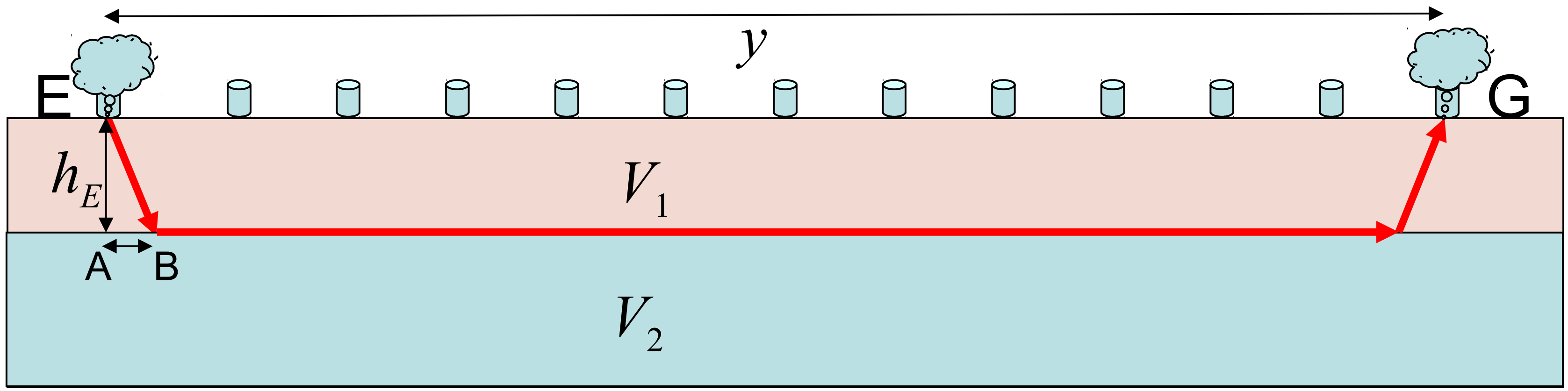
Refraction from an irregular surface: ***Delay-Time Method***



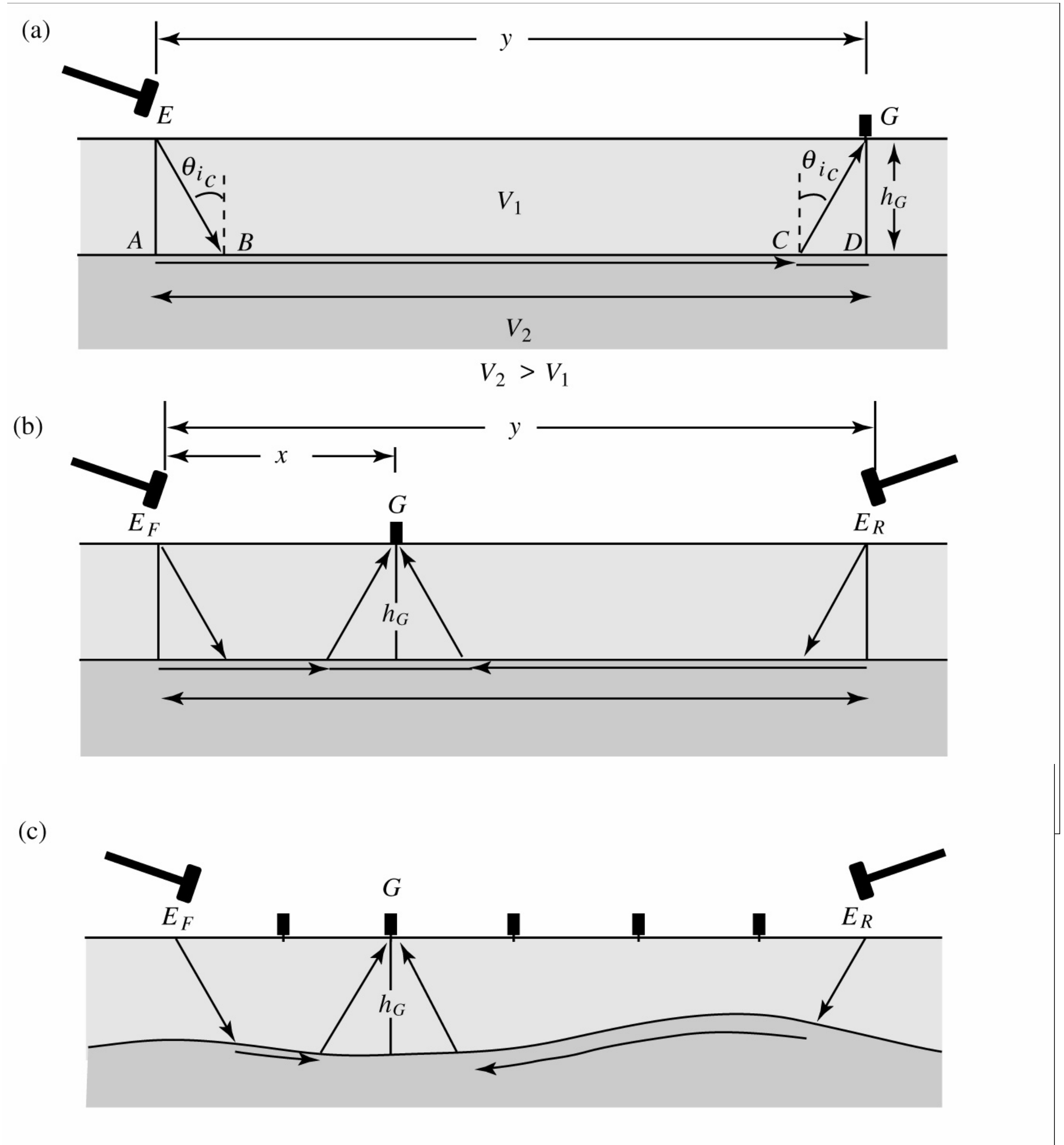
Define ***delay time*** as the time the ray traveled in layer 1 along a "slant path", less the time it would have taken to travel the horizontal distance (AB) at velocity V_2. Thus, the total delay time τ_{EG} traveling from E to G (or G to E) is

