Sarah Lambart - 2016

LECTURE 3: INTRODUCTION TO THERMODYNAMICS

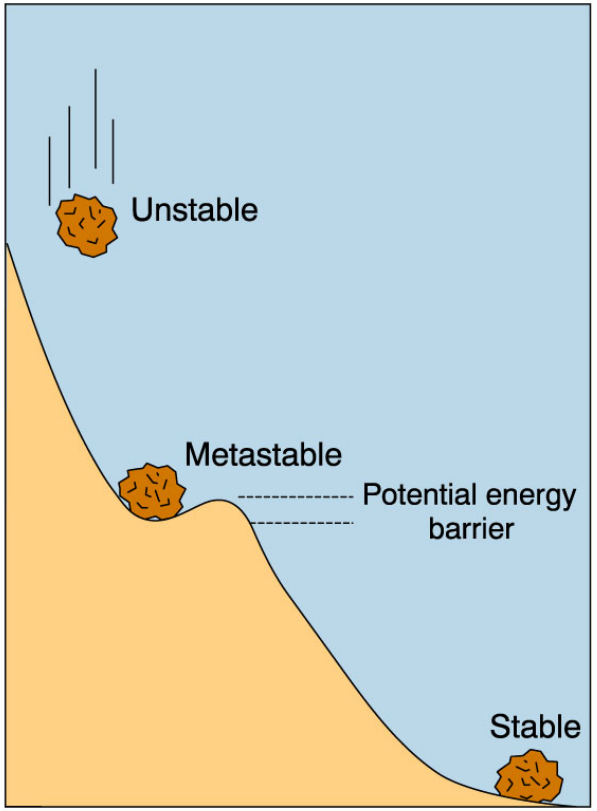
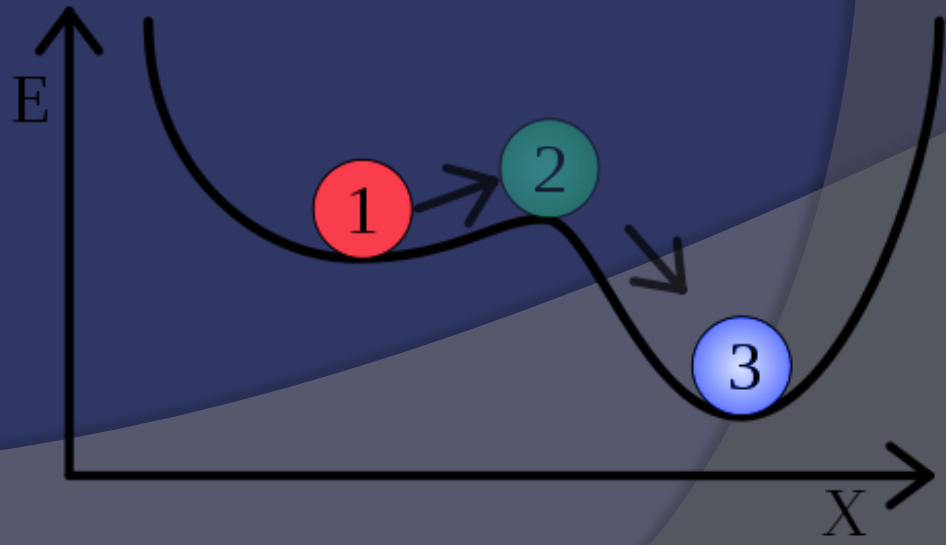


Fig. 5.1 Winter

Magma formation and evolution law

=> PHASE DIAGRAMS

- Stability of a silicate melt
- Minerals in equilibrium with that melt
- Phase proportions
- Effect due to change of P or T



