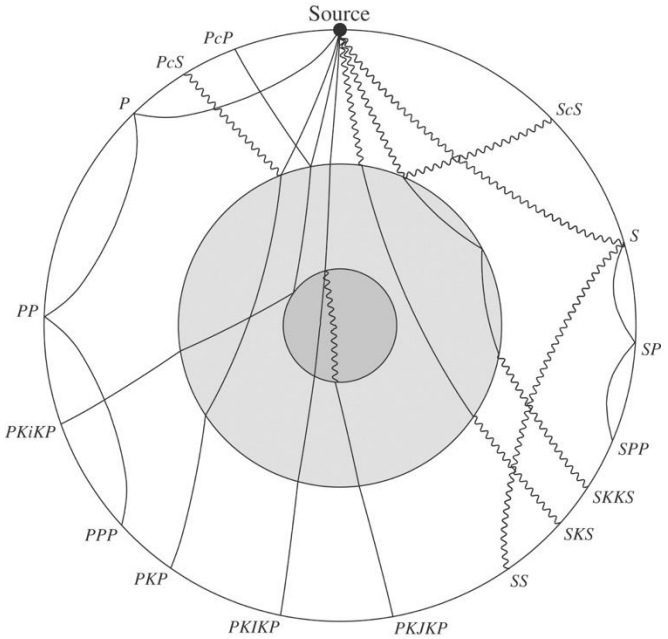
9. Refraction Seismic

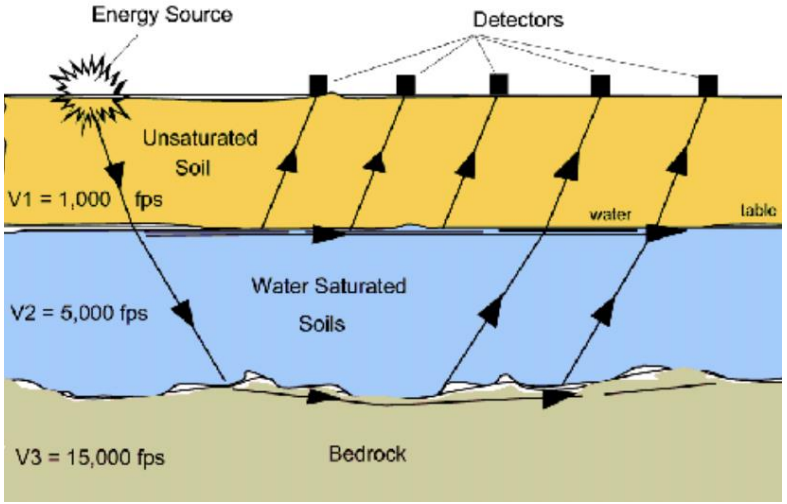
M. Ravasi

ERSE 210 Seismology

Refracted Waves

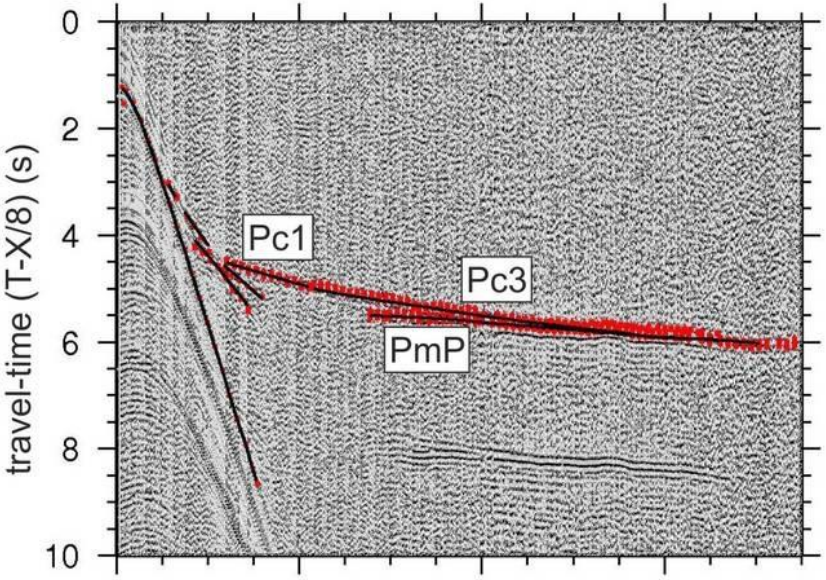


