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 acquifers
- Engineering geology
- Shallow faults
- Mapping Quaternary deposits
- Preconstruction ground investitation 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

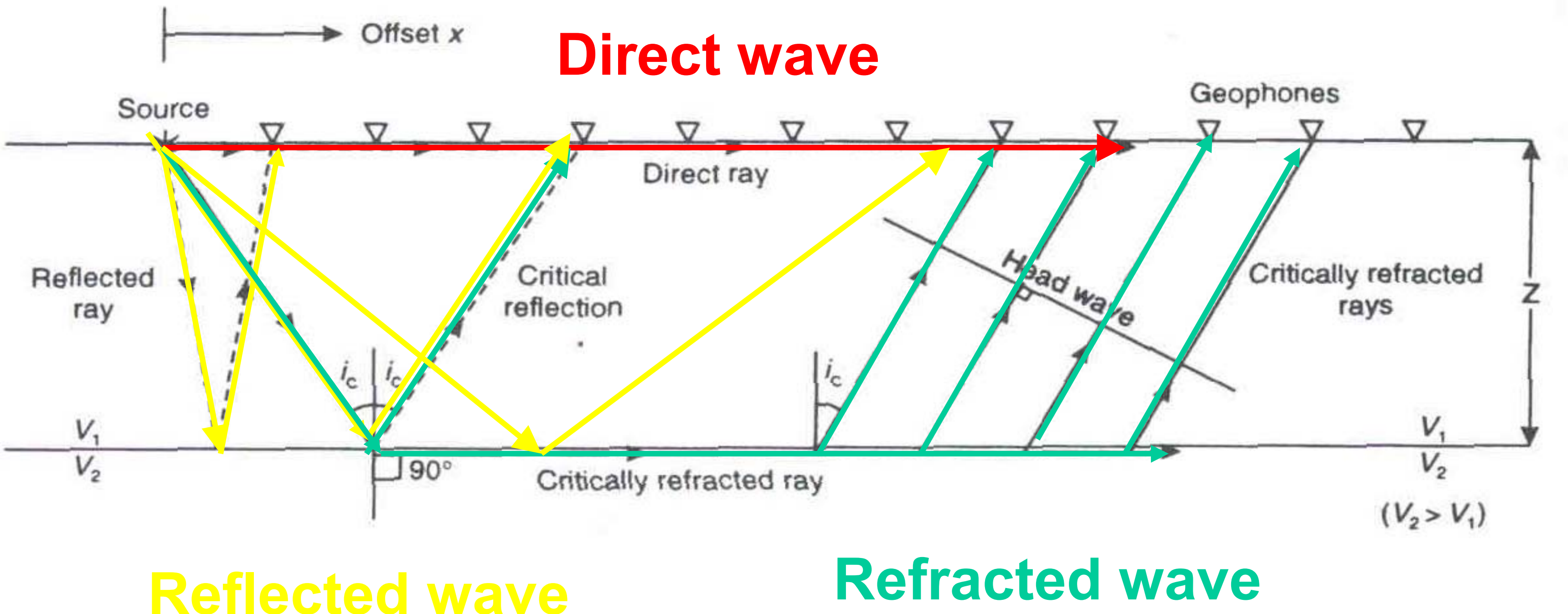
Refraction seismic

- 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*

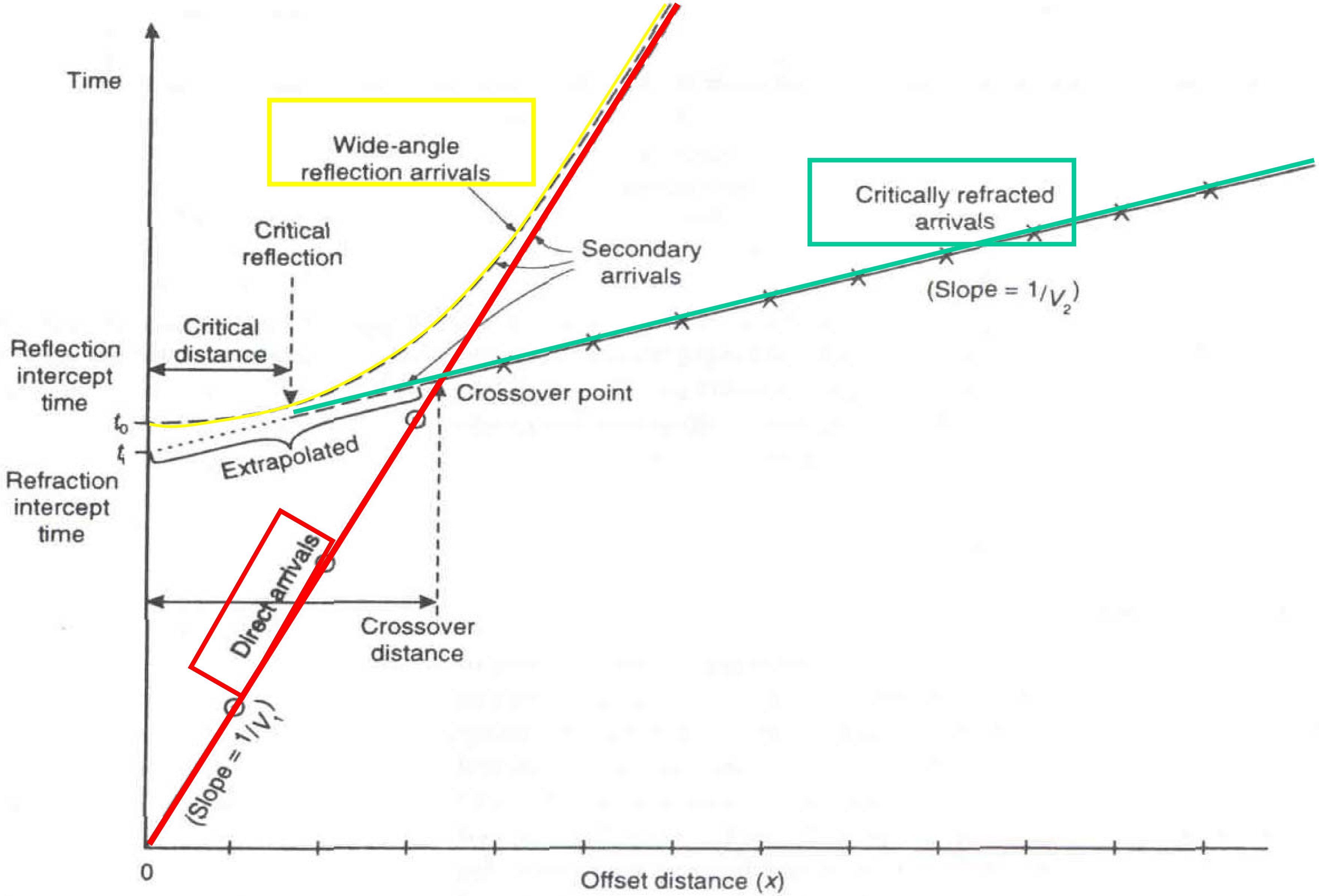
Reflection seismic

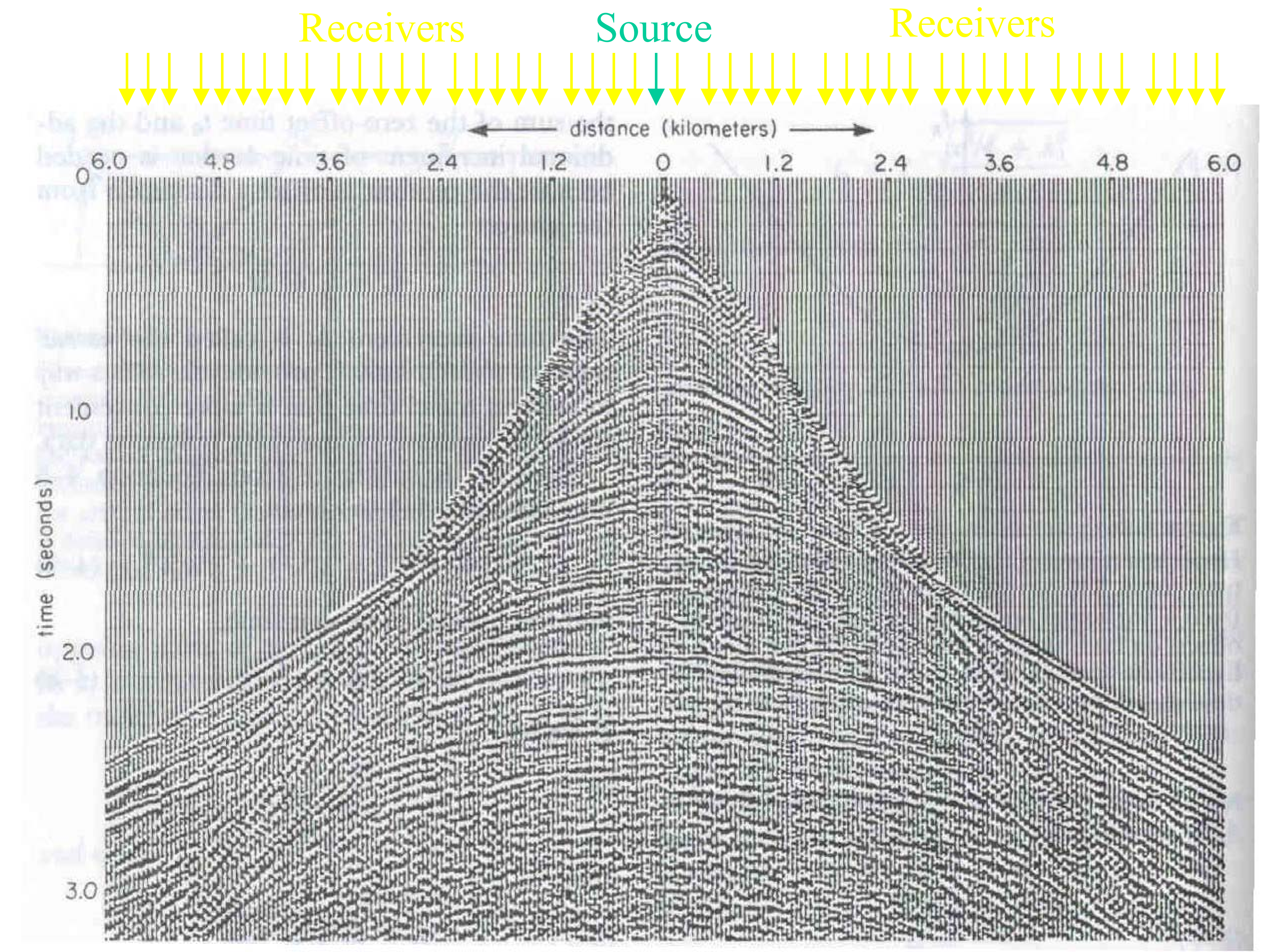
- Reflected Waves (“Echo lot principal”)
- Mainly vertical wave propagation
- Complete seismic recording is used
- *Distribution of the velocity variation*

