basic flexural solutions provided in Turcotte & Schubert

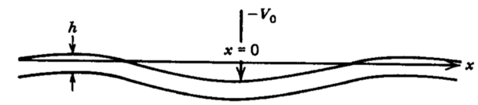


Figure 3-29 Deflection of the elastic lithosphere under a line load.

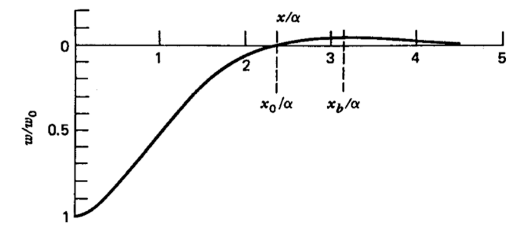


Figure 3-30 Half of the theoretical deflection profile for a floating elastic plate supporting a line load.

$$w = w_0 e^{-x/\alpha} \cos\frac{x}{\alpha} \qquad (3\text{-}142)$$

This profile is given in Figure 3-32.

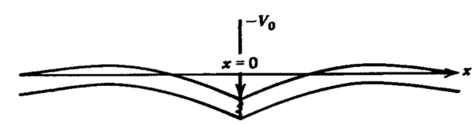


Figure 3-31 Deflection of a broken elastic lithosphere under a line load.

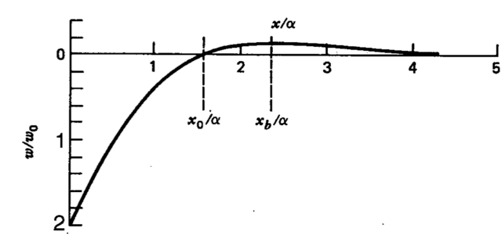


Figure 3-32 The deflection of the elastic lithosphere under an end load.

seamount flexure:

mostly elastic

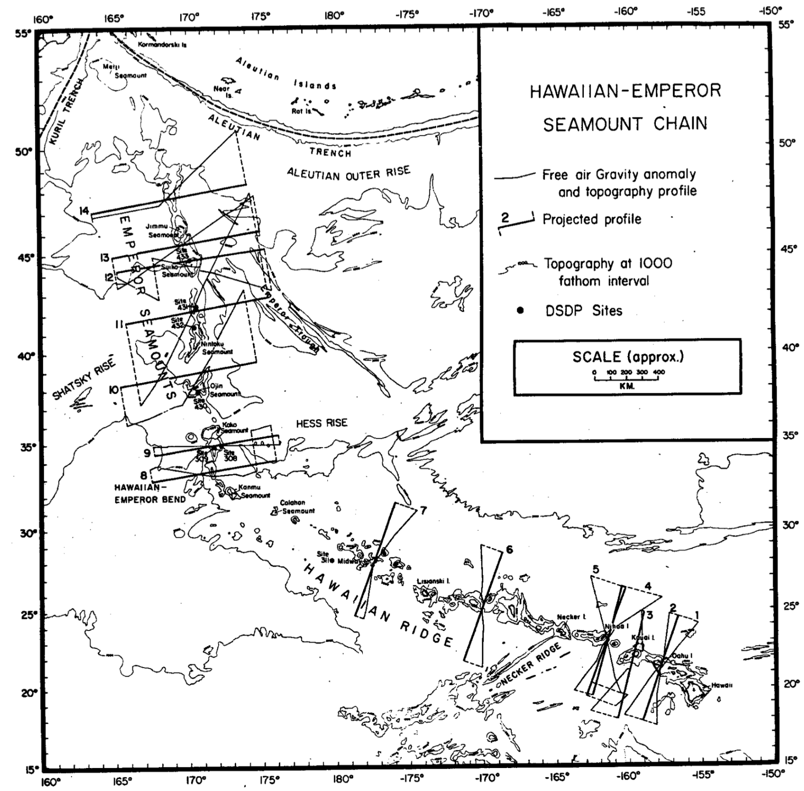
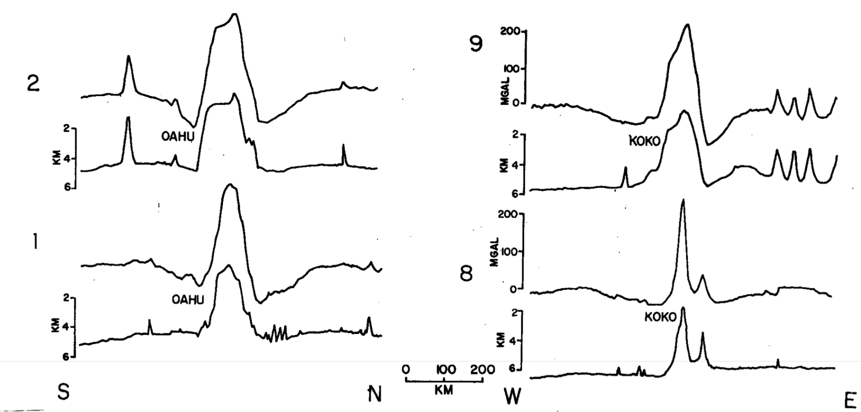


