Today

1) Quiz: Chapter 3 Vocabulary/ Chapter 2 Review

2) Igneous Rock lecture (part 1)

Igneous Rocks and Processes

Tierra del Fuego, South America

Does the mineral in the <u>middle</u> have a cleavage?

a) yes
b) no
c) don't understand cleavage and couldn't tell even if I had the sample.

Does the mineral in the <u>middle</u> have a cleavage?

a) yes
b) no
c) don't understand cleavage and couldn't tell even if I had the sample.

How many directions of cleavage can you see?

a) One

b) Two

c) Three

d) Four

How many directions of cleavage can you see?

a) One

b) Two

c) Three

d) Four

What is the orientation of the cleavage planes with respect to each other?

a) Right angles

b) 60 degrees

c) Between 90 and 60 degrees.

What is the orientation of the cleavage planes with respect to each other?

a) Right angles

b) 60 degrees

c) Between 90 and 60 degrees.

What Mineral is this?

a) Quartz

b) Calcite

c) Gypsum

d) Halite (salt)

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Use Cleavage to determine what Mineral this is?

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Use Cleavage to determine what Mineral this is?

a) Quartz

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c) Gypsum

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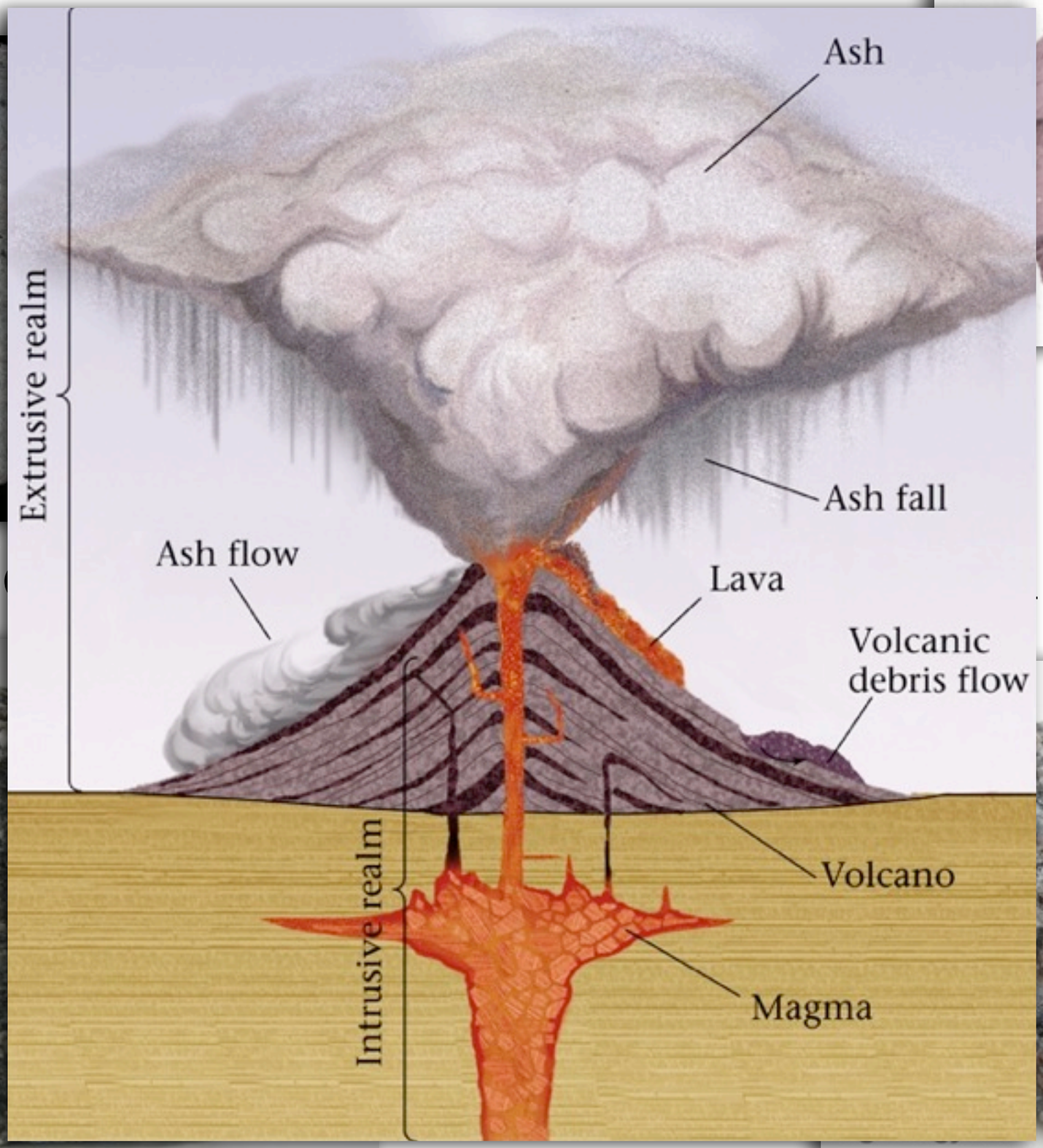
Igneous Rocks

Igneous Rocks

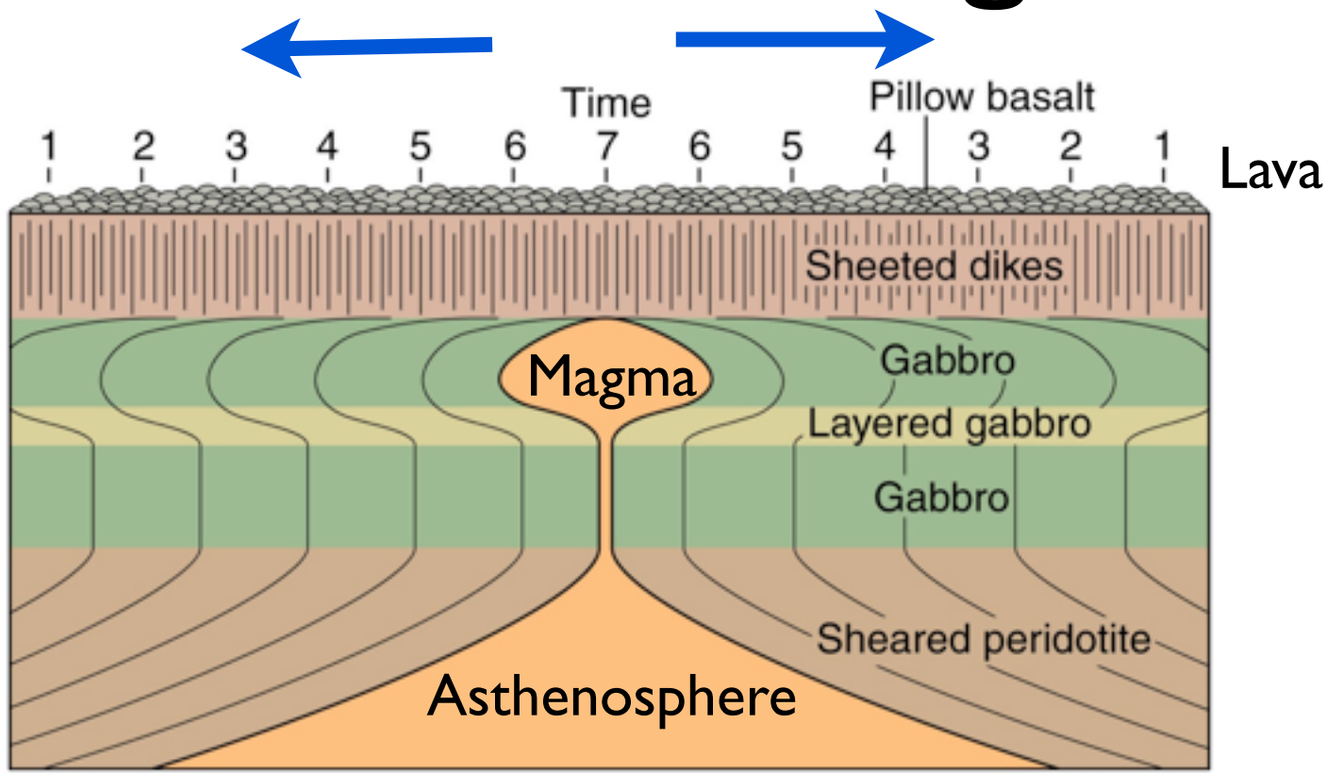
Form from solidification of lava or magma

