

“HARD ROCK”: IGNEOUS ROCKS

**Slides for lecture preceding
Igneous Triangles Exercise**

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What Is an Igneous Rock?

- Start with:
 - Molten (liquid) rock
 - Usually silicate composition (not always)
 - Called *magma* or *lava*
 - Underground (intrusive)*
 - At or near the surface (extrusive)*
 - Minerals crystallize; liquid rock → solid

Where Does Magma Come From?

- *Partial melting*: some of a rock melts
 - When temperature and pressure are just right, rock can melt
 - Occurs only in certain places & times
- About melting . . .

Aerial view of lava flow May 24, 2018



How Does Rock Melt?

1. Increase temperature (at constant P)

- Temperature increases with depth

- $\sim 25^{\circ}\text{C}/\text{km}$

- *Geotherm*: graph of the increase in temperature with depth

Heat causes solids to melt:

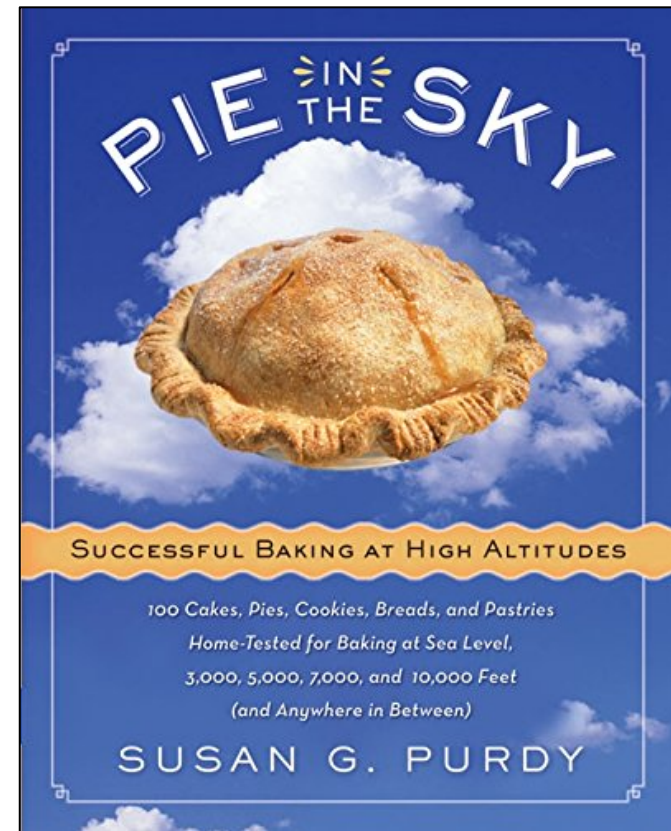


Another Way To Melt a Rock

2. Decrease pressure (at constant T)

- Pressure also increases with depth
- For solid rock at just below the melting temperature, a decrease in pressure → melting

Lower air pressure affects baking temperature:



