Planetary Interiors

Earth's Interior Structure

Hydrostatic Equilibrium

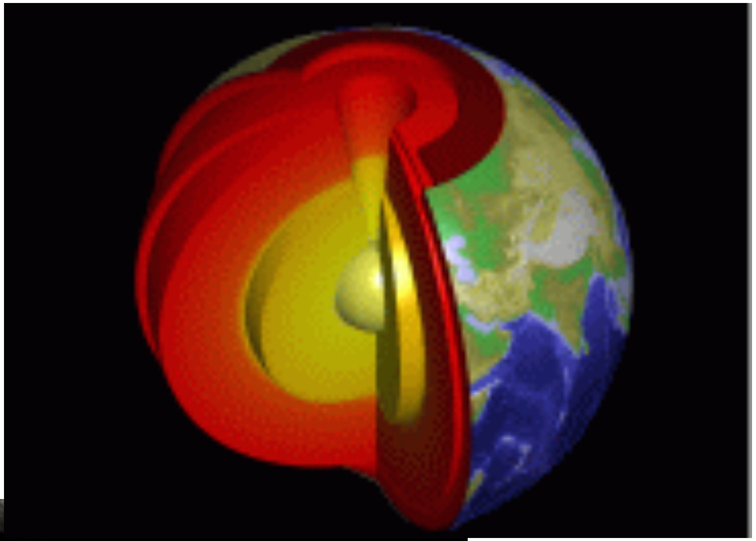
Heating

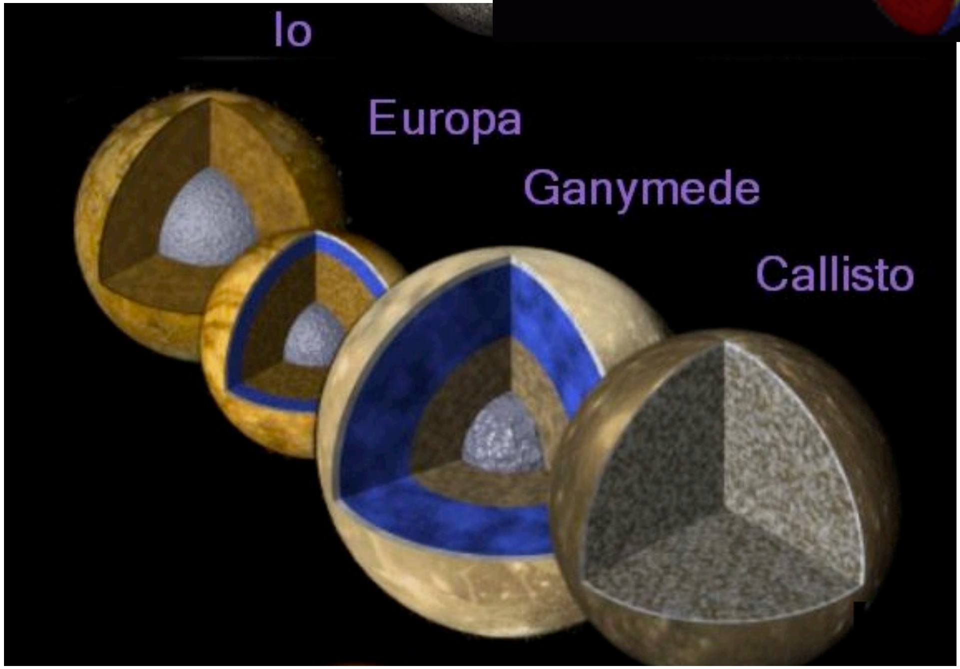
Constituent Relations

Gravitational Fields

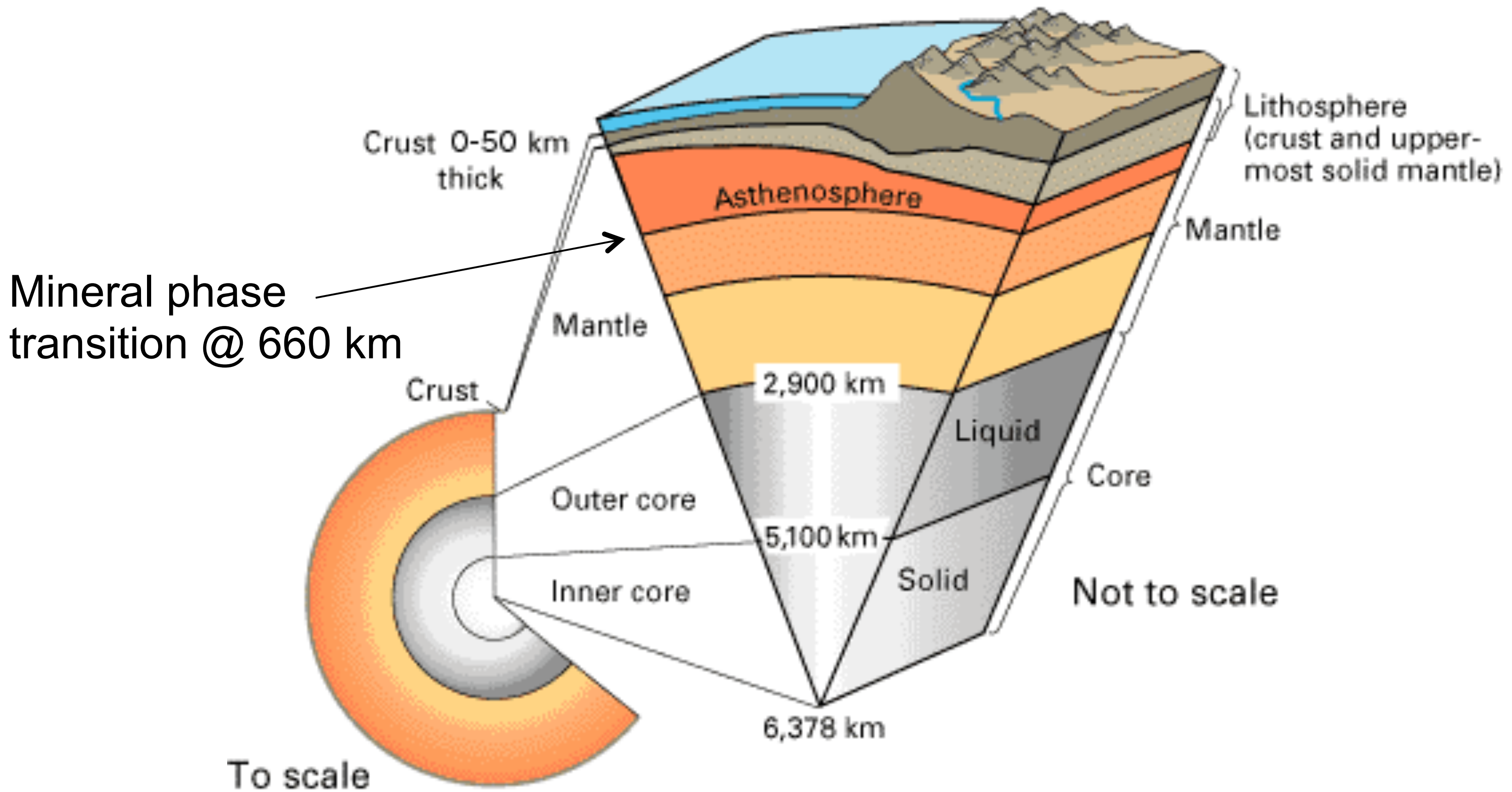
