2h\sqrt{v_2^2 - v_1^2}}{v_1 v_2}$$

$$t = \frac{x}{v_2} + t_i$$

$$x_{\text{cross}} = 2h \sqrt{\frac{v_2 + v_1}{v_2 - v_1}}$$



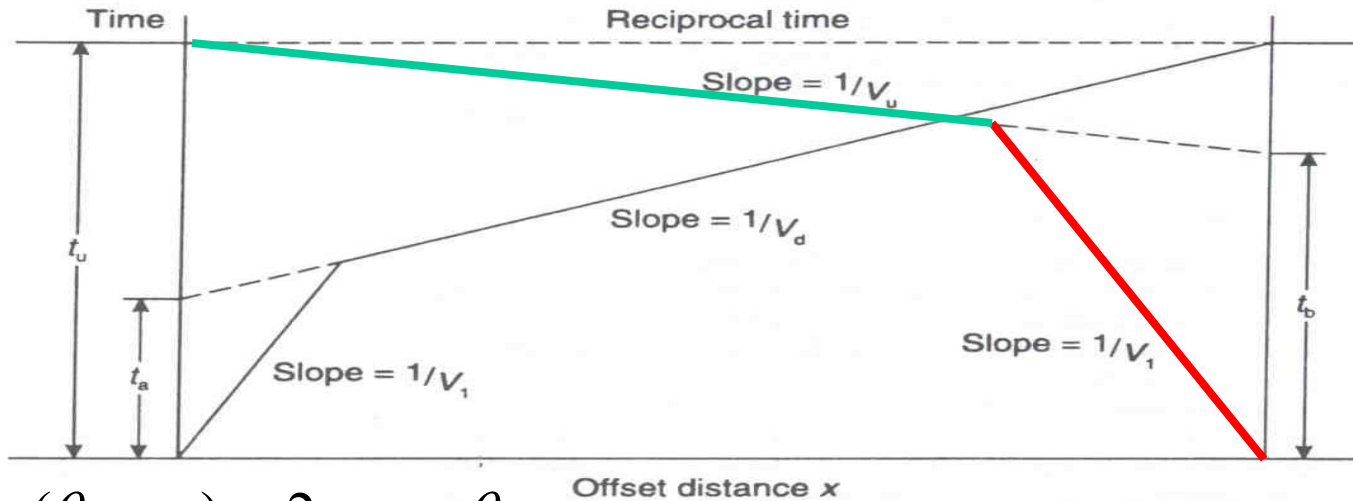
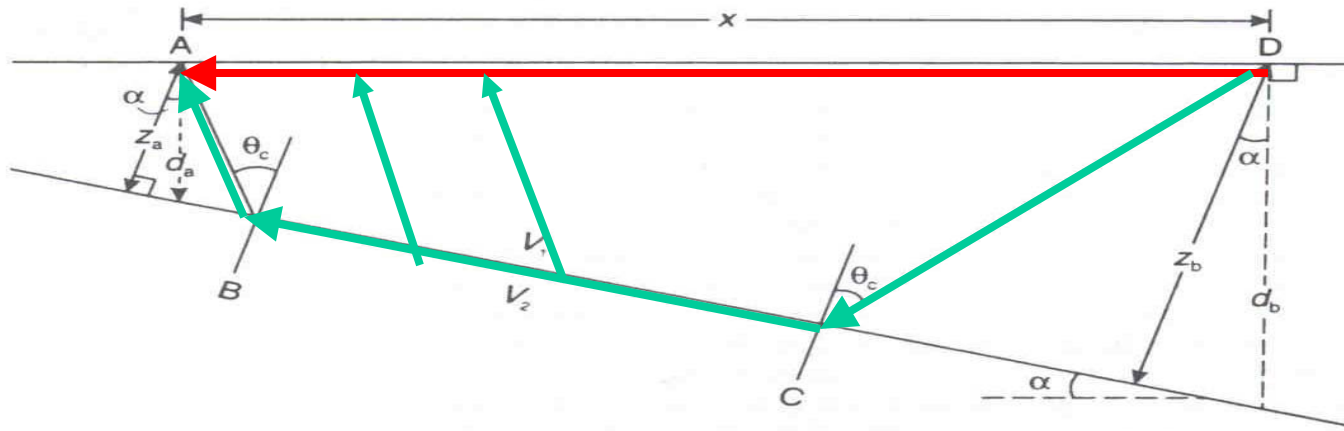