Igneous Rocks



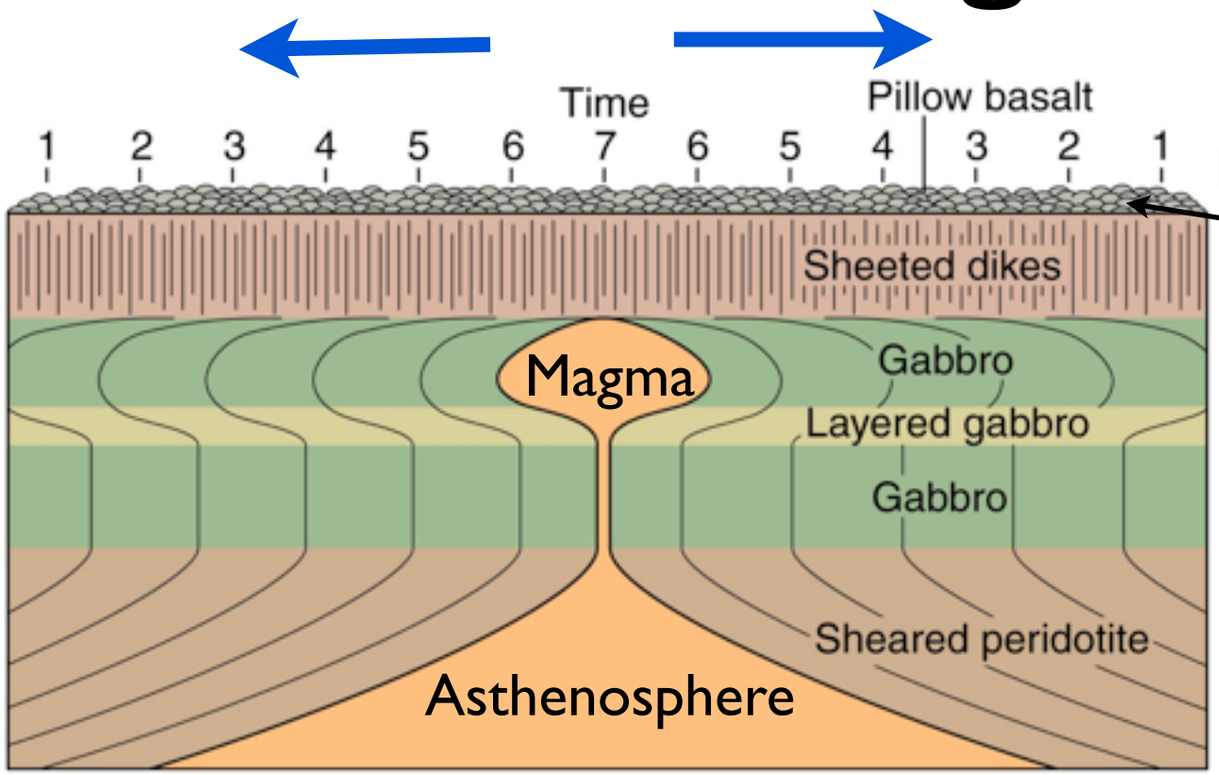
F or magma

Magma vs. Lava



Ophiolite Suite

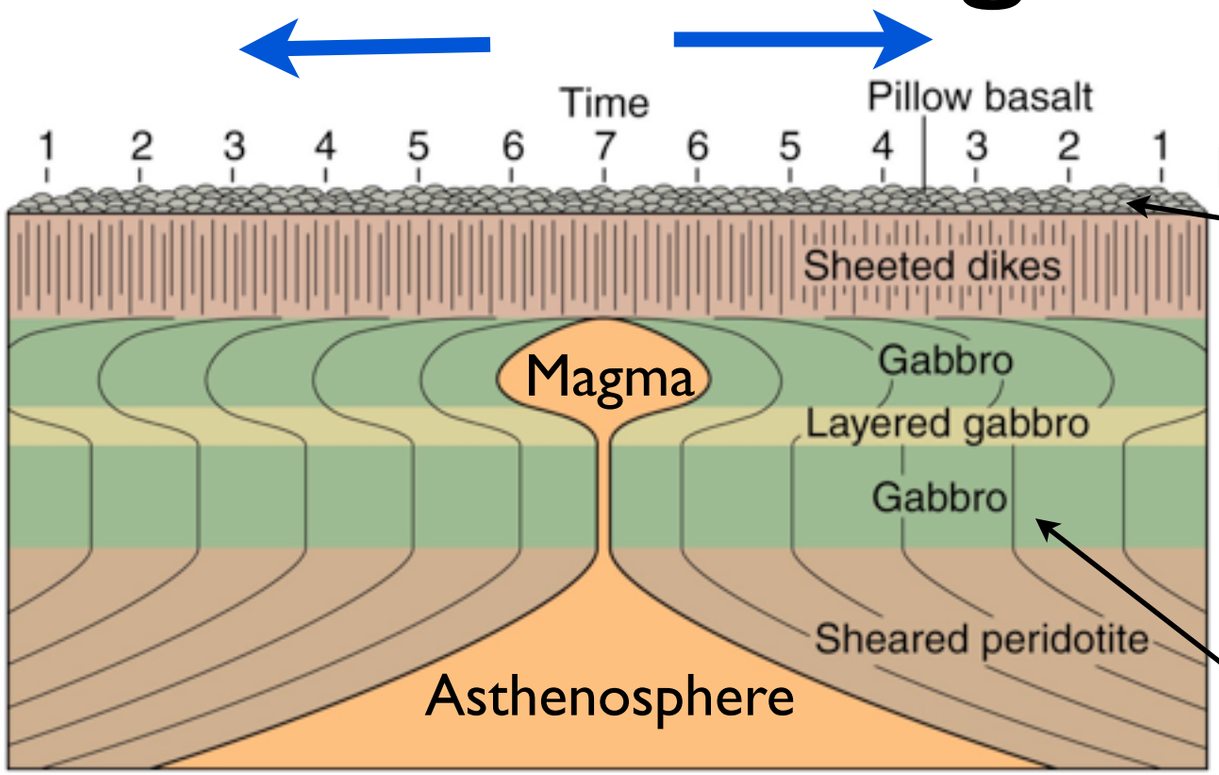
Magma vs. Lava



Lava

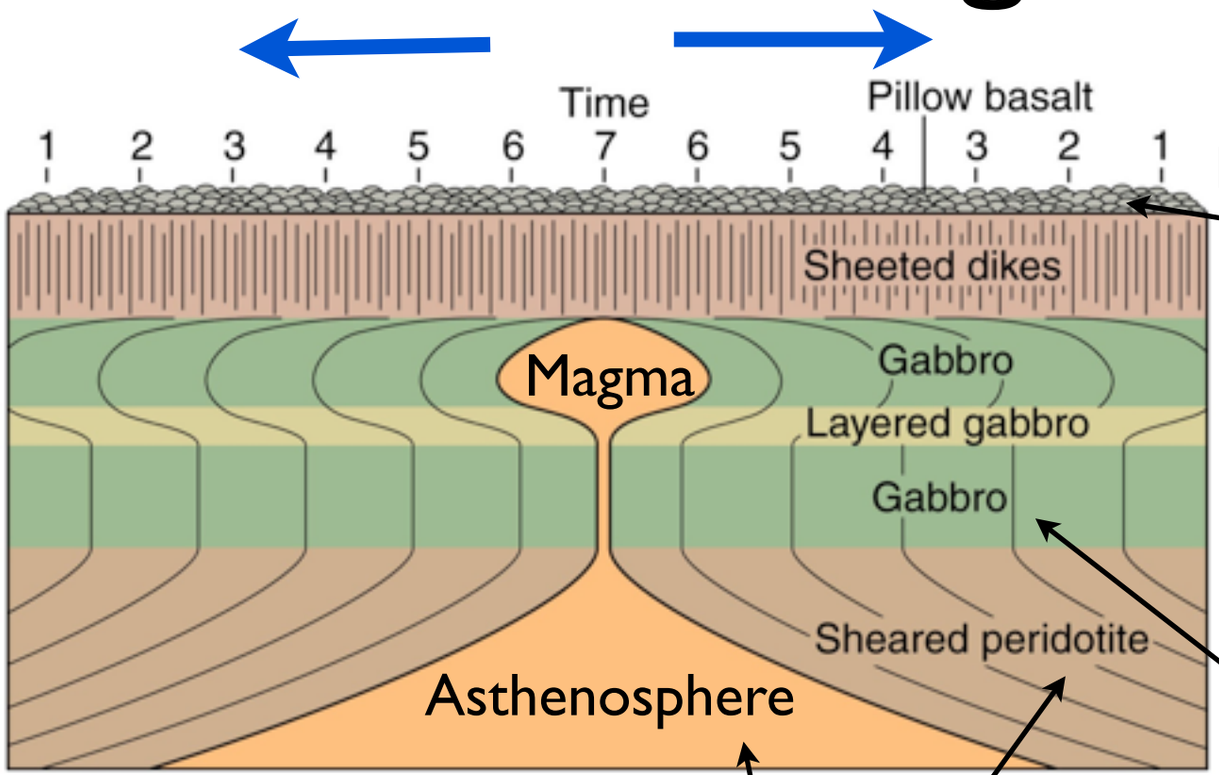
Ophiolite Suite

Magma vs. Lava



Ophiolite Suite

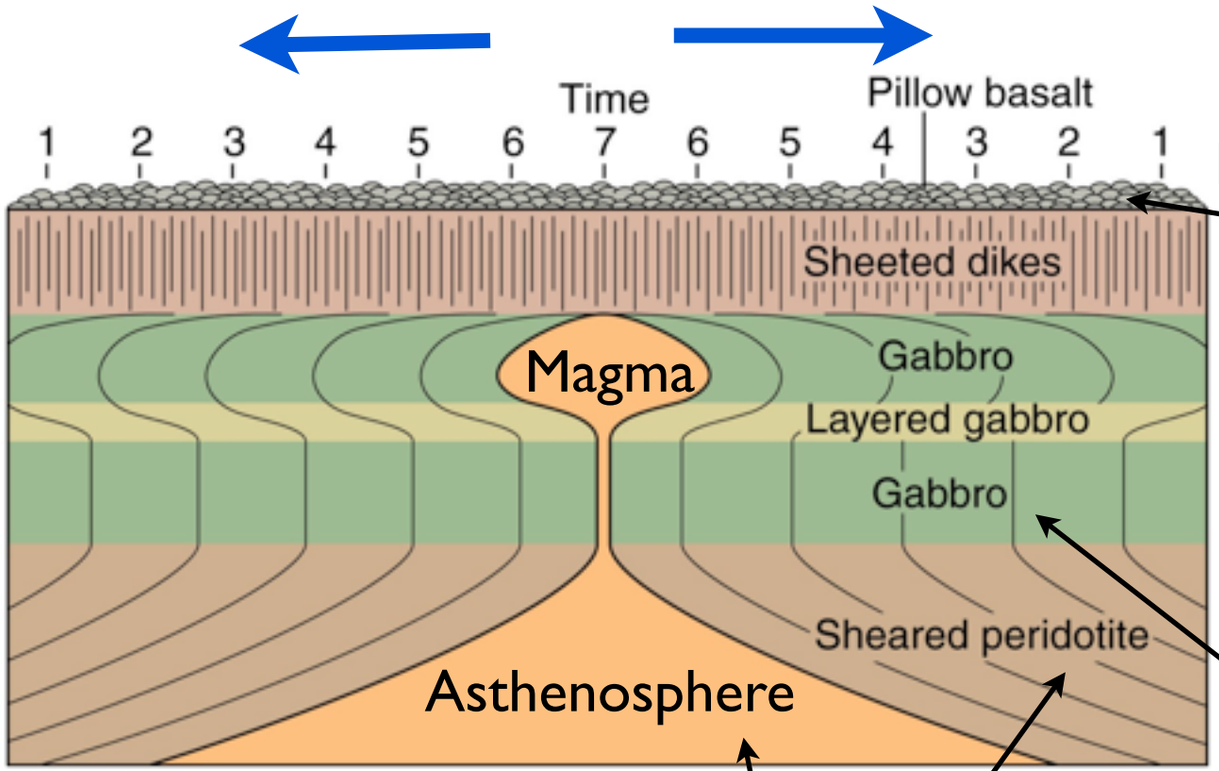
Magma vs. Lava



Ophiolite Suite

Lava

How does the composition of these rocks compare?