Isostasy

Magnetism

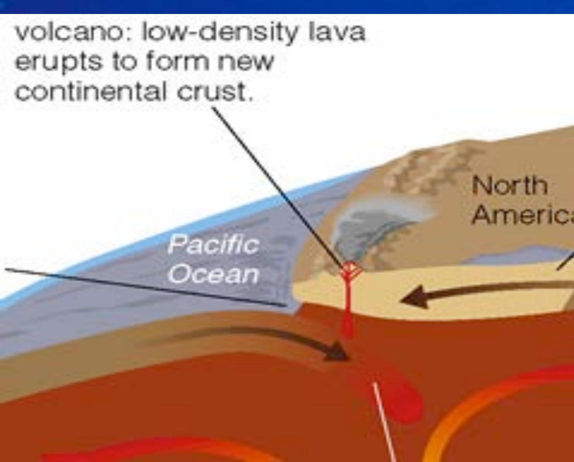




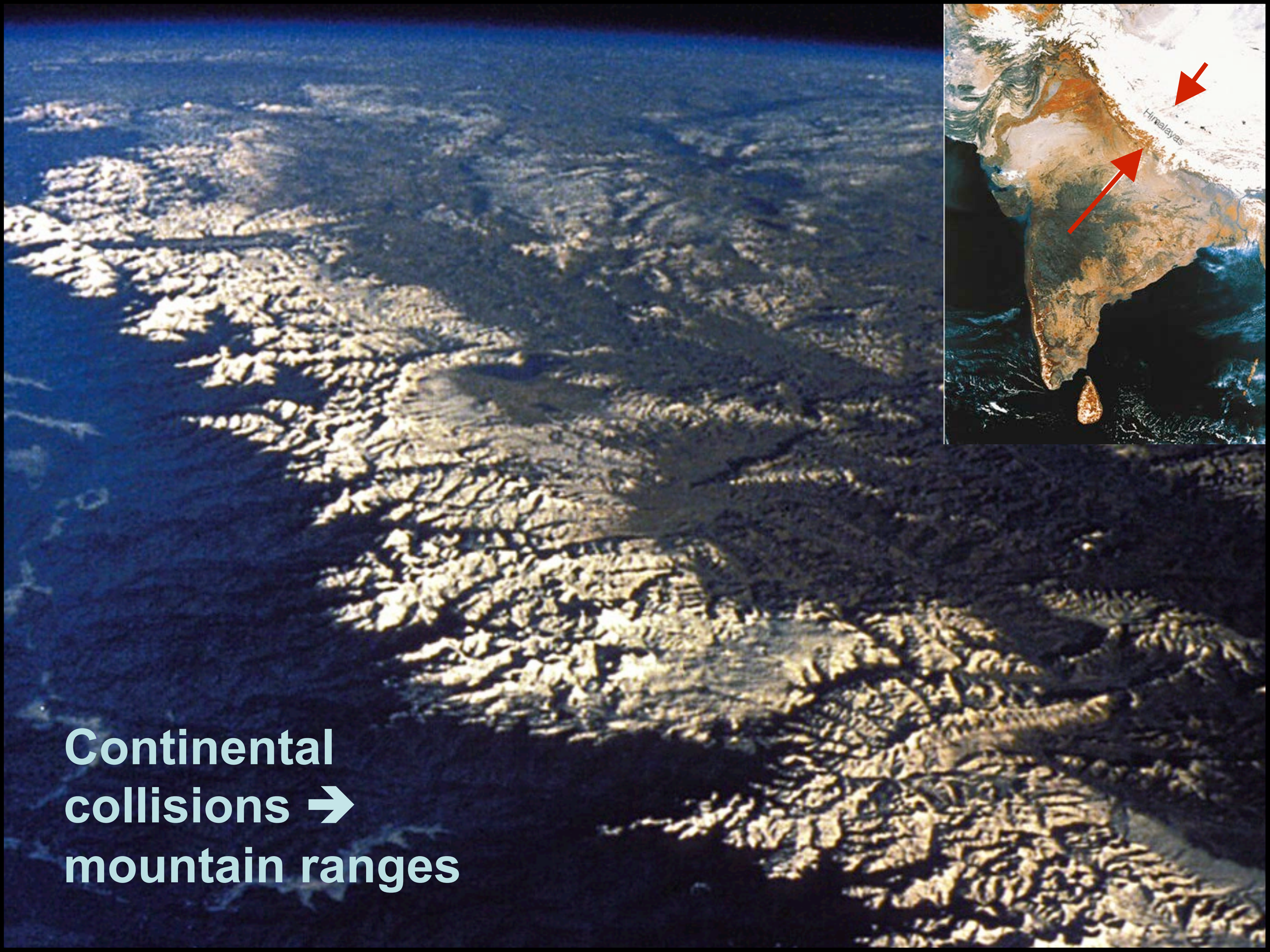
Earth's Interior - Our Terrestrial Template



Determined through a combination of observation and modeling, validated/refined via seismology.