$$\tau_{EG} = t_R - \frac{y}{V_2}$$, where t_R is total travel time.

Delay time under E: $$\tau_E = t_R - \frac{y}{V_2} - \tau_G = \frac{EB}{V_1} - \frac{AB}{V_2}$$

$$\tau_E = \frac{h_E}{V_1 \cos i_c} - \frac{h_E \tan i_c}{V_2} = h_E \frac{\sqrt{V_2^2 - V_1^2}}{V_1 V_2} \Rightarrow h_E = \tau_E \frac{V_1 V_2}{\sqrt{V_2^2 - V_1^2}}$$

(This is half of the "time intercept" on our t–x plots!)



Key Assumptions

τ_H from E ≈ τ_H from G

Refractor surfaces are planar

* Beneath source
* Beneath geophone

Refractor surface undulations are small compared to its extent

- i.e., long wavelength, with dips <10º

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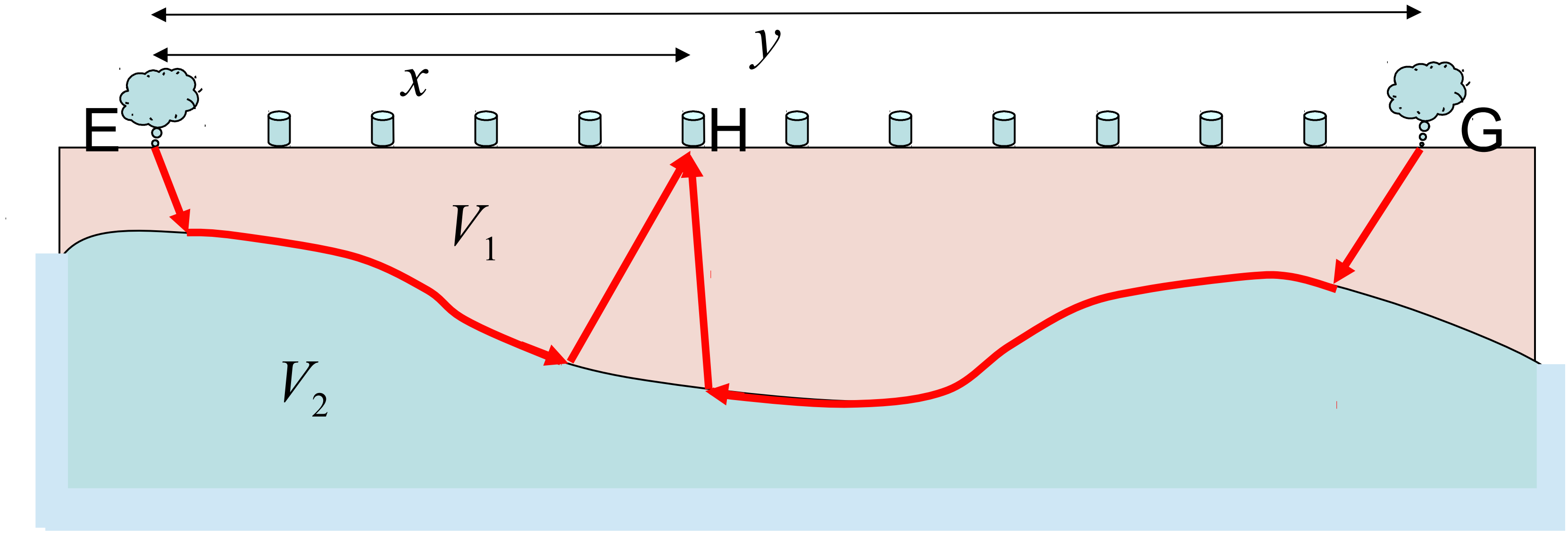