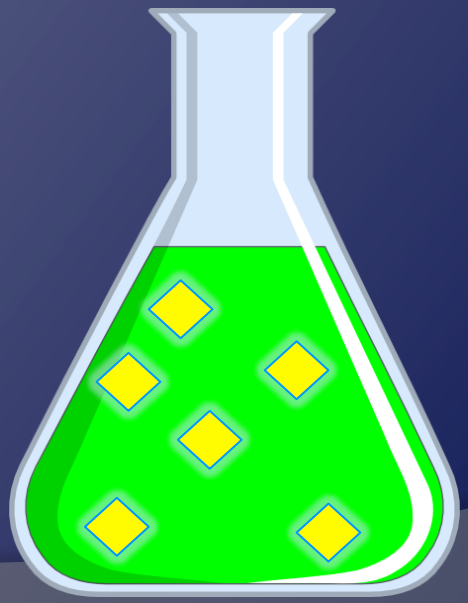
Recap Lecture 2

3 ingredients to create a igneous rock

Melting

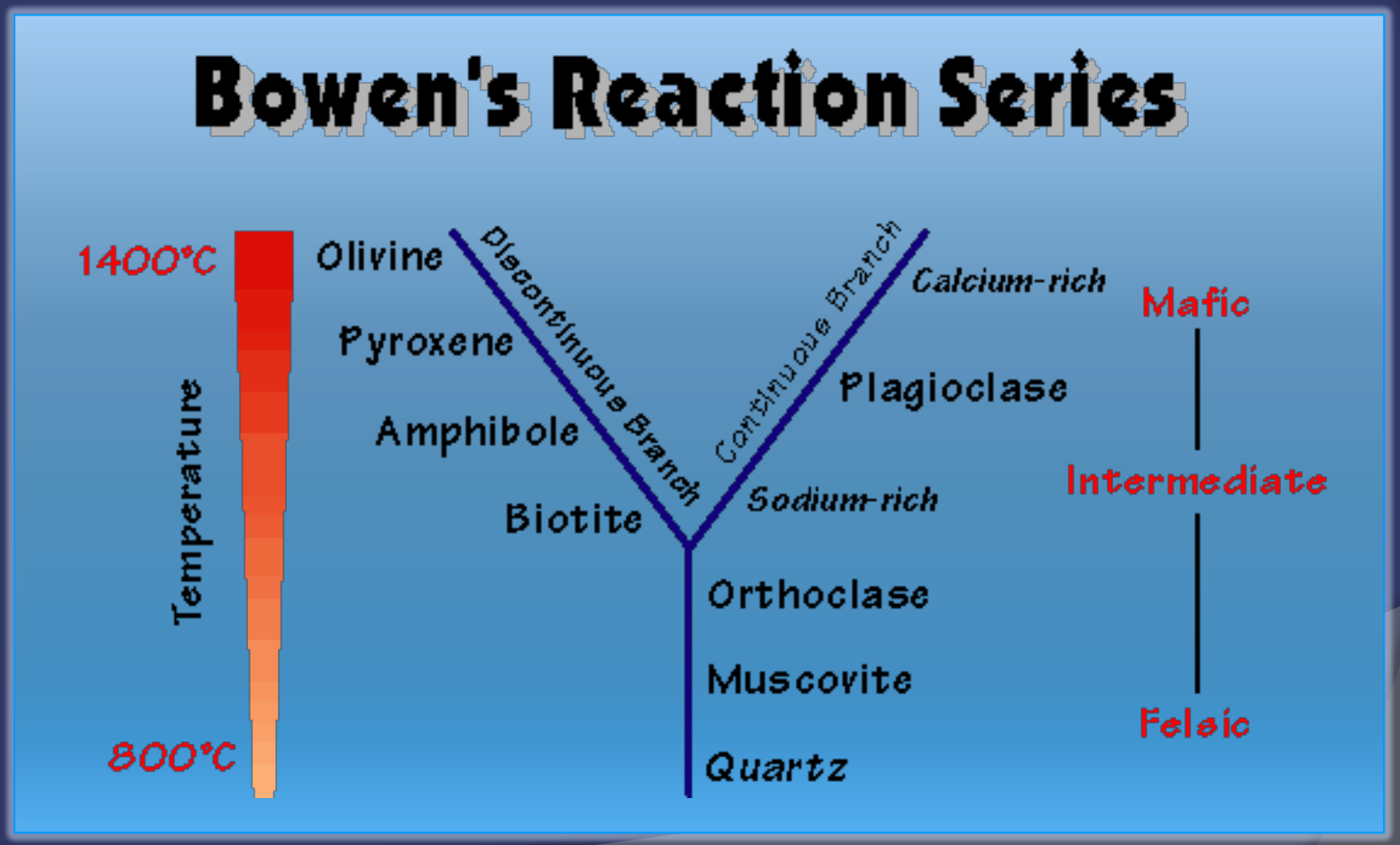
Crystallization

Mixing/ assimilation



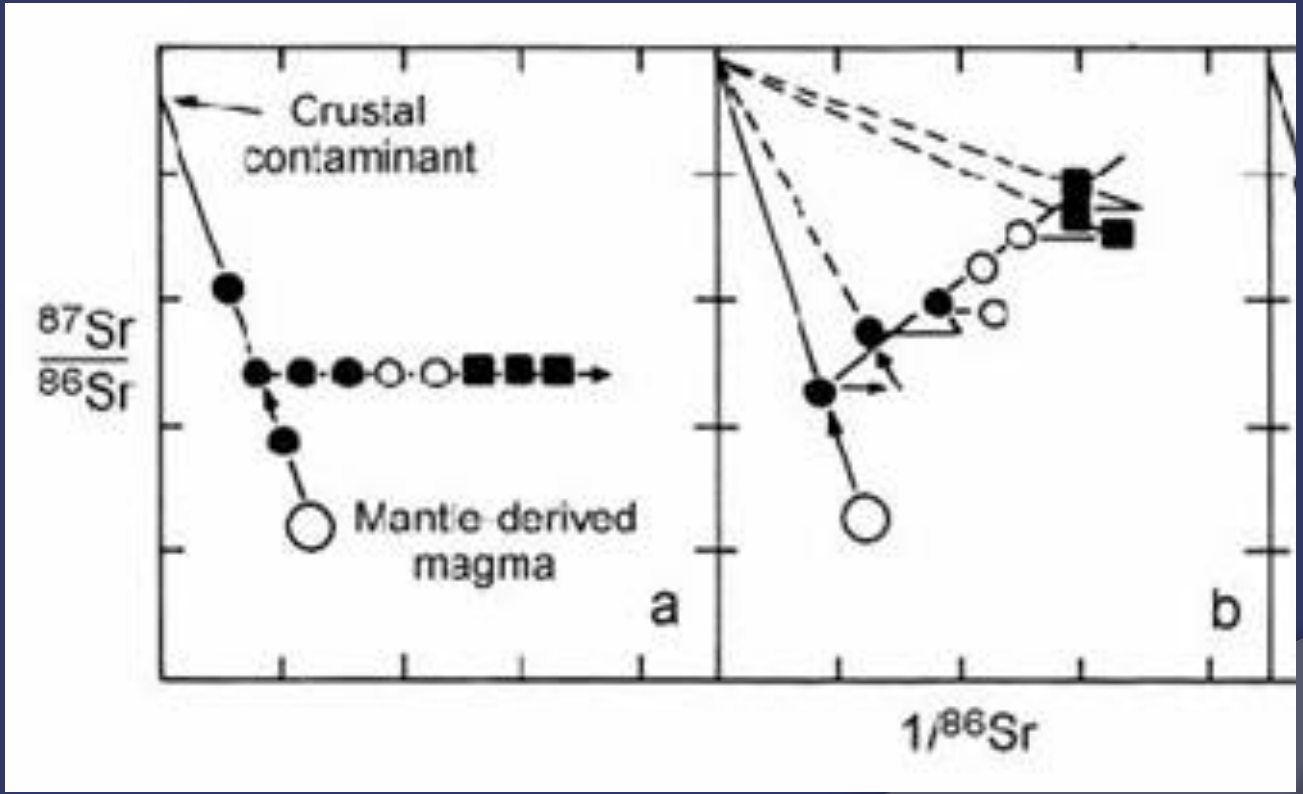
Recap Lecture 2

- Magmatic differentiation: crystallization



Recap Lecture 2

- Magmatic differentiation: assimilation