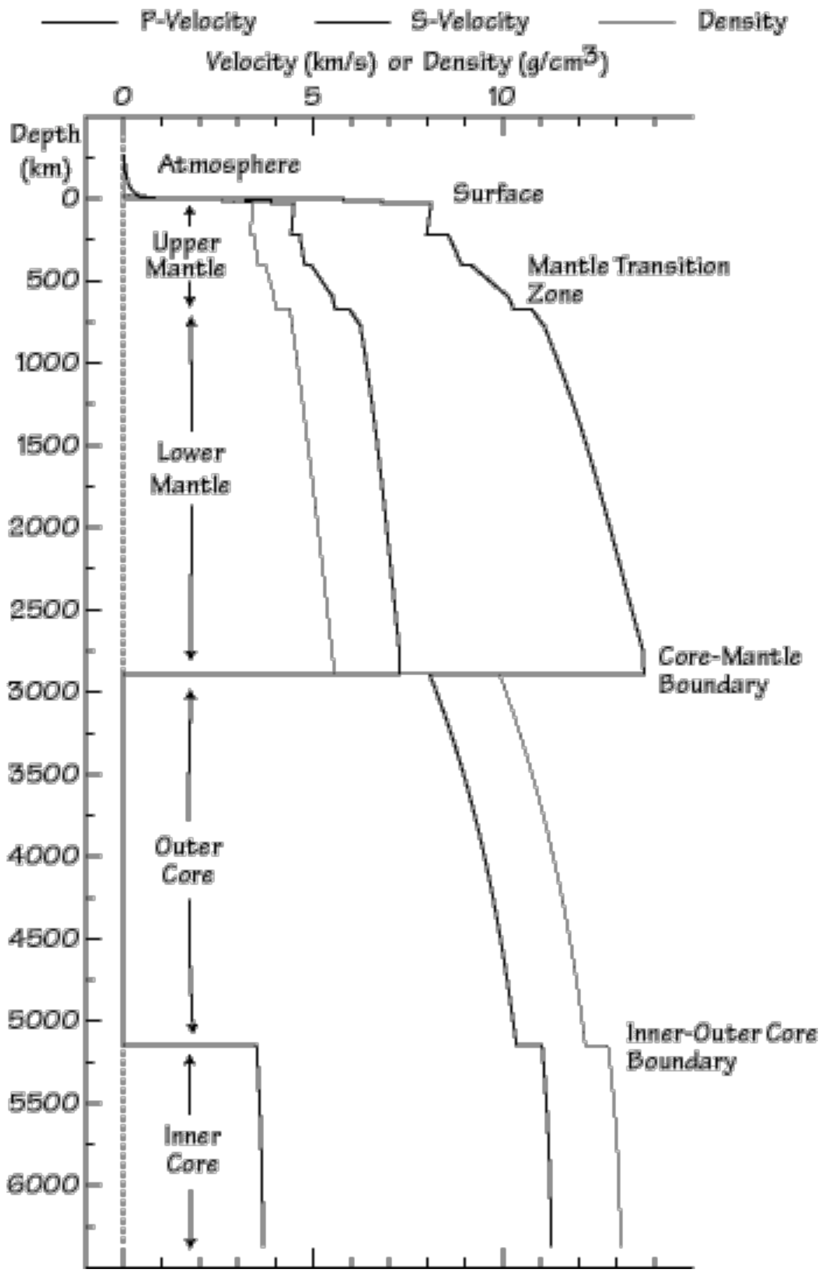


Andes - Pacific ocean plate sinks under South American plate