Fig. 1. Location of free air gravity anomaly and bathymetry profiles used in this study. The thin lines indicate the actual ship track, and the heavy lines indicate the profile the data along each track were projected onto. The bathymetry is based on *Chase et al.* [1970]. DSDP sites located on or near the seamount chain are shown as solid circles.

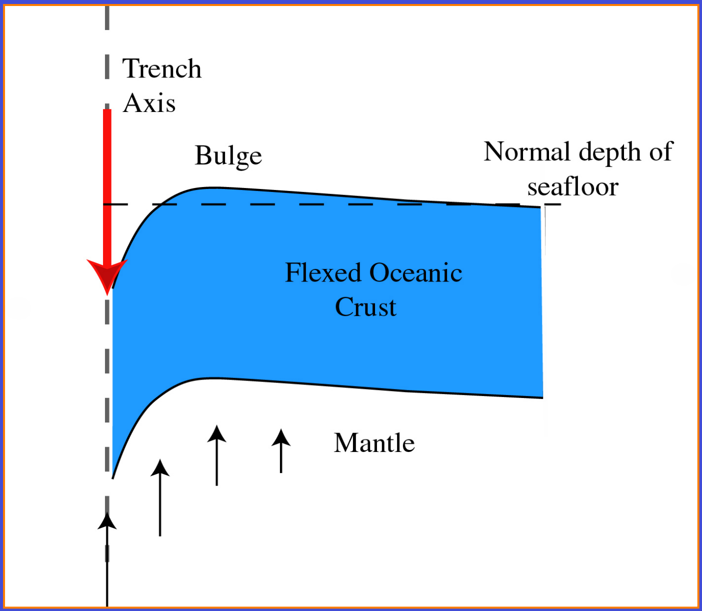


Watts and Cochran, Gravity anomalies and flexure of the lithosphere along the Hawaiian Emperor Chain, Geophys. J. Ror. Astr. Soc., v. 38, p. 119-141, 1979