Ophiolite Suite

Lava

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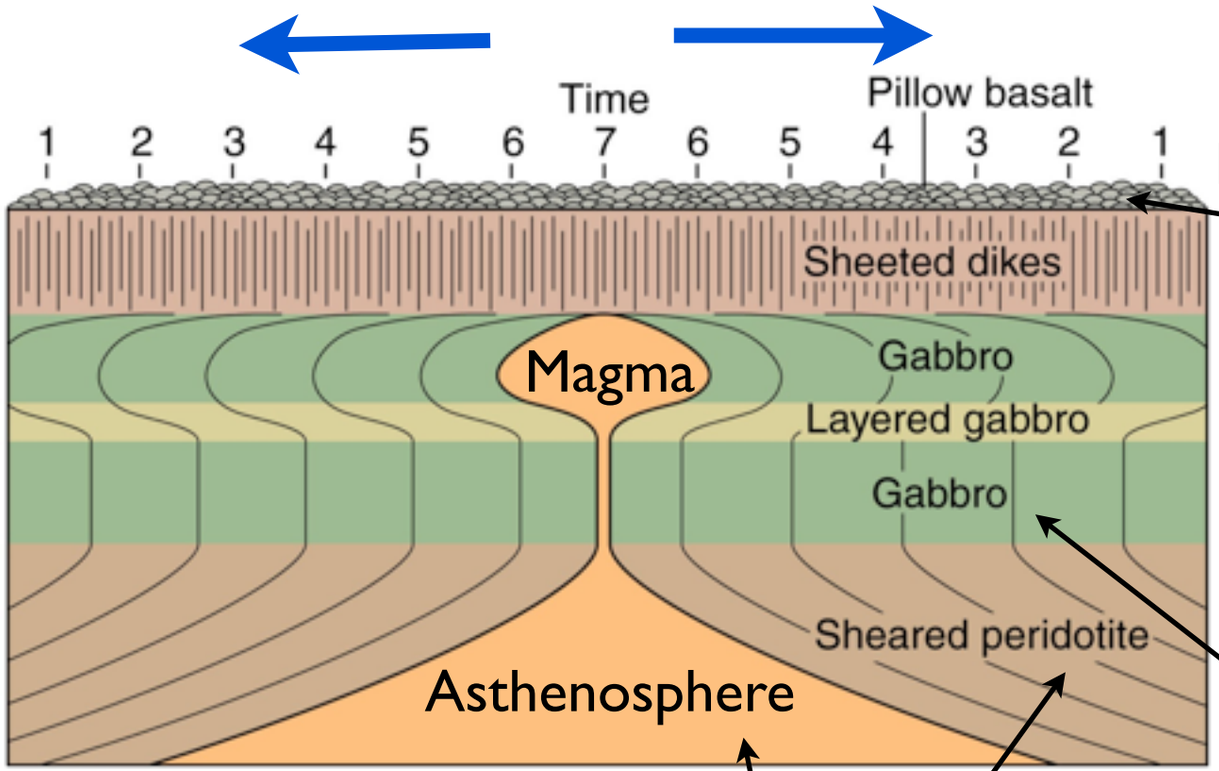
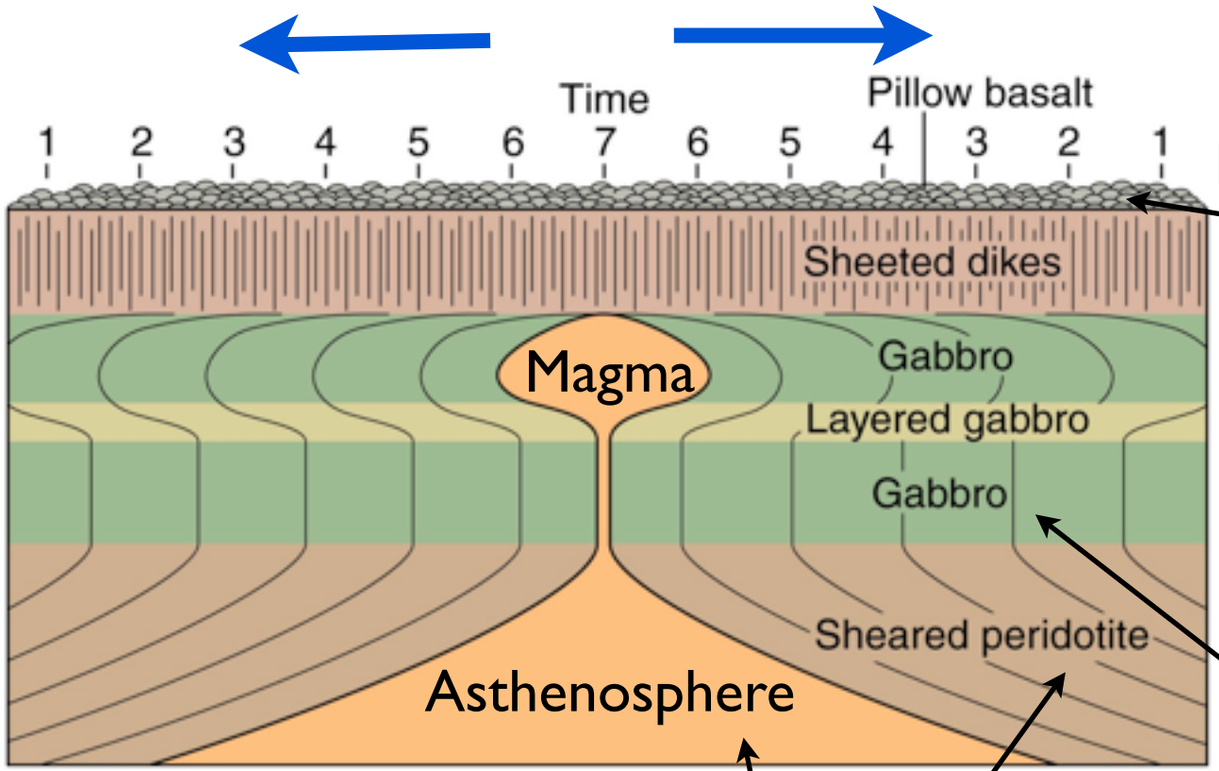


Ophiolite Suite

Lava

Same

How does the composition of these rocks compare?



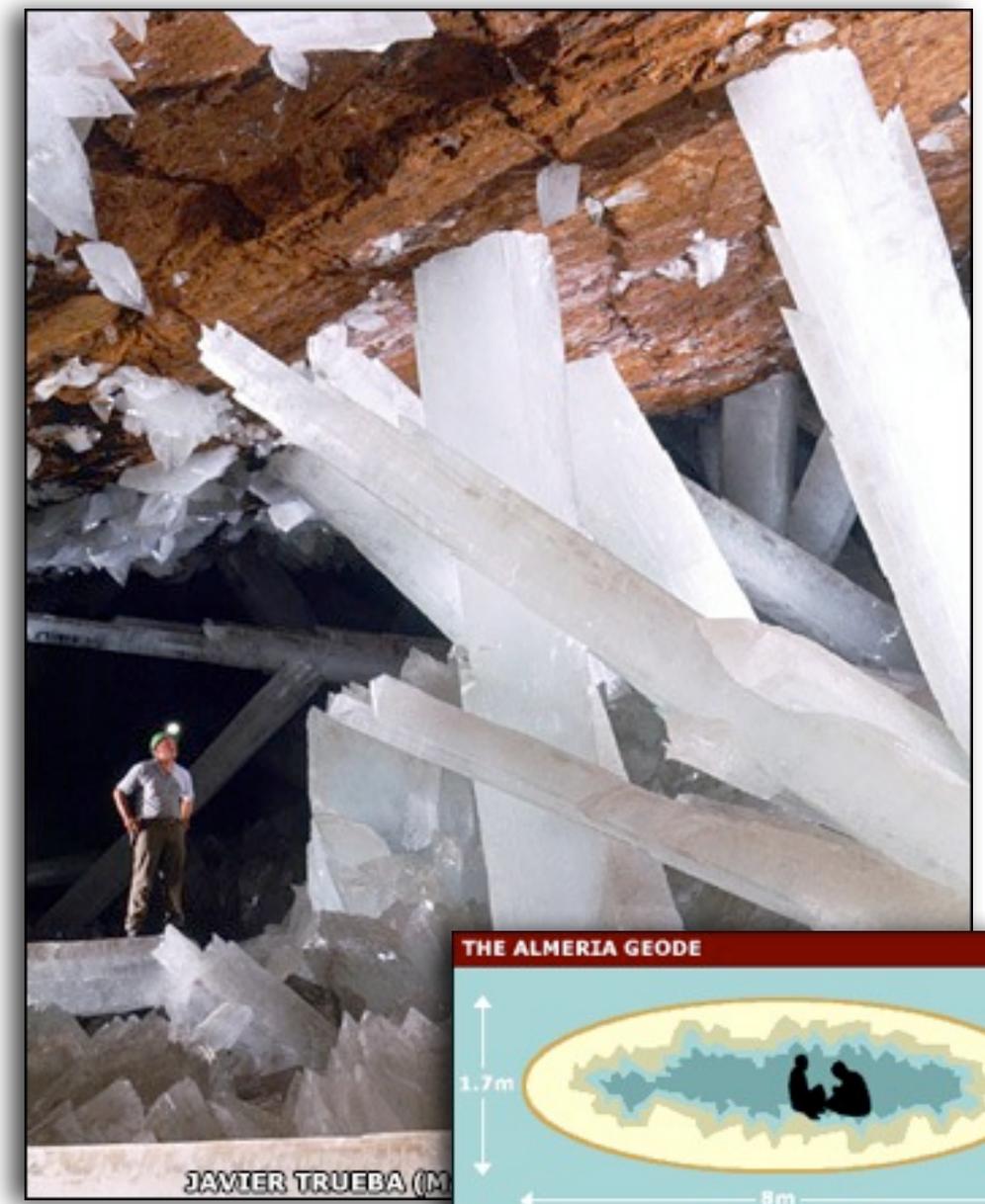
Ophiolite Suite

Lava

Same

Different

Why are some minerals small and some minerals large?



