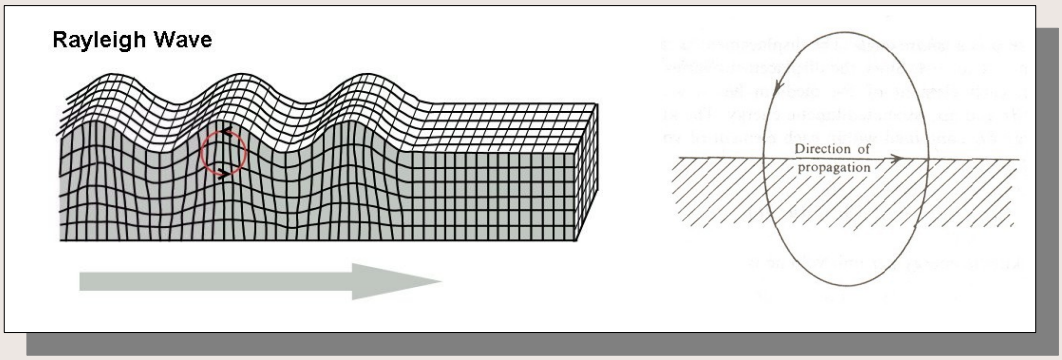
Surface waves

- Rayleigh and Love waves
- Particle motion
- Phase and group velocity
- Dispersion

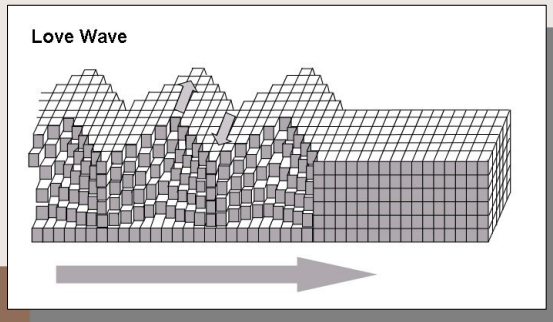
- Reading:
  - Telford *et al*., Sections 4.2.4, 4.2.6

Surface wave types

- When a medium is bounded by a velocity contrast (*e.g.*, the *free surface*), additional types of waves exist:
  - Rayleigh waves (a mix of *P*- and *SV* wave motions)
    - Elliptical particle motion confined to the vertical plane;
    - Velocity < V_S (for $\sigma = 0.25$, $V_R = 0.92V_S$);



  - Love waves (*SH*) (*A.E.H. Love, 1911*)
    - Horizontally-polarized;
    - Requires *layered* subsurface.
    - Velocity intermediate between V_S of the layers.

