Lecture 5: Making the Earth

1. Condensation temperatures
2. Goldschmidt classification
3. The primitive mantle

We acknowledge and respect the lək^{w}əŋən 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.

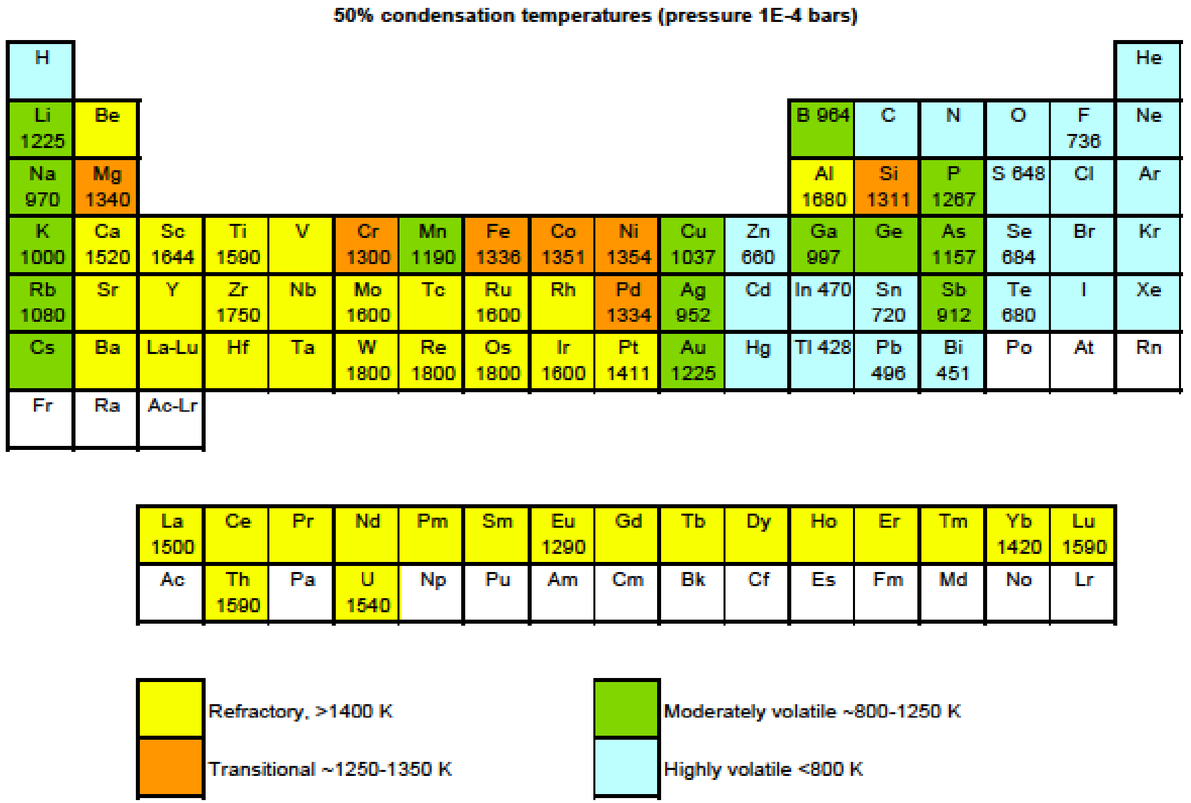


Figure 2.13. 50% condensation temperatures taken from [*Wasson*, 1985] and [*O'Neill and Palme*, 1998].

Which 6 elements make up most of Earth's mass?