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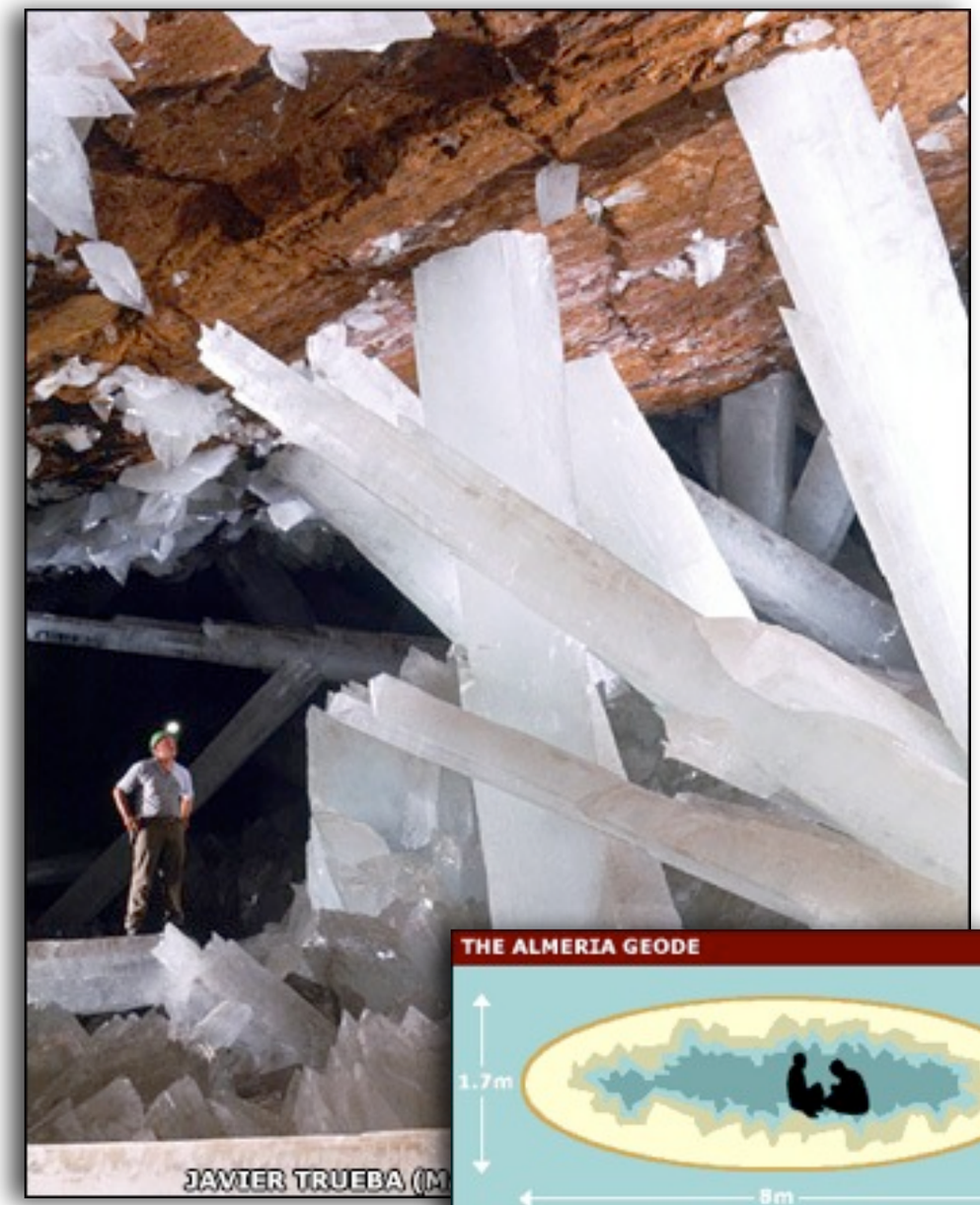
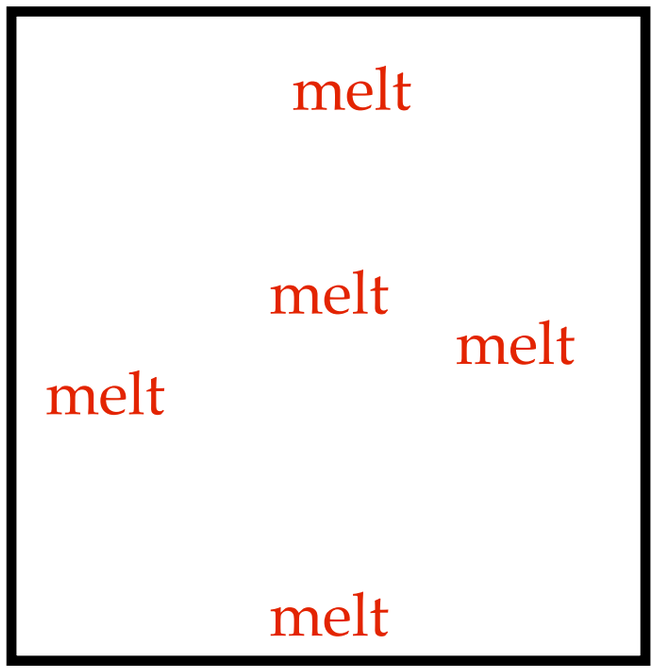


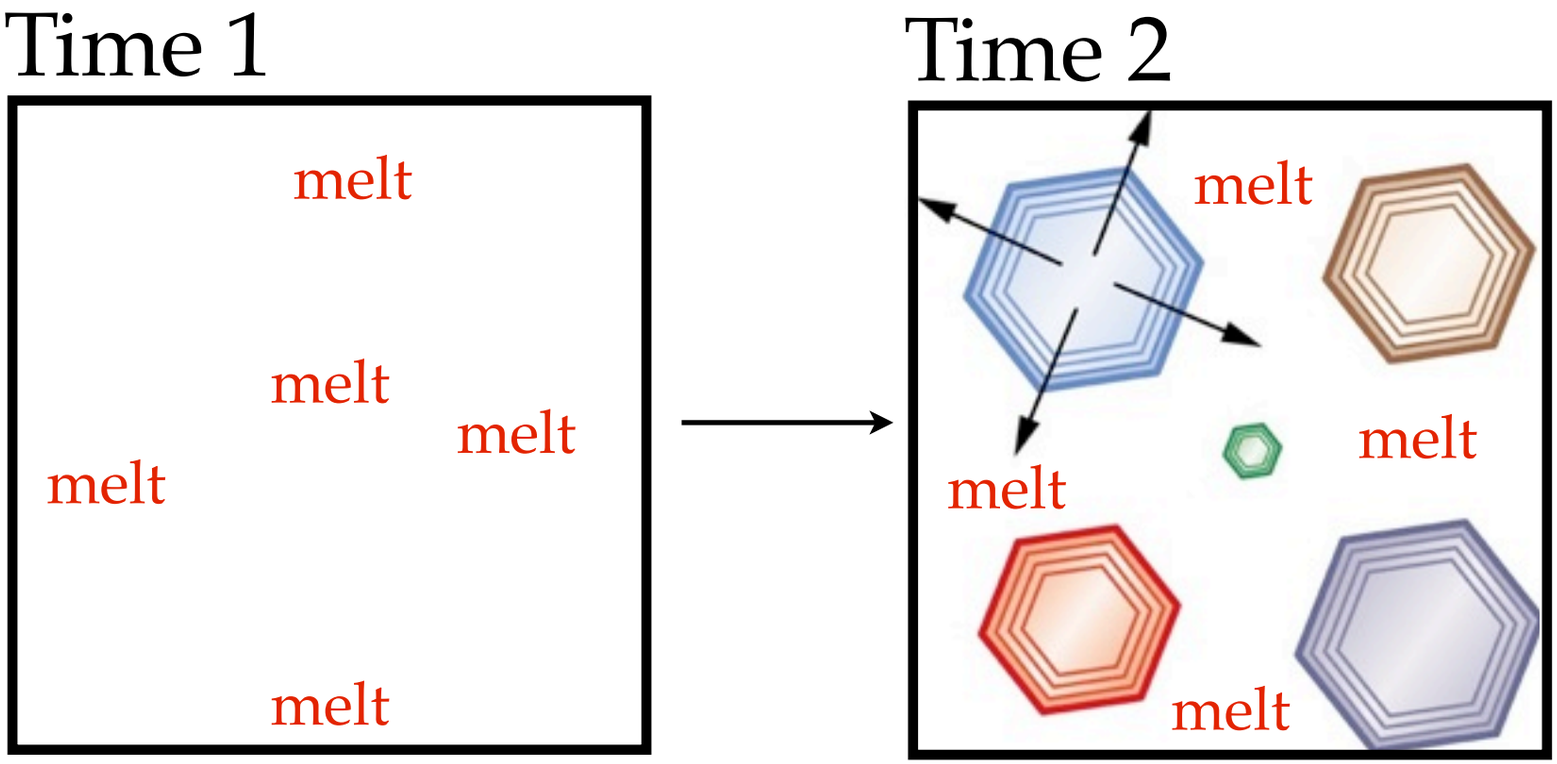
Temperature
Pressure
Composition (including H2O)
Time