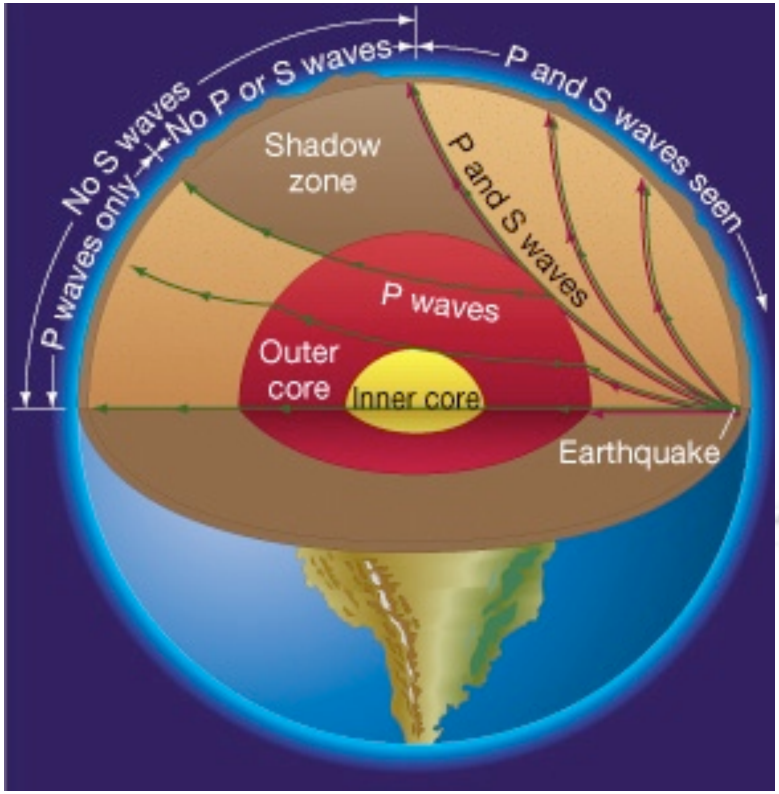


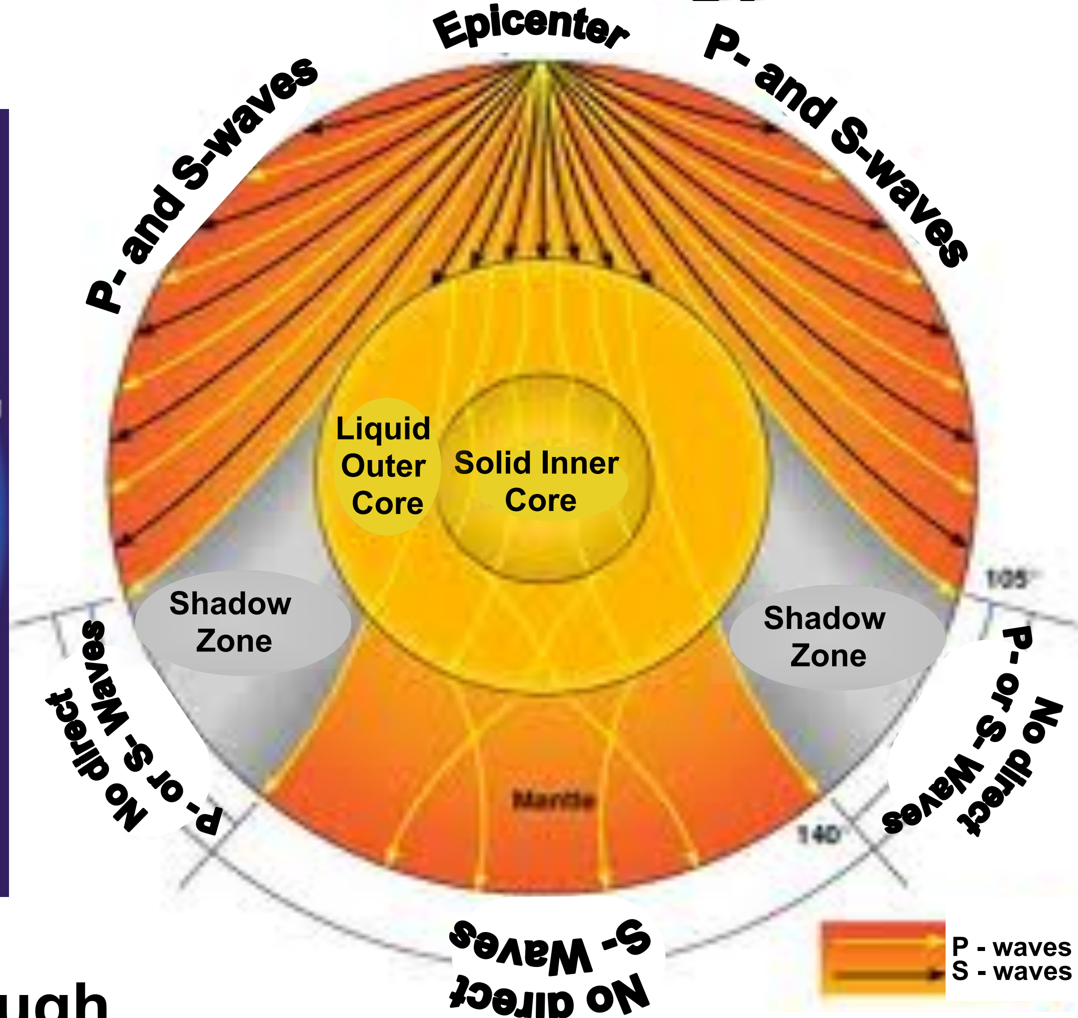
Continental collisions ➔ mountain ranges