<https://www.amazon.com/Pie-Successful-Baking-High-Altitudes/dp/0060522585/>

One More Way To Melt a Rock

3. Change composition

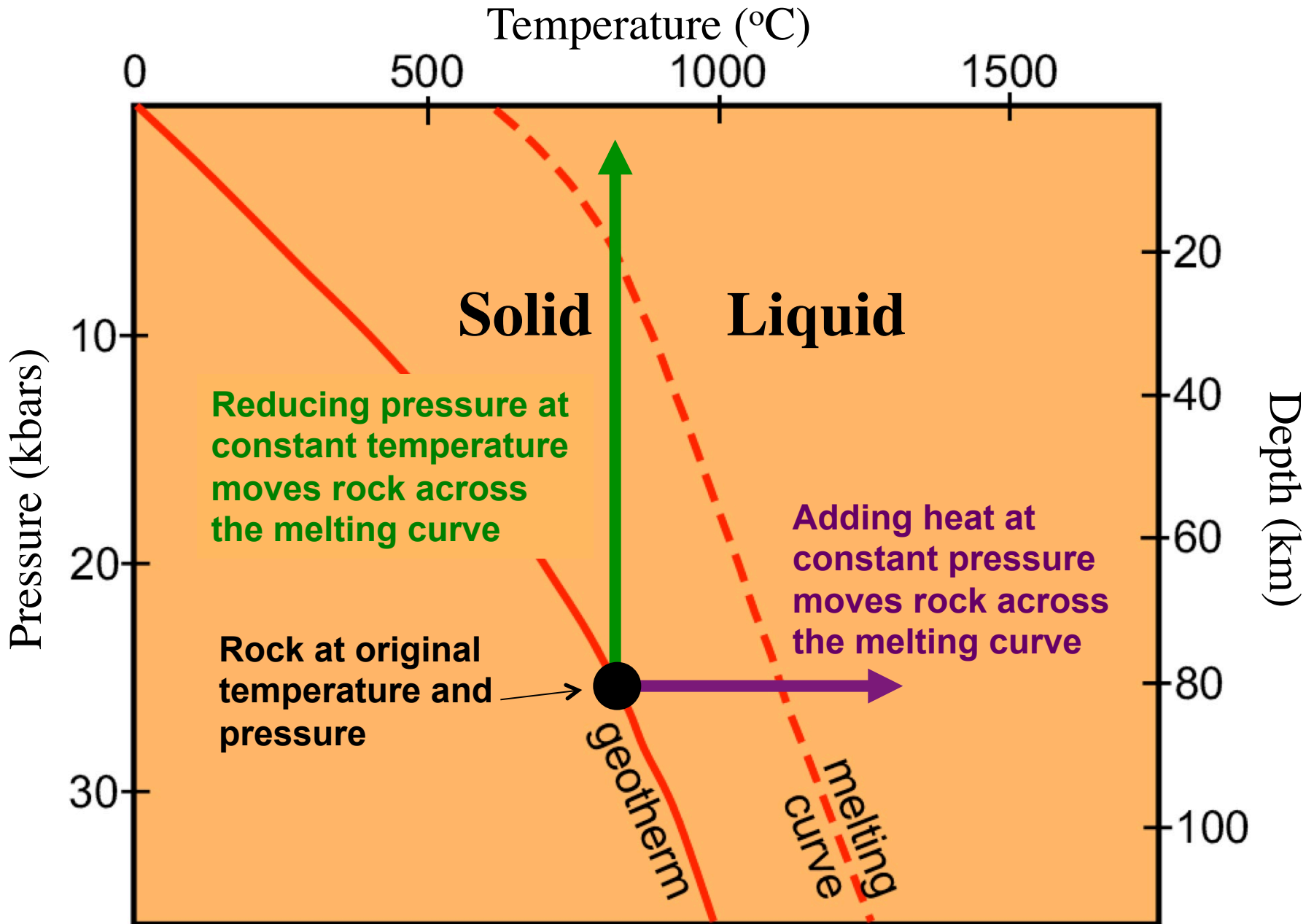
- Increasing water content reduces melting T
- For solid rock at just below its melting temperature, adding water \rightarrow melting

Adding salt to snow and ice triggers melting:

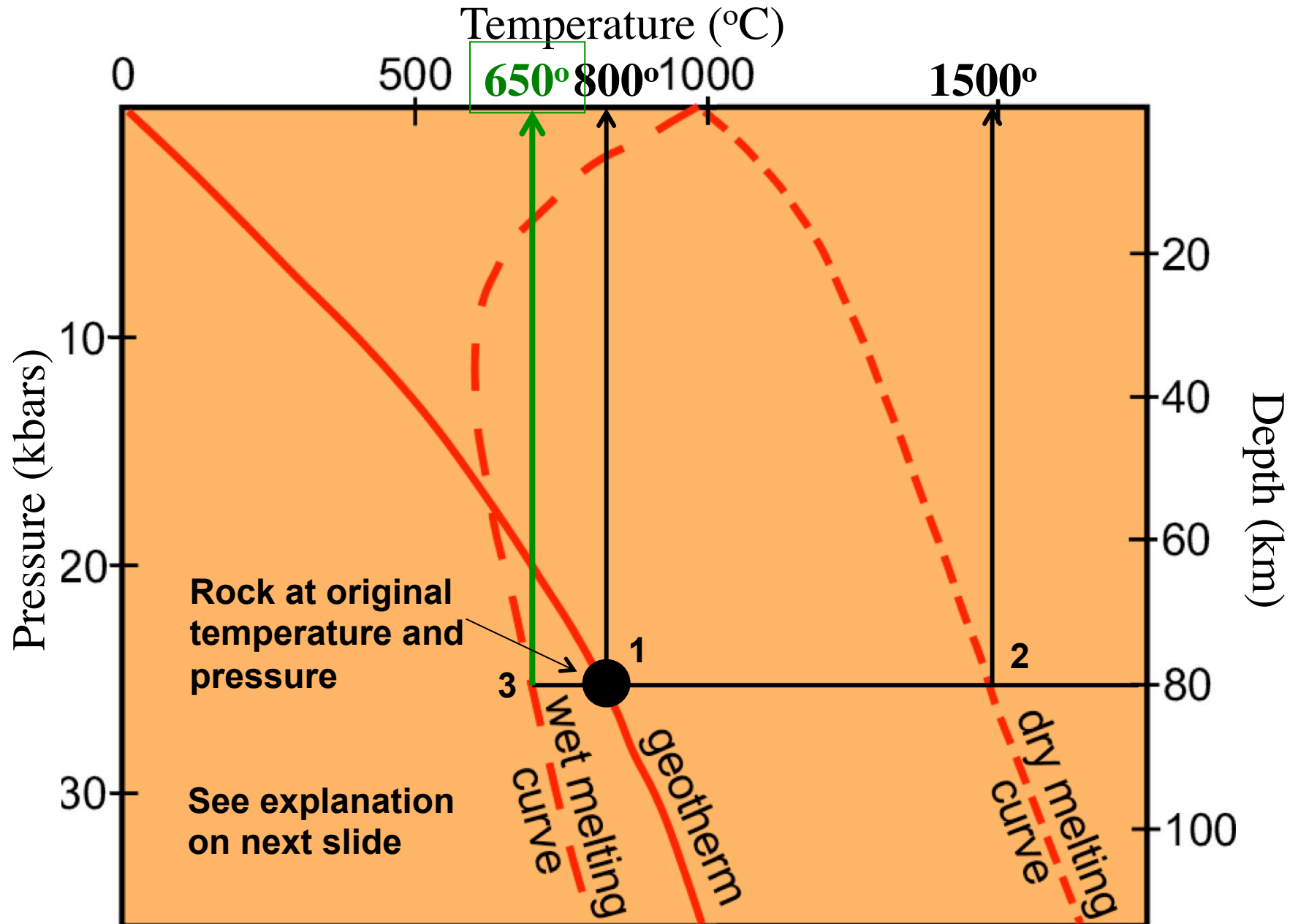
https://cdn.shopify.com/s/files/1/0840/1021/products/50_ROCK.jpg