Mineral Formation in Silicates

Time 1

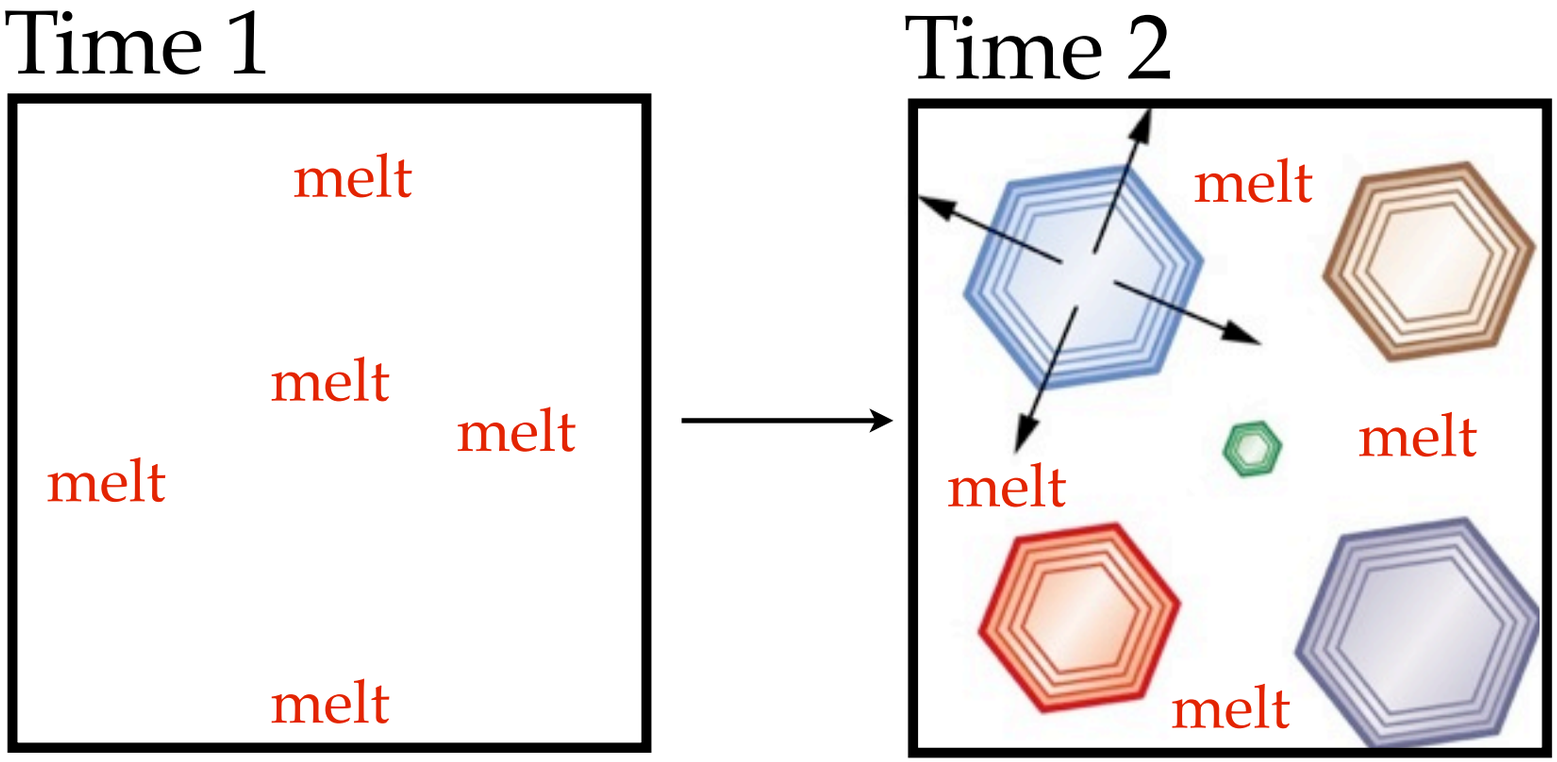


Mineral Formation in Silicates



Minerals crystallize from a melt

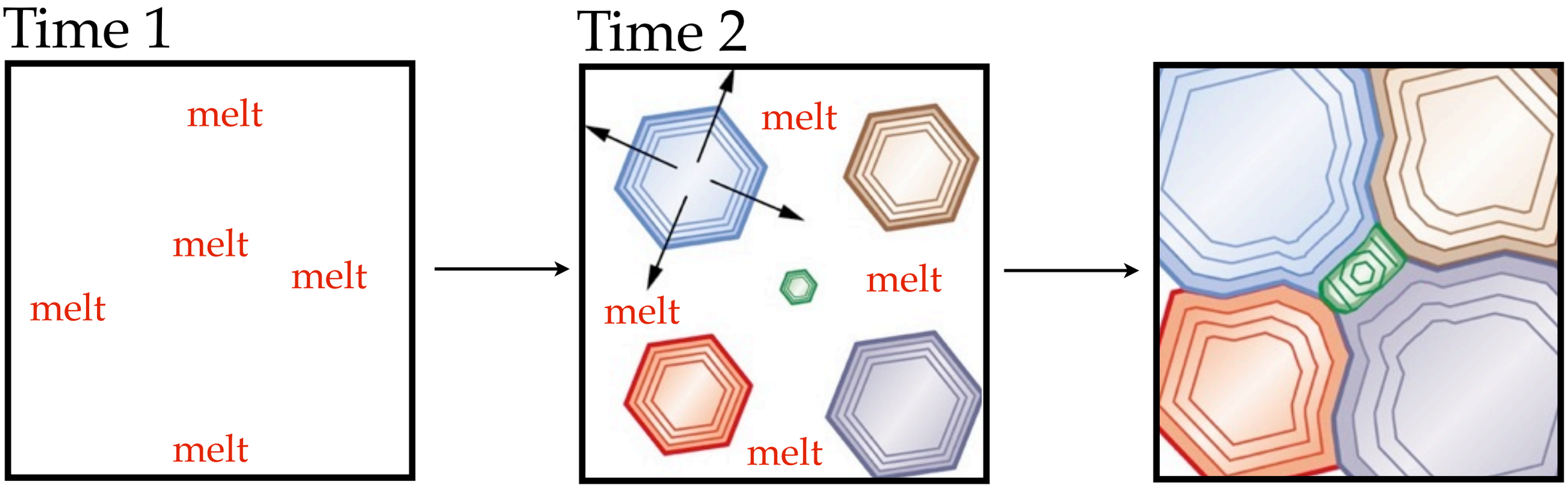
Mineral Formation in Silicates



Minerals crystallize from a melt

What would the rock look like if we rapidly cooled it at Time 1?
What would the rock look like if we rapidly cooled it at Time 2?

Mineral Formation in Silicates



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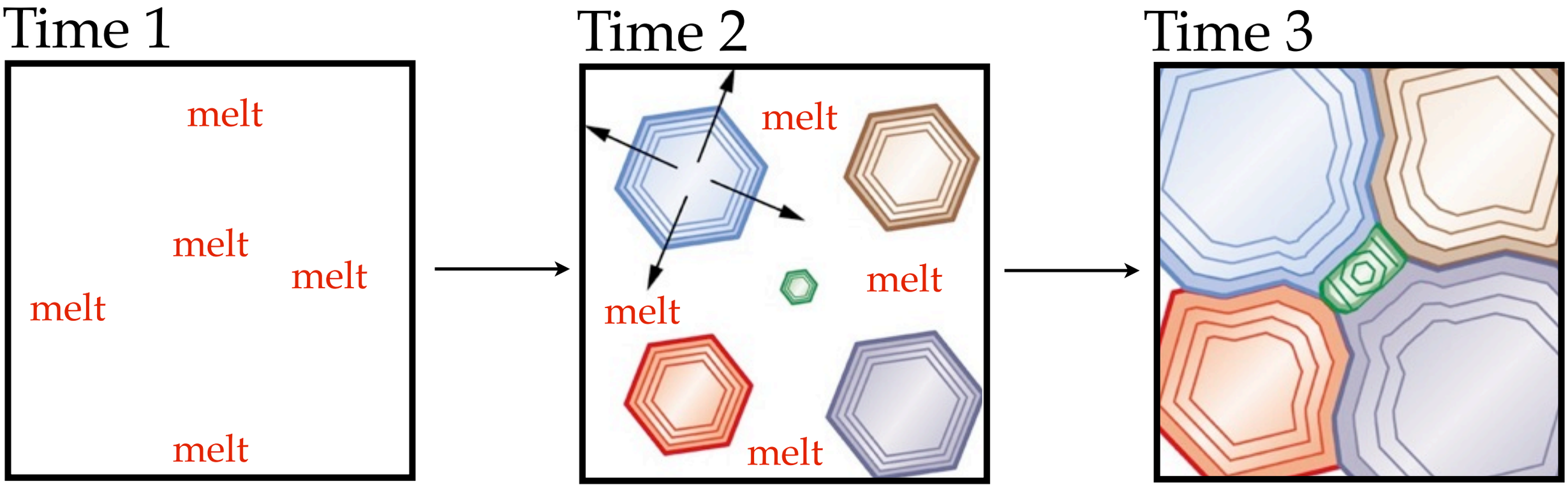

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What would the rock look like if we rapidly cooled it at Time 3?

Mineral Formation in Silicates

Time 1

Time 2

Time 3

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Mineral Formation in Silicates

Time 1

Mineral Formation in Silicates

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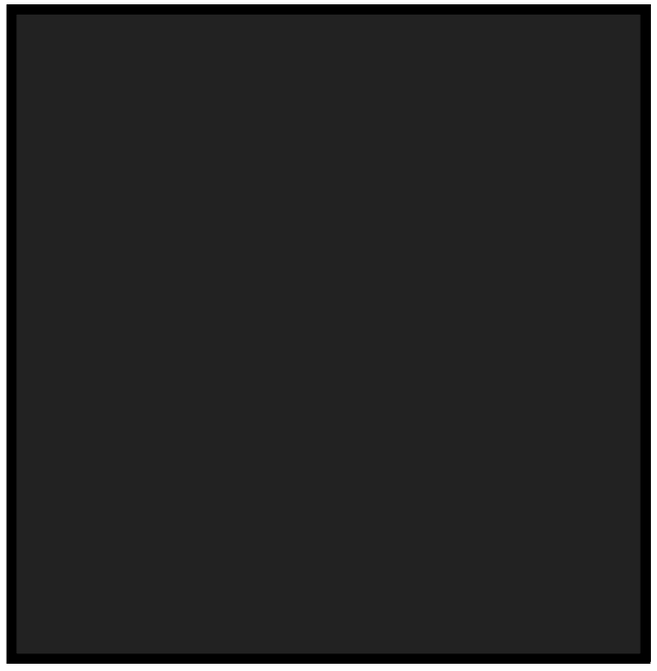
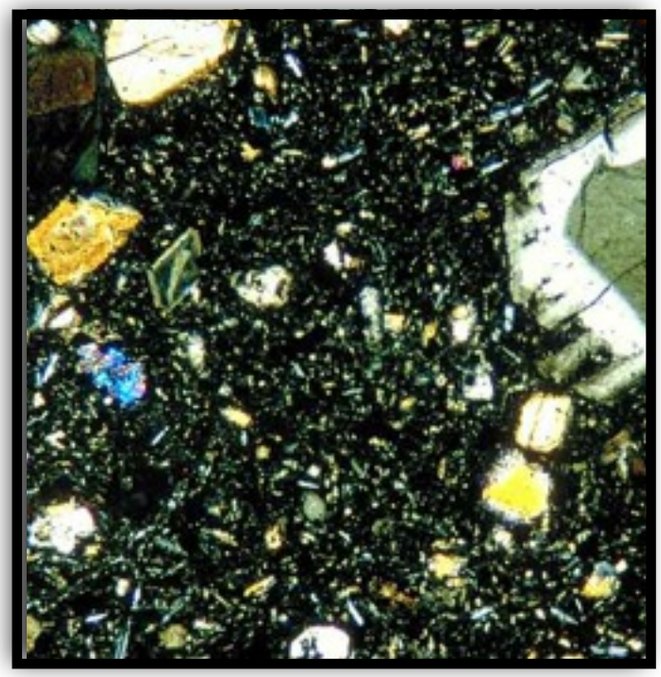


Time 2



Time 3

Minerals crystallize
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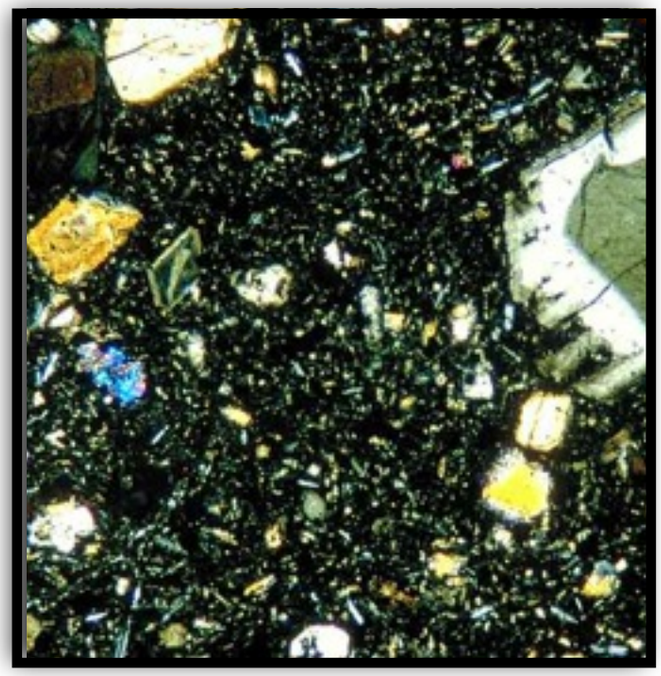
Mineral Formation in Silicates