Topography seaward of the Kuril Trench

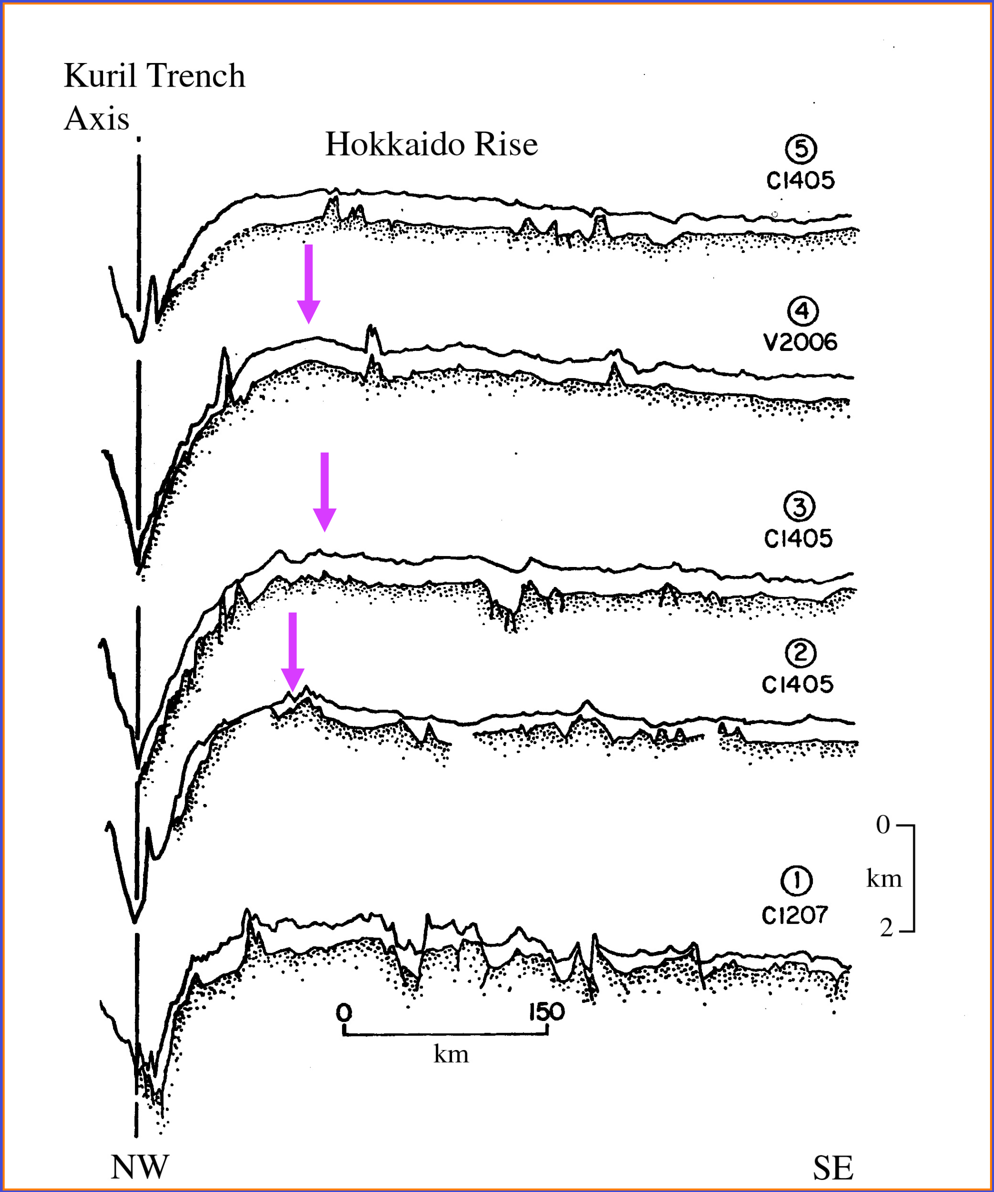
trench flexure:

plastic hinge zone



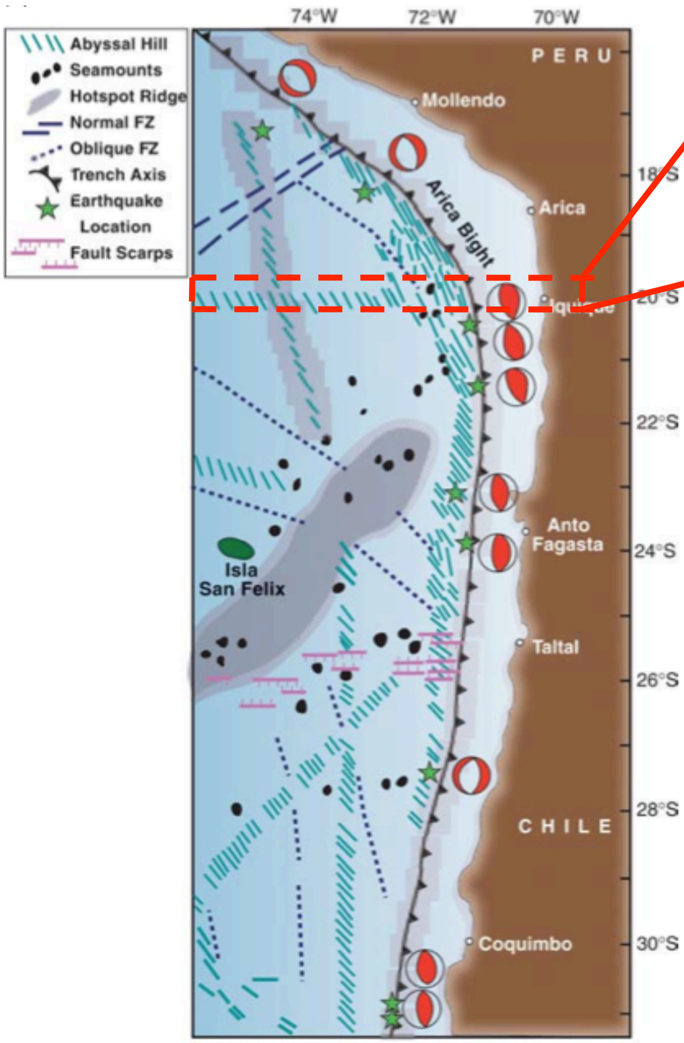
Distance to bulge ~ 120-140 km

T_e ~ 30 km



[slides provided by Tony Watts]

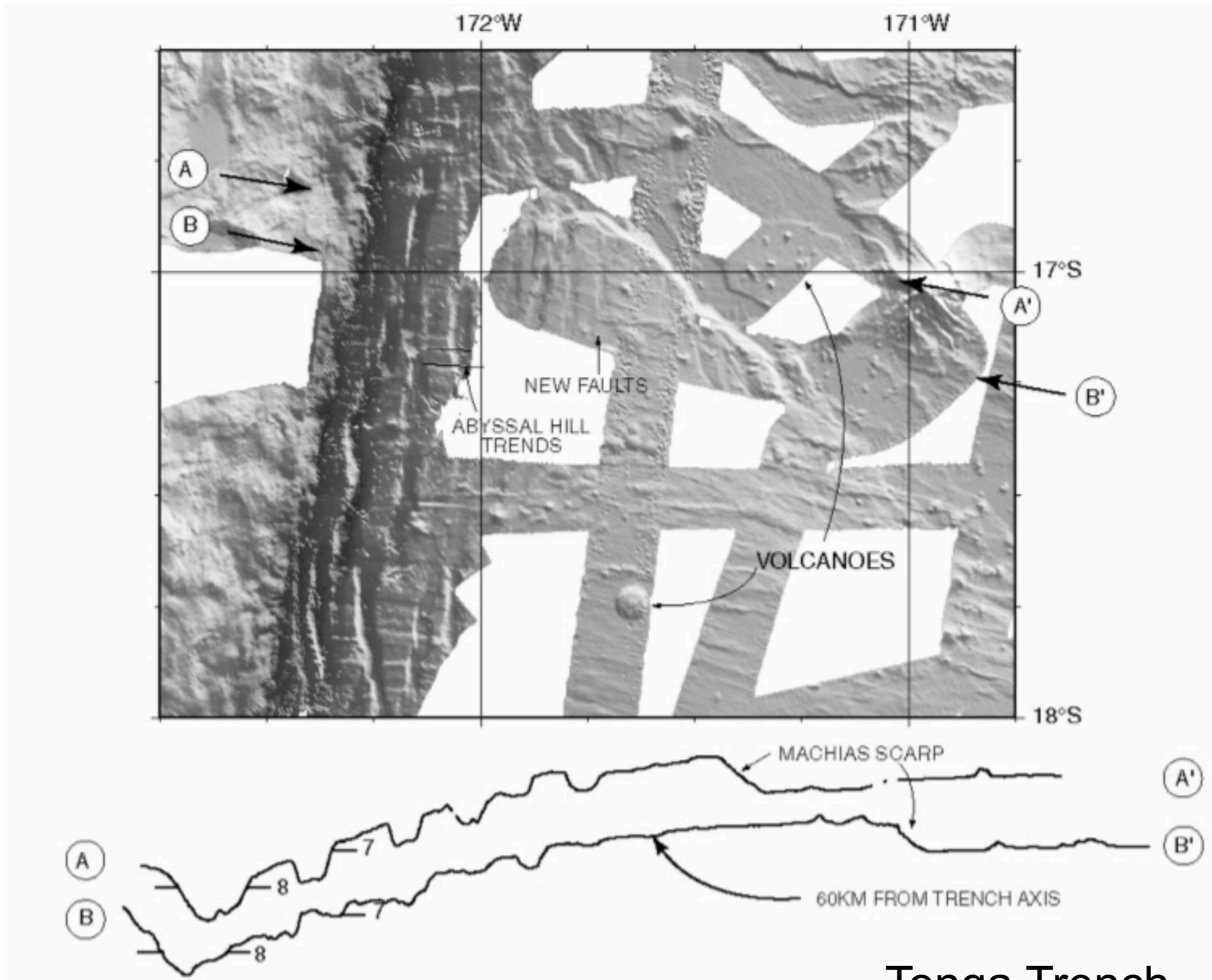
outer trench wall fractures



- The outer rise height can range from 0-1.3 km.
- The outer rise region contains two types of bending-induced faults

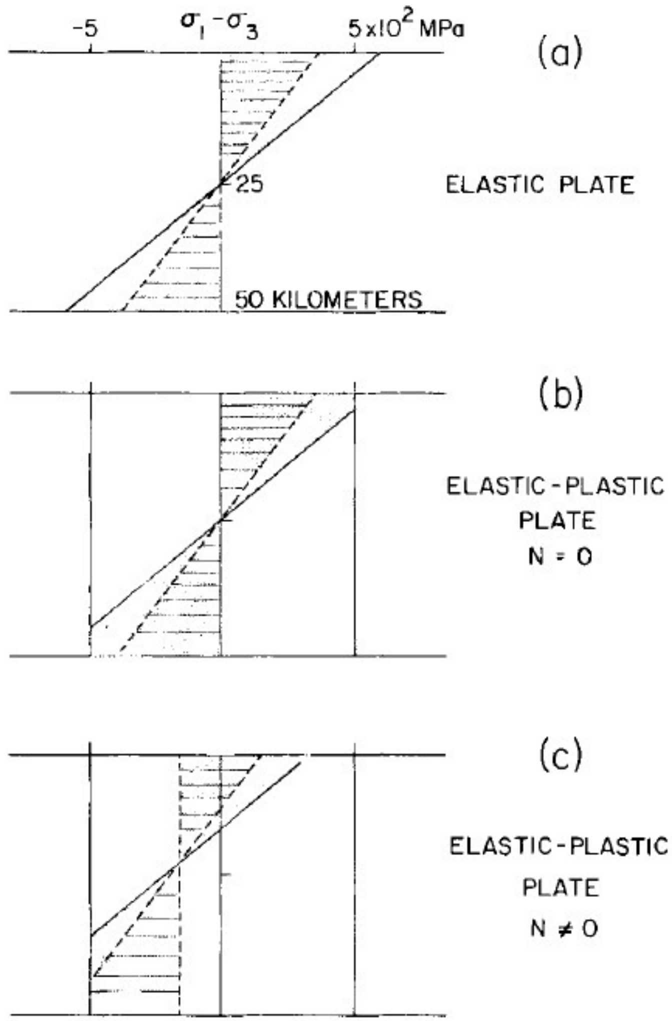
[Mofjeld et al., 2004]

fractures



Tonga Trench
[Massell – 2001]

finite yield strength



Stress difference are linearly proportional to distance from the neutral axis in the elastic plate.

Real earth materials do have a finite strength.

The plate behaves elastically up to the yield stress, at which point the plate fails. Additional strain causes no increases in stress.

finite yield strength

Three zones of rock behavior:

1. Brittle zone

   Upper cool lithosphere. Governed by brittle failure. Strength increases with overburden pressure but is insensitive to temperature, strain rate and rock type.

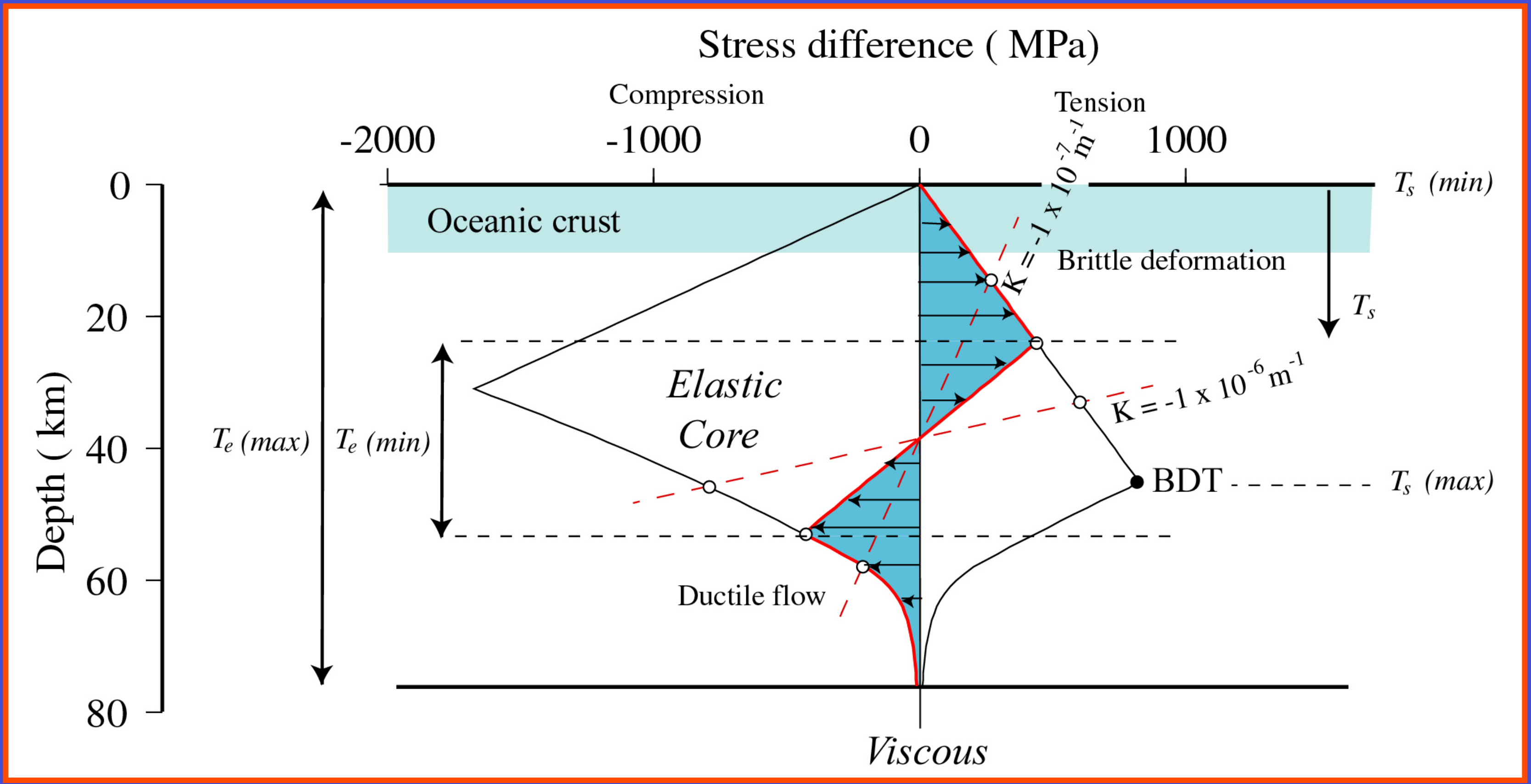
2. Semi-brittle zone

   Both brittle and ductile processes occur, usually not included in the yield envelope.

3. Ductile zone

   Lower hot lithosphere. Governed by ductile flow. Strength is insensitive to pressure effects but decreases with decreasing strain rate.

yield strenth envelope



Oceans : earthquakes occur in the sub-oceanic mantle, but the mantle is also involved in the support of long-term loads.

Continents : earthquakes are rare in the sub-continental mantle, but it is still involved in the support of long-term loads

[slides provided by Tony Watts]

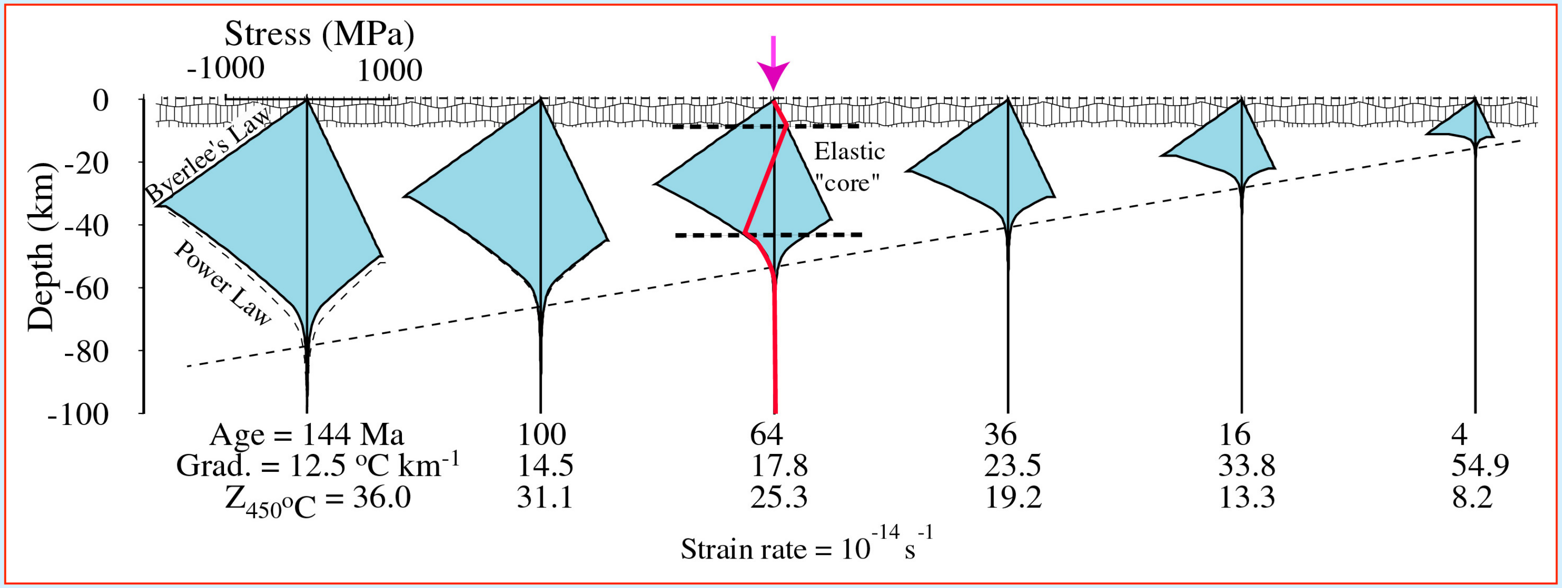
Yield Strength Envelope

The Yield Strength Envelope (YSE) combines the brittle and ductile deformation laws of rock mechanics into a single strength profile for the lithosphere.

The ductile flow law is given by:

$$\dot{\varepsilon} = A_p\,(\sigma_1 - \sigma_3)^n\, e^{-\frac{Q_p}{R_g T}}$$

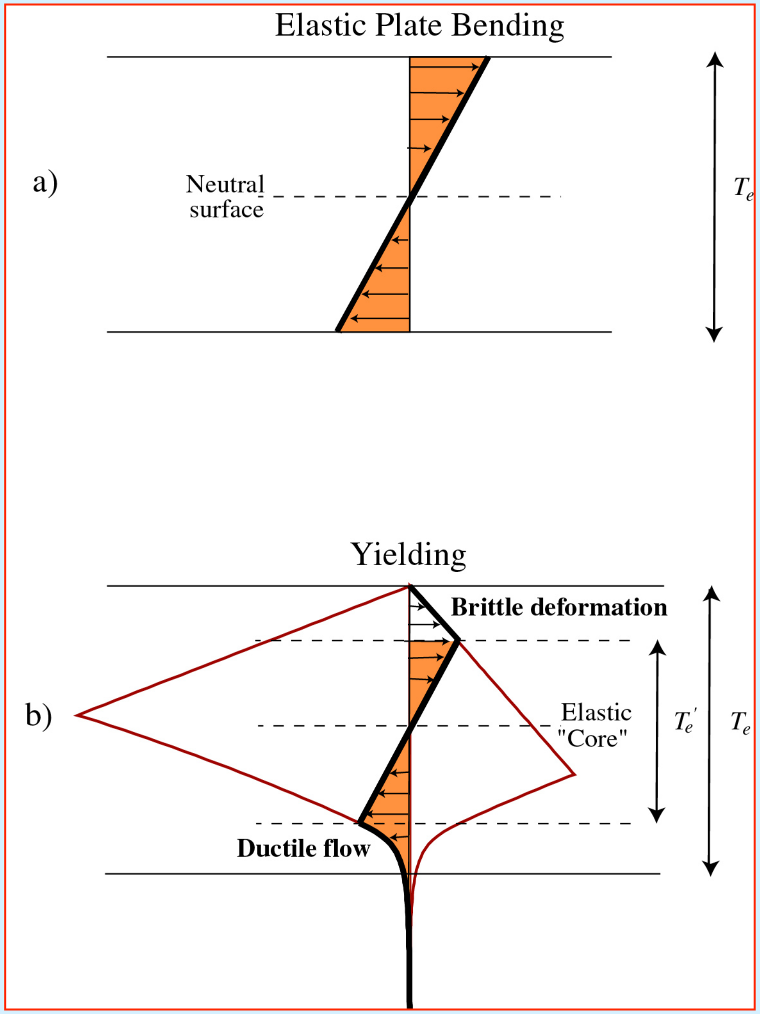
where n is a positive integer, A_n is the power law stress constant, $(\sigma_1\text{-}\sigma_3)$ is the stress difference, Q_p is the power law activation energy, R_g is the universal gas constant and T is temperature.
[Olivine : n=3, A_n =7.0 x 10^{-14} and Q_p =520 kJ mol^{-1}]



The area under the YSE is a measure of the **integrated strength** of the lithosphere. The YSE shows that the thickness of the strong zone is greater than the elastic core and increases linearly with the square root of age.

[slides provided by Tony Watts]

T_e and the Yield Strength Envelope



The elastic model implies that all stresses are supported elastically and that the maximum stresses accumulate in the uppermost and lowermost part of the plate.

$$M_{elastic} = \int_{\frac{T_e}{2}}^{\frac{-T_e}{2}} \sigma_x \, y_f \, dy$$

$$\frac{1}{r} = K = \frac{-M_{elastic}\ 12\,(1-\nu^2)}{E\,T_e^3}$$

In the YSE model, however, stresses are relieved by brittle failure in the uppermost part of the plate and by ductile flow in the lowermost part.

$$M_{YSE} = M_{upper} + M_{core} + M_{lower}$$

T_e' of an inelastic plate (ie one that yields) can be computed from M_{YSE} by assuming it to have the same curvature as an elastic plate.

[slides provided by Tony Watts]