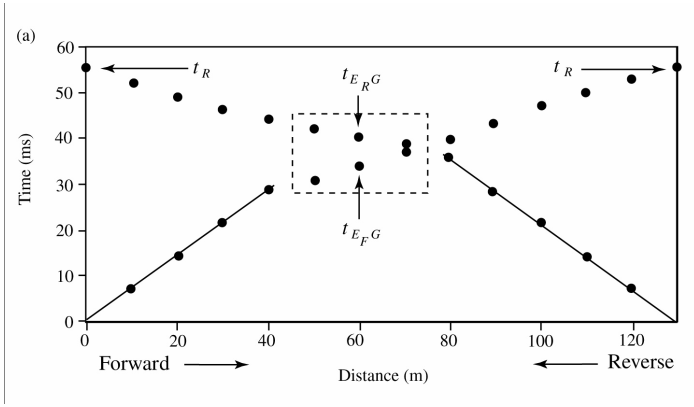
$$t_{EH} + t_{GH} \rightarrow \tau_H = \frac{t_{EH} + t_{GH} - t_{EG}}{2} \qquad h_H = \tau_H \frac{V_1 V_2}{\sqrt{V_2^2 - V_1^2}}$$

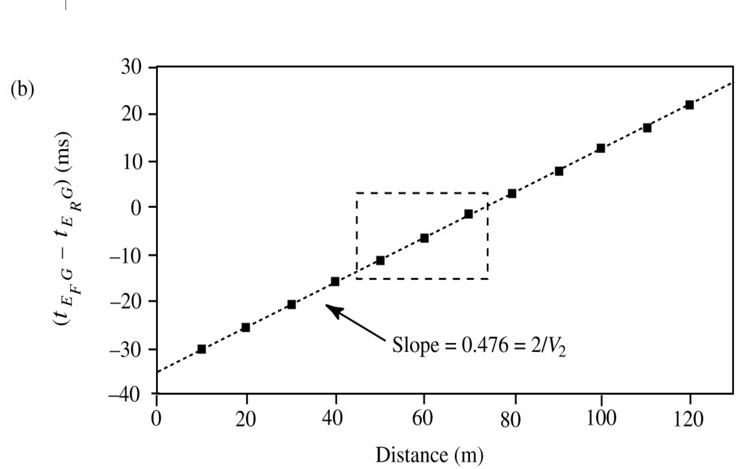
Problem however: to get h_H from τ_H, we need to know V_2! However, we have:

$$t_{EH} - t_{GH} = \left(\tau_E + \tau_H + \frac{x}{V_2}\right) - \left(\tau_G + \tau_H + \frac{y-x}{V_2}\right) = \tau_E - \tau_G - \frac{y}{V_2} + \frac{2x}{V_2}$$

($\Rightarrow$ a line with slope $2/V_2$!)

