Sources of Noise

- Ground motion caused by other things
  - Wind shaking trees
  - Traffic, running motors, people banging on stuff
  - Sounds in the atmosphere (aircraft, thunder)
- Electrical noise
  - Bad cable connection, wet connectors
  - Motion of cables in Earth’s magnetic field
- Geologic noise
  - Structures to the side of the survey line
  - Subsurface complexity we can’t model
What will ray paths look like?
Can we observe all three layers?
What will ray paths look like?

- Each layer will refract the ray path to shallower angles
- Each layer will make its own head wave
Multiple subsurface layers

Time = 198 ms

Depth (m)

Distance (m)

Reflected

Direct

Head Wave (B1)

Head Wave (B2)
Multiple subsurface layers

- $V = 1500 \text{ m/s}$
- $V = 3000 \text{ m/s}$
- $V = 4500 \text{ m/s}$
Multiple subsurface layers

\[ D_1 = \frac{t_{01} \nu_2 \nu_1}{2\sqrt{(\nu_2^2 - \nu_1^2)}} \]

\[ D_2 = \left[ t_{02} - \frac{2D_1 \sqrt{(\nu_3^2 - \nu_1^2)}}{\nu_3 \nu_1} \right] \left( \frac{\nu_3 \nu_2}{2\sqrt{(\nu_3^2 - \nu_1^2)}} \right) + D_1 \]
- Low velocity layers

![Diagram of hidden layers with velocities V1 = 1500 m/s, V2 = 1000 m/s, V3 = 5000 m/s, and no head wave generated.](image)
- Low velocity layer
  - Layer will not appear
  - Will cause thickness of upper layer to be overestimated
Thin layers with large velocity contrasts

- Head wave from middle layer is overtaken by head wave from bottom layer
- Leads to an incorrect depth measurement for high velocity region
- Misses existence of thin intermediate velocity layer
Extra distance waves have to travel
Cross over distance will be at a larger offset & $\text{hs}$ will be overestimated.

Velocity of 2nd layer will be too small.

$\text{hs}$ – thickness of upper layer below source.
Cross over distance will be at a smaller offset & hr will be underestimated

Velocity of 2\textsuperscript{nd} layer will be too large

hr – thickness of upper layer below source
How to deal with dipping layers

Source 1: shot down dip
Source 2: shot up dip

Flat Layer: Shot Both Directions

Time (ms)

Position (m)

1/\sqrt{2}   1/\sqrt{2}

1/\sqrt{1}   1/\sqrt{1}
How to deal with dipping layers

$V_1$ is the same both ways
$V_2$ changes with direction

\[
\frac{1}{v_2} = \frac{\left(\left|\frac{1}{v_{2a}}\right| + \left|\frac{1}{v_{2b}}\right|\right)}{2}
\]
How to deal with dipping layers

- Calculate layer depth \((h_s \text{ and } h_r)\) using \(t_{01a}\) and \(t_{01b}\)
- Use distance between sources and geometry to calculate dip

\(t_{01a}\) (zero-offset time) will be different from \(t_{01b}\)
Multiple dipping layers

First Arrivals: Two Dipping Layers

Time (ms)

Distance (m)

1/V3a
1/V3b
1/V2a
1/V1

Source Location a
Source Location b