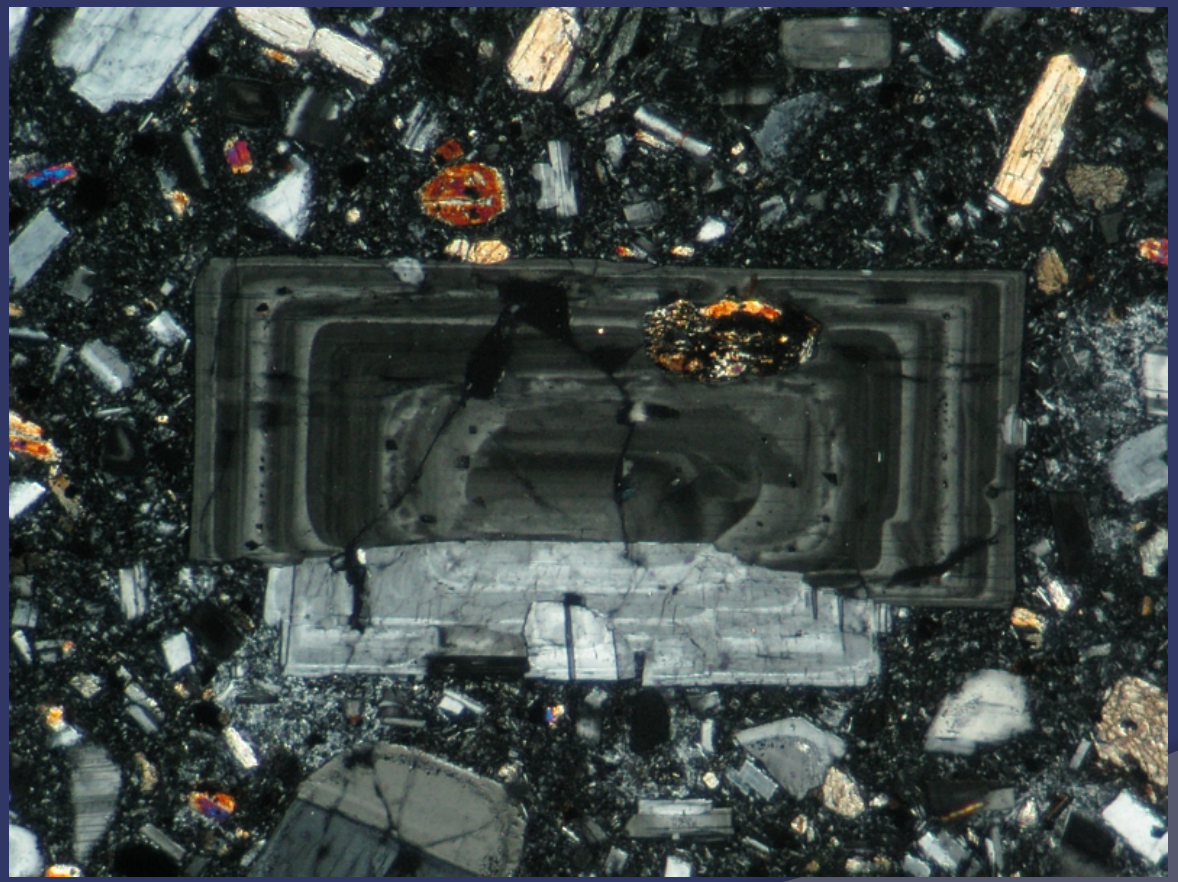
Recap Lecture 2

- Magmatic differentiation: magma mixing

Credit: B. J. Andrews

Recap Lecture 2

- Magmatic differentiation: magma mixing



Oscillatory zoning - *https://wwwf.imperial.ac.uk/*

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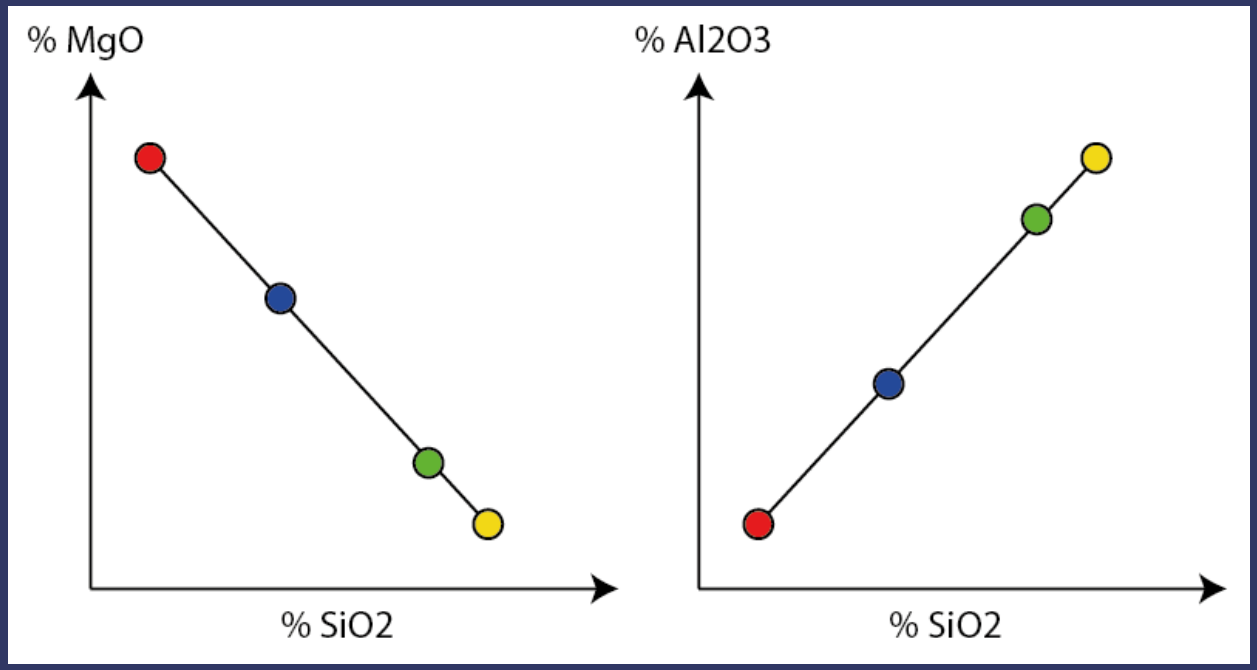
Recap Lecture 2