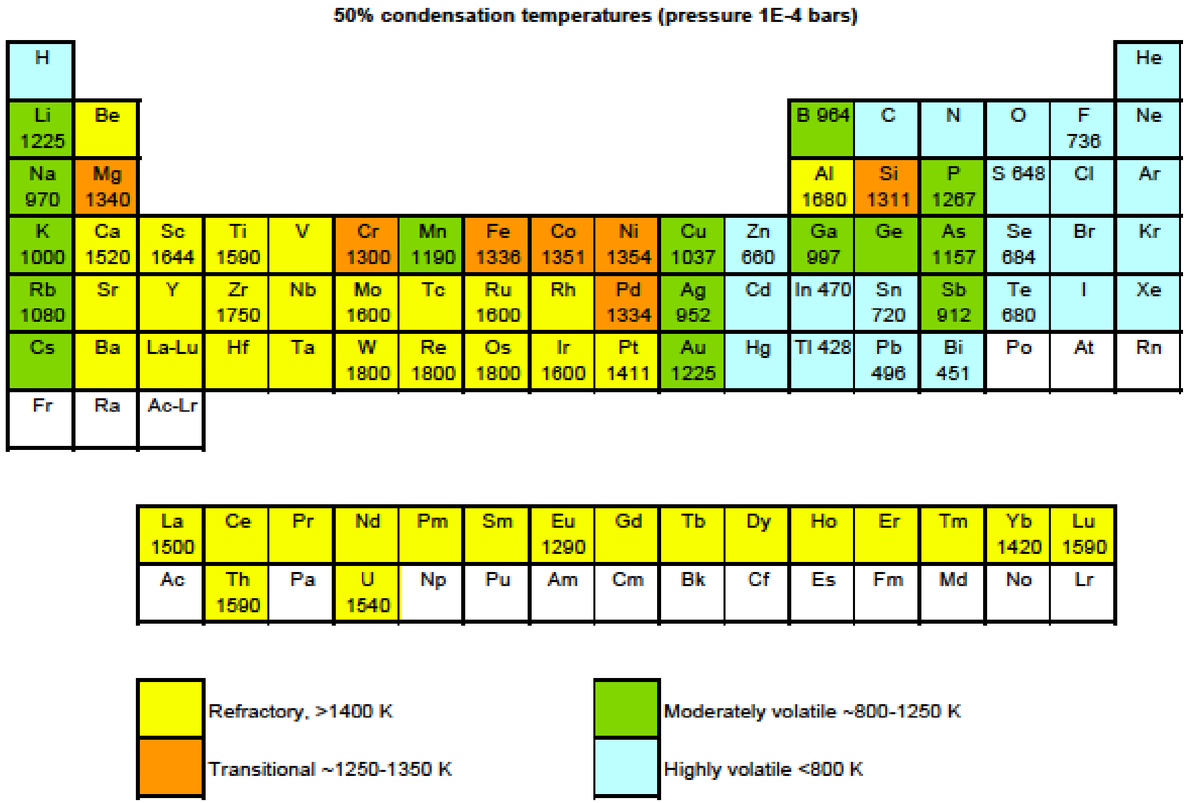
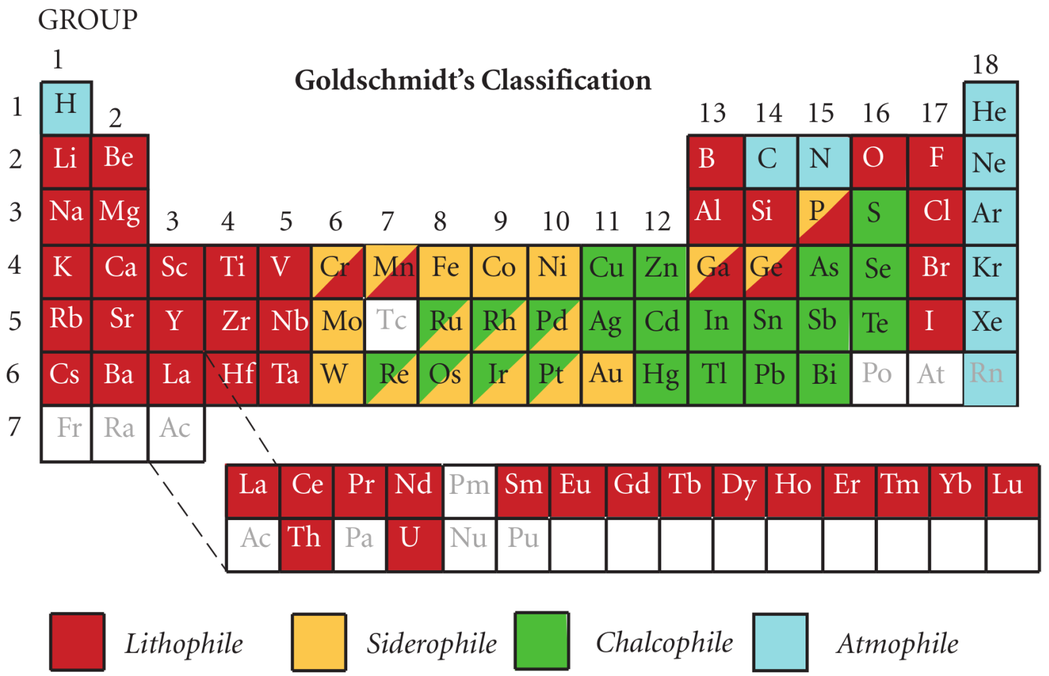


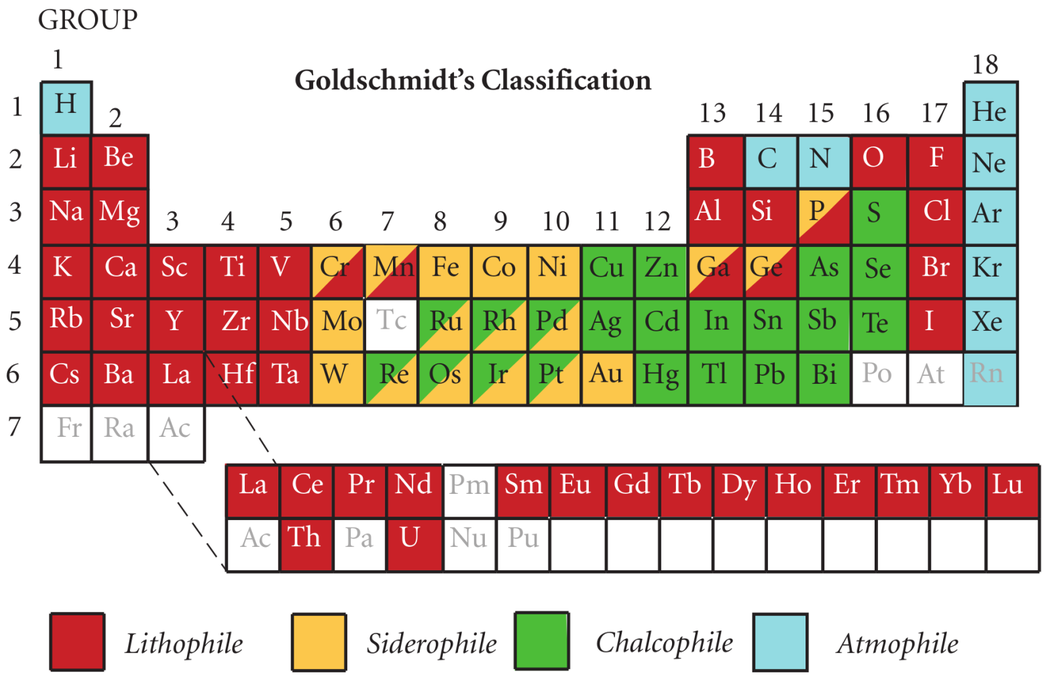
Figure 2.13. 50% condensation temperatures taken from [*Wasson*, 1985] and [*O'Neill and Palme*, 1998].