$$t_d = \frac{x \sin(\theta_c + \alpha)}{v_1} + \frac{2z_a \cos \theta_c}{v_1}$$

For small slopes ($\alpha < 10^\circ$):

$$t_u = \frac{x \sin(\theta_c - \alpha)}{v_1} + \frac{2z_b \cos \theta_c}{v_1}$$

$$v_2 \approx \frac{v_d + v_u}{2}$$



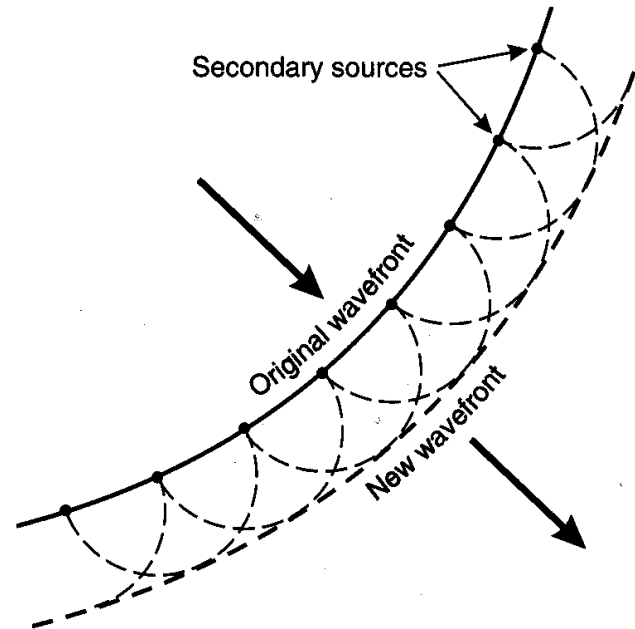
$$t_d = \frac{x \sin(\theta_c + \alpha)}{v_1} + \frac{2z_a \cos \theta_c}{v_1}$$

For small slopes ($\alpha < 10^\circ$):