Earth's Interior - Our Terrestrial Template



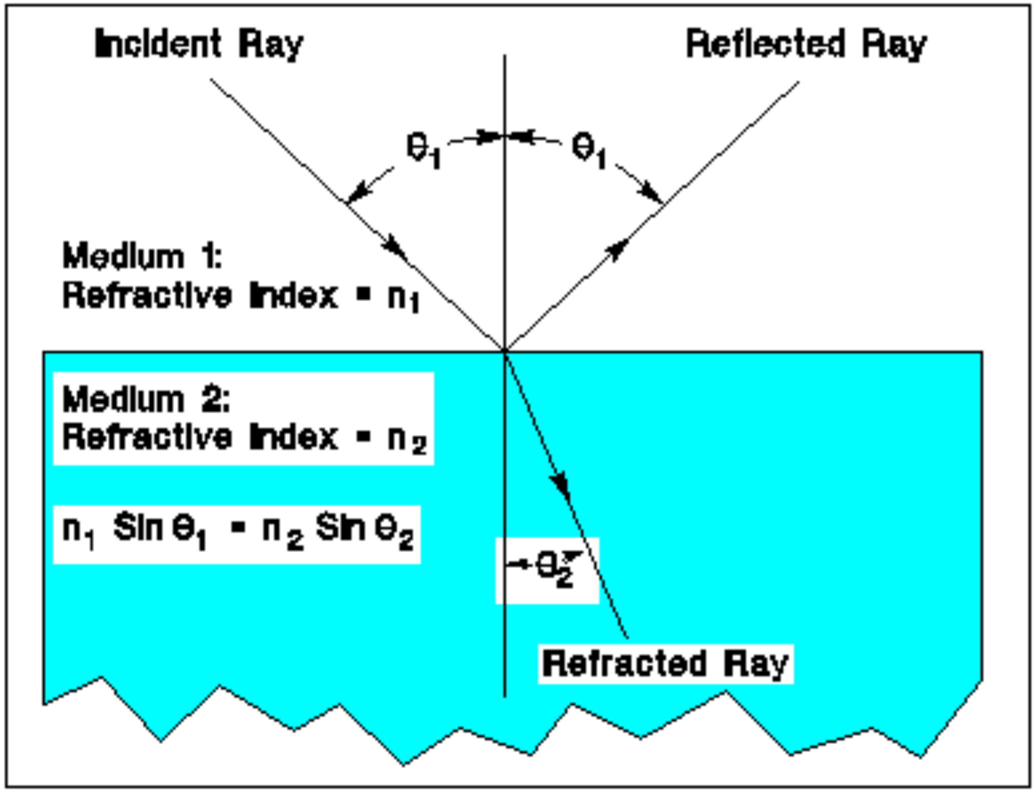
Earth's Interior - Seismology





P - waves can travel through the liquid outer core, while S - waves cannot. Waves are also deflected away from areas of higher density, creating shadow zones where no S - or P - waves are observed.