$$\text{Earth} \approx MgO + CaO + SiO_2 + Al_2O_3 + FeO$$

Define Goldschmidt classification.

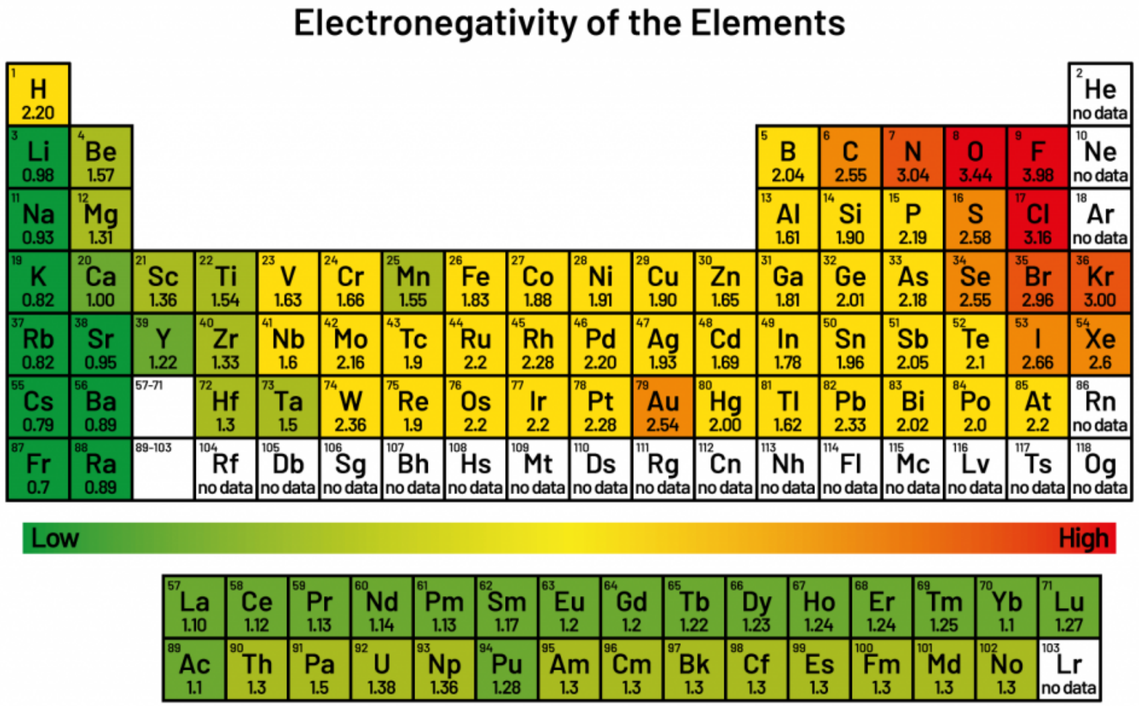


Define Goldschmidt classification.