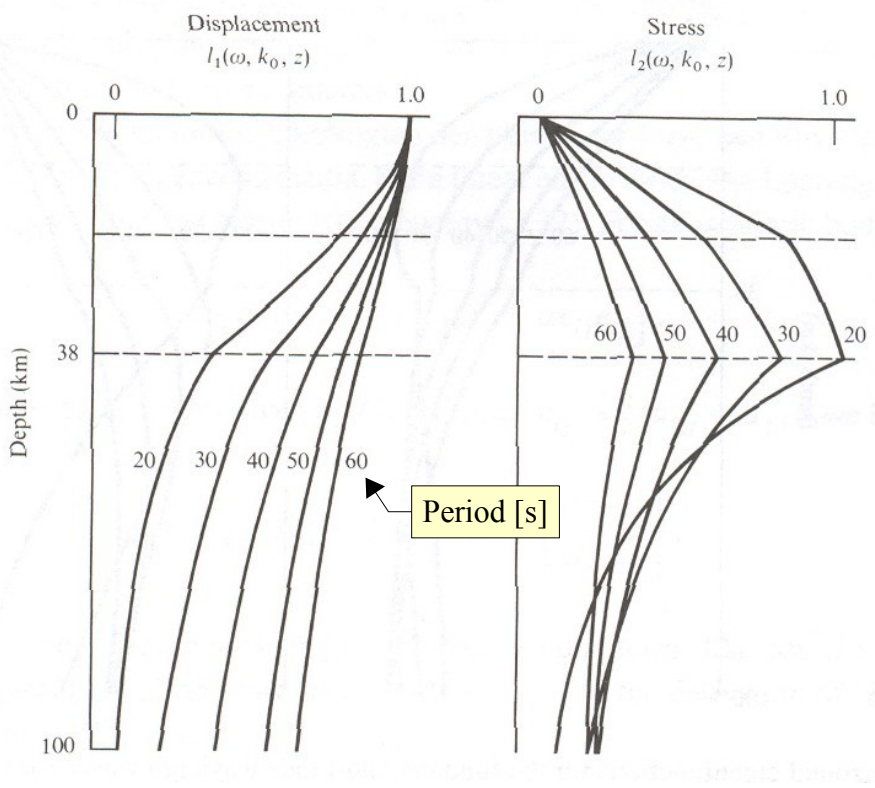


Surface wave properties

Amplitude vs depth

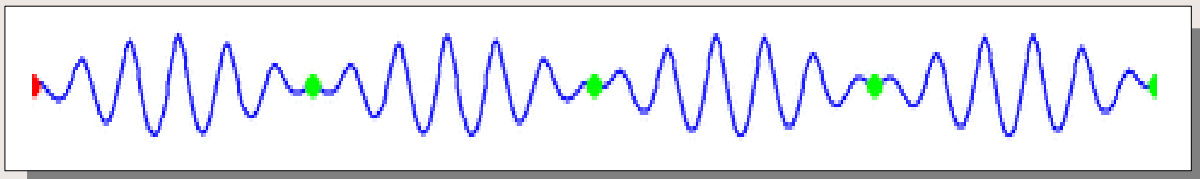
- For all surface waves, amplitude exponentially decays away from the surface.
- With distance, amplitude decay is *slow*, $\sim\sqrt{R}$
  - Therefore, surface waves override reflections.

Displacement and stress in Love wave



Dispersion

- All surface waves exhibit *dispersion*:
  - Harmonic components propagate at different *phase* velocities that also differ from the *group* velocity of the energy packet;
  - Wave group ("wavelet") changes shape during propagation.

