2.1 Convection caused by thermal gradients in the upper mantle is thought to be a primary cause of continental drift. Estimate the average thermal gradient in the upper mantle.

The temperature of the upper mantle varies considerably. At depths less than about 160 km (100 miles), the average gradient from Fig. 2.4 is about

$$13\,^{\circ}F/\text{mile} = 11.6\,^{\circ}C/\text{km}$$

At depth of 160 km - 650 km (100-400 miles), the average gradient is about

$$1\,^{\circ}F/\text{mile} = 0.9\,^{\circ}C/\text{km}$$

The overall average gradient (from bottom to top) is about

$$4.6\,^{\circ}F/\text{mile} = 4.1\,^{\circ}C/\text{km}$$

2.2 The coefficient of thermal expansion of the upper mantle is about 2.5×10^{-5}/°K. Estimate the ratio of the density at the top of the upper mantle to that at the bottom on the upper mantle.

Temperature at top of upper mantle ≈ 1500°F = 816°C = 1089°K

Temperature at bottom of upper mantle ≈ 3500°F = 1927°C = 2200°K

Temperature difference = 2200°K − 1089°K = 1111°K = ΔT

Assume volume of element at top = V_t

Then $V_b = V_t + \Delta V = V_t + \alpha \Delta T V_t = V_t (1 + \alpha \Delta T)$

$= V_t \left(1 + (2.5 \times 10^{-5}/°K)(1111°K)\right)$

$= 1.028\, V_t$

So $V_b / V_t = 1.028$

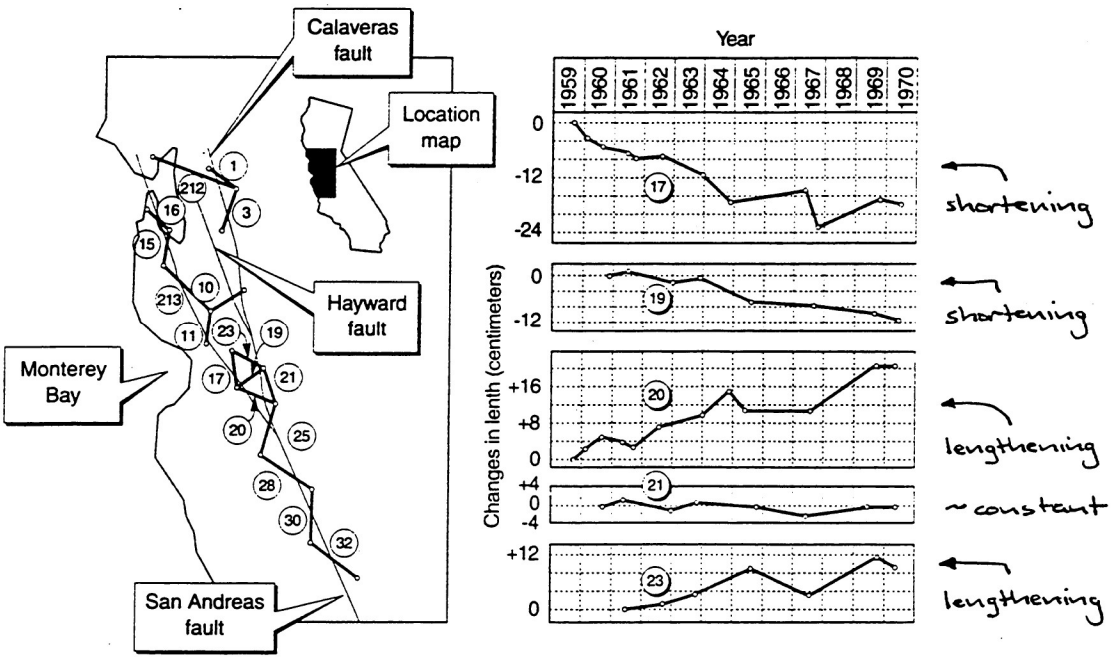
Consequently

$\rho_t / \rho_b = 1.028$ ← density difference due to thermal expansion effects

2.3 Using the data from Figure 2.21, determine whether the San Andreas and Calaveras faults are undergoing right lateral or left lateral strike slip faulting.

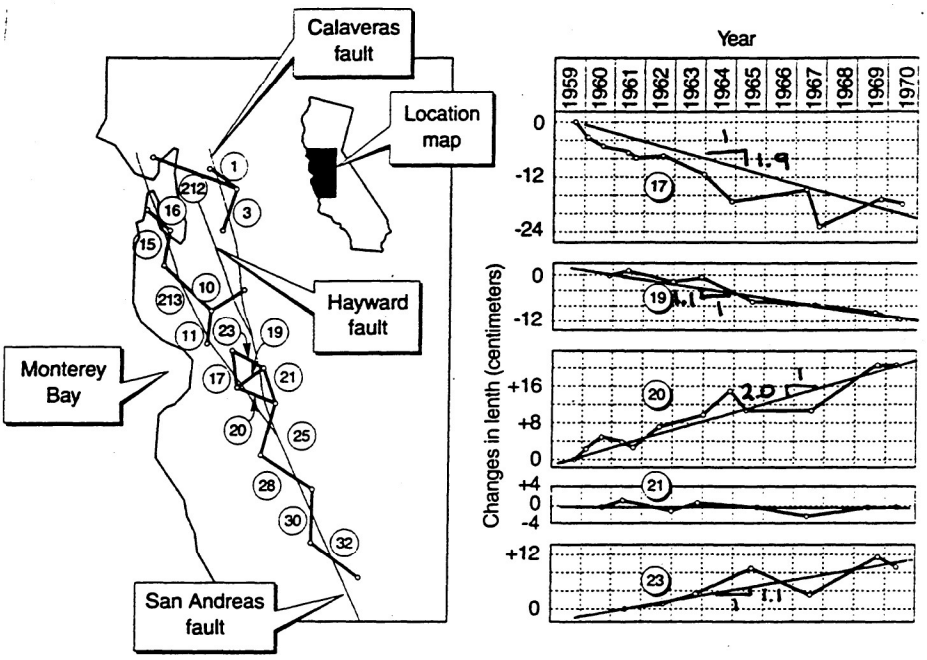
Chord 17 is shortening → San Andreas movement must be right lateral

Chord 23 is lengthening → Calaveras movement must be right lateral



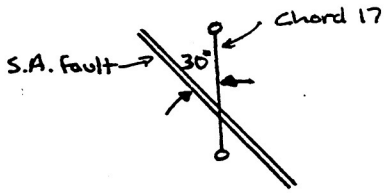
Note that Chord 20 spans both faults and shows even larger movements that are consistent with right lateral movement on both faults

2.4 Using the data from Figure 2.21, estimate the average rate of relative movement along the San Andreas and Calaveras faults during the period from 1959 to 1970.



San Andreas:

Average rate of movement on Chord 17 ≈ 1.9 cm/yr



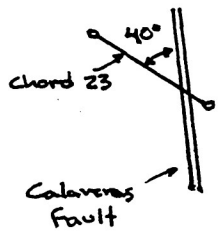
$$\text{Fault movement} = \frac{\text{Chord movement}}{\cos 30^\circ}$$

$$= \frac{1.9 \text{ cm/yr}}{0.866}$$

$$= 2.2 \text{ cm/yr}$$

Calaveras:

Average rate of movement on Chord 23 ≈ 1.1 cm/yr



$$\text{Fault movement} = \frac{\text{Chord movement}}{\cos 40^\circ}$$

$$= \frac{1.1 \text{ cm/yr}}{0.766}$$

$$= 1.4 \text{ cm/yr}$$