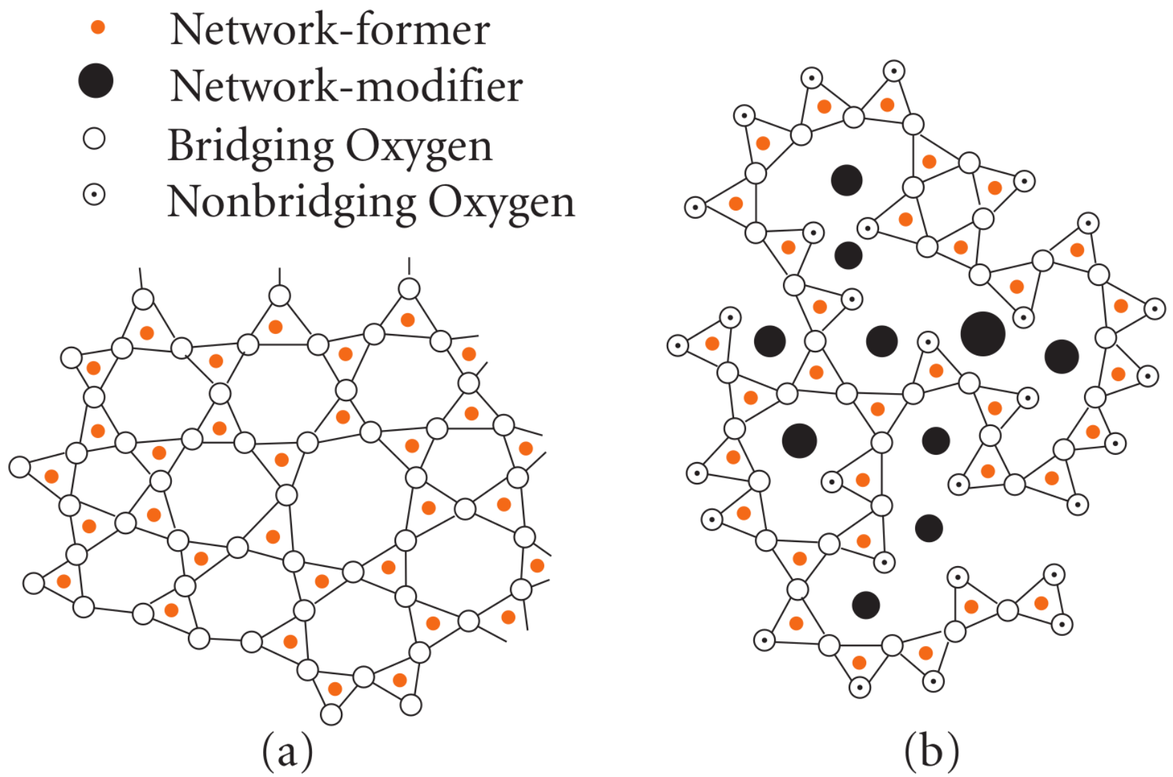


Describe the arrangement of Lithophile vs Siderophile elements in the periodic table. What might explain this arrangement?

Electronegativity



Silicate melt structure, is *oxyphile* a better word?



In Geochemistry, we often use the word **fractionate** to indicate that the original mass (*the nebula*) led to one or more smaller fractions of mass (*different planets*) that have compositional variations. Through our understanding of condensation temperatures and Goldschmidt's classification scheme, planet *formation* and planetary *differentiation* lead to predictable fractionations, and so the chemistry of a rock can tell us a lot about how it came to be.

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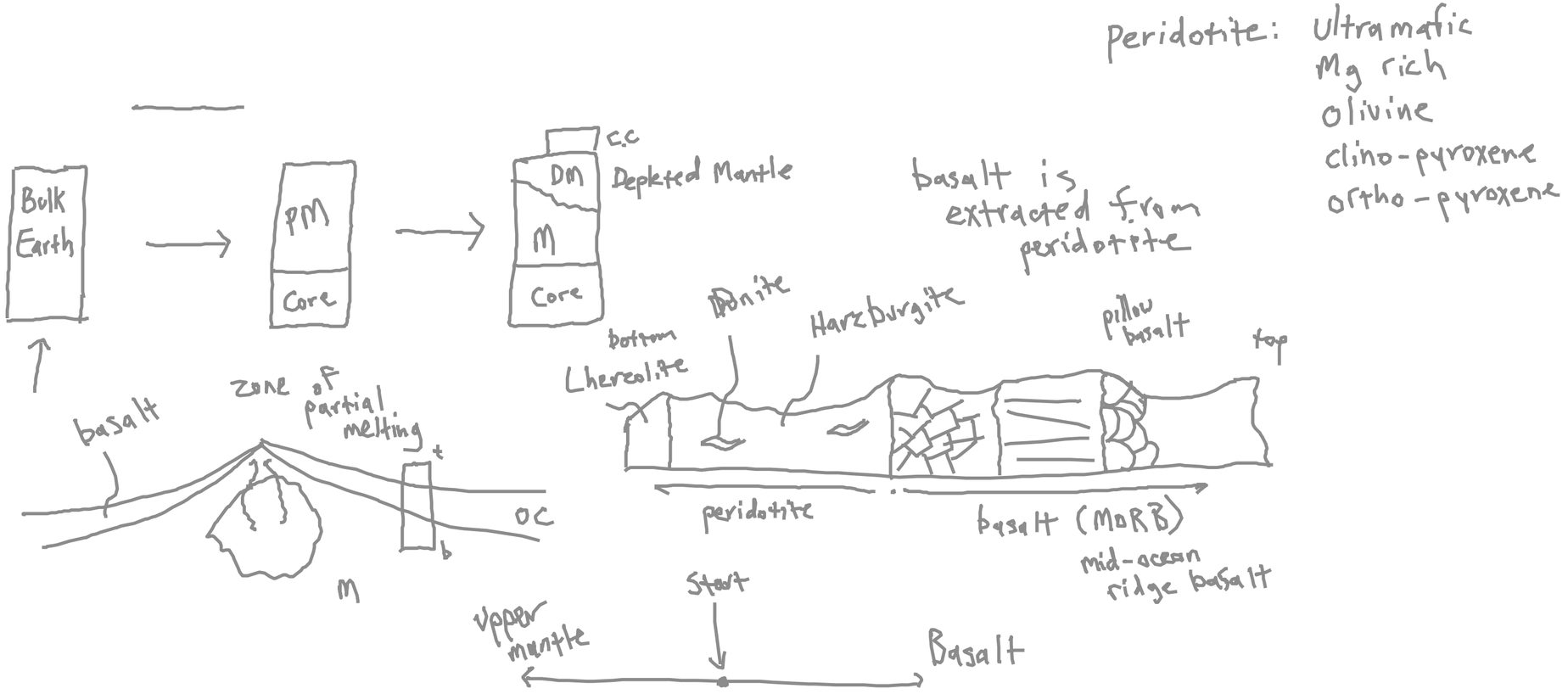
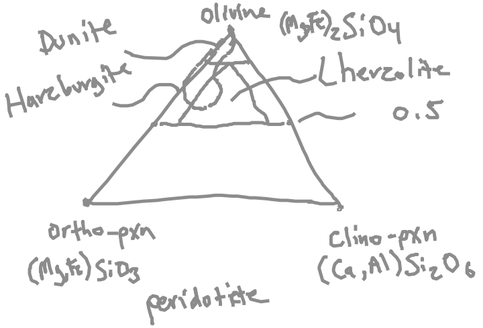
Some review questions to consider:

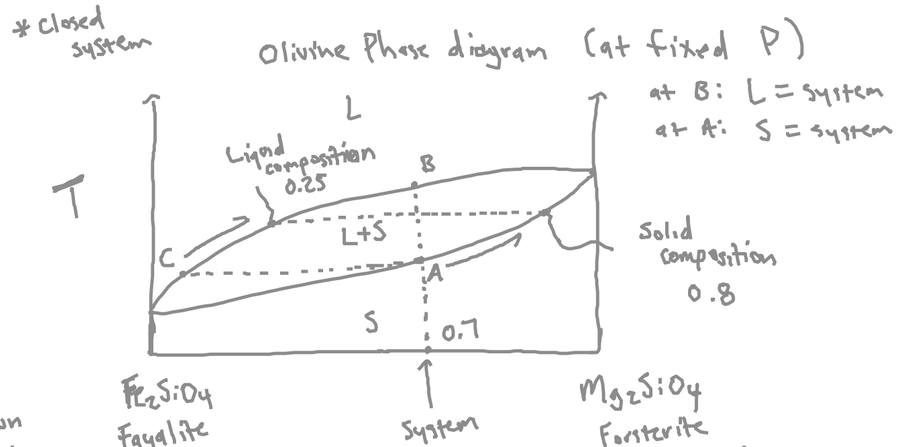
- **How does the Ca/Al ratio change from the inner solar system to the outer?** *(draw a figure showing this ratio vs distance from the Sun)*
- **How does the Na/Al ratio change from the inner solar system to the outer?** *(draw a figure showing this ratio vs distance from the Sun)*
- **Is the weight % of CaO on Bulk Earth higher or lower than the weight % of CaO on Bulk Jupiter?**
- **Is the Si/Fe ratio higher in an undifferentiated meteorite or the Earth's mantle?**

Define Primitive Mantle. What do we know about the modern mantle?



Olivine Solid Solution Phase Diagram.





Lever Rule:
(mass balance)

unknown fraction

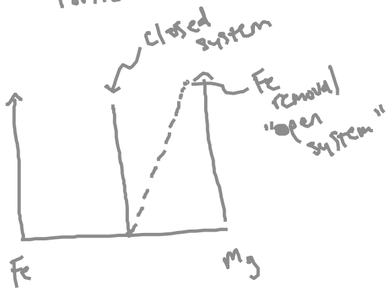
$$\underline{a} \cdot L + \underline{b} S = \text{System}$$