Geometrical situation



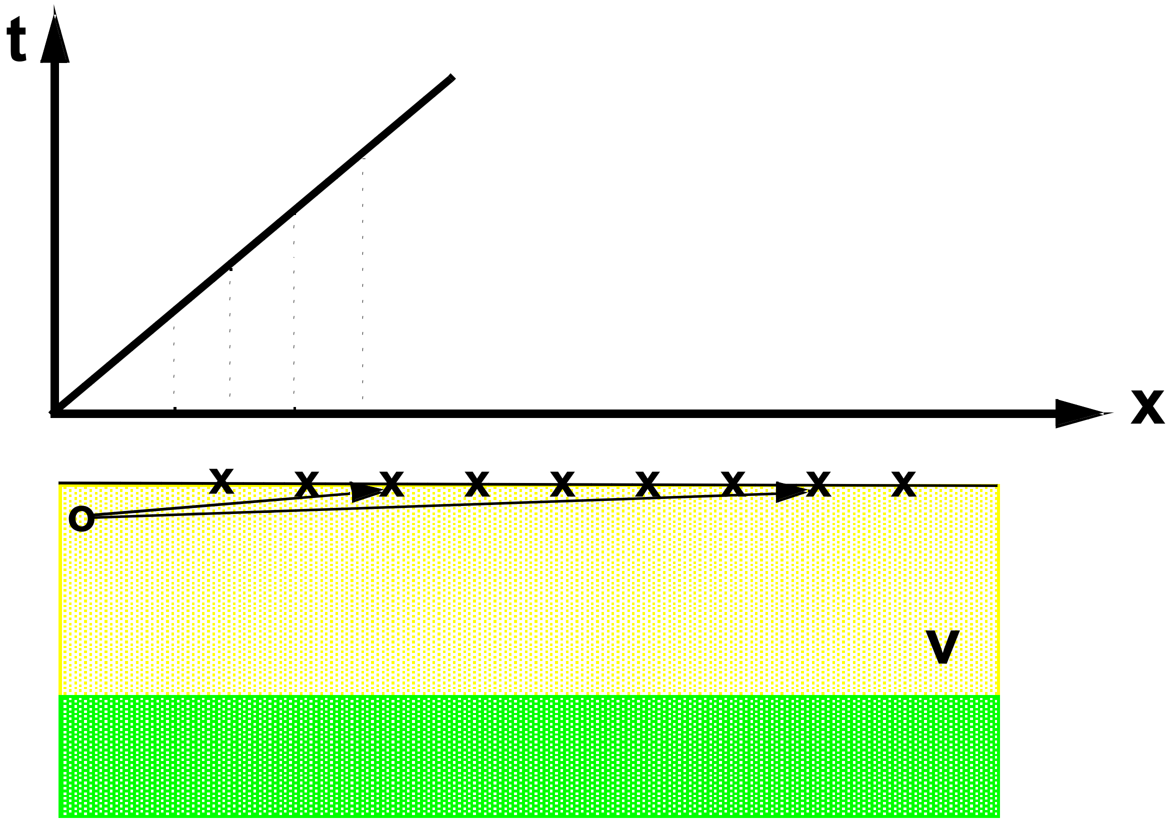
Traveltime curve





Receivers
Source
Receivers
distance (kilometers)
6.0
4.8
3.6
2.4
1.2
0
1.2
2.4
3.6
4.8
6.0
0
1.0
2.0
3.0
time (seconds)

Direct wave

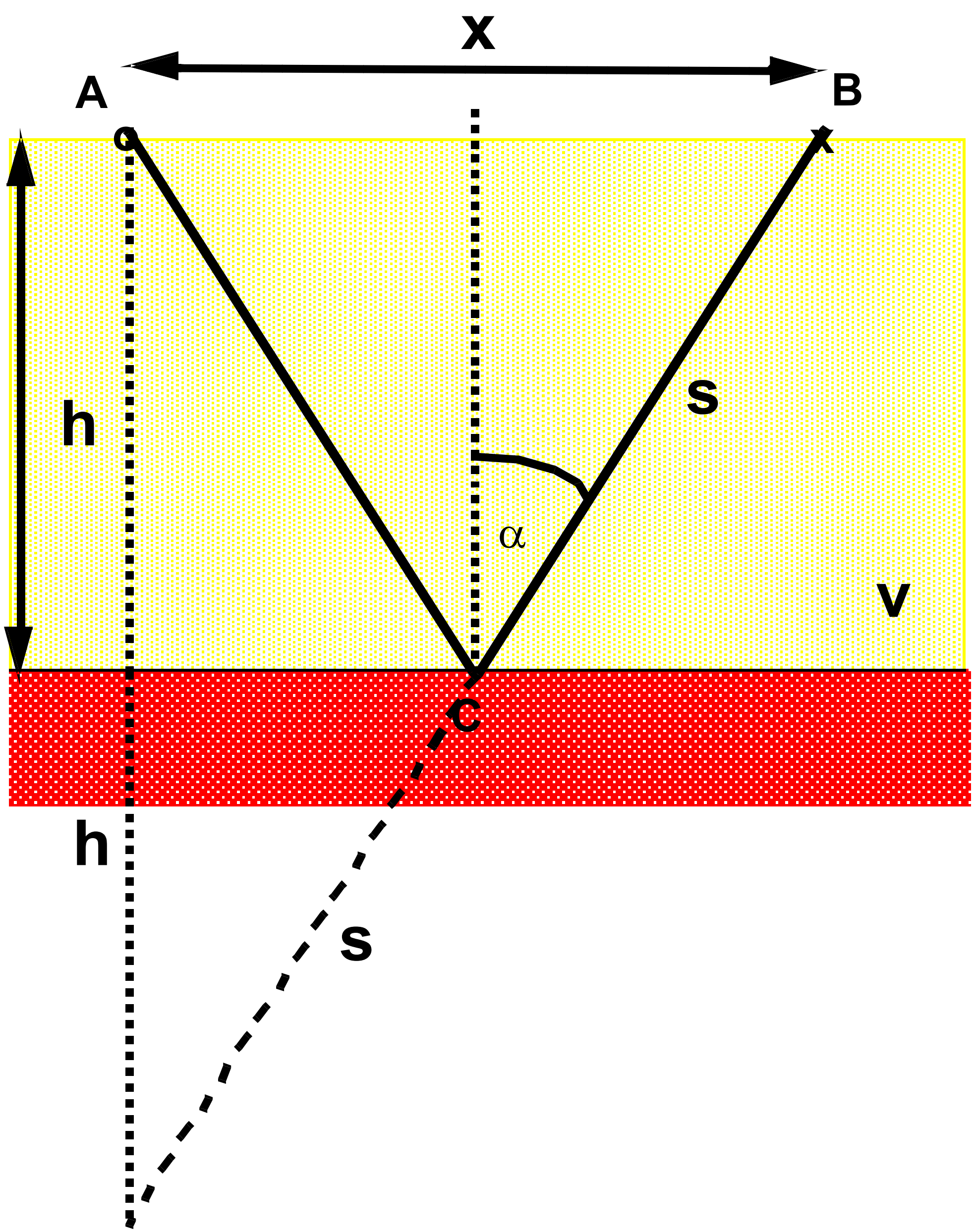


$$t = \frac{1}{v} x$$

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

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

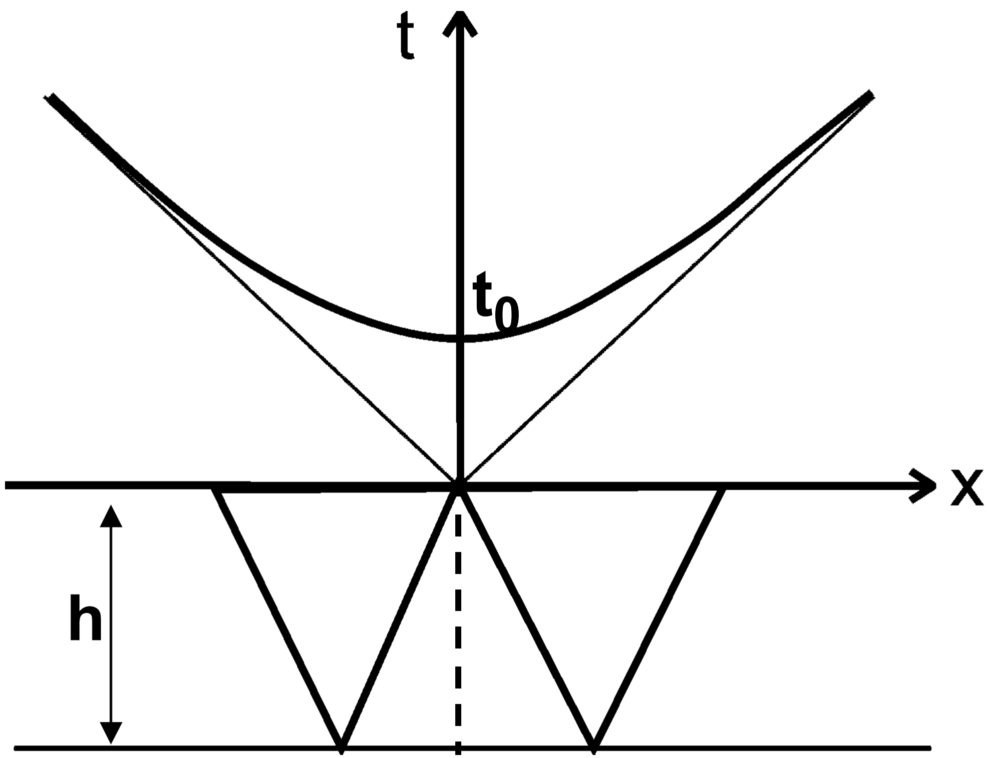
Reflection: Horizontal reflector



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

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

Reflection: Horizontal reflector



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

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

for x=0:

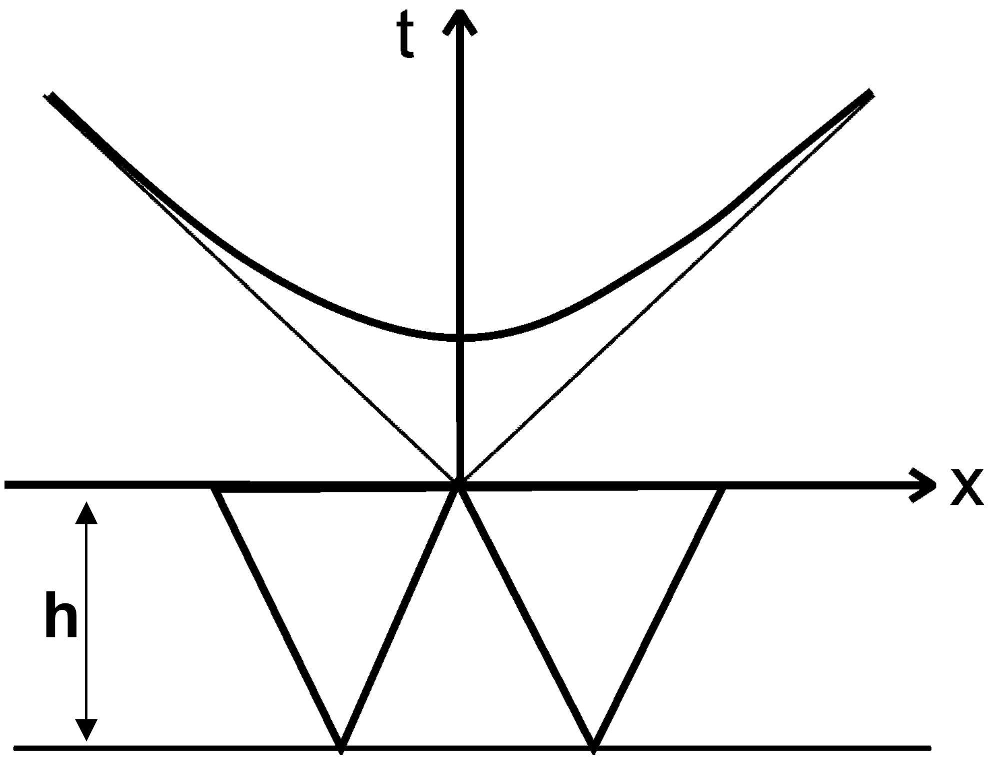
$t^2v^2=4h^2$

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

or

$h=t_0v/2$

Reflection: horizontal reflector



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

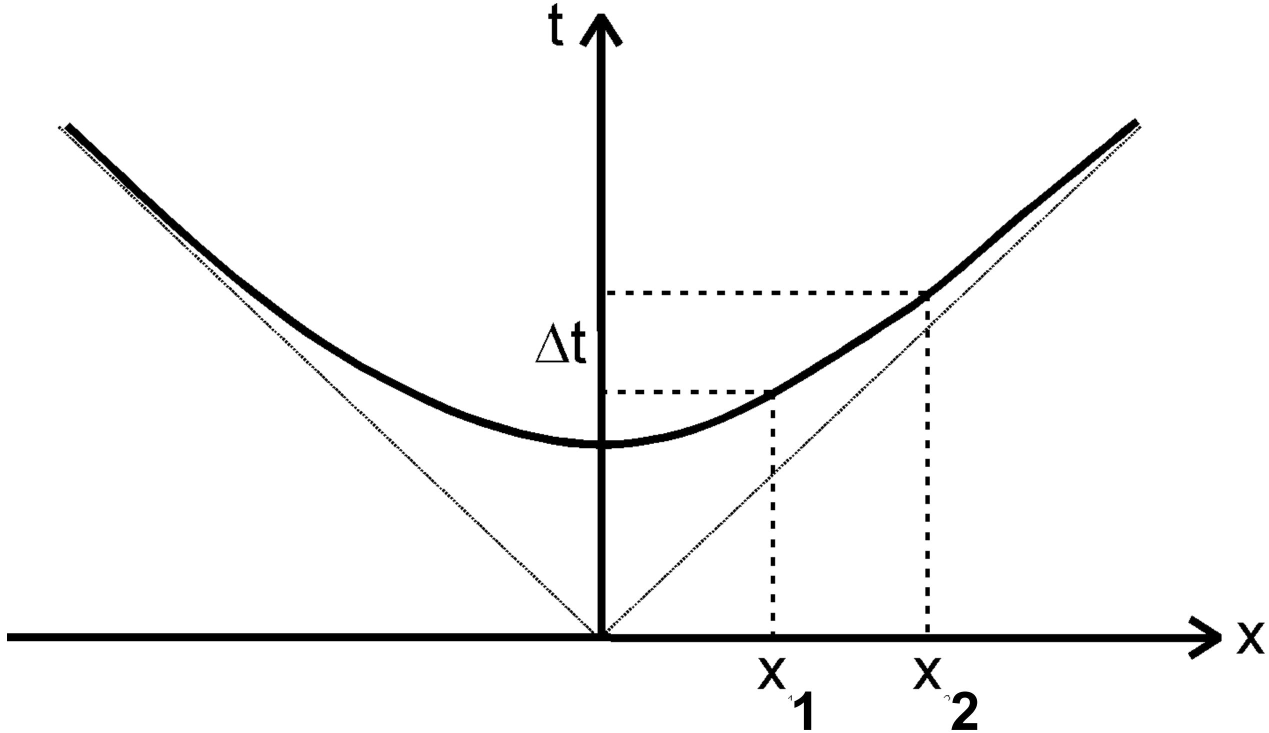
$$t^2v^2 - x^2 = 4h^2$$

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

Hyperbola

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

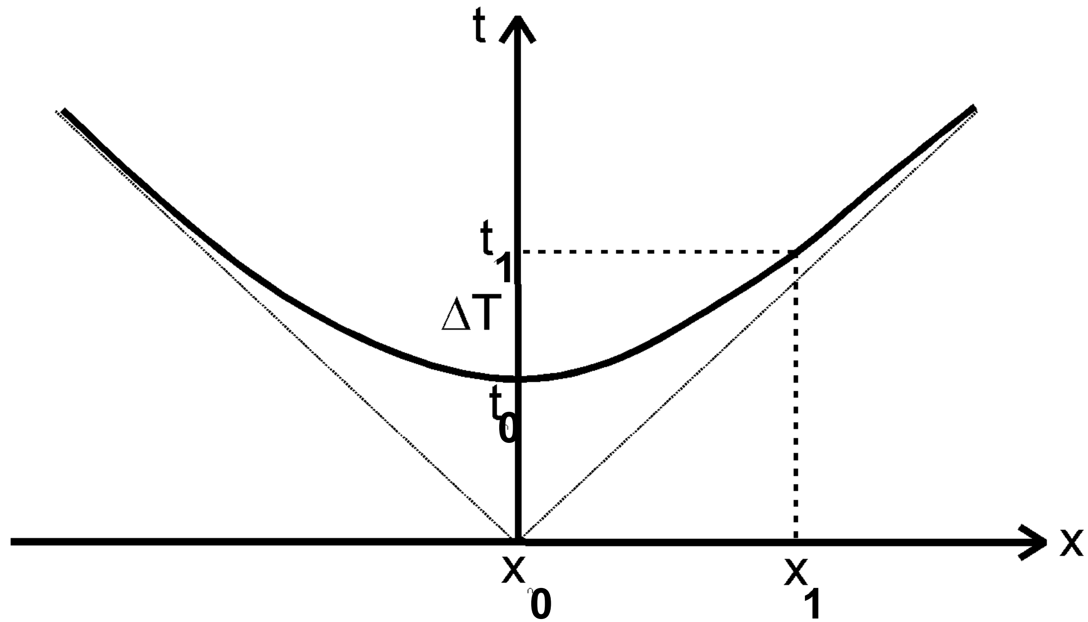
Moveout



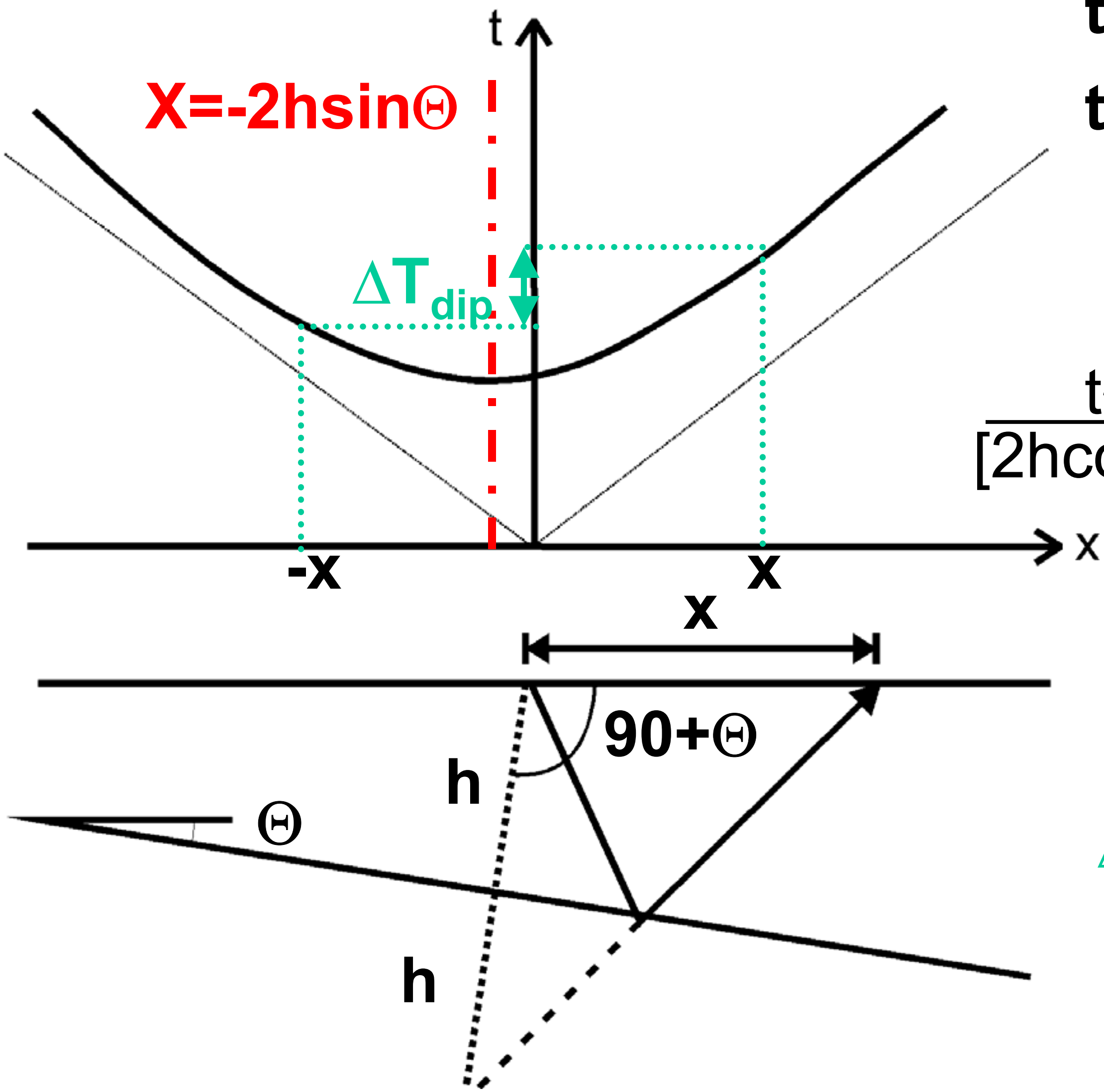