Wave Phenomena: Snell's law



Snell's law

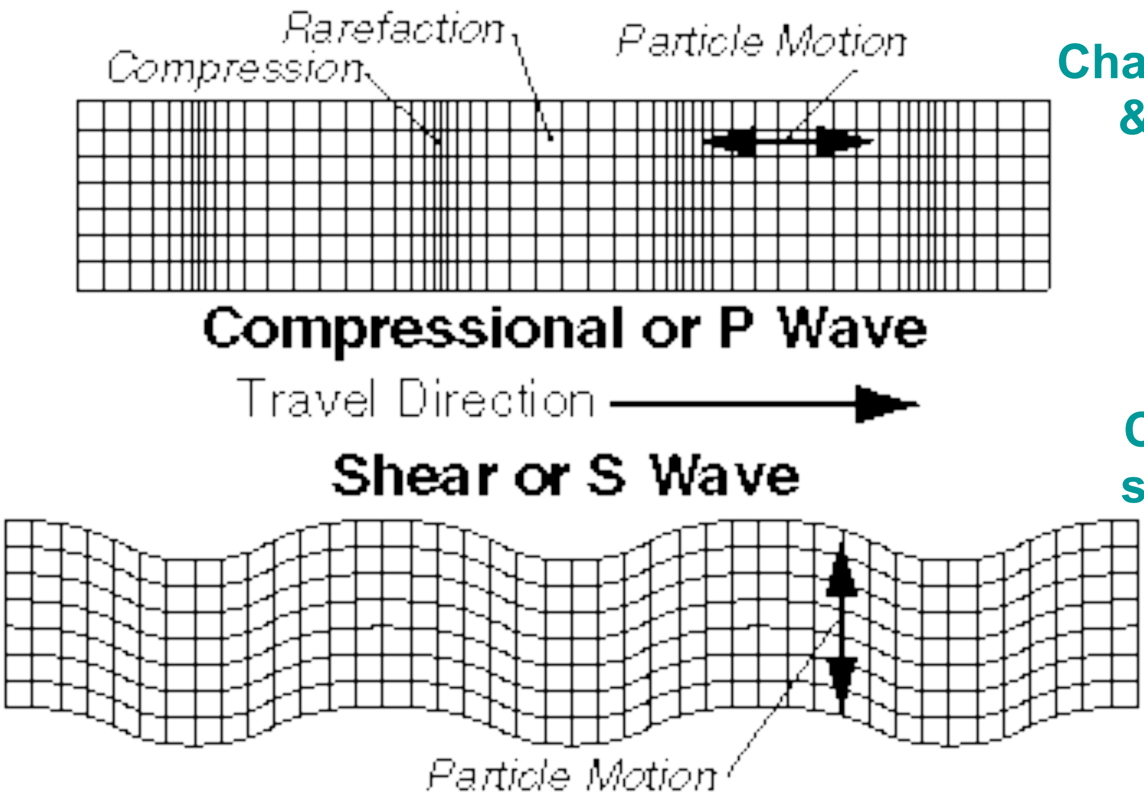
$n = c/v$ (by definition)

therefore

$\sin\theta_1/\sin\theta_2 = v_1/v_2$

Propagation through smoothly varying densities
→ smoothly curved trajectory

Earth’s Interior - Seismology



Change in shape & in volume

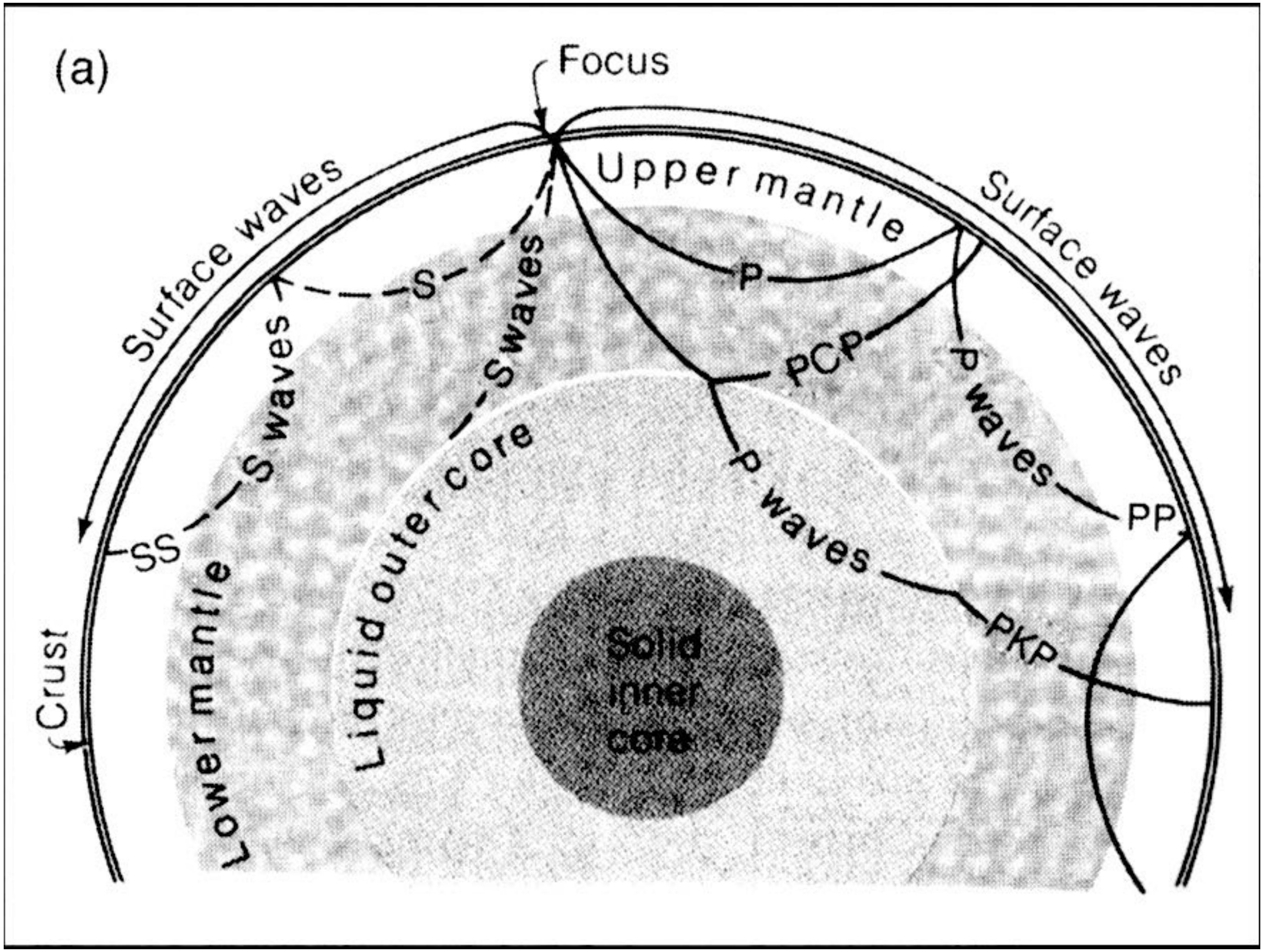
$$v_P = \sqrt{\frac{K_m + \frac{4}{3}\mu_{rg}}{\rho}}$$