$a + b = 1$ mass balance

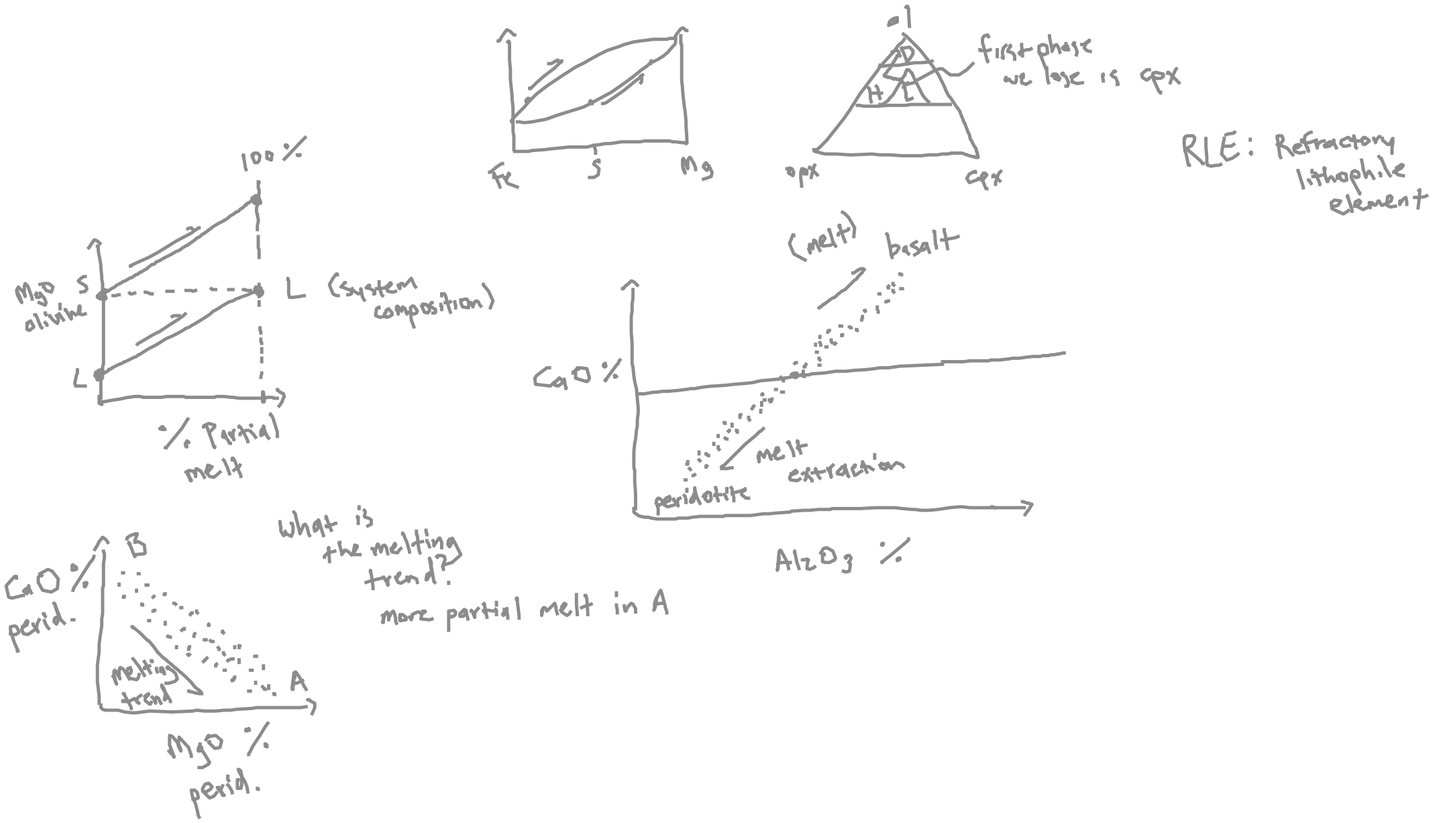
$b = 1 - a$

$$aL + (1-a)S = \text{system}$$

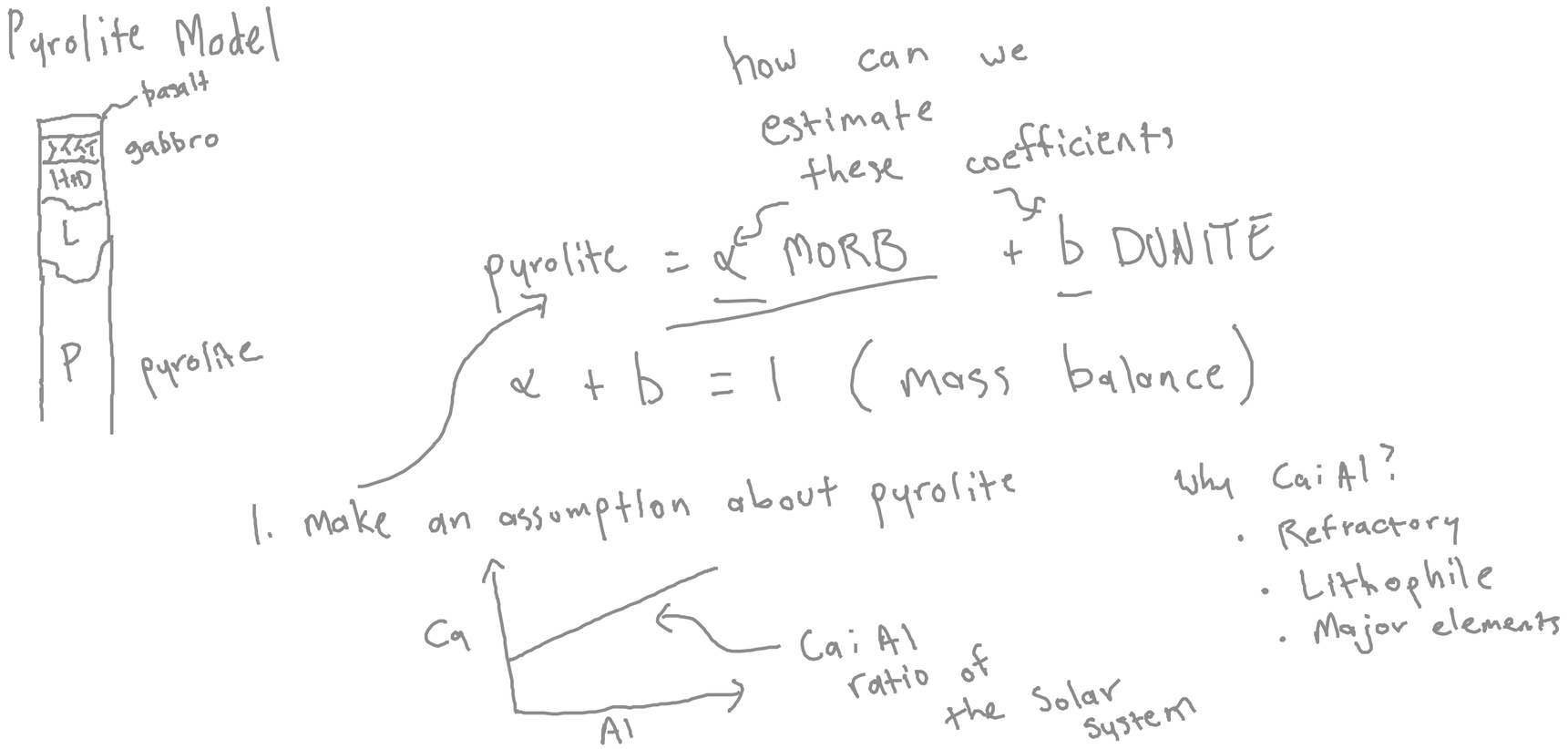
$$a\,0.25 + (1-a)\,0.8 = 0.7$$



Melting trends.