Difference in travel time $t(x_1)$ und $t(x_2)$:

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

Normal Moveout



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



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

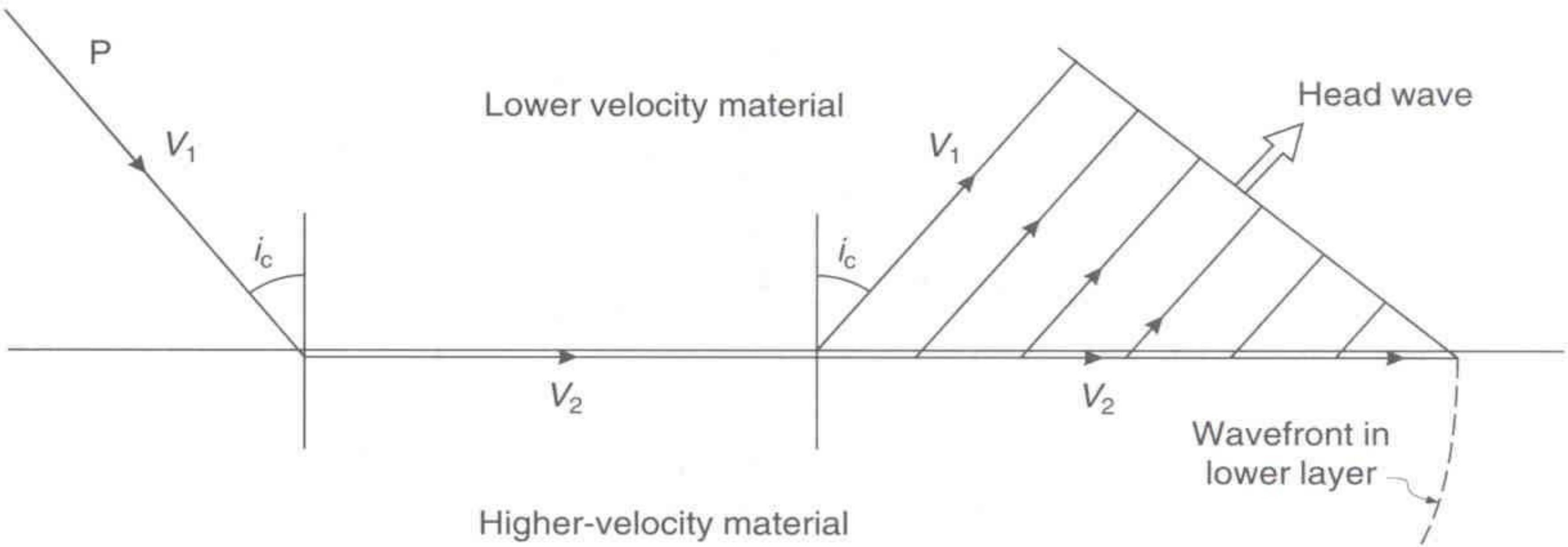
$$t^2v^2=4h^2+x^2+4hx\sin(\Theta)$$

Hyperbola:

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

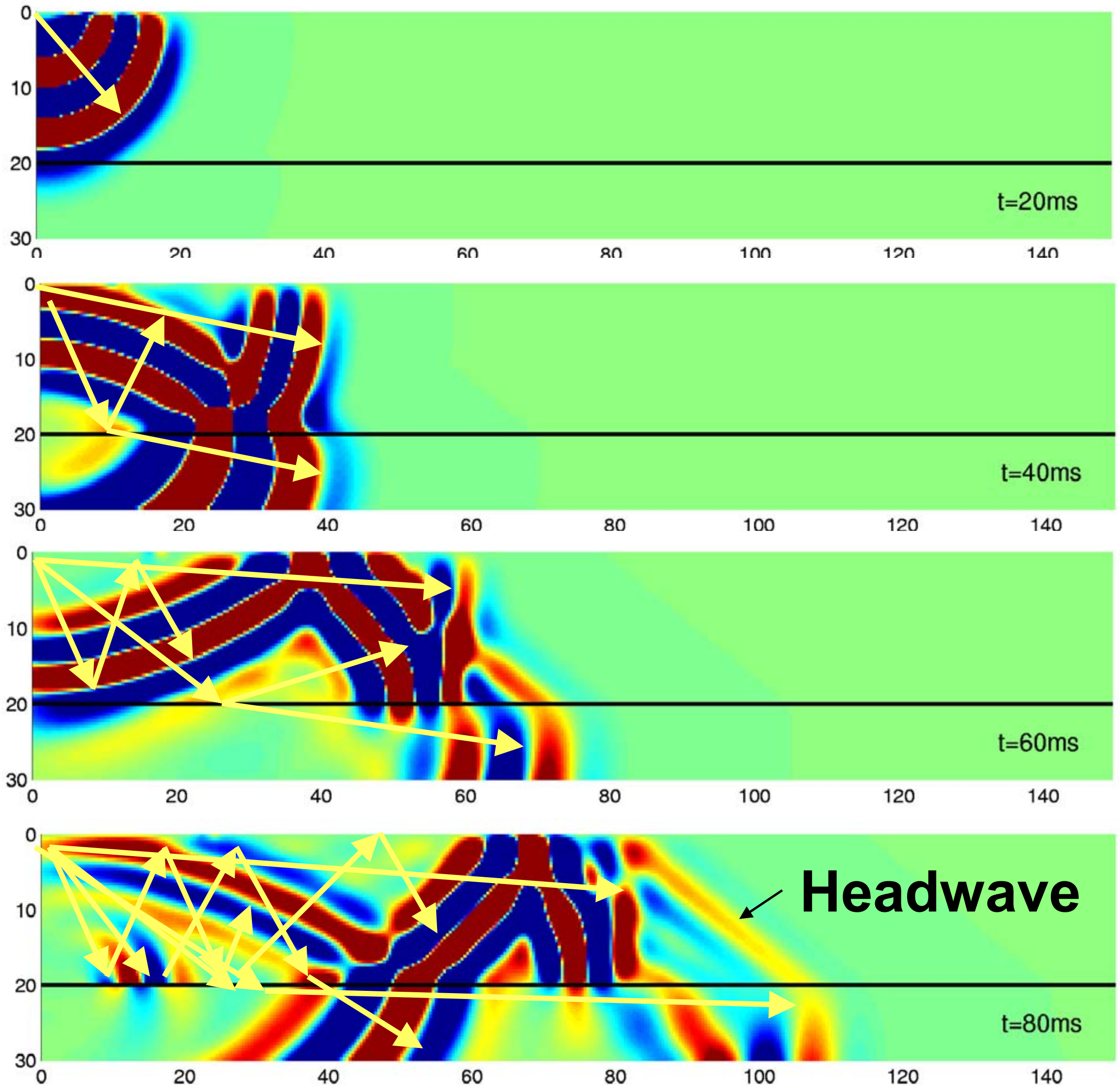
$$\Delta T_{dip}=t_x-t_{-x}=\frac{2x\sin\Theta}{V}$$