- Magmatic differentiation: magma mixing



oxide-oxide variation diagrams:

- mixtures lie along a straight line
- proportional distances are the same on all diagrams

Geothermal gradient

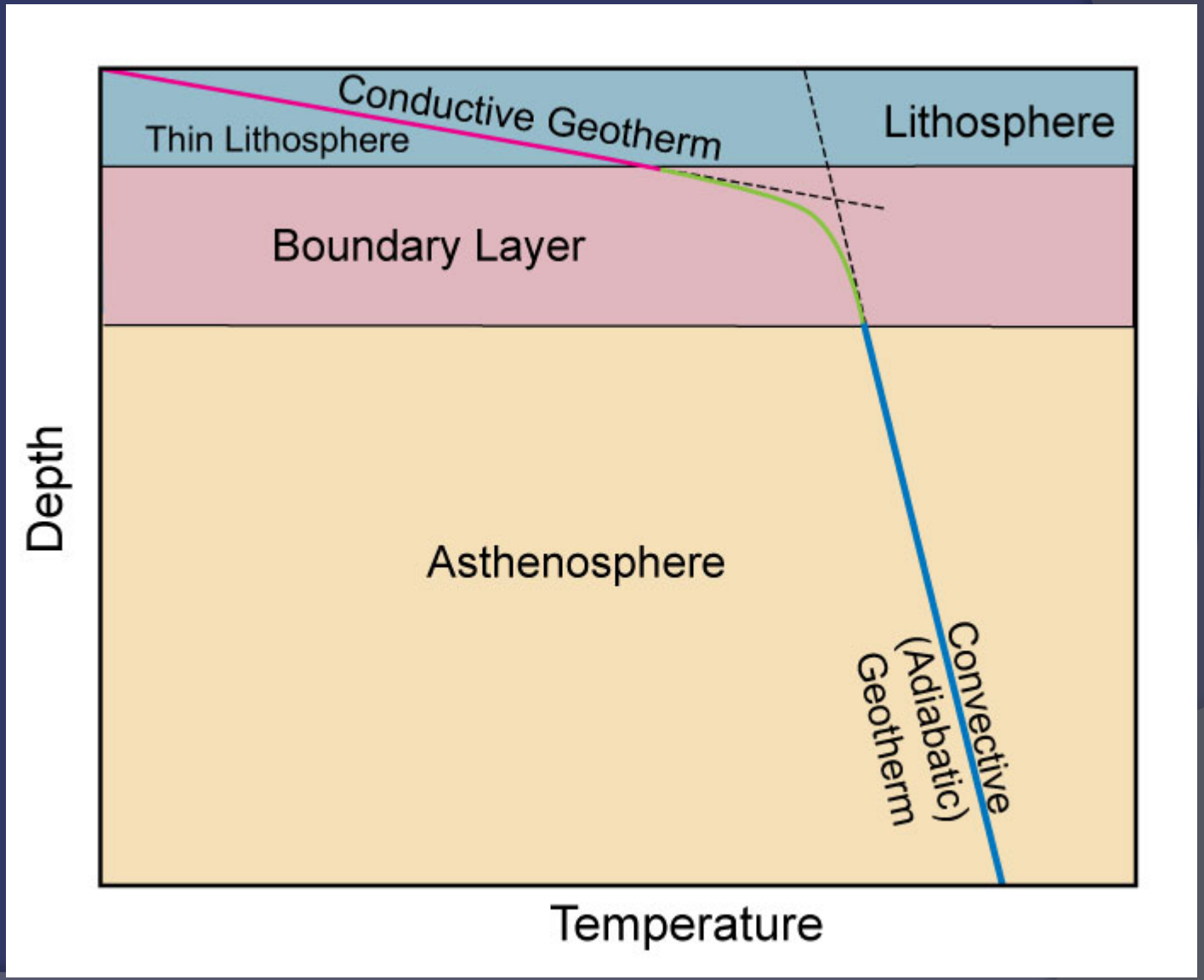


Fig. 1.9 Winter

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Pressure gradient

$$\Rightarrow P = \rho g z$$

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Pressure gradient

$$\Rightarrow P = \rho g z$$

- Pressure gradient in the crust: 30 MPa/km
- Pressure gradient in the upper mantle: 35 MPa/km