Pyrolite Model: Ringwood, A.E., 1962. **A model for the upper mantle**. *Journal of Geophysical Research*.



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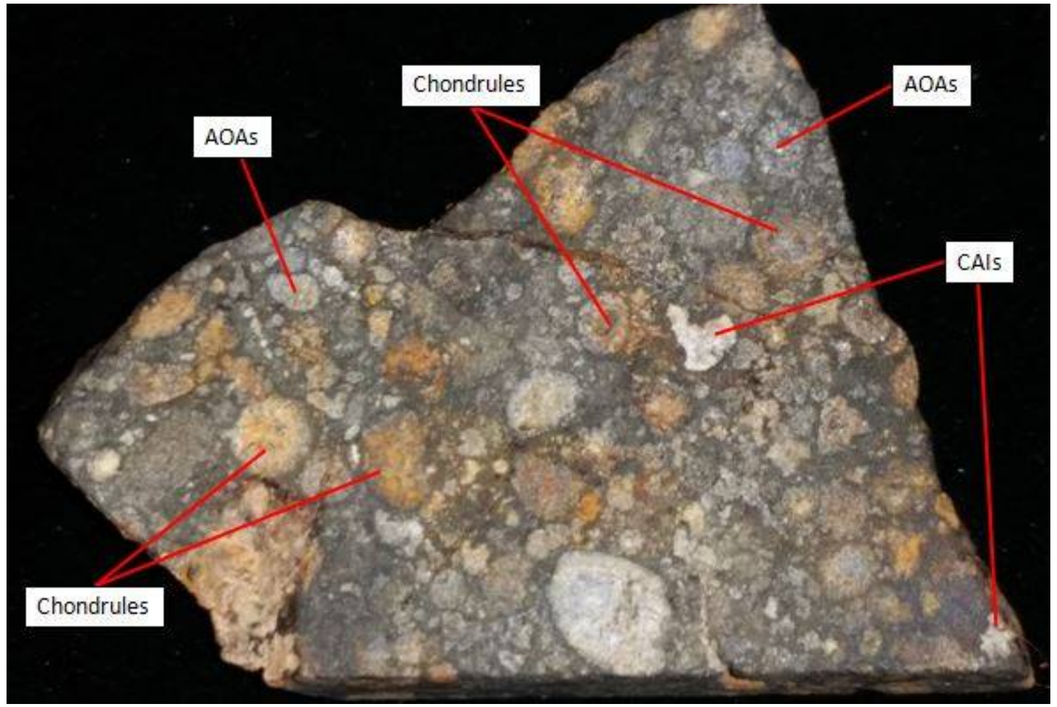
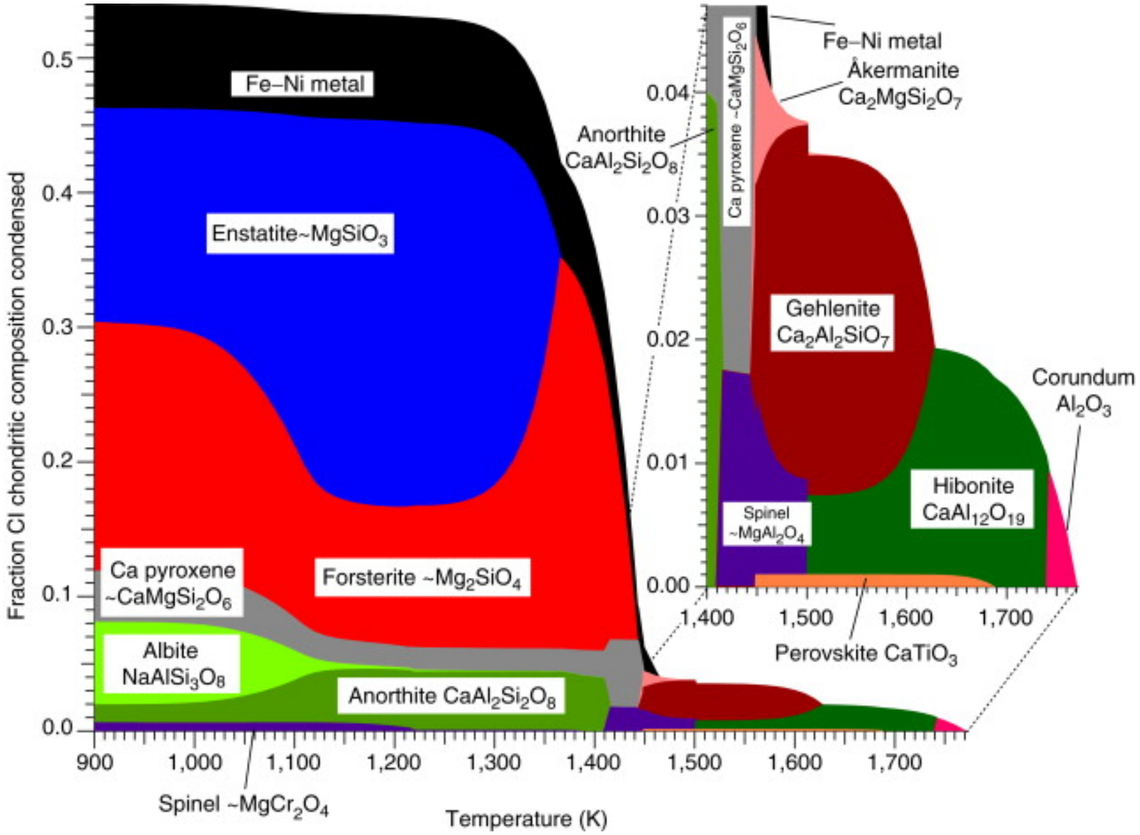
Chondrites