Time 1

Aphanitic Texture

Time 2



Porphyritic Texture

Time 3

Phaneritic Texture

Igneous rock textures through a Microscope

Mineral Formation in Silicates

Time 1

Aphanitic Texture

Time 2

Porphyritic Texture

Time 3

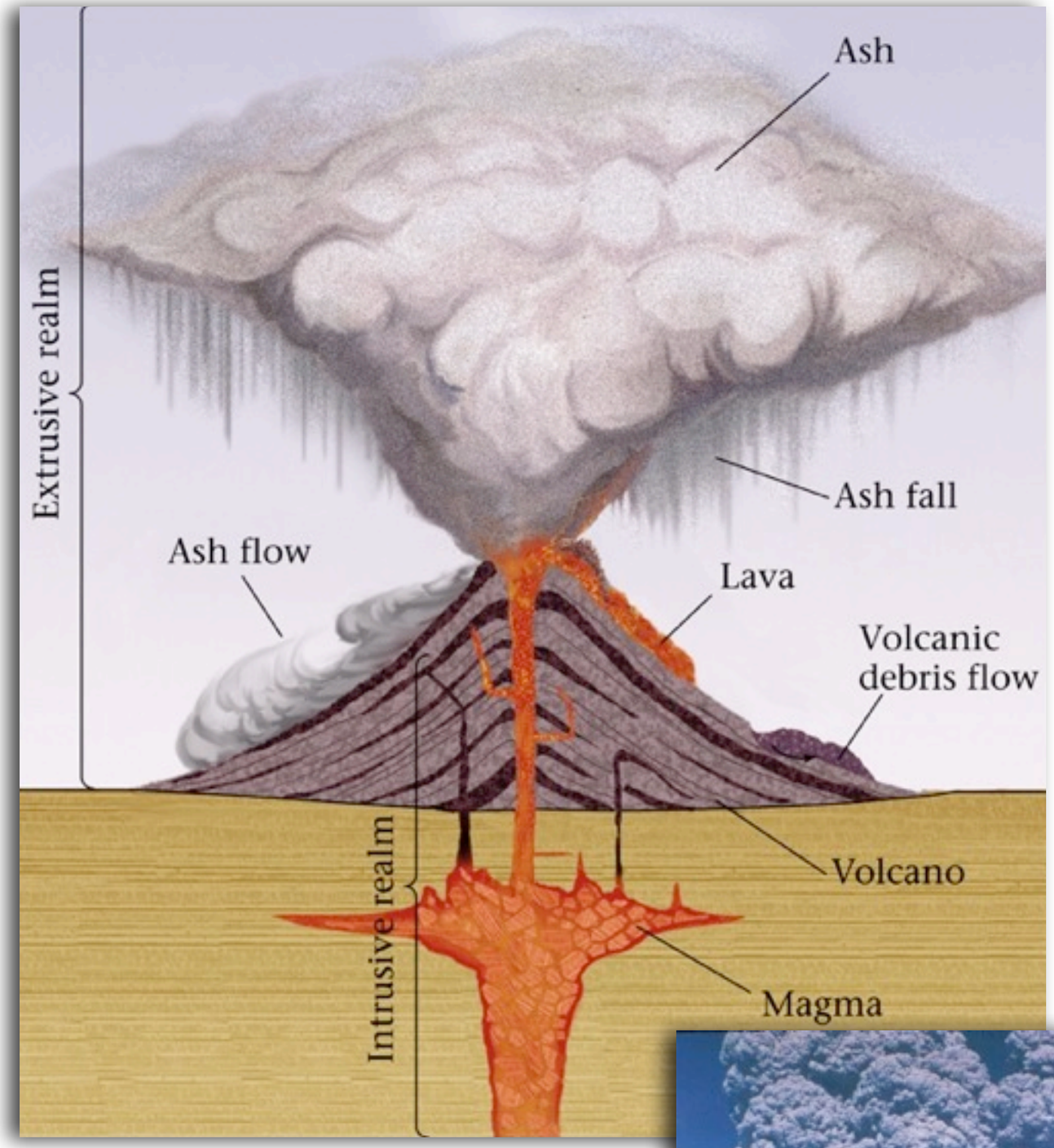
Phaneritic Texture

Igneous rock textures in hand sample

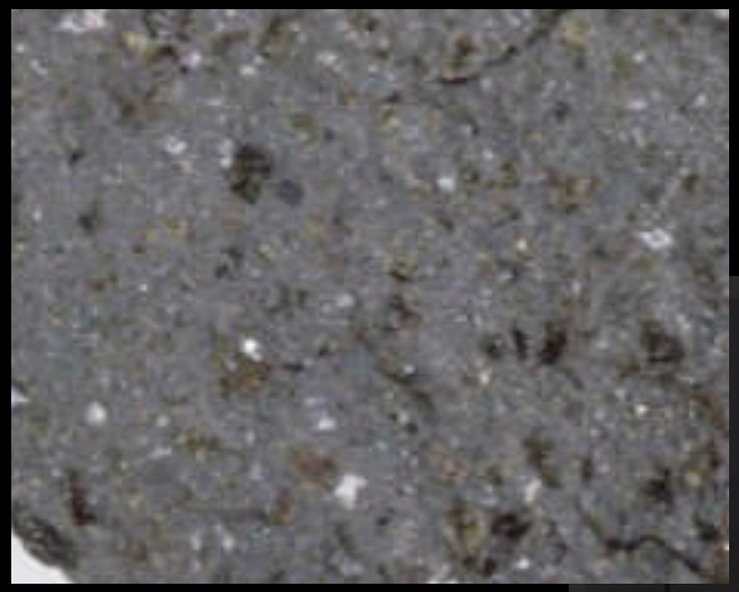
Igneous Rocks

<u>Extrusive Igneous Rock</u>
A rock that solidifies from a melt at the Earths Surface.
--Referred to as volcanic rock.

<u>Intrusive Igneous Rock</u>
A rock that solidifies beneath the Earths surface.
--Referred to as a plutonic rock.



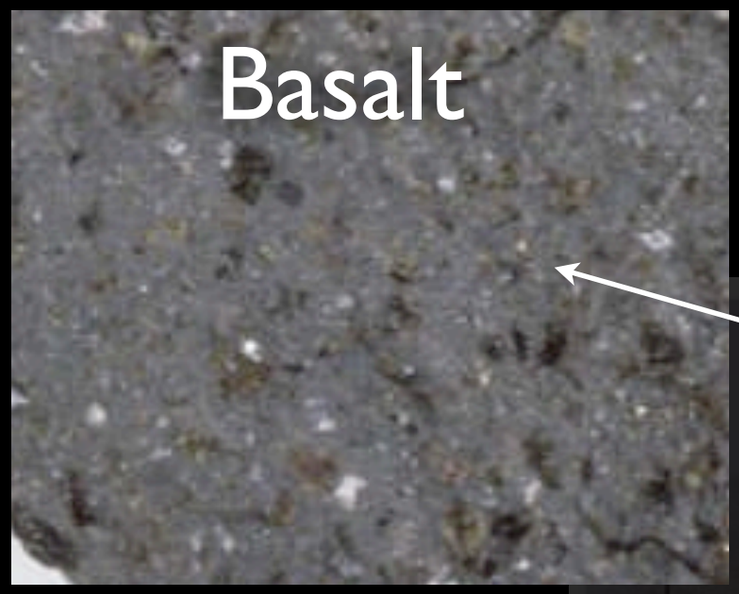
Compositional Variability



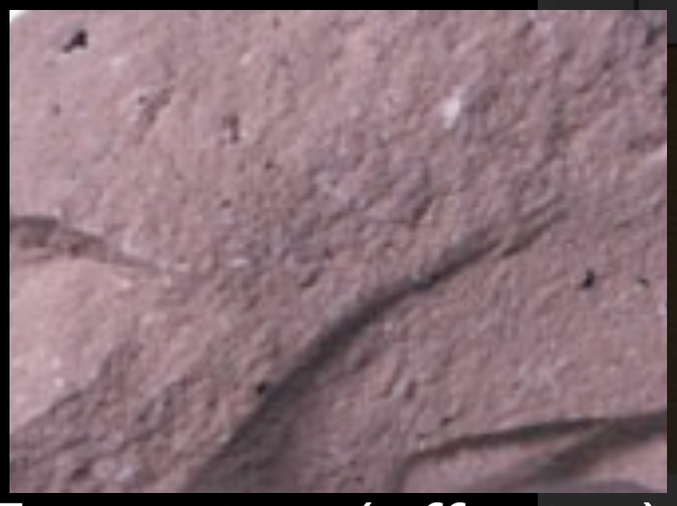
Extrusive (effusive)

Intrusive

Compositional Variability



Olivine
Pyroxene



Extrusive (effusive)

Intrusive

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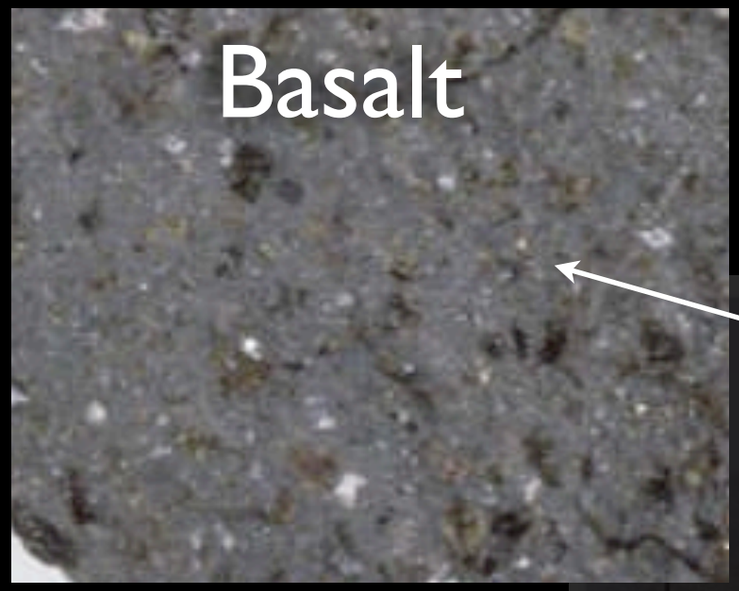


Basalt

Gabbro

Olivine
Pyroxene

Andesite

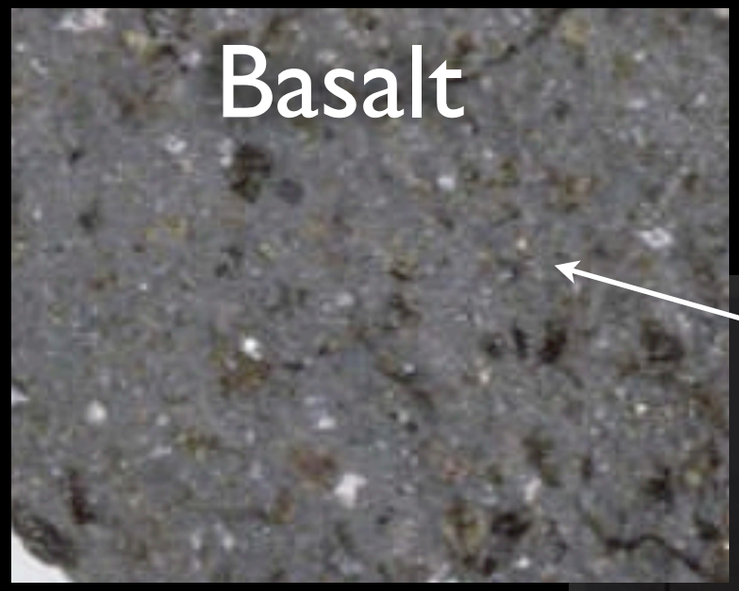
Diorite

Hornblende
Biotite

Extrusive (effusive)