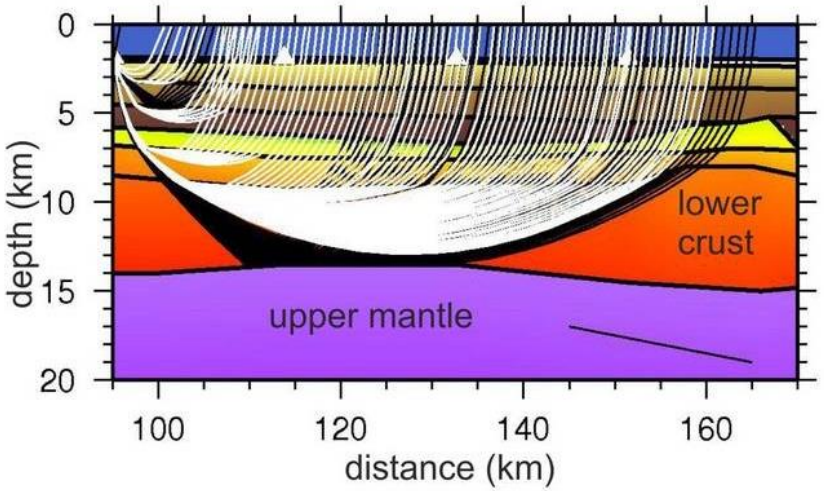
Global



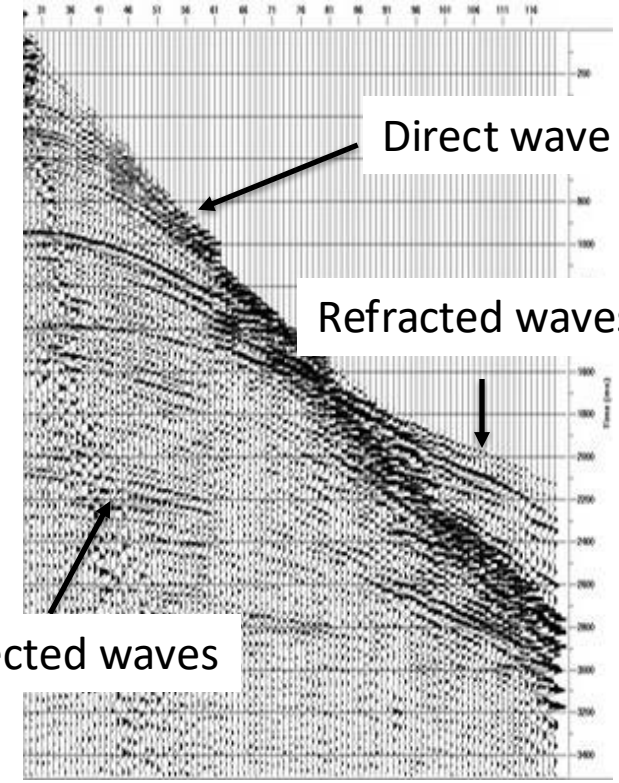
Local

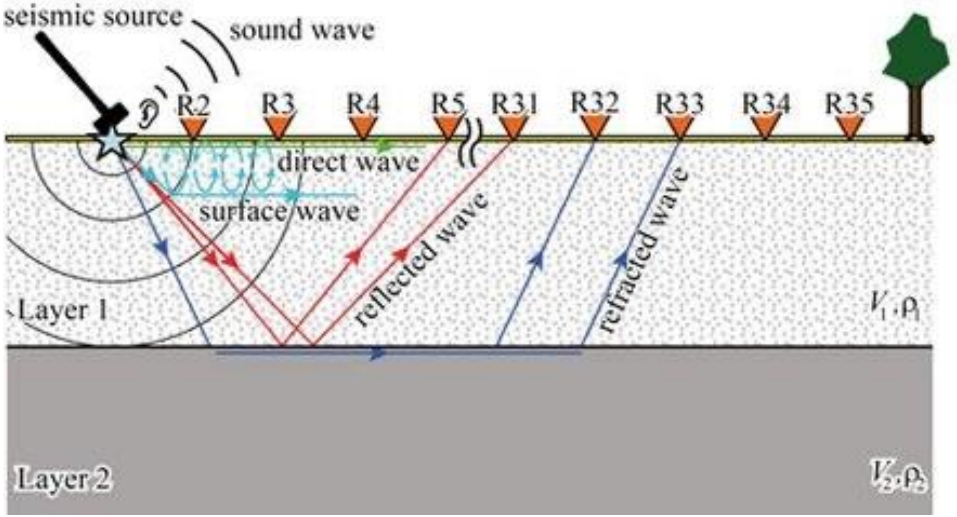
Refracted Waves in OBS



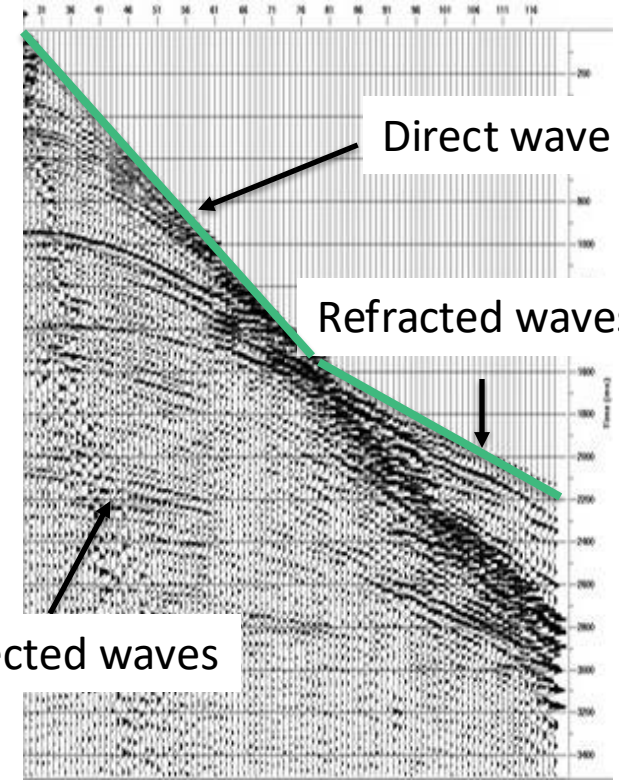