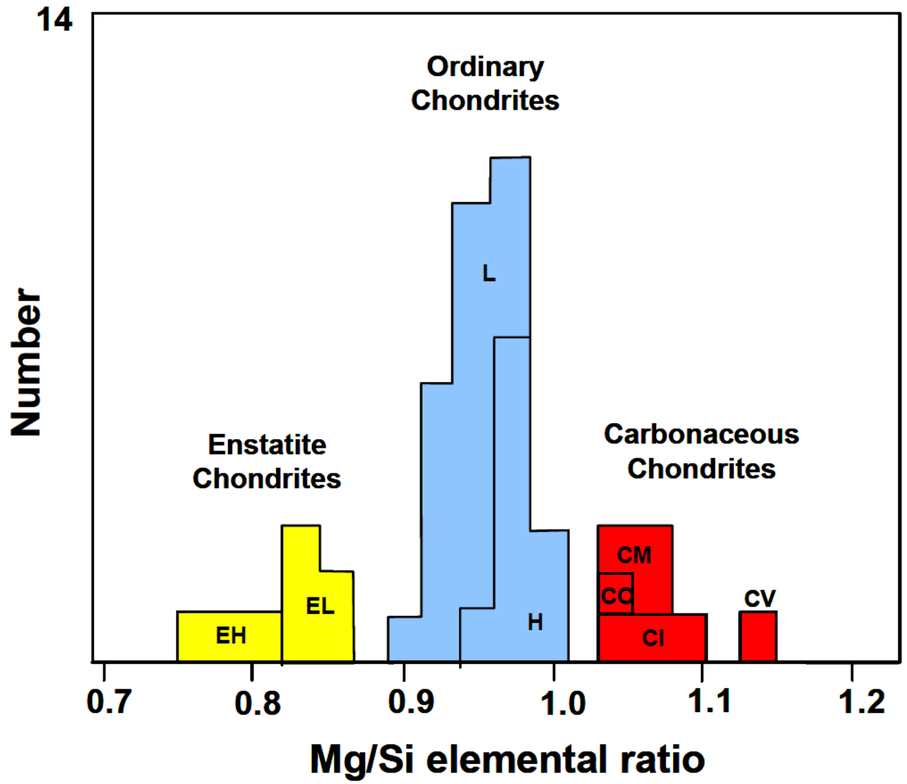


Chondrules: molten 'droplets' of nebular dust
AOAs: Ameboidal Olivine Aggregates ~100% olivine
CAIs: Calcium Aluminum Inclusions are the first condensates

Mineralogy of Chondrite phases



Chondrites have variable composition



Practice problem

The observed chondritic mass abundances for Calcium and Aluminum are:

Element	wt % in Chondrite	Atomic Mass
Ca	0.92	40.1
Al	0.85	27

The average wt % of CaO and Al_2O_3 in Basalt and Harzburgite:

Oxide	wt % in Basalt	wt % in Harzburgite
CaO	11.3	6.1
Al_2O_3	15.1	5.1

What ratio do you need to mix basalt and harzburgite back together to get the composition of the mantle before melt was removed? Assumptions:

- Pyrolite is a combination of melt (basalt) and melted mantle (harzburgites)
- Earth has the same Refractory Lithophile Elemental (RLE) abundances as Chondrites