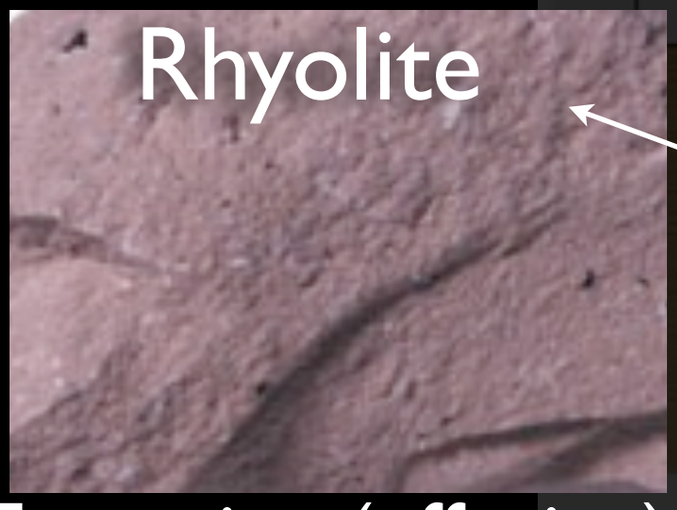
Intrusive

Compositional Variability

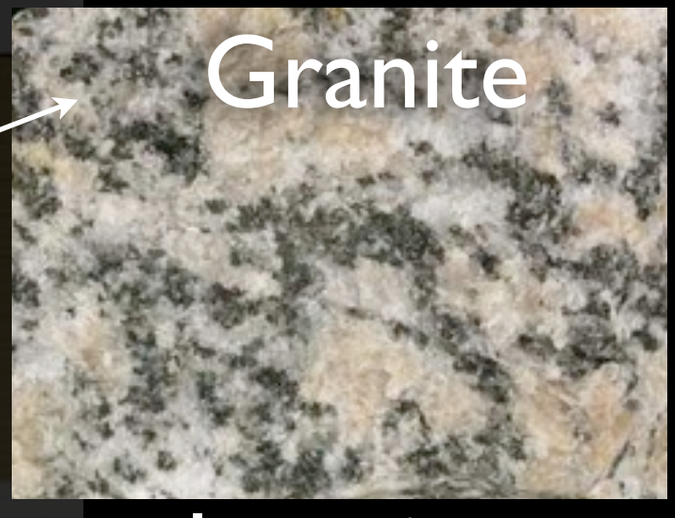


Olivine
Pyroxene

Hornblende
Biotite



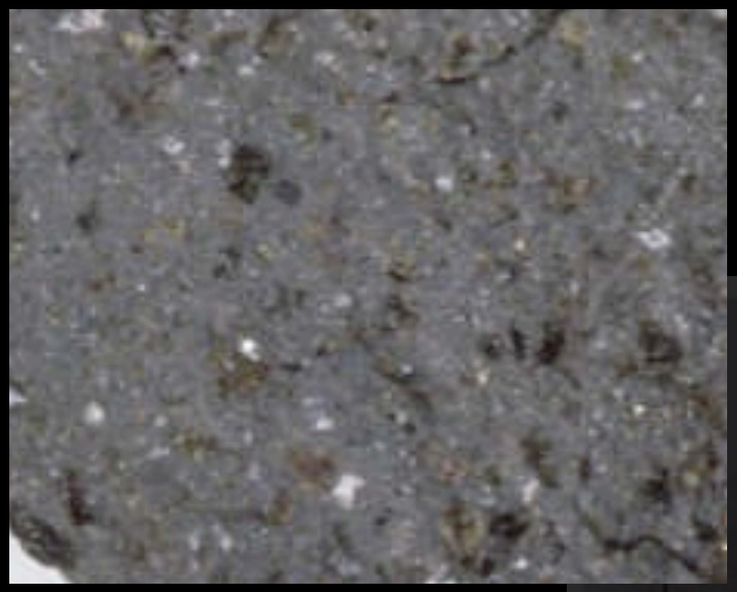
Biotite
Muscovite
Quartz

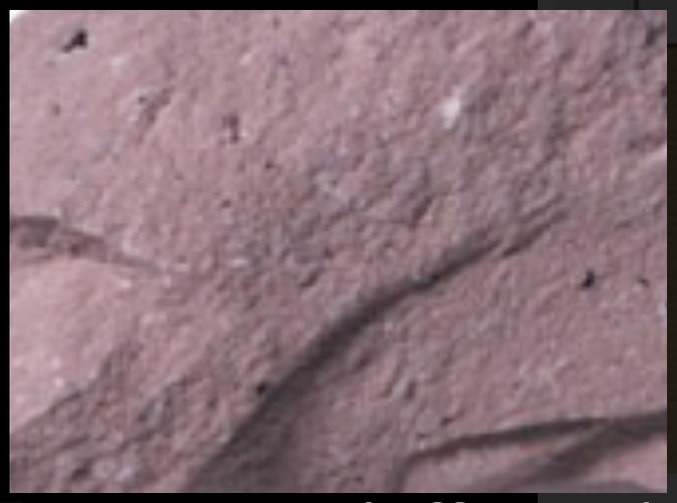


Extrusive (effusive)

Intrusive

Compositional Variability



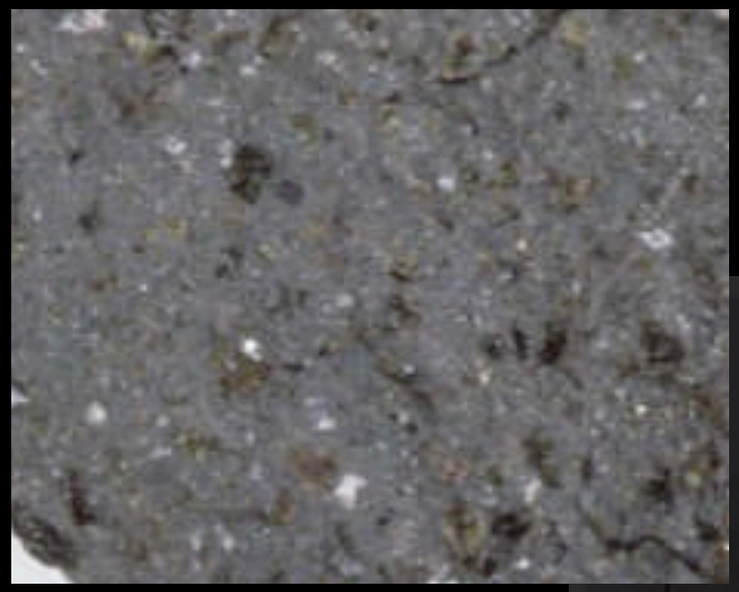


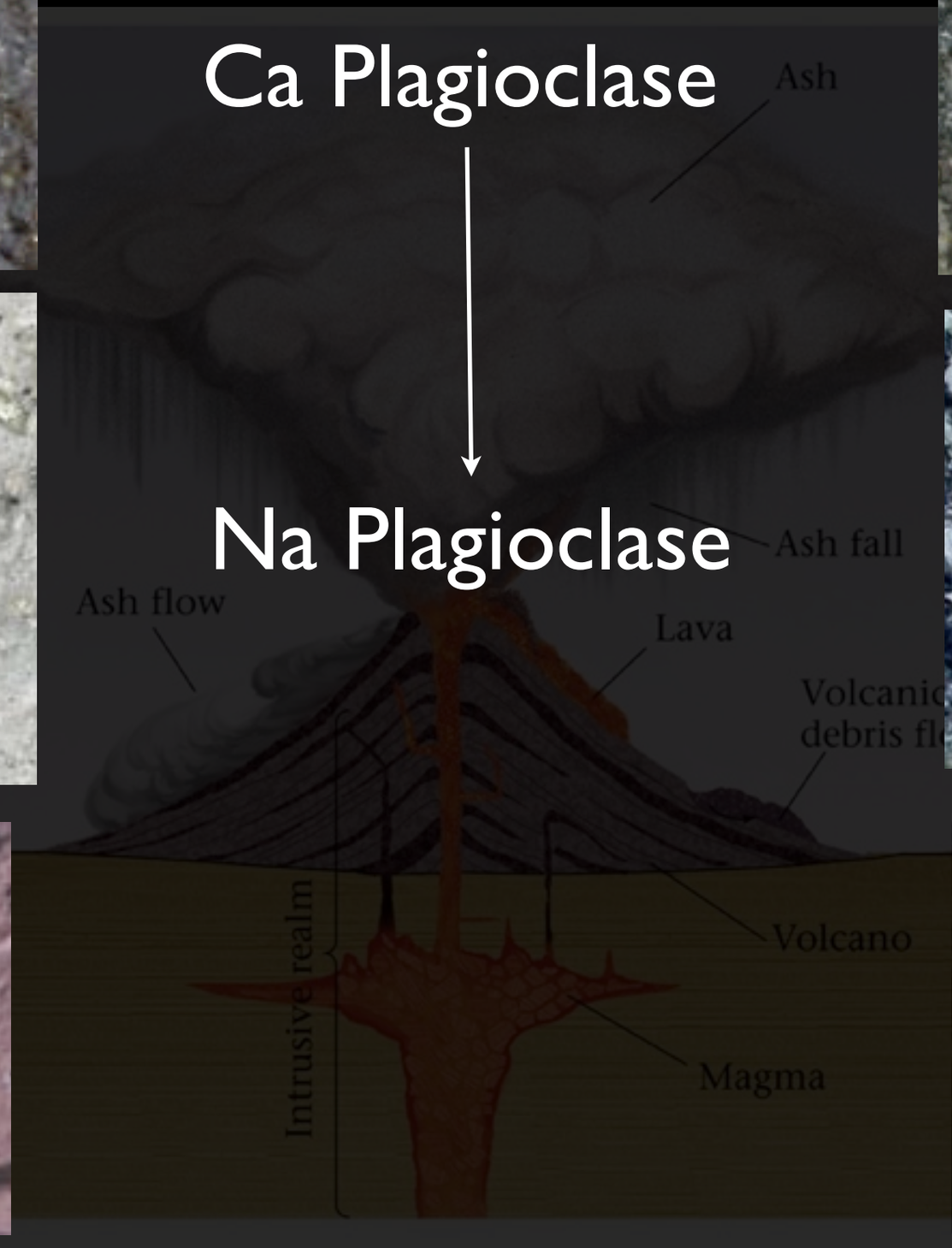
Extrusive (effusive)