Refraction seismic

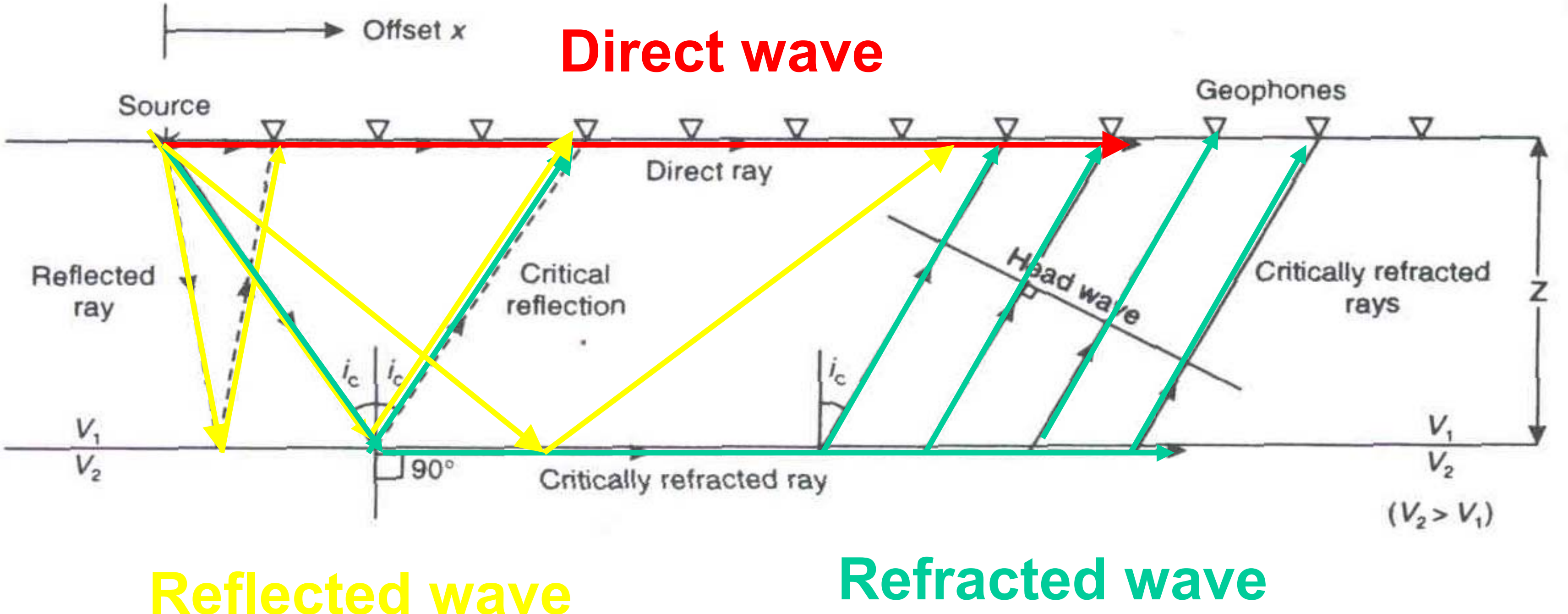


$$\frac{\sin i_c}{\sin 90} = \frac{v_1}{v_2} \Leftrightarrow \sin i_c = \frac{v_1}{v_2}$$

Propagation of seismic waves

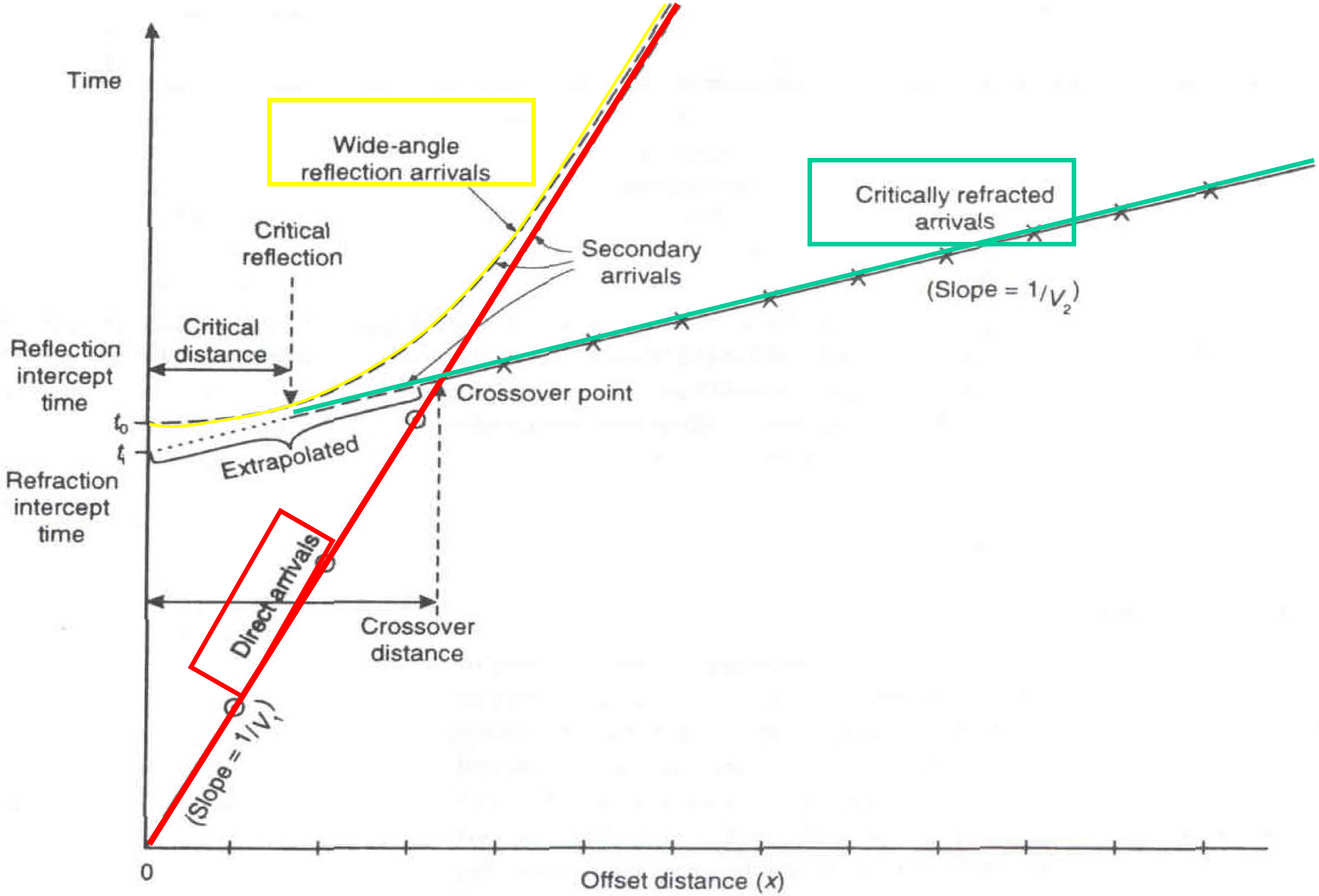


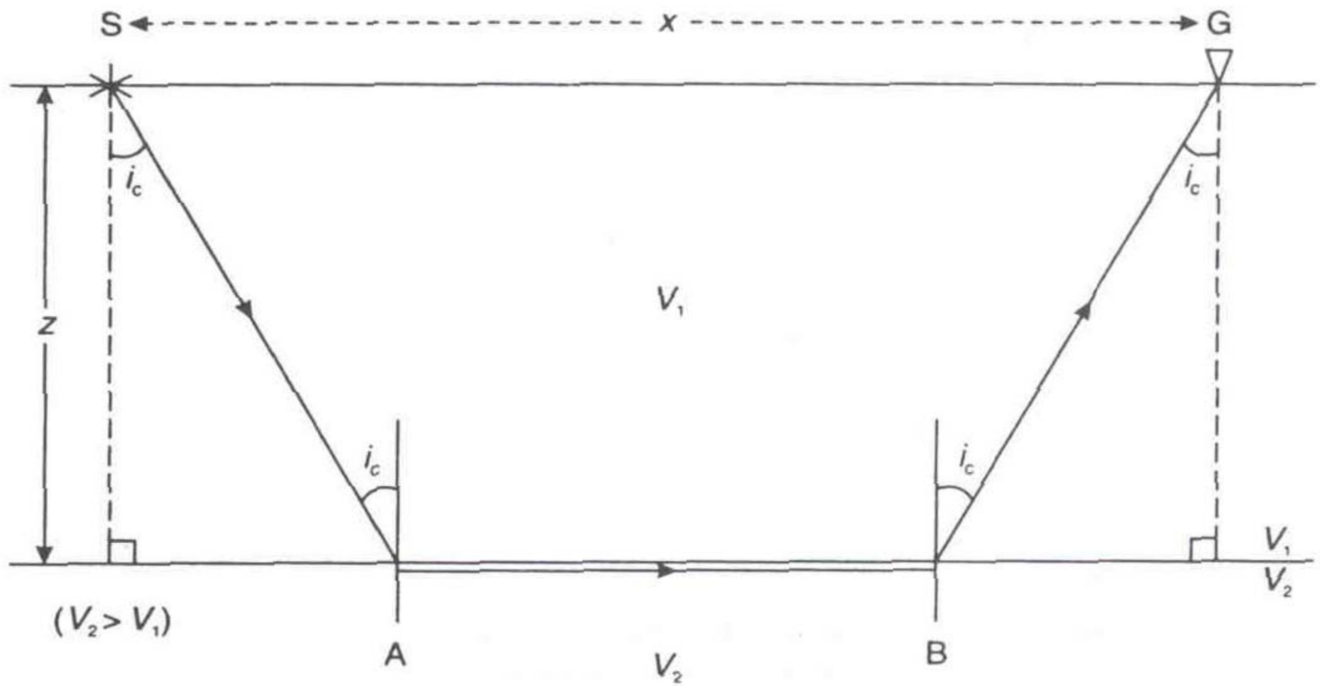
(Roth et al., 1998)



Offset x
Direct wave
Source
Geophones
Direct ray
Reflected ray
Critical reflection
Head wave
Critically refracted rays
Z
i_c
i_c
i_c
V_1
V_2
90°
Critically refracted ray
V_1
V_2
$(V_2 > V_1)$
Reflected wave
Refracted wave