Melting by T & P Changes



Melting by Compositional Change



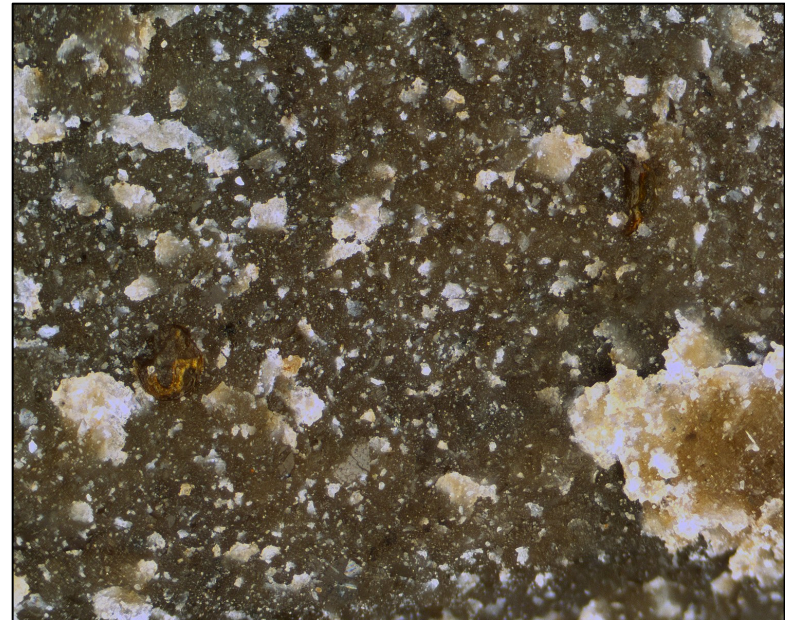
Compositional Change Melting

- **Black circle represents solid rock on the geotherm (1) where $T = 800^{\circ}\text{C}$**
 - **Temperature at 1 is lower than at 2 on the dry melting curve where $T = 1500^{\circ}\text{C}$, so no melting.**
 - **Add water – then refer instead to the wet melting curve:**
 - **Temperature at 1 is higher than at 3 on the wet melting curve where $T = 650^{\circ}\text{C}$, so rock melts.**

Classification of Rocks

- All rocks named by 2 properties
 - *Composition*: what minerals are present
 - *Texture*: how grains look
 - Size
 - Shape
 - Arrangement