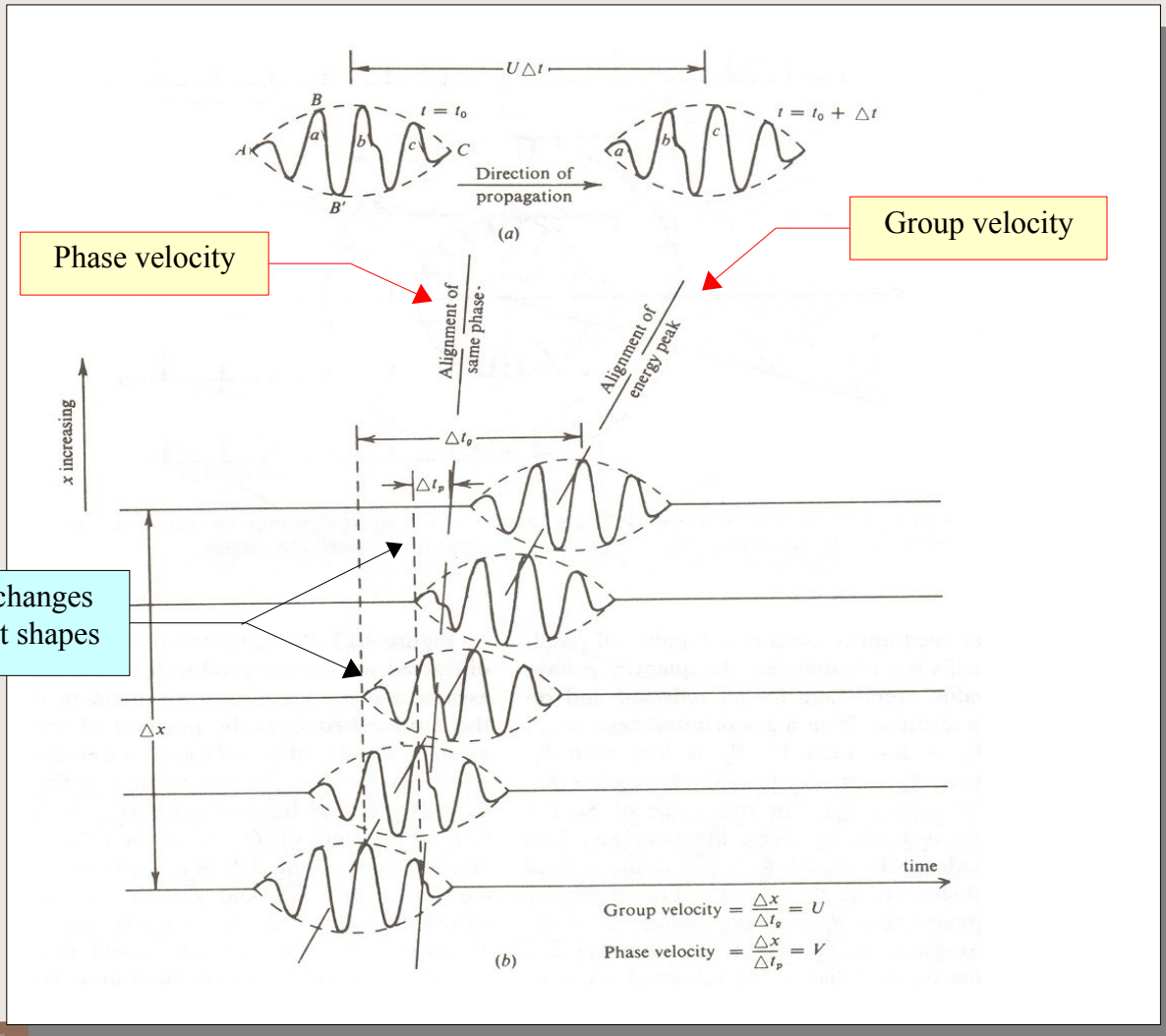


Phase and Group velocities

- Usually, group velocities are slower than phase velocity

. ..and both decrease with frequency

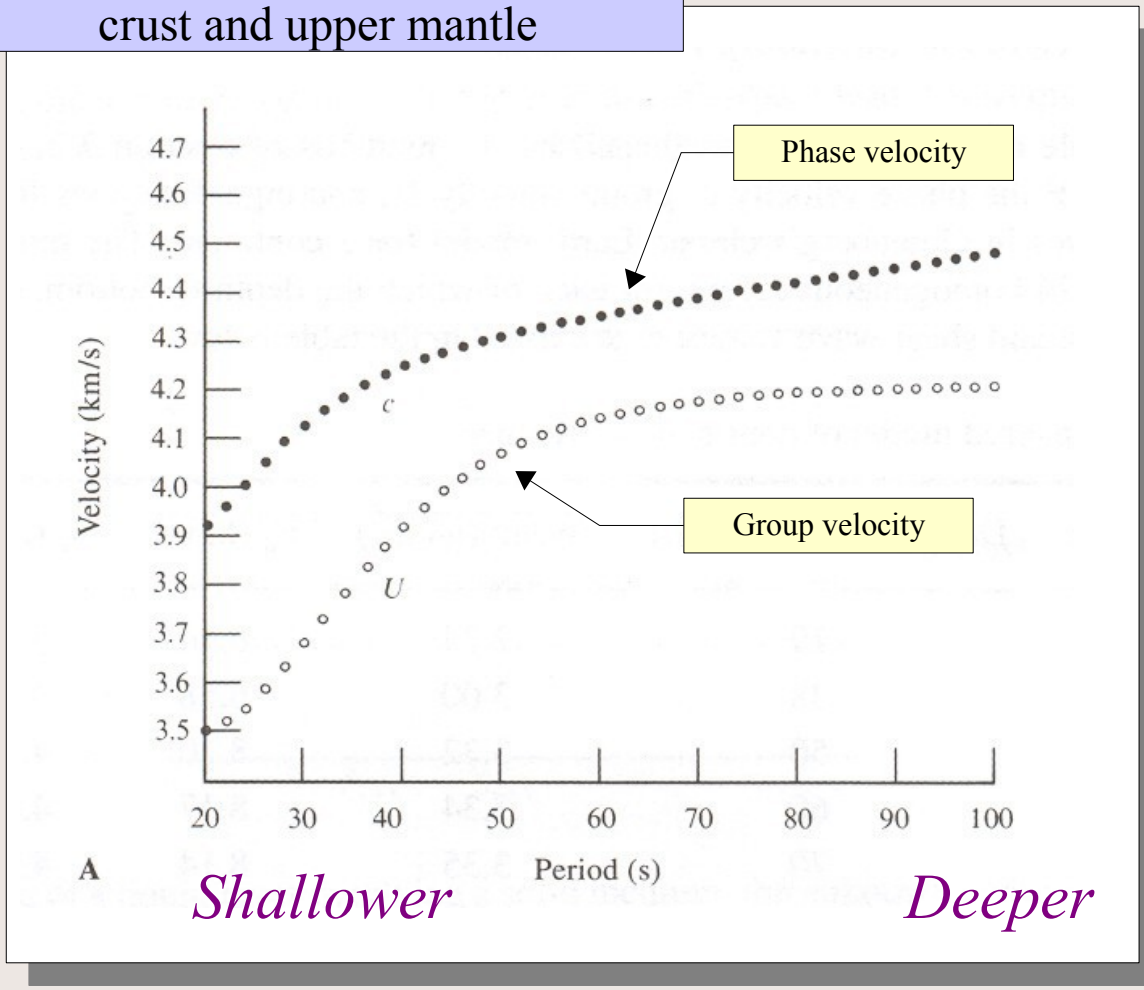
- This is called "normal dispersion":



Note the changes in wavelet shapes

Example:
normal dispersion of surface waves

Long-period Love waves within the crust and upper mantle



- Normal dispersion occurs because the deeper layers are generally faster