Geothermal gradient = change of P + change of temperature with depth

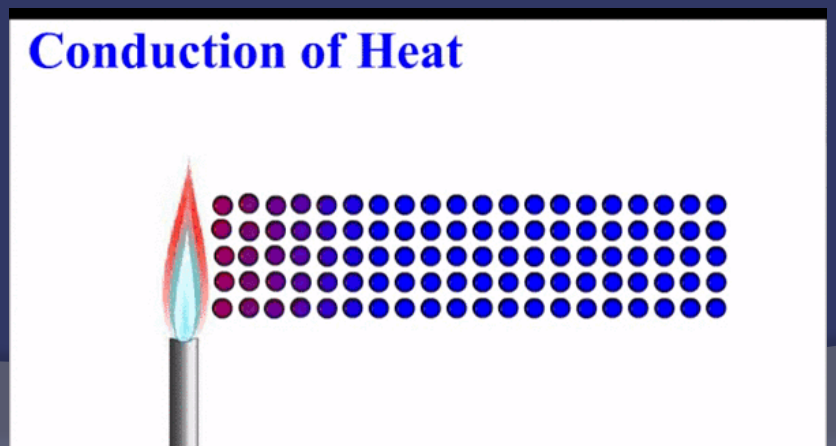
Change of *T*: Heat transfer

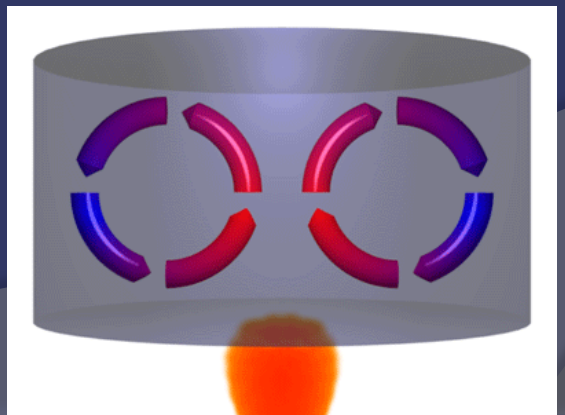
- Heat sources:
  - Secular cooling
  - Radioactive decay