Various sizes & colors of minerals



Igneous Classification

- Based on

- Grain size

- Fine or coarse

Hand lens for examining rocks



<https://www.amazon.com/Bausch-Lomb-Hastings-Triplet-Magnifier/dp/B0007LRNG6>

- Composition

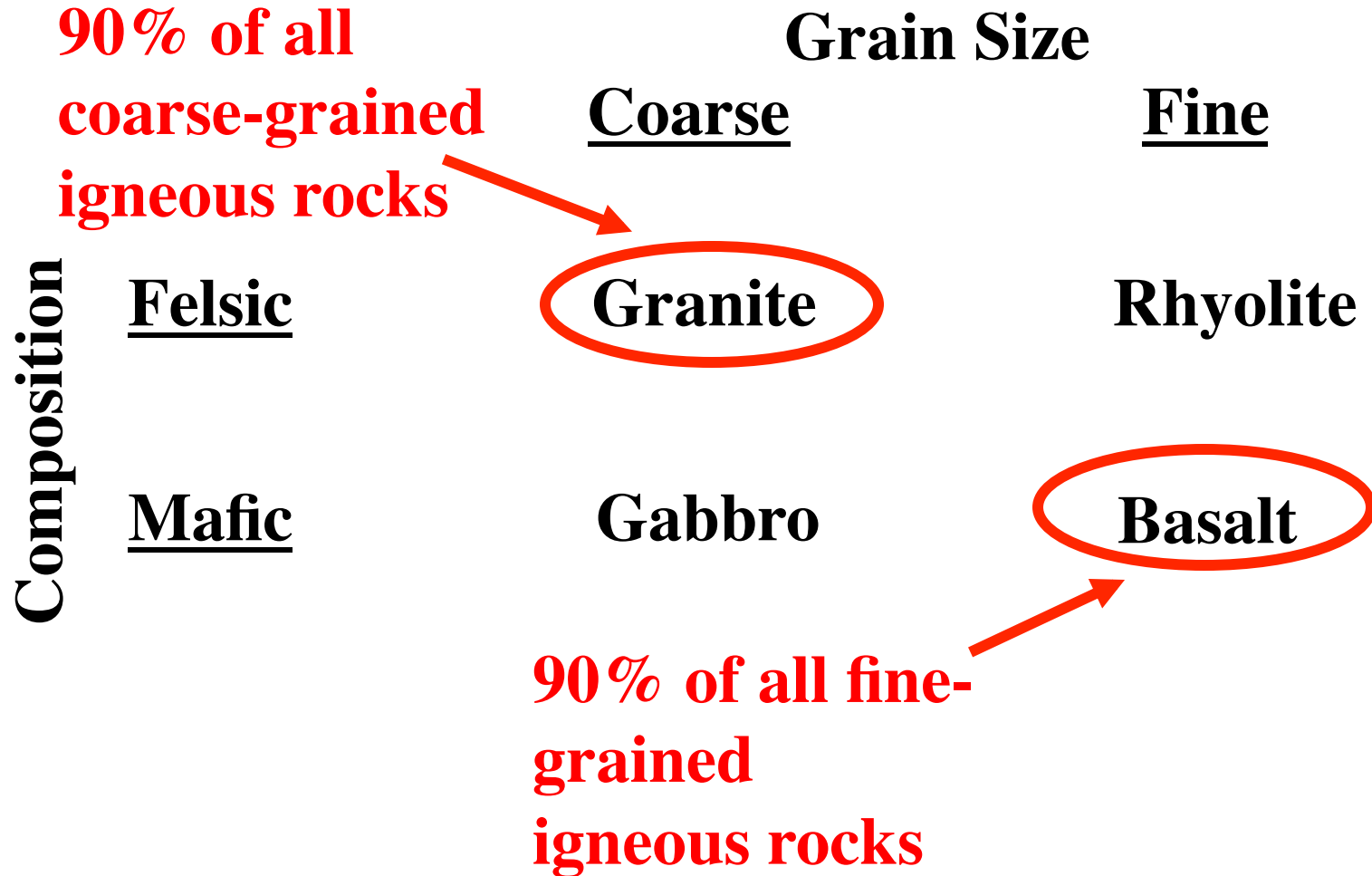
Light-colored

- *Felsic*: lots of feldspar (fel) & quartz (Si)

- *Mafic*: lots of magnesium (Mg) and iron (Fe)

Dark-colored

Igneous Rock Names



Igneous Rocks Illustrated

Granite



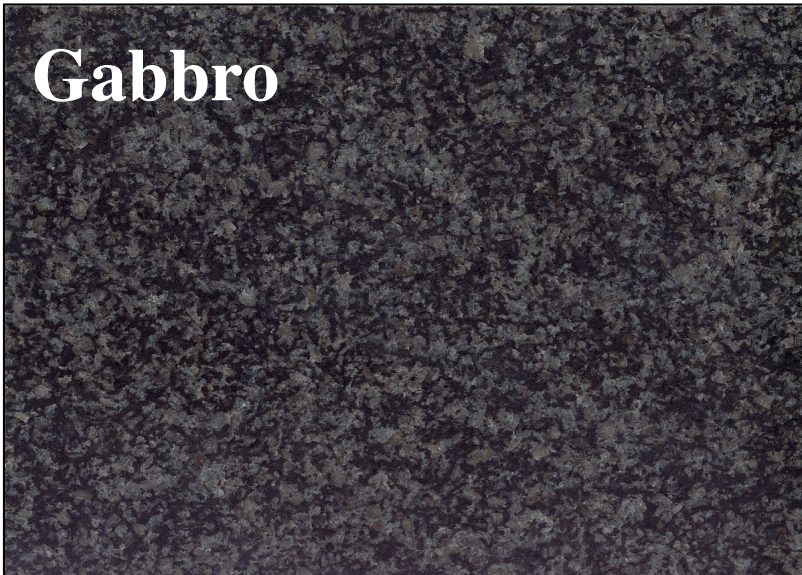
<https://en.wikipedia.org/wiki/Granite>

Rhyolite



<https://commons.wikimedia.org/wiki/File:PinkRhyolite.tif>

Gabbro



<https://commons.wikimedia.org/wiki/File:Impala1200.jpg>

Basalt



<https://commons.wikimedia.org/wiki/File:Basalt.JPG>

Grain Size and Cooling Rate of Lava

- Lava cools quickly
 - Many small crystals
 - Fine-grained
 - Not enough time for crystals to grow large

Lava flow in Hawaii in 2003



Grain Size and Cooling Rate of Magma

- Magma cools slowly
 - Fewer, larger crystals
 - Coarse-grained
 - The more slowly it cools, the larger the crystals grow

Large crystals in intrusive rock



Compositions

- **As magma cools ...**
 - **Minerals form in a specific order**
 - **Mafic minerals crystallize at higher T**
 - 1: olivine**
 - 2: pyroxene + anorthite (Ca-plagioclase)**
 - 3: amphibole + albite (Na-plagioclase)**