Delay Time, or "Plus-Minus" Method

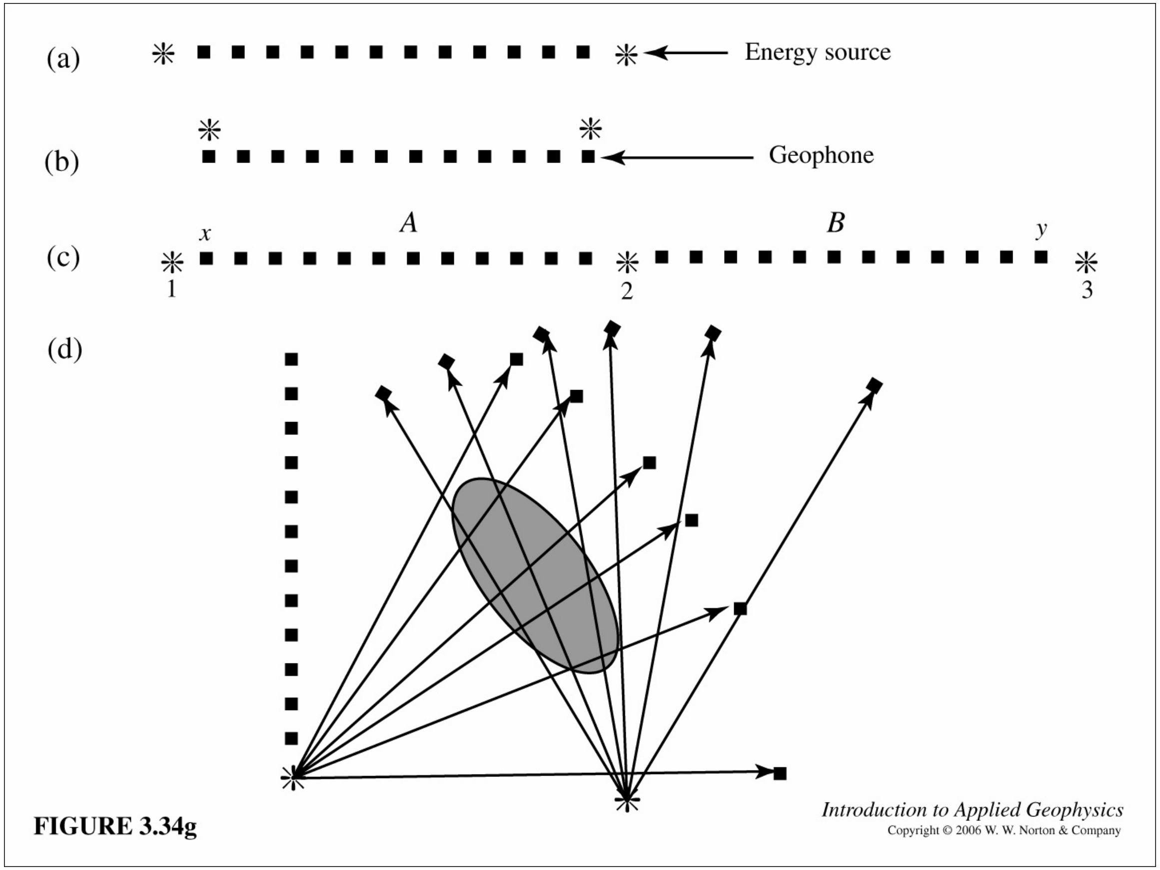




- Plot t_{1i}–t_{2i} vs x_i for SP1, SP2 and all geophones i.
- Calculate V_2 from slope of the line fit ($V_2 = 2/m$).
- At each geophone i, calculate thickness as:

$$h_i = \left(\frac{t_{1i} + t_{2i} - t_{12}}{2}\right)\frac{V_1 V_2}{\sqrt{V_2^2 - V_1^2}}$$

Key Field considerations



* **Local Geology**
* **Spread-lengths**
  - bedrock depths of 50-70 *m*
  - $L_{min} + n.\Delta x_{take\text{-}out}$
  - Typically, L_{min} ~ 200 *m*, ***n*** > 3
* **Geophone coupling**
  - Auger 1 m deep holes
  - Fill with water to saturate
* **Elevation effects**
  - Minimize OR use elevation corrections
* **Wind**
  - calm day
  - night-time
* **Continual Traffic**
  - vehicles, trains
  - pedestrians
* **Source**
  - Hammer or shotgun?
* **Signal Attenuation**
* **Noise filtering**