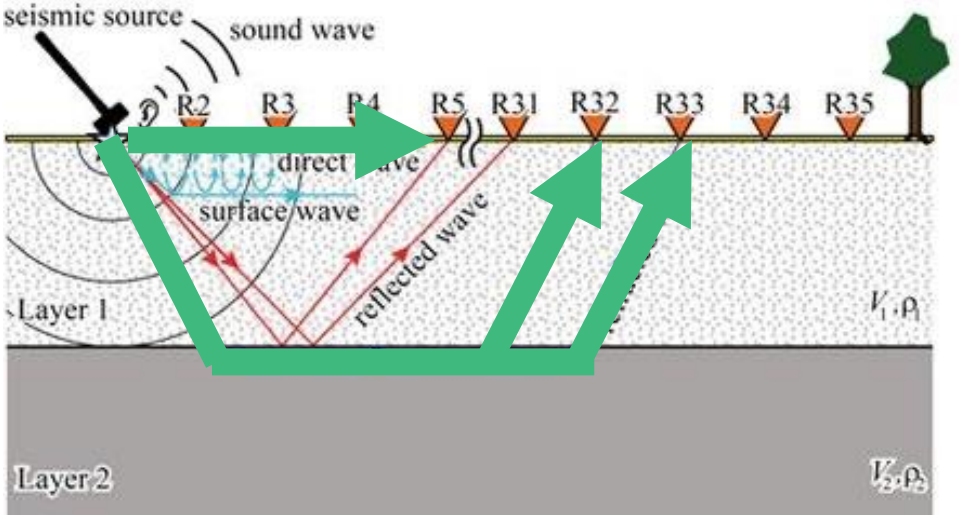
Seismic recordings



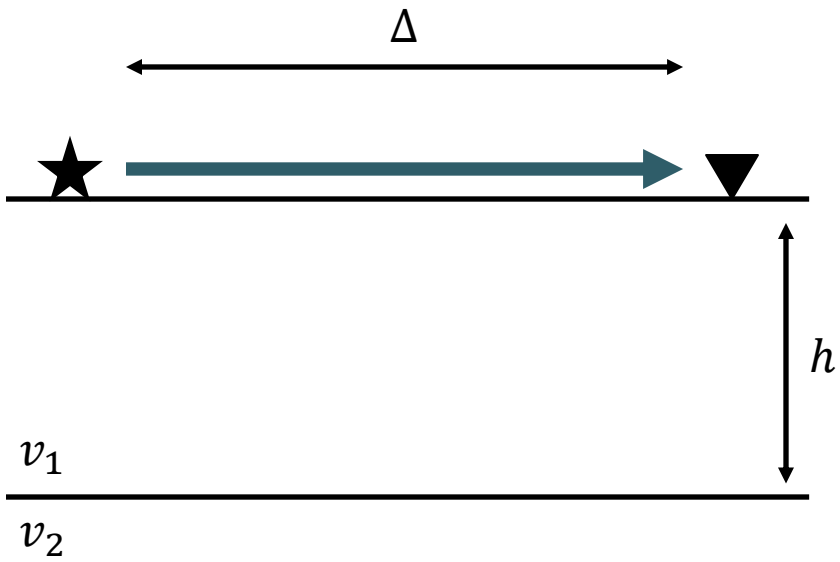


Seismic recordings



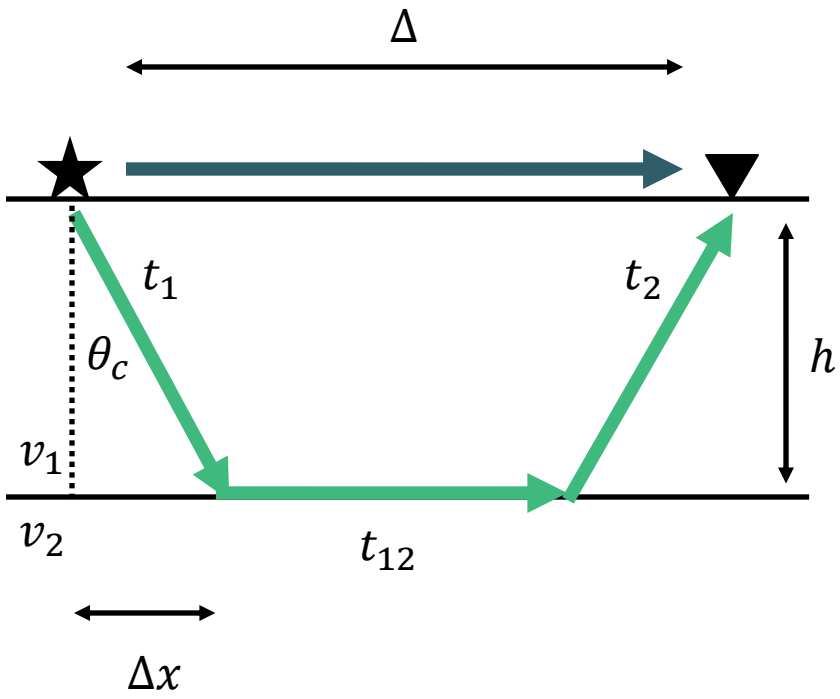


Seismic refractions – 2 layers



Direct arrival: $t_{dir}(\Delta) = \frac{\Delta}{v_1}$

Seismic refractions – 2 layers



Direct arrival: $t_{dir}(\Delta) = \dfrac{\Delta}{v_1}$

Refracted arrival:

$\theta_c = \mathrm{asin}(v_1/v_2)$ Snell's law

$t_1 = t_2 = h/(v_1 \cos\theta_c)$

$t_{12} = (\Delta - 2\Delta x)/v_2 = \Delta/v_2 - 2h\tan\theta_c/v_2$

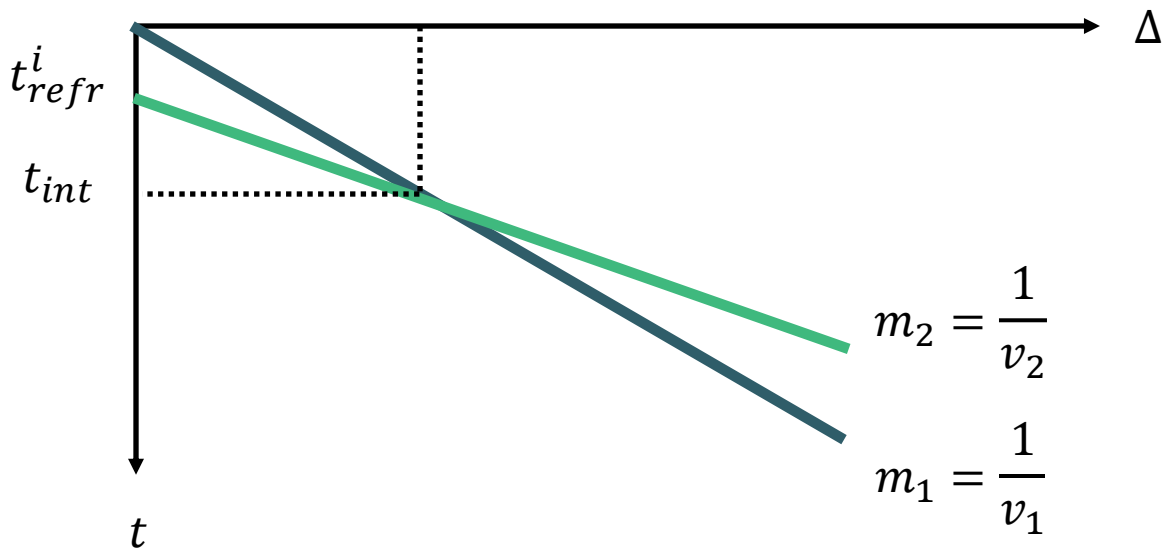
$t_{refr}(\Delta) = 2t_1 + t_{12} = \cdots = \Delta/v_2 + 2h\cos\theta_c/v_1$

Seismic refractions – 2 layers

$$t_{dir}(\Delta) = \frac{\Delta}{v_1}$$

$$t_{refr}(\Delta) = \Delta/v_2 + \overbrace{2\mathrm{h}\cos\theta_c/v_1}^{t^i_{refr}}$$

$$\Delta_u = 2\mathrm{h}\sqrt{\frac{v_2+v_1}{v_2-v_1}}$$ (Overtaking distance - $t_{dir} = t_{refr}$)