Change of *T*: Heat transfer

- Heat sources:
  - Secular cooling
  - Radioactive decay

- Heat transfer:
  - Conduction
  - Convection





Geothermal gradient

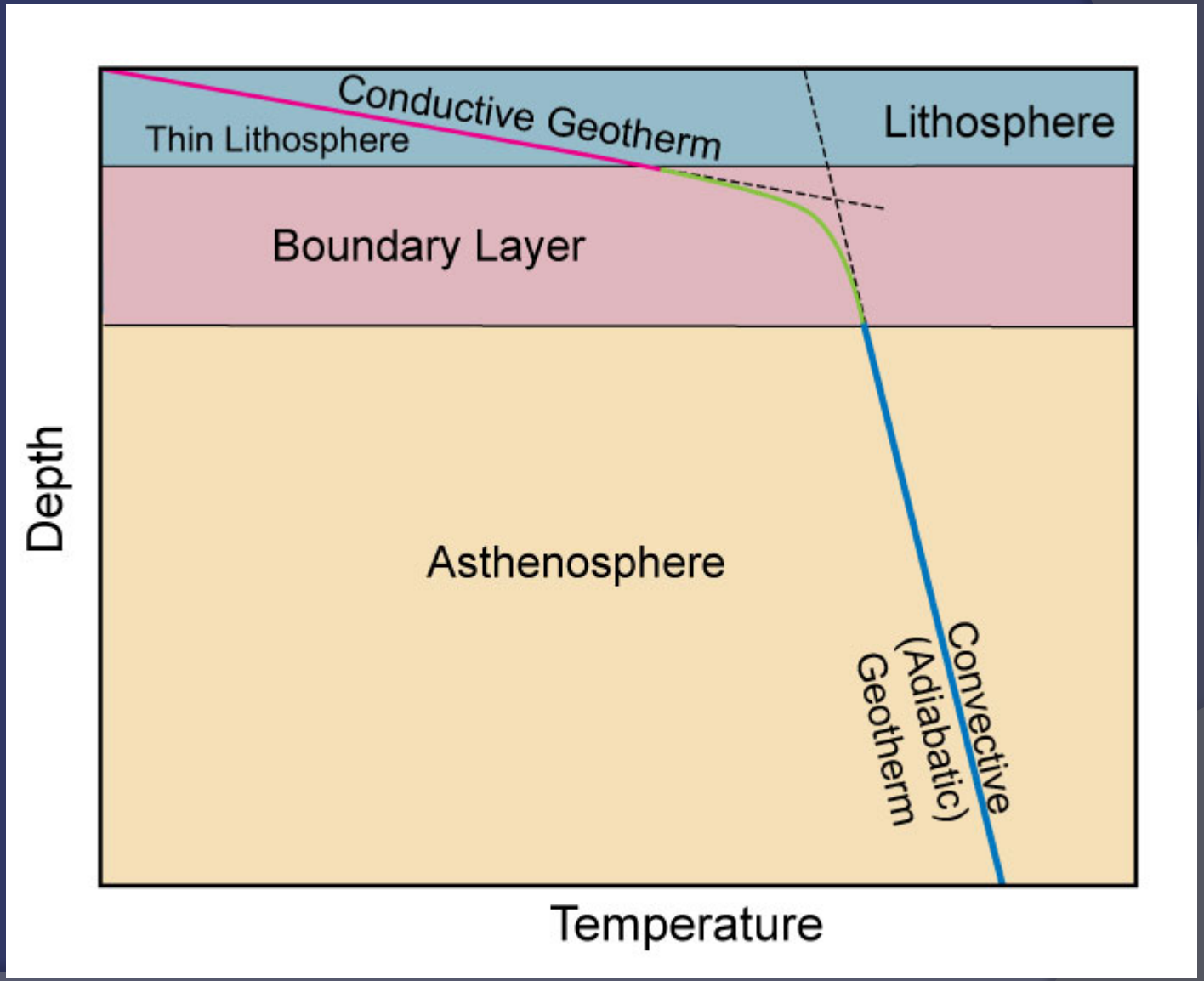


Fig. 1.9 Winter

Geothermal gradient

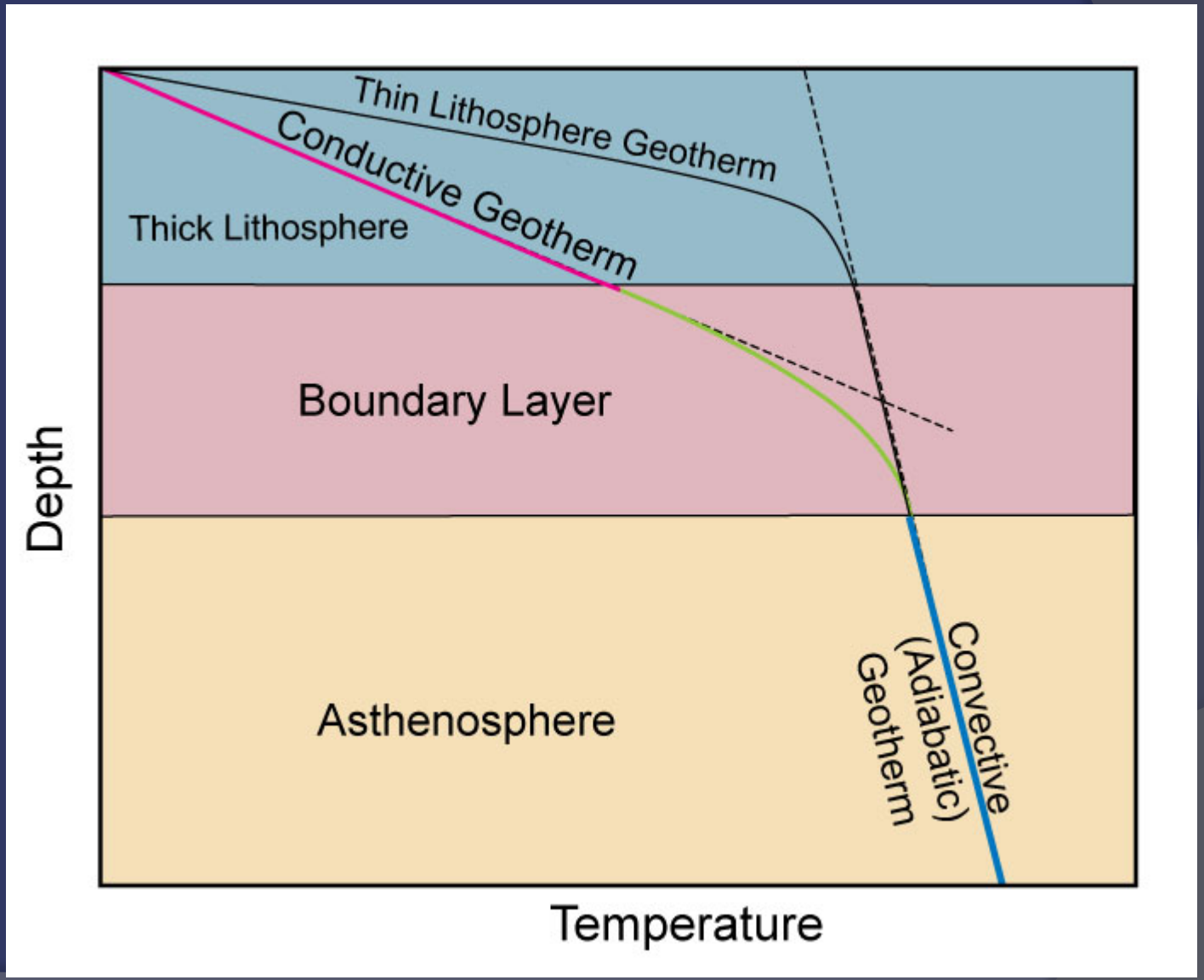


Fig. 1.9 Winter

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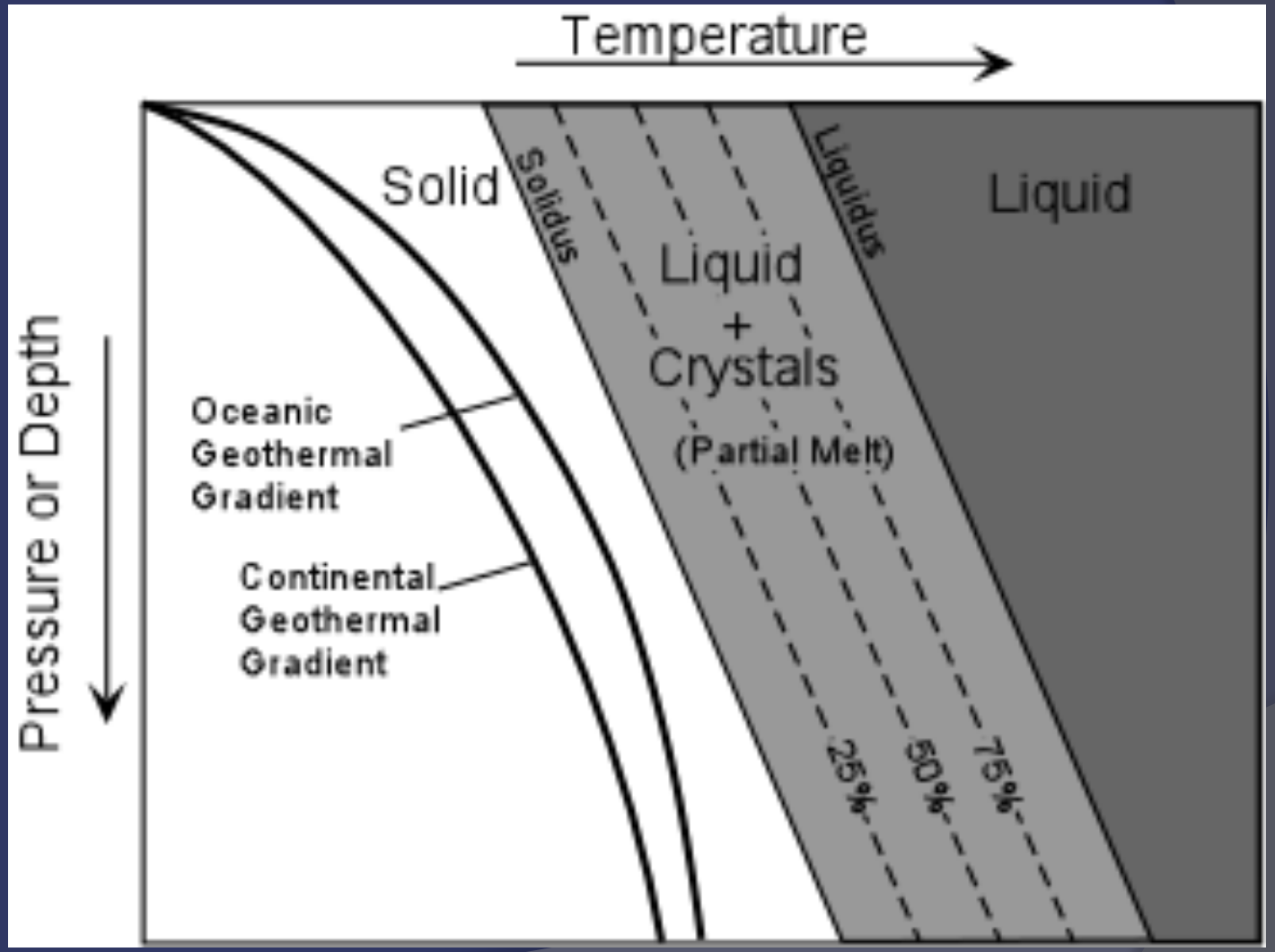
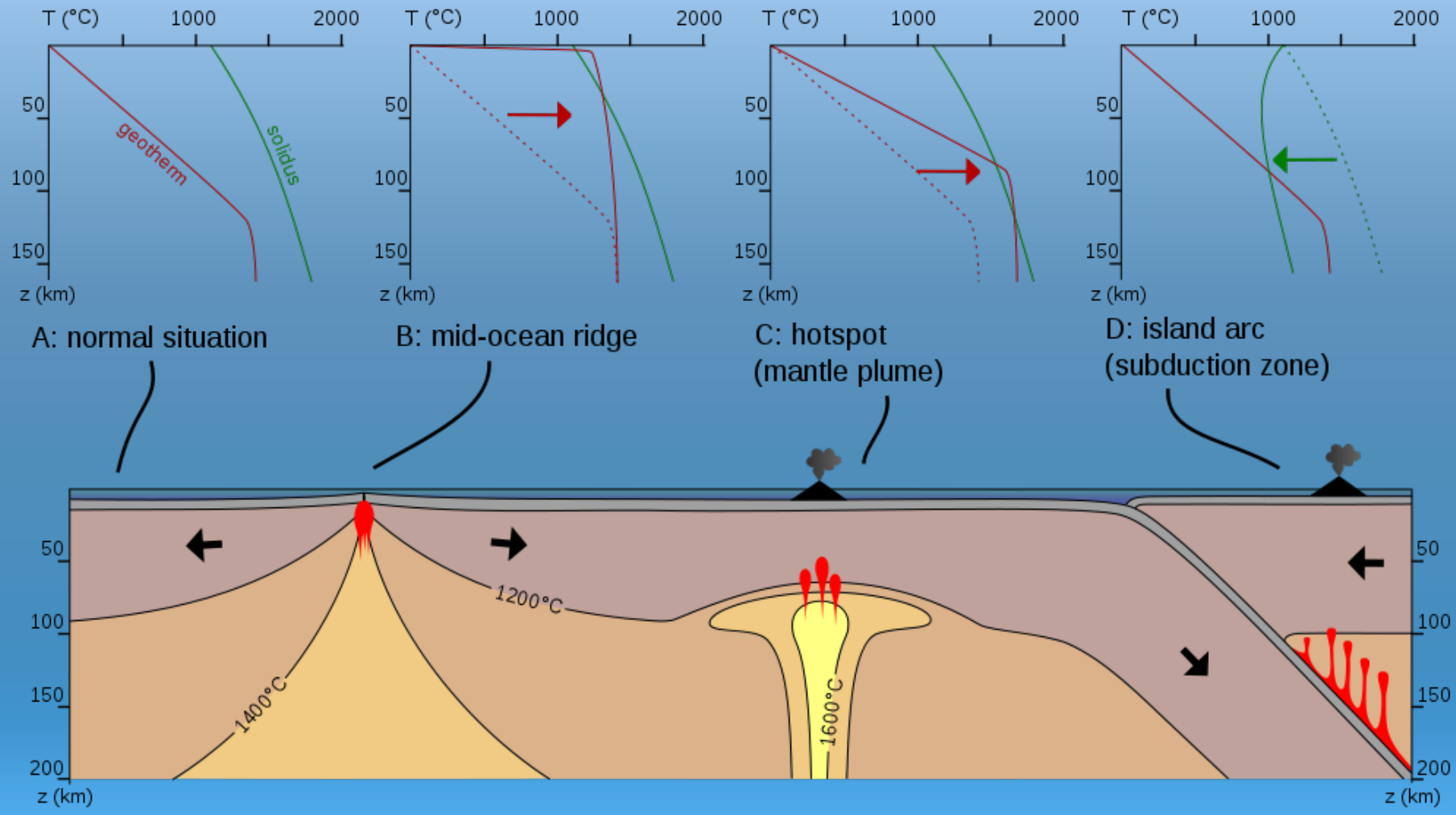
Geothermal gradient



http://www.tulane.edu/

Geothermal gradient



http://ei.lehigh.edu/

THERMODYNAMICS:

"science that tells us which mineral(s) will be stable under different conditions"

Definitions: System

some portion of the universe that you wish to study

- Surroundings = the adjacent part of the universe outside the system
- Isolated system
- Closed system
- Open system

Definitions: System

some portion of the universe that you wish to study

- Surroundings = the adjacent part of the universe outside the system
- Isolated system = no exchange of mass or heat with the surroundings
- Closed system = no exchange of mass
- Open system = exchange of heat and mass with surroundings

Definitions: State variables

- Extensive variables: depends on the size of the system
  - Mass
  - Moles
  - Volume
  - G (free energy)
  - S (entropy)
  - H (enthalpy)

Definitions: State variables

- Intensive variables: independent of the size of the system

Definitions: State variables

- Intensive variables: independent of the size of the system
  - T (≠ Heat)
  - P
  - $\underline{X}$ (composition)
  - $\overline{G}$ (specific free energy – G/mole)
  - $\overline{S}$ (specific entropy - S/mole)
  - $\overline{H}$ (specific enthalpy – H/mole)

Definitions: phase (p)

= any part of the system that is physically (and most often chemically) distinct and mechanically separable

≠ state of matter (Ex. SiO_2 system)

Definitions: Component (c)

= the minimum number of independent chemical compounds necessary to describe the compositions of all the phases in the system

≠ phase !