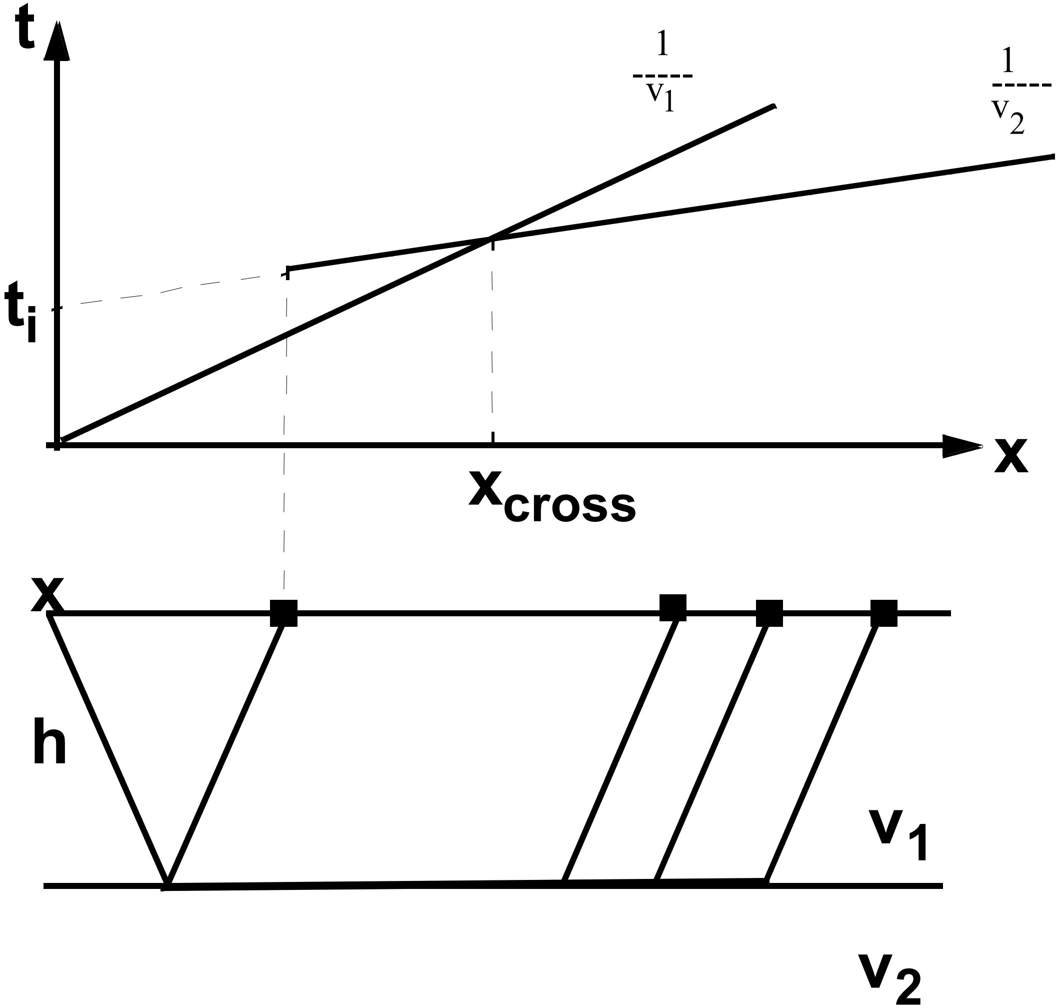
Traveltime curve





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

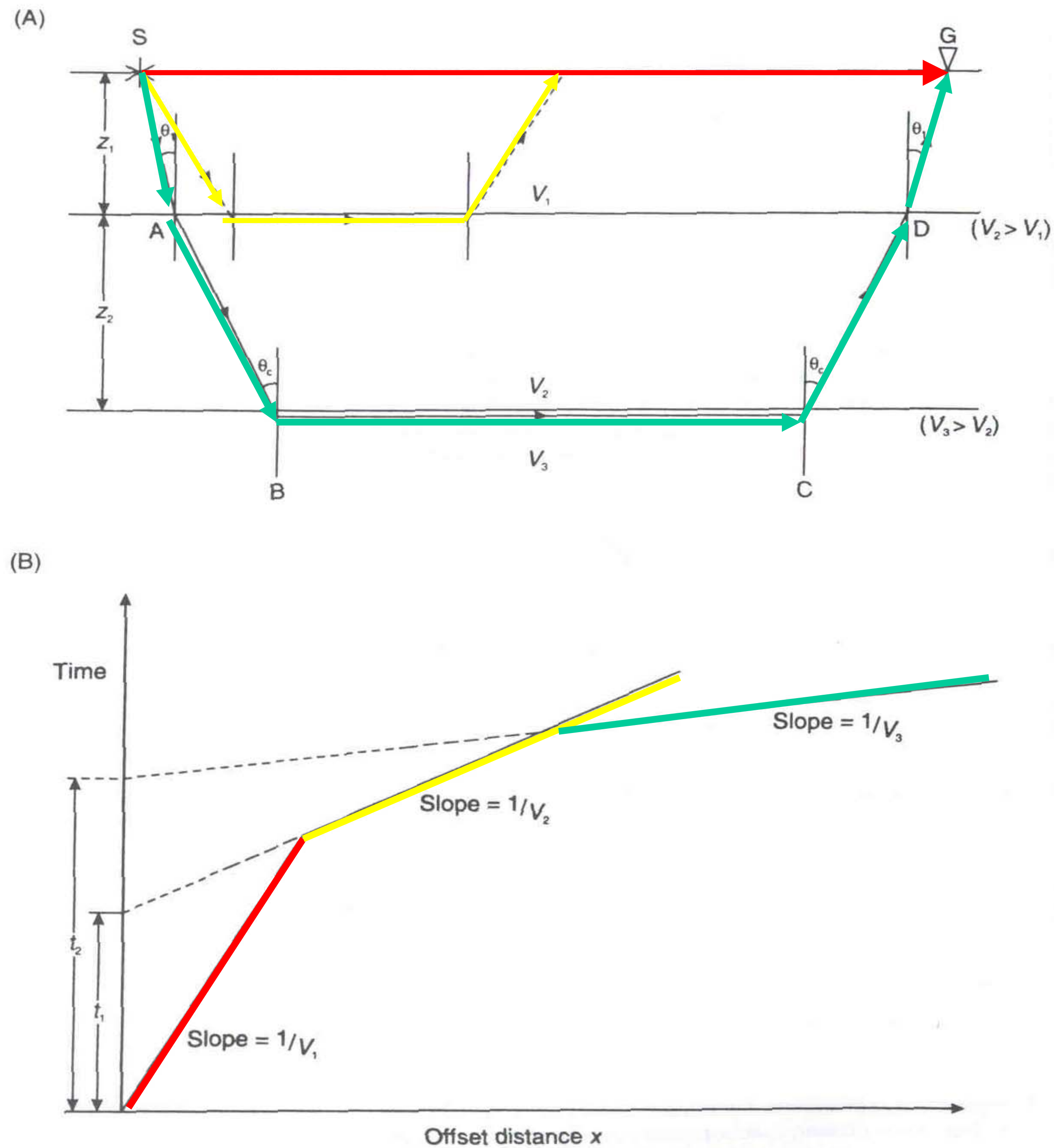
Refraction: horizontal reflector

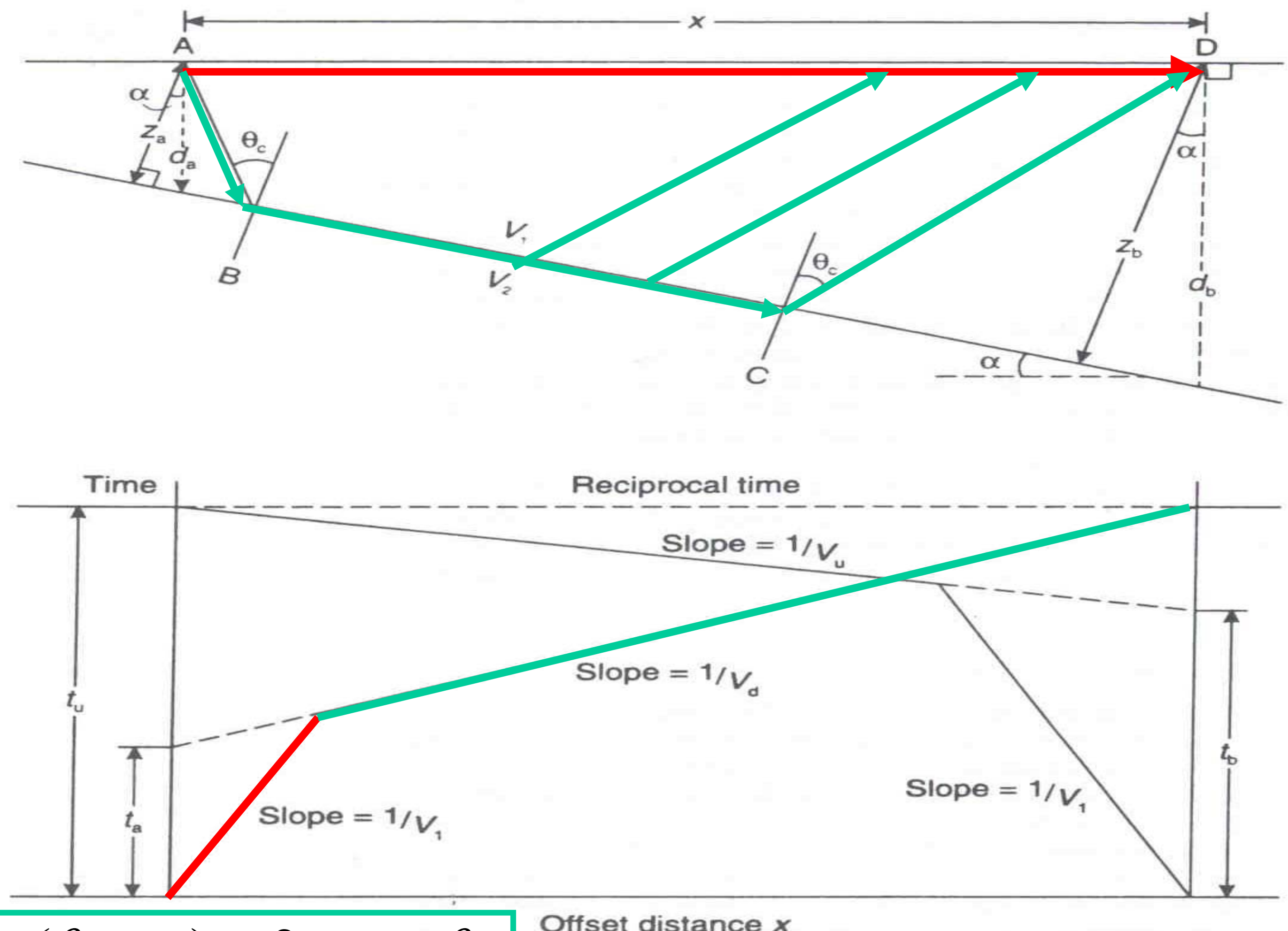


$$t = \frac{x}{v_2} + \frac{2h\sqrt{v_2^2 - v_1^2}}{v_1 v_2}$$

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

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


(A)
S
G
z_1
θ_1
θ_1
V_1
A
D
$(V_2 > V_1)$
z_2
θ_c
θ_c
V_2
$(V_3 > V_2)$
V_3
B
C
(B)
Time
Slope = $1/V_3$
Slope = $1/V_2$
t_2
t_1
Slope = $1/V_1$
Offset distance x