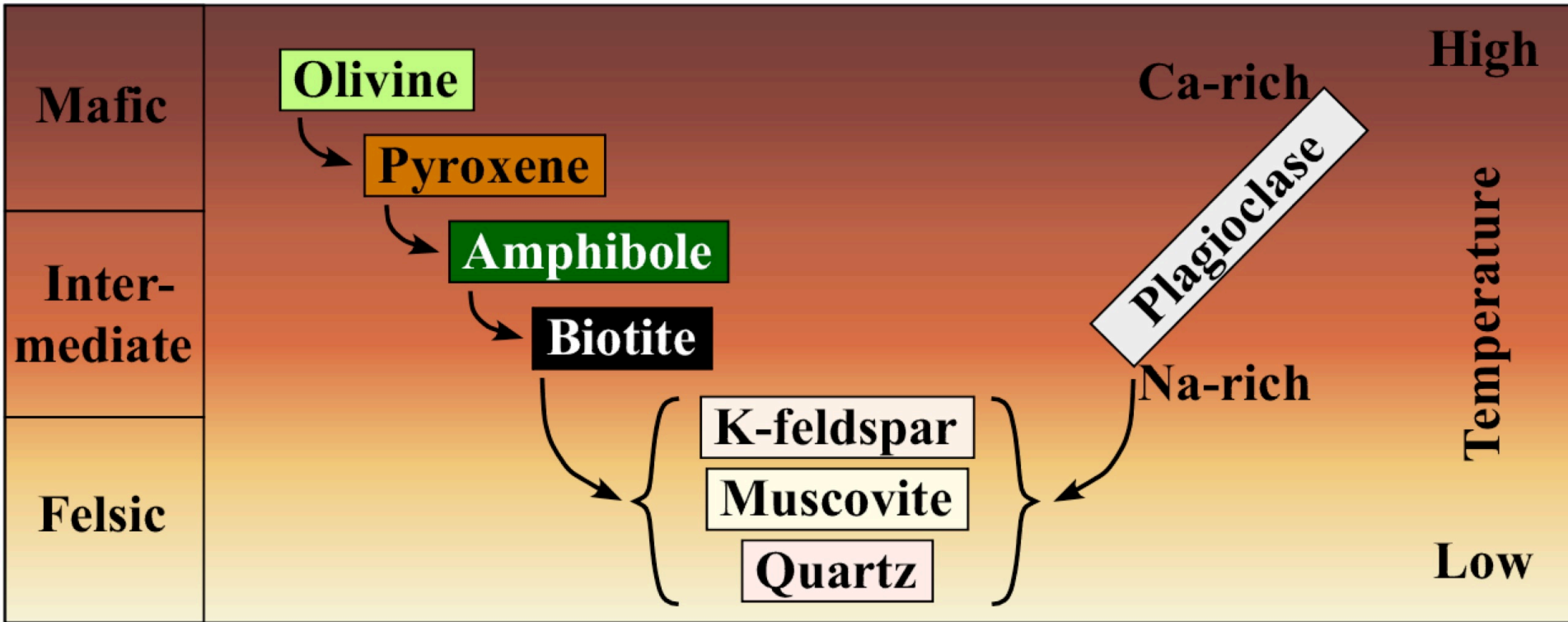
Temperature and Type of Igneous Rock

- **As magma cools ...**
 - **Felsic minerals crystallize at lower T**
 - 4: biotite and muscovite**
 - 5: quartz and orthoclase (K-feldspar)**
- **Thus ...**
 - **Granite & rhyolite \approx lower T of formation**
 - **Basalt & gabbro \approx higher T of formation**

Bowen's Reaction Series

Basalt/gabbro

Last minerals to melt,
First minerals to crystallize



Rhyolite/granite

First minerals to melt,
Last minerals to crystallize

Teaching Notes and Tips

This exercise is divided into three complementary sections. The exercise may be completed in one extended laboratory period, or individual sections may be assigned as separate, shorter activities or as homework.

In Parts I and II, students would ideally handle physical specimens of granite (composed of orthoclase, plagioclase, quartz, and biotite) and gabbro (composed of pyroxene, plagioclase, and hornblende). Thin section observation may be included if available. Note that if the instructor uses physical samples, then some answers may need to be changed to match the specimens. Alternatively, the instructor may provide the sample images illustrated in the Igneous Triangles Samples file (PDF) either in electronic form or as hard copy.

Because computer software changes so rapidly, the instructions for accomplishing certain tasks with Excel might differ from those given in the student instructions. Thus, the instructor should be aware of possible difficulties using Excel.