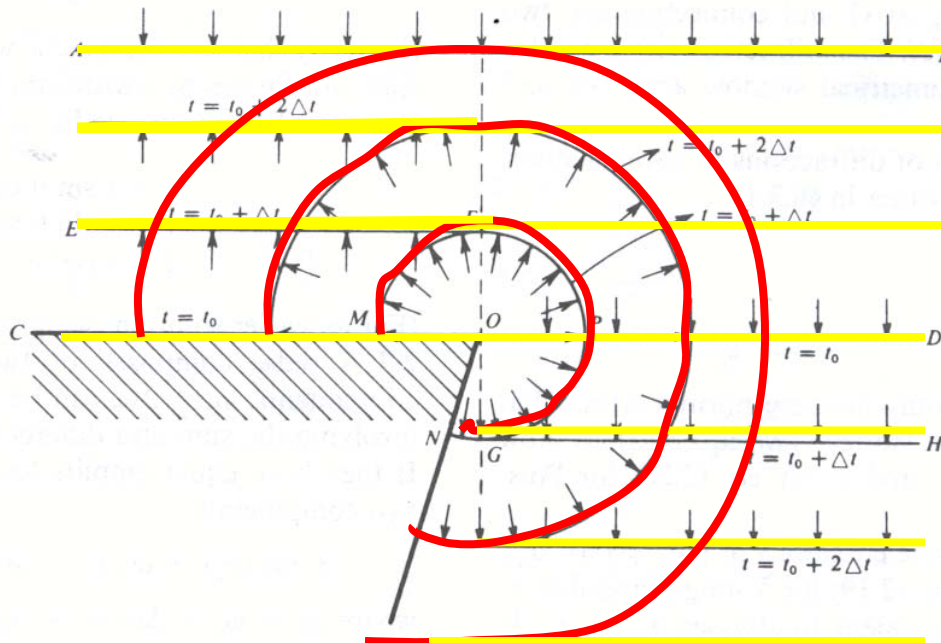
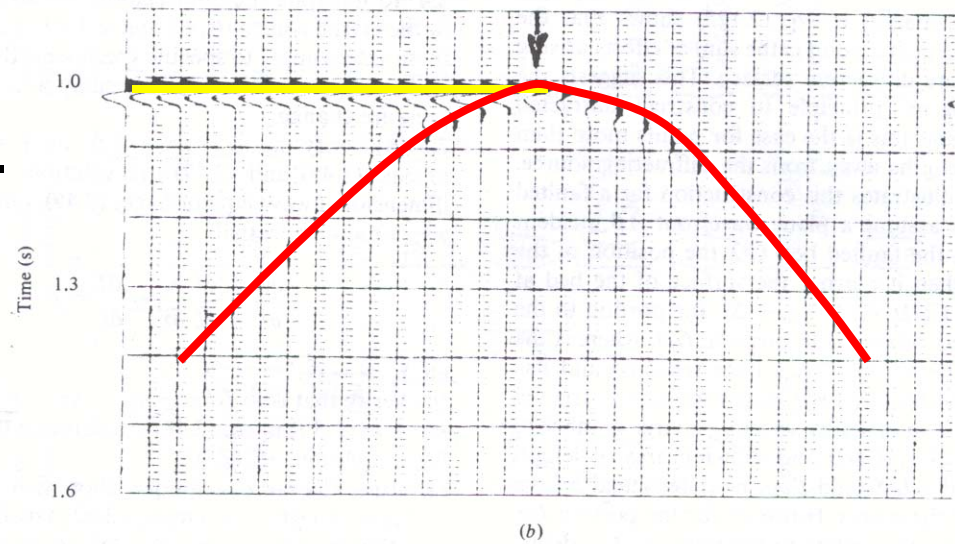
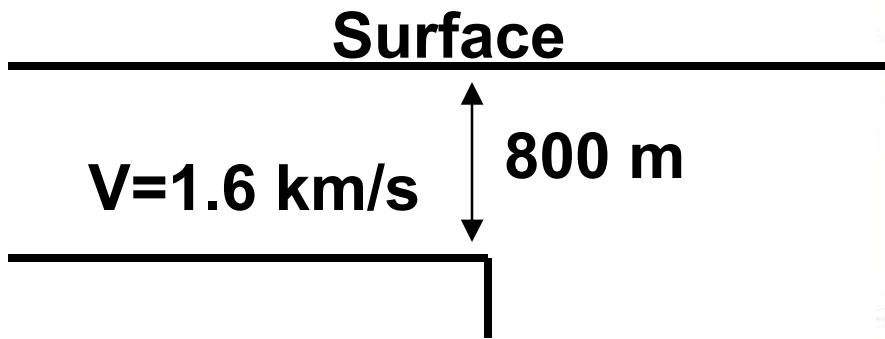
$$t_u = \frac{x \sin(\theta_c - \alpha)}{v_1} + \frac{2z_b \cos \theta_c}{v_1}$$