Seismic refractions – 2 layers

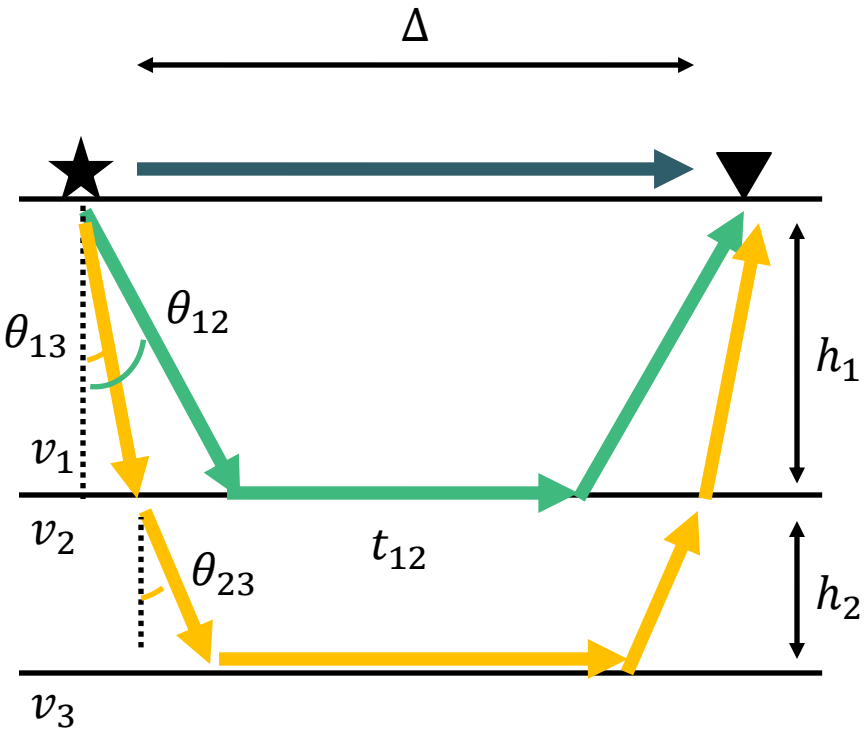
Recipe:

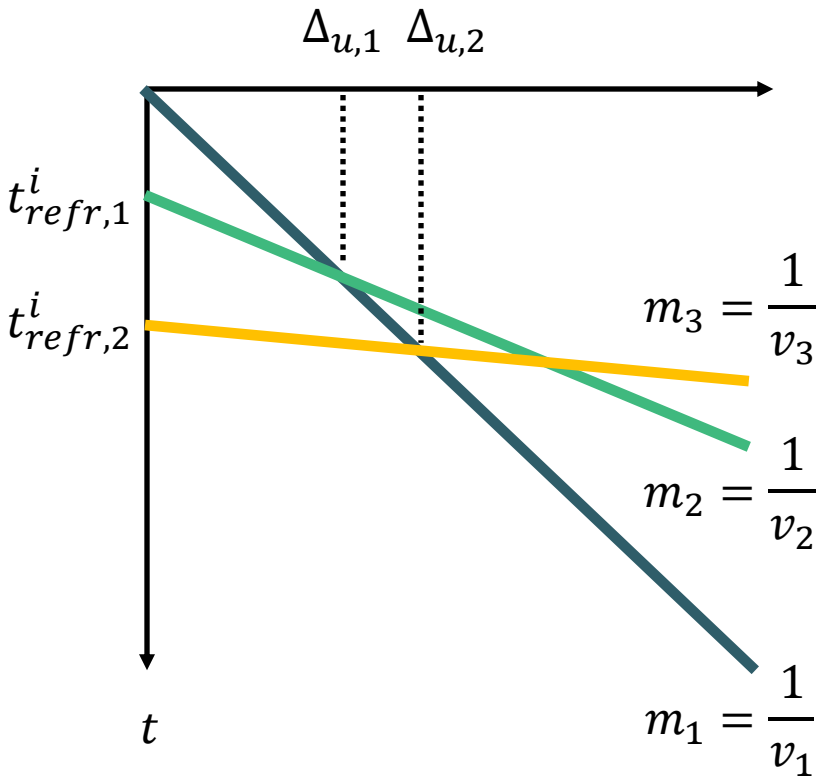
- Estimate slopes of direct arrival (m_1) → $v_1 = 1/m_1$
- Estimate slopes of refracted arrival (m_2) → $v_2 = 1/m_2$
- Calculate critical angle → $\theta_c = \mathrm{asin}(v_1/v_2)$
- Estimate intercept (t^i_{refr}) and compute thickness → $\mathrm{h} = v_1 t^i_{refr}/2\mathrm{hcos}\theta_c$

or

- Estimate overtaking distance (Δ_u) and compute thickness →$\mathrm{h} = \frac{\Delta_u}{2}\sqrt{\frac{v_2 - v_1}{v_2 + v_1}}$