Change in shape only

$$v_S = \sqrt{\frac{\mu_{rg}}{\rho}}$$

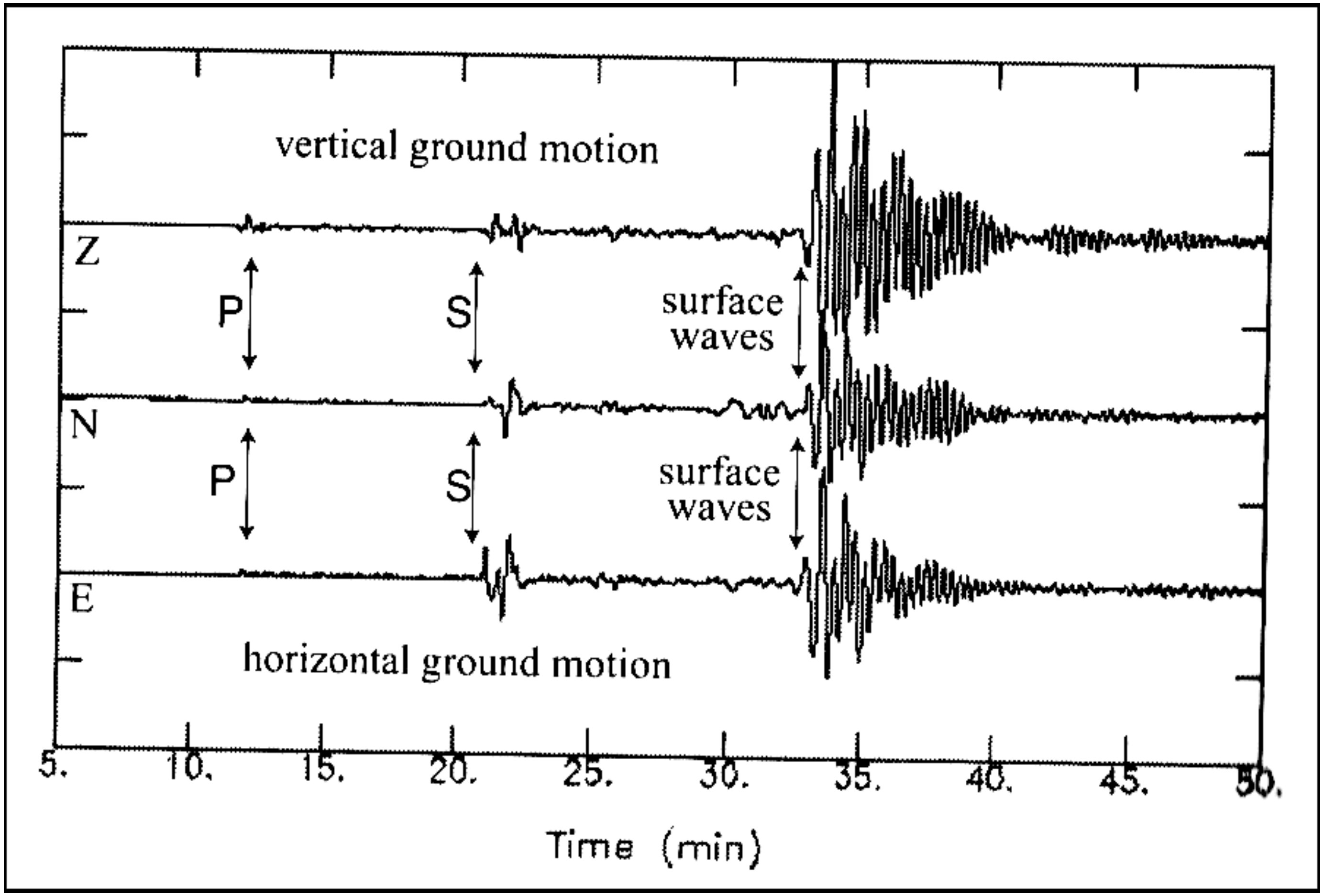
The velocities of these body waves are described above, where K_m is the bulk modulus, or the messure of stress needed to compress a material. μ_{rg} is the shear modulus, or the messure of stress needed to change the shape of a material without changing the volume.