Ash
Ash fall
Ash flow
Lava
Volcanic debris fl
Volcano
Intrusive realm
Magma

Intrusive

Compositional Variability

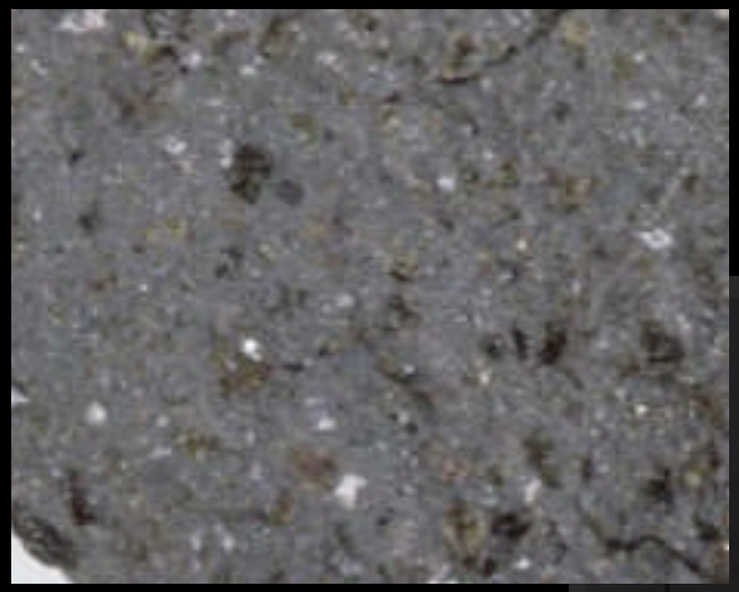




Extrusive (effusive)

Intrusive

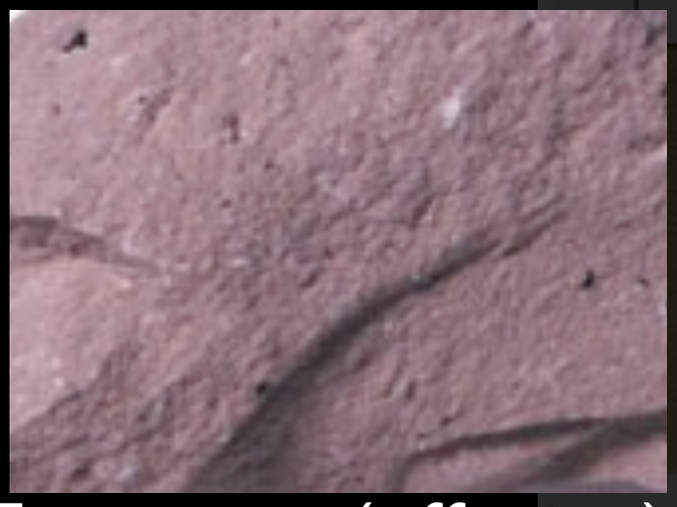
Compositional Variability



Ca Plagioclase

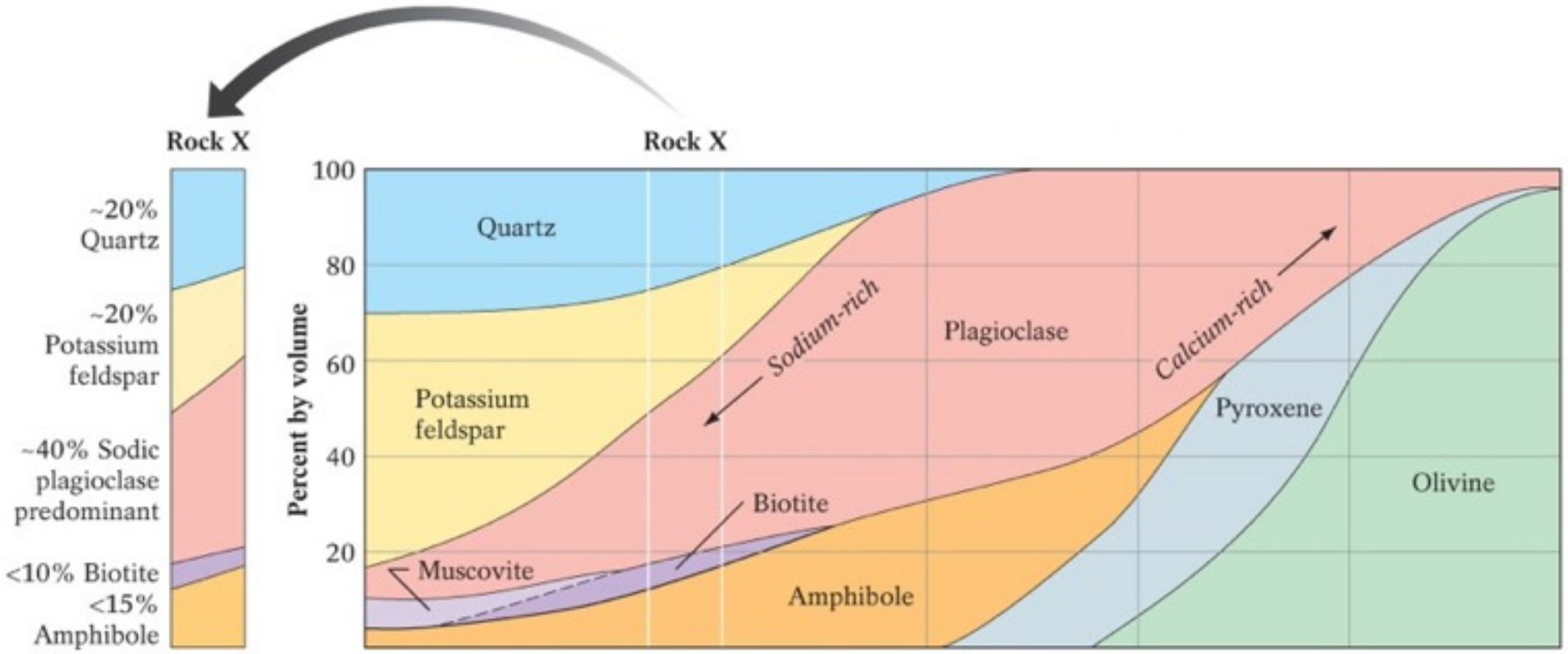
Na Plagioclase

K Feldspar



Extrusive (effusive)

Intrusive



Phaneritic rock	Granite	Diorite	Gabbro	Peridotite
Aphanitic rock	Rhyolite	Andesite	Basalt	Komatiite
Composition type	Felsic	Intermediate	Mafic	Ultramafic

Increasing silica content

Increasing potassium (K) and sodium (Na)

Increasing calcium (Ca), iron (Fe), and magnesium (Mg)

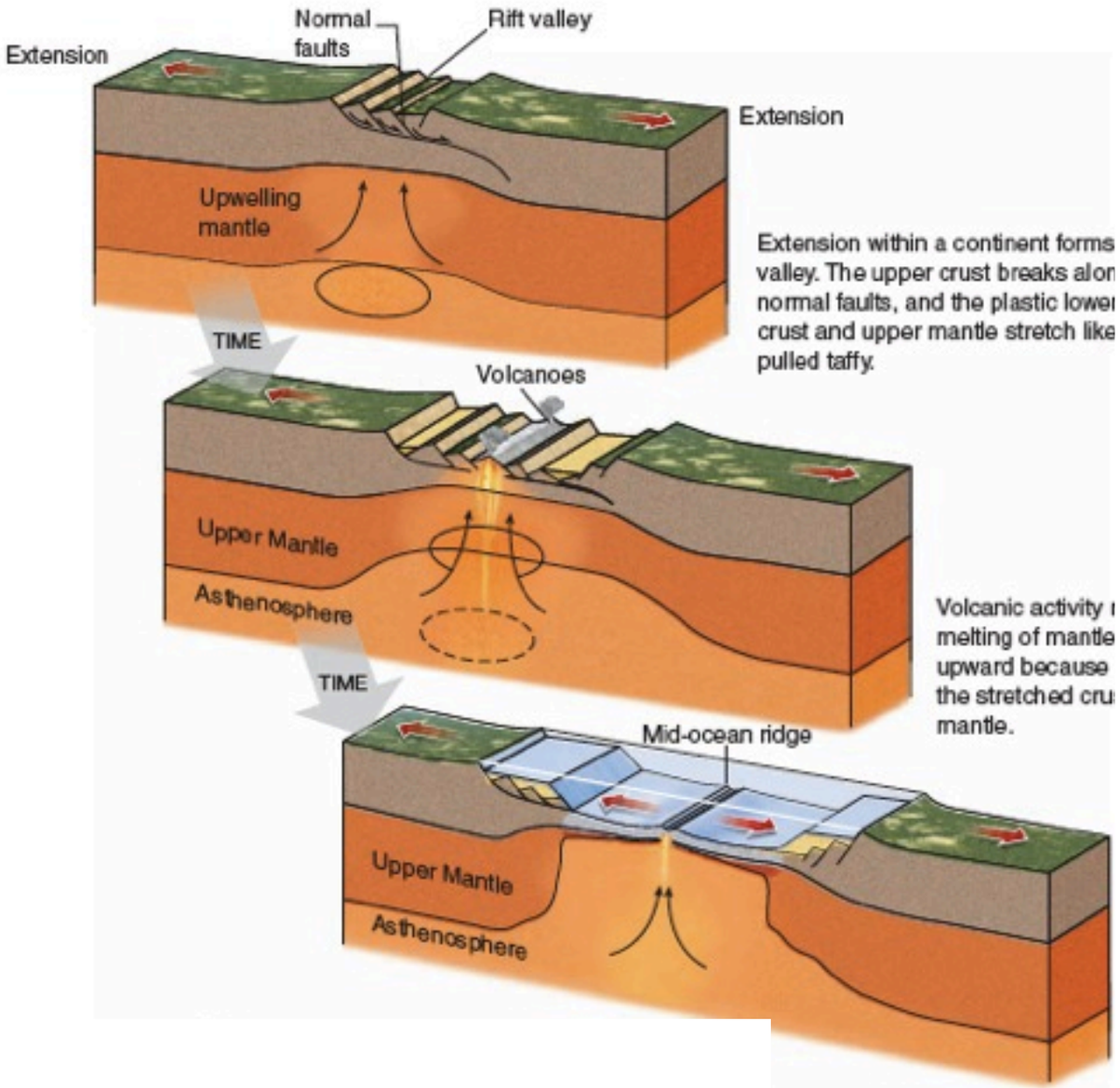
Granite

Diorite