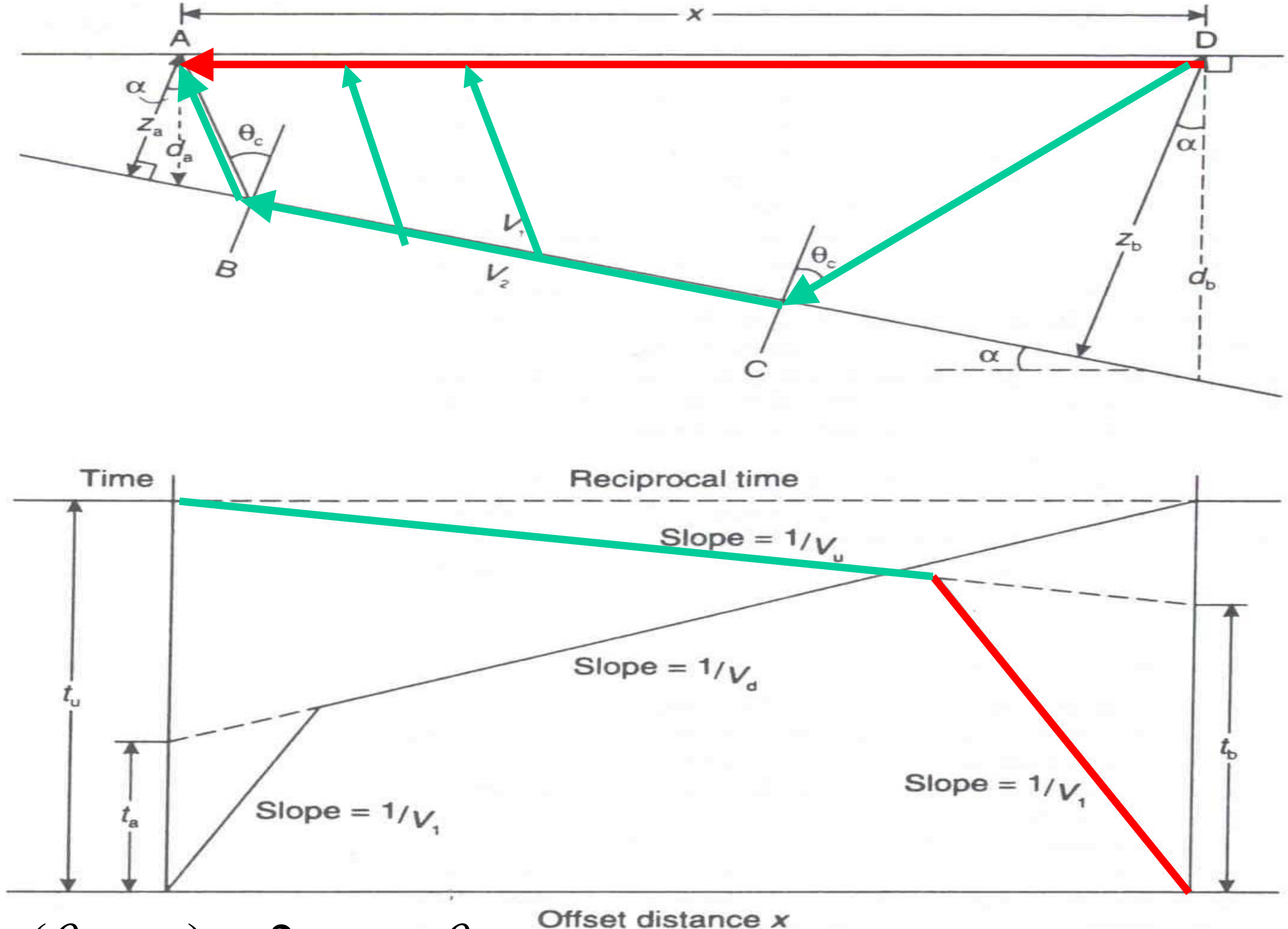


$$\boxed{t_d = \frac{x\sin(\theta_c + \alpha)}{v_1} + \frac{2z_a\cos\theta_c}{v_1}}$$

For small slopes ($\alpha < 10^0$):

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

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



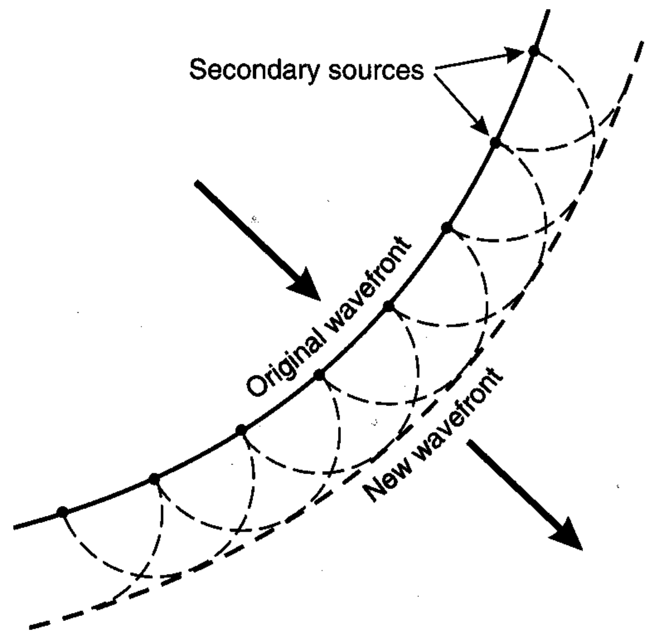
$$t_d = \frac{x\sin(\theta_c + \alpha)}{v_1} + \frac{2z_a\cos\theta_c}{v_1}$$

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

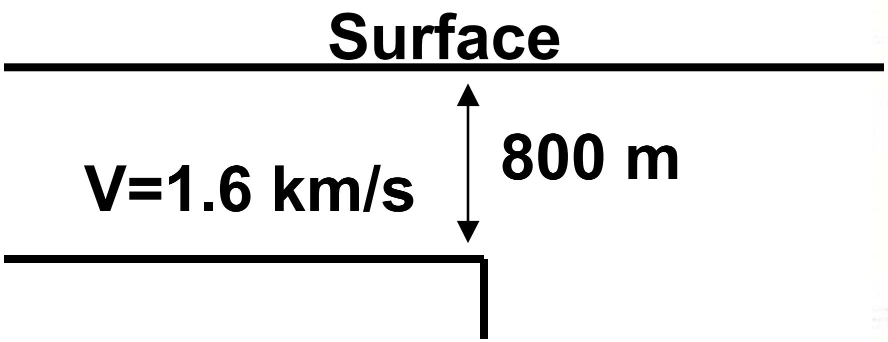
For small slopes ($\alpha < 10^0$):

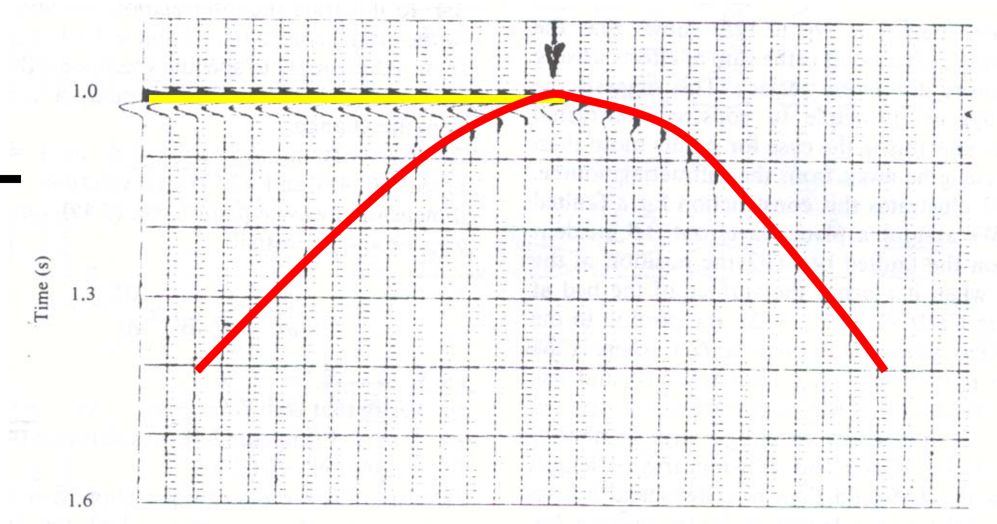
$$v_2 \approx \frac{v_d + v_u}{2}$$

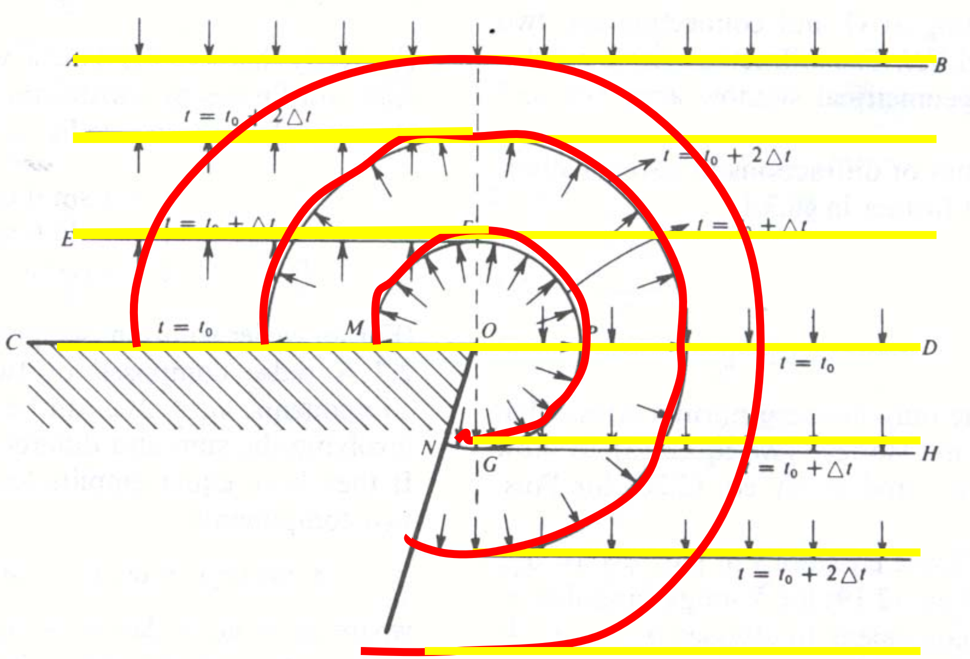
Huygens' Principle:



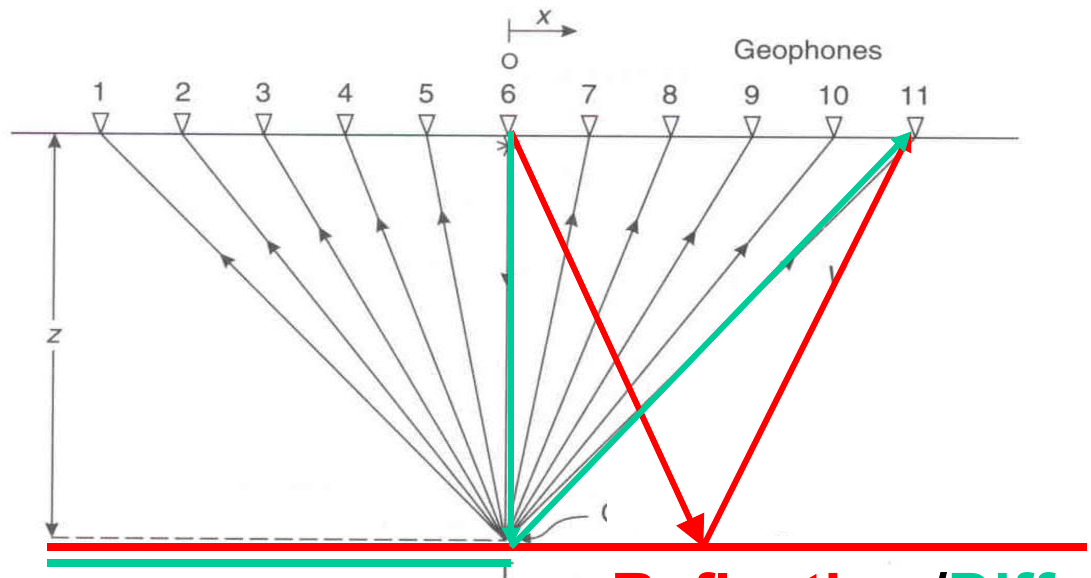
Every point on a wavefront can be considered as a secondary source of spherical waves


Surface
800 m
V=1.6 km/s

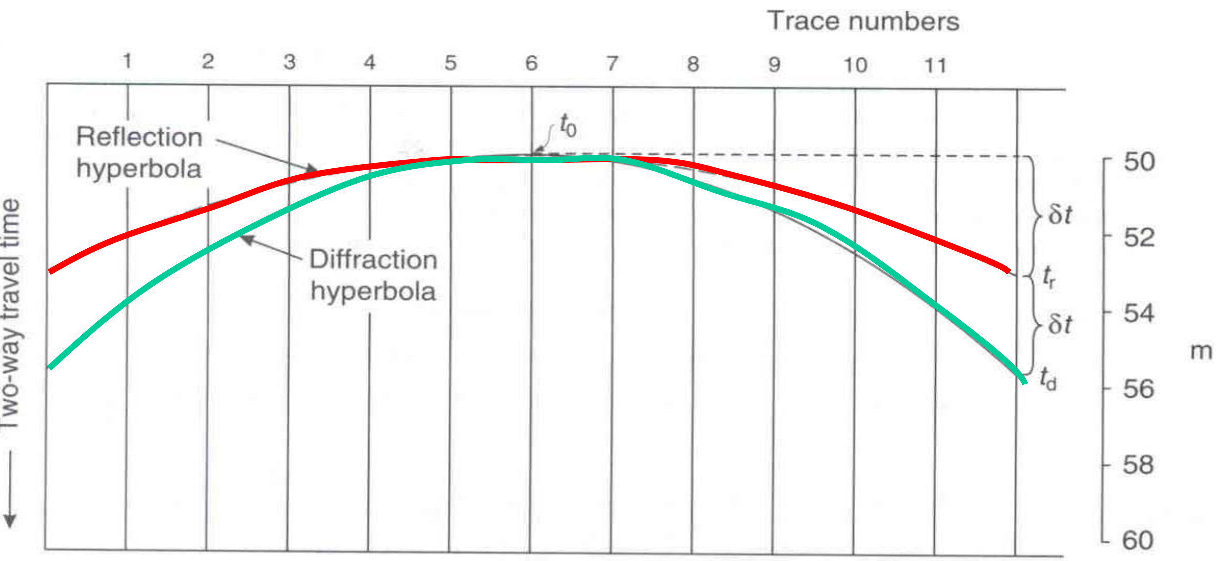

1.0
1.3
1.6
Time (s)
(b)


A
B
$t = t_0 + 2\Delta t$
$t = t_0 + 2\Delta t$
E
$t = t_0 + \Delta t$
C
$t = t_0$
M
O
D
$t = t_0$
N
G
H
$t = t_0 + \Delta t$
$t = t_0 + 2\Delta t$

Reflection/Diffraction



Reflection/Diffraction



Reflection:

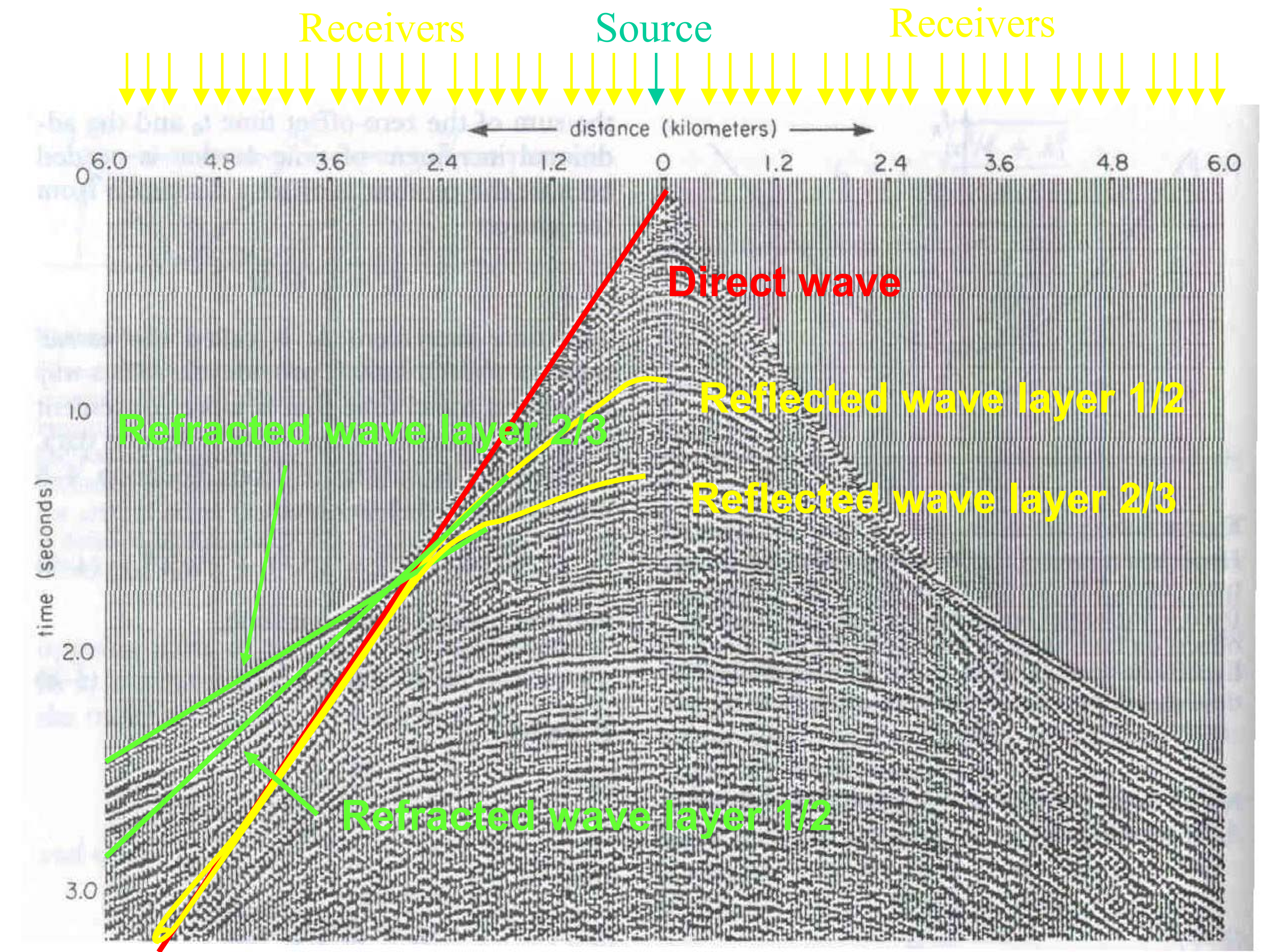
$t_r \approx t_0 + \delta t$

$t_0 = 2h/v$

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

Diffraction:

$t_d \approx t_0 + 2\delta t$


Receivers
Source
Receivers
distance (kilometers)
6.0
4.8
3.6
2.4
1.2
0
1.2
2.4
3.6
4.8
6.0
0
1.0
2.0
3.0
time (seconds)
Direct wave
Reflected wave layer 1/2
Refracted wave layer 2/3
Reflected wave layer 2/3
Refracted wave layer 1/2