⇒ Unary (one component), binary (two components) and ternary (three components) systems.

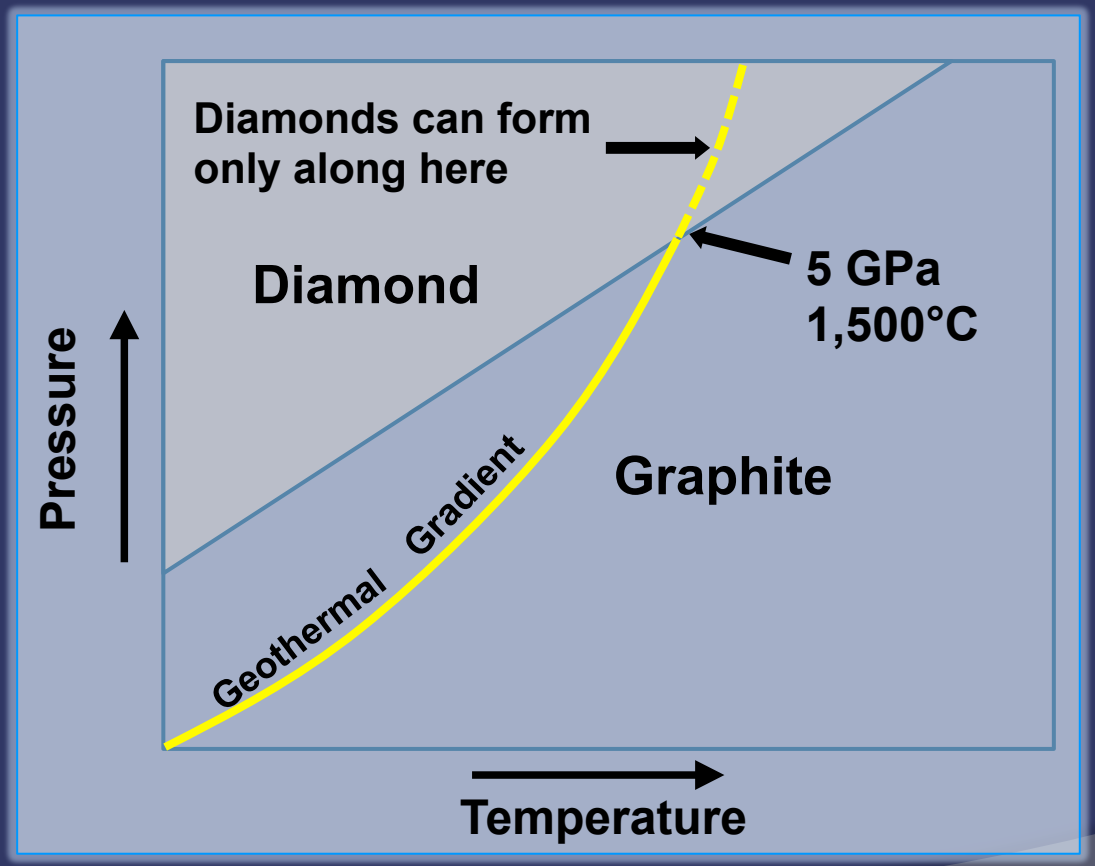
Definitions: Equilibrium

= the minimum energy state of a system under imposed conditions

- Le Chatelier's Principle → if a chemical system at equilibrium experiences a change in concentration, temperature, volume or partial pressure, then the equilibrium shifts to counteract the imposed change

Definitions: Equilibrium

- Metastability



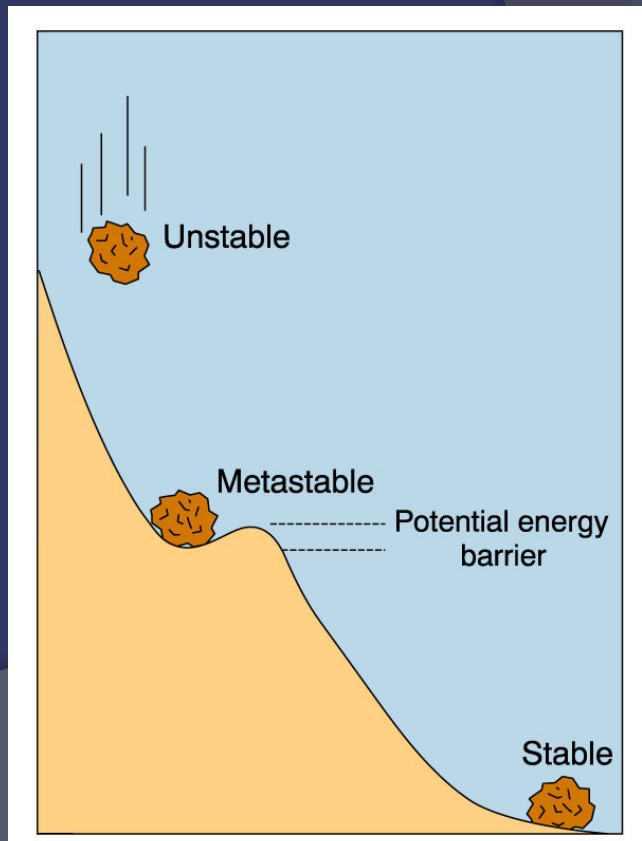


Fig. 5.1 Winter

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NEXT TIME

One and two component systems

TO READ:

Chapter 6

Chapters 1 & 2 Ehlers (smartsite)

FIGURE PRESENTATION