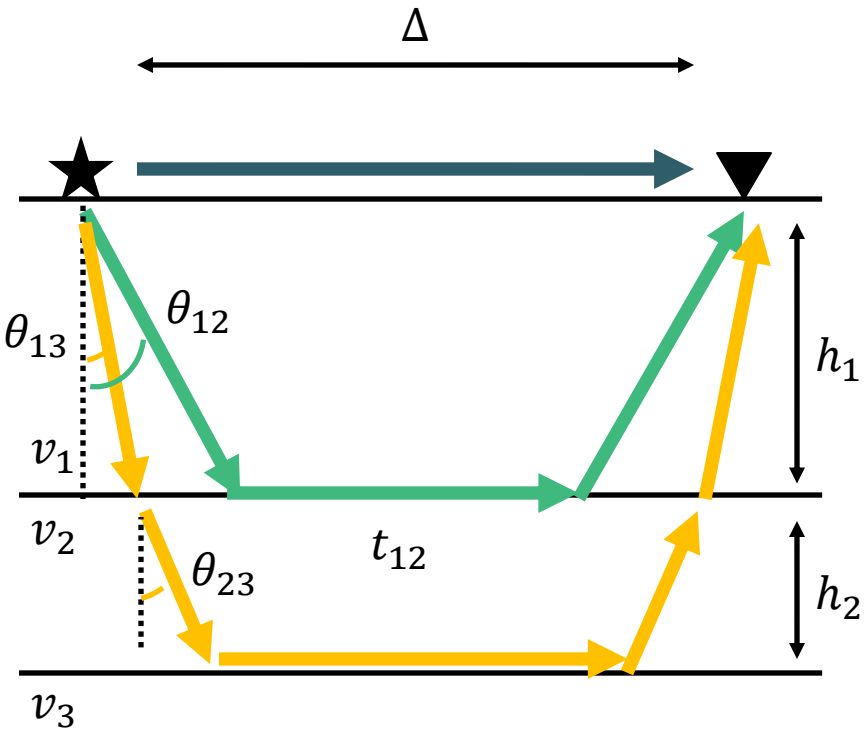
Seismic refractions – N layers





$\theta_{ij} - i$: layer of angle, j: layer where refraction occurs

Seismic refractions – N layers



$\theta_{ij} - i$: layer of angle, j: layer where refraction occurs

Snell's law: $\frac{sin\theta_{13}}{v_1} = \frac{sin\theta_{23}}{v_2} = \frac{1}{v_3}$

2nd layer refracted arrival:

$$t_{refr,2}(\Delta) = \Delta/v_3 + t^i_{refr,2}$$

$$t^i_{refr,2} = \frac{2h_1 cos\theta_{13}}{v_1} + \frac{2h_2 cos\theta_{23}}{v_2}$$

Nth layer refracted arrival:

$$t_{refr,N}(\Delta) = \Delta/v_{N+1} + t^i_{refr,N}$$

$$t^i_{refr,N} = \sum_{i=1:N} \frac{2h_i cos\theta_{i(N+1)}}{v_i}$$

Seismic refractions – N layers

Recipe:

- Estimate slopes of all arrivals ($m_i, i = 1, \dots N$) → $v_i = 1/m_i$
- Calculate angles → $\theta_{ij} = \mathrm{asin}(v_i/v_j)\ j = 2, \dots, N; i = 1, \dots, j-1$
- Estimate intercepts ($t^i_{refr,i}\ i = 1, \dots N$)

- Estimate thicknesses sequentially

$$\mathrm{h_i} = \left(t^i_{refr,i} - \sum_{j=1:i-1} \frac{2\mathrm{h_j}\cos\theta_{j(i+1)}}{v_j}\right) * (v_i/2\cos\theta_{i(i+1)})$$