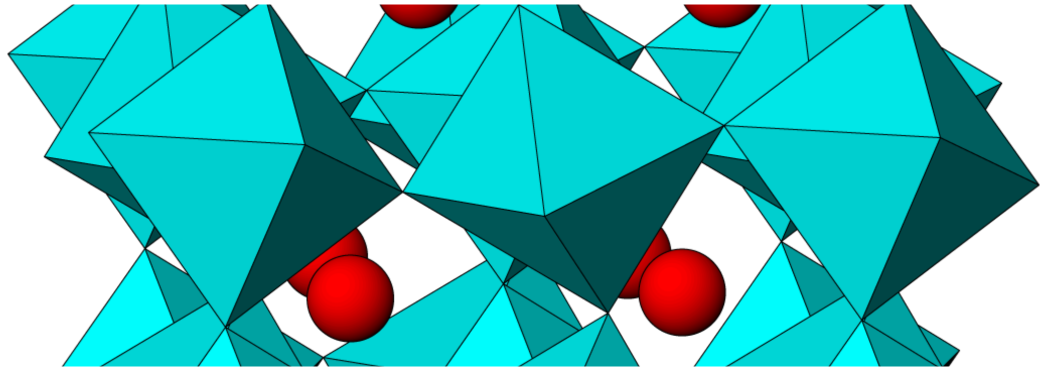
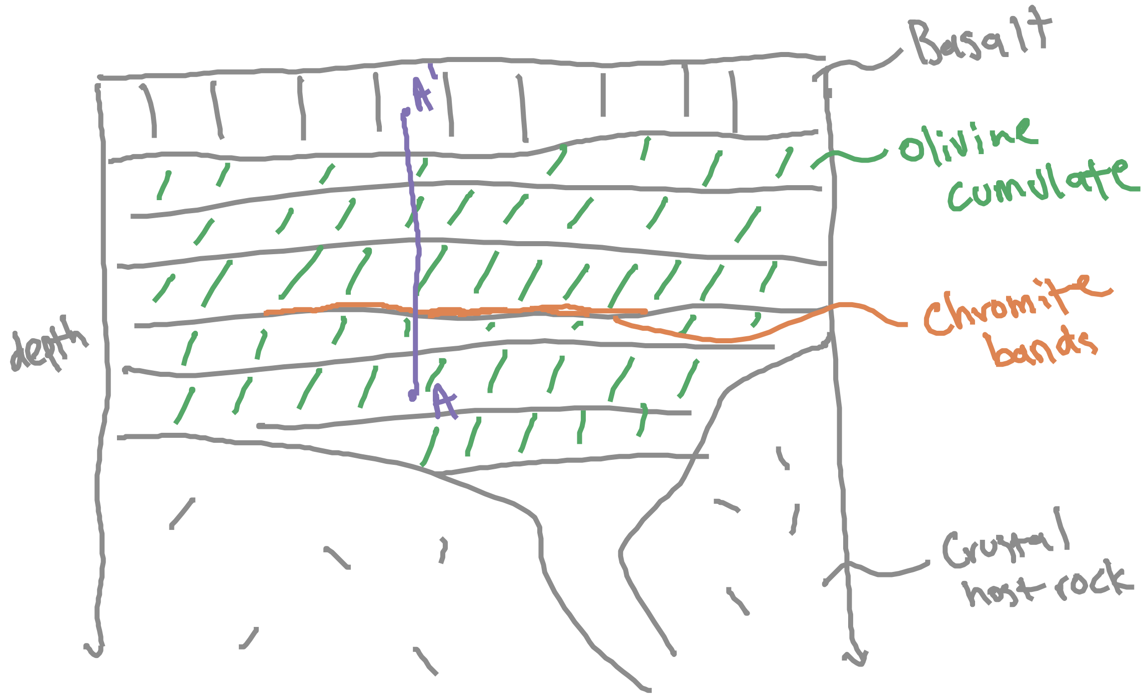