$$v_2 \approx \frac{v_d + v_u}{2}$$

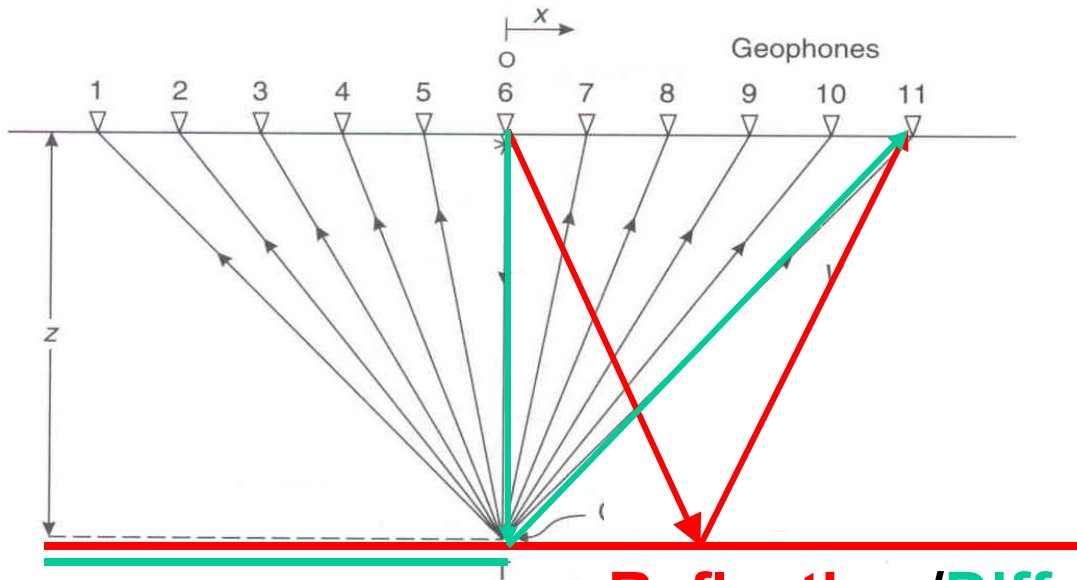
Huygens' Principle:



Every point on a wavefront can be considered as a secondary source of spherical waves



Reflection/Diffraction



Reflection/Diffraction

Reflection:

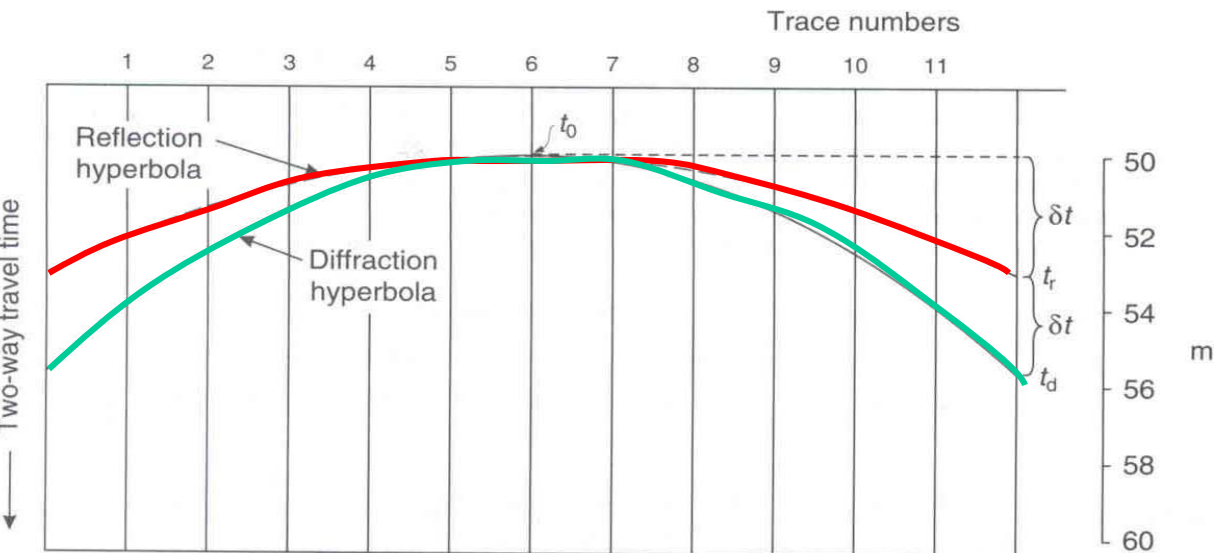
$$t_r \approx t_0 + \delta t$$

$$t_0 = 2h/v$$

$$\delta t = x^2 / (4vz)$$

Diffraction:

$$t_d \approx t_0 + 2\delta t$$



Receivers

Source

Receivers