Earth’s Interior - Seismology



de Pater & Lissauer (2010)

Earth's Interior - Seismology



de Pater & Lissauer (2010)

Many seismic stations allow us to watch these propagate…

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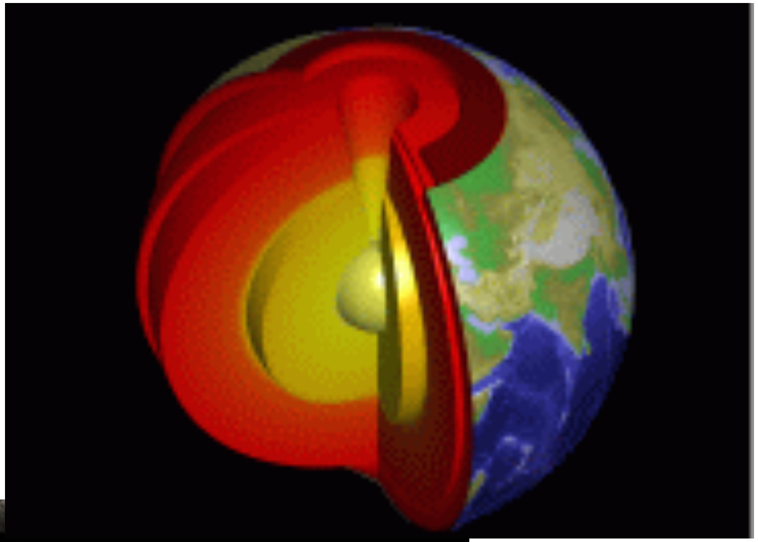

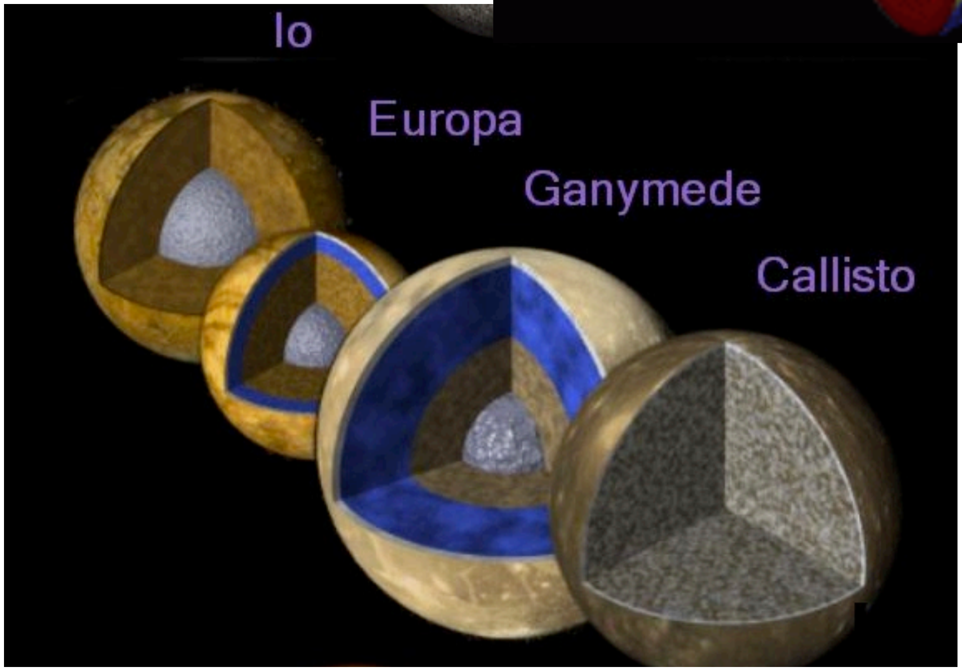

Hydrostatic Equilibrium

First order for a spherical body: Internal structure is determined by the balance between gravity and pressure:

$$P(r) = \int_r^R g_P(r')\rho(r')\,dr'$$

Which is solvable if the density profile is known. If we assume that the density is constant throughout the planet, we obtain a simplified relationship for the central pressure:

$$P_C = \frac{3GM^2}{8\pi R^4}$$

*** Which is really just a lower limit since we know generally density is higher at smaller radii.**

Hydrostatic Equilibrium

Alternatively you can approximate the planet as a single slab with constant density *and* gravity, which gives a central pressure 2x the the previous approach.

Generally speaking, the first approximation works within reason for smaller objects (like the Moon) even though their densities are not entirely uniform.

The second approximation overestimates the gravity, which somewhat compensates for the constant density approximation and is close to the solution for the Earth. It is not enough to compensate for the extreme density profile of planets like Jupiter.

~Mbar pressures for terrestrial planets!

Moment of Inertia

$L/\omega_{rot} = I = 0.4MR^2$ for a uniform density sphere, but most planets are centrally concentrated, so $I < 0.4MR^2$

For planets at hydrostatic equilbrium, can infer *I* from mass, radius, rotation rate and oblateness

Body	I/mr^2
Moon	0.391
Mars	0.365
Earth	0.3307
Neptune	0.29
Jupiter	0.26
Uranus	0.23
Saturn	0.20
Sun	0.06