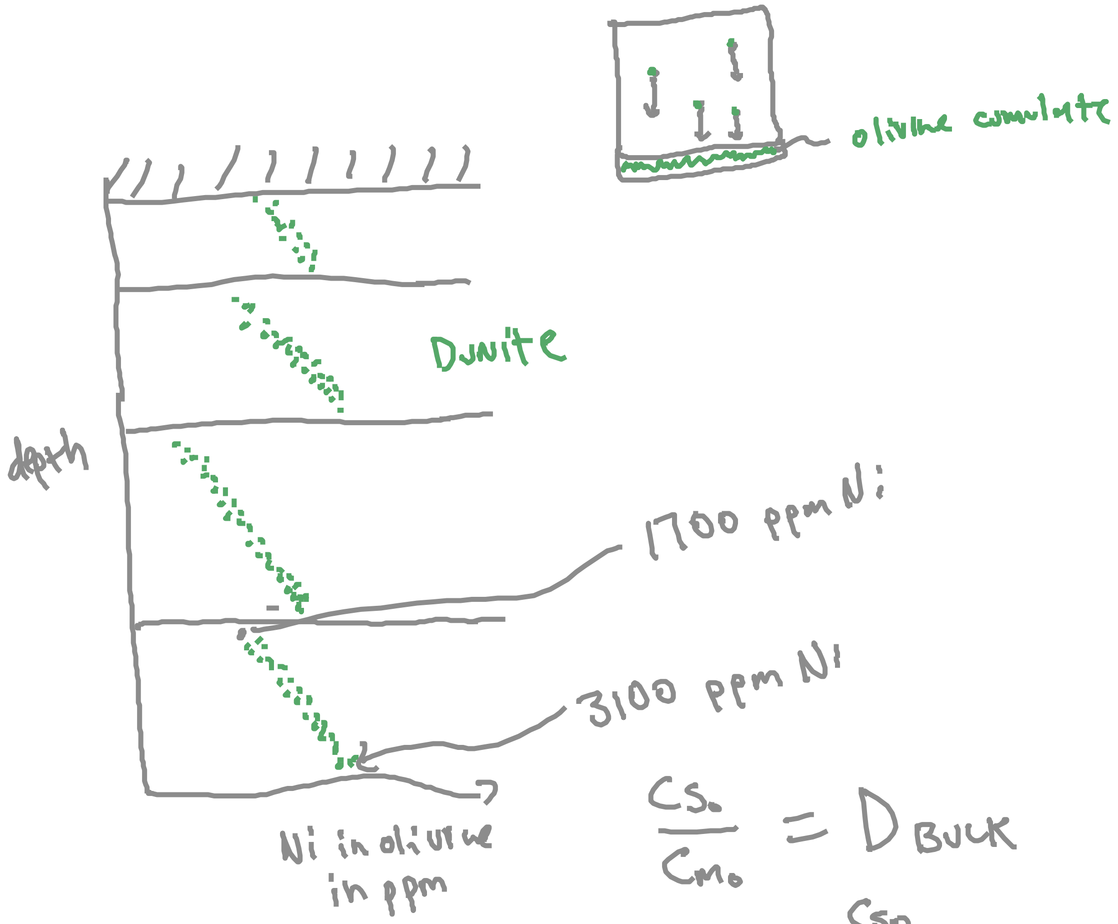
Lecture 8: Bulk Partitioning and Partial Melting

1. Fractional Crystallization
    - A. Examples
        - b. Muskox layered intrusion
2. Bulk Partition Coefficient, D_{bulk}
    - A. Decoupling of Major and Trace elements

We acknowledge and respect the lək̓ʷəŋən peoples on whose traditional territory the university stands and the Songhees, Esquimalt and W̱SÁNEĆ peoples whose historical relationships with the land continue to this day.

Muskox Layered Intrusion Example





$$\frac{C_{s_0}}{C_{m_0}} = D_{Bulk}$$

$$C_{m_0} = \frac{C_{s_0}}{D}$$

Assume $D^{Ni}_{Bulk} = 15$

From 3100 ppm to 1700 ppm, how much melt crystallized?

$$\frac{C_m}{C_{m_0}} = F^{D-1} \qquad \frac{C_s}{C_{m_0}} = D \cdot F^{D-1} \qquad \frac{1700}{\left(\frac{3100}{\cancel{15}}\right)} = \cancel{15} \cdot F^{15-1}$$

Solution.

$$\frac{1700}{3100} = F^{15-1}$$

$$\log X^Y = Y \log X$$

$$\ln\left(\frac{1700}{3100}\right) = \ln F^{15-1} = (15-1)\ln F$$

* can use ln or log but make sure you use the correct base in this step

$$\frac{\ln \frac{1700}{3100}}{(15-1)} = \ln F$$

$$e^{\frac{\ln \frac{1700}{3100}}{(15-1)}} = F \approx 0.96 \quad \text{or} \quad 4\% \text{ crystallized}$$

Bulk Partitioning

$$D_{BULK} = D^{ol} \cdot X^{ol} + D^{opx} \cdot X^{opx} + D^{cpx} \cdot X^{cpx} = \sum D^i X^i$$

mass fraction of minerals

$$\sum X^i = 1$$

if:

$D^{ol} = 0.01$ $X^{ol} = 0.5$ $X^{cpx} = 0$

$D^{opx} = 0.1$ $X^{opx} = 0.5$

$$D_{BULK} = 0.055$$

What if we melt olivine and opx in equal proportions? (modal melting)

Bulk Partitioning

$$\sum Y^i = F$$ melt fraction

$$X_1^{ol} = X_1^{opx} = 0.5$$

$$Y^{ol} = 0 \quad Y^{opx} = 0.06$$

$$D_{Bulk} = D^{ol} \cdot \frac{X_i^{ol} - Y^{ol}}{1 - F} + D^{opx} \cdot \frac{X_i^{opx} - Y^{opx}}{1 - F}$$

after melting $D_{Bulk} = 0.051$ slightly changed

modal vs non-modal:

→ trace element "i" behaves almost the same

→ major element evolution of the melt could be very different

melting opx source of Mg, Fe, Ca, Al, Si, O

melting olivine source of Mg, Fe, Si, O

Bulk Partitioning

Consider impact of rare mineral with very different D

$D_{BULK} = D^{ol} \cdot X^{ol} + D^{opx} \cdot X^{opx} + D^{min} \cdot X^{min}$

$D^{min} = 10$

$X^{min} = 0.01$ or 1%

$X^{ol} = X^{opx} = 0.495$

$D^{ol} = 0.01$ $D^{opx} = 0.1$

$D_{BULK} = 0.15445$ ← very different even though mineral assemblage almost the same (mostly olivine and opx)

* (high P) garnets and (lower P) zircons are examples of minor mineral phases that have large impact on the D_{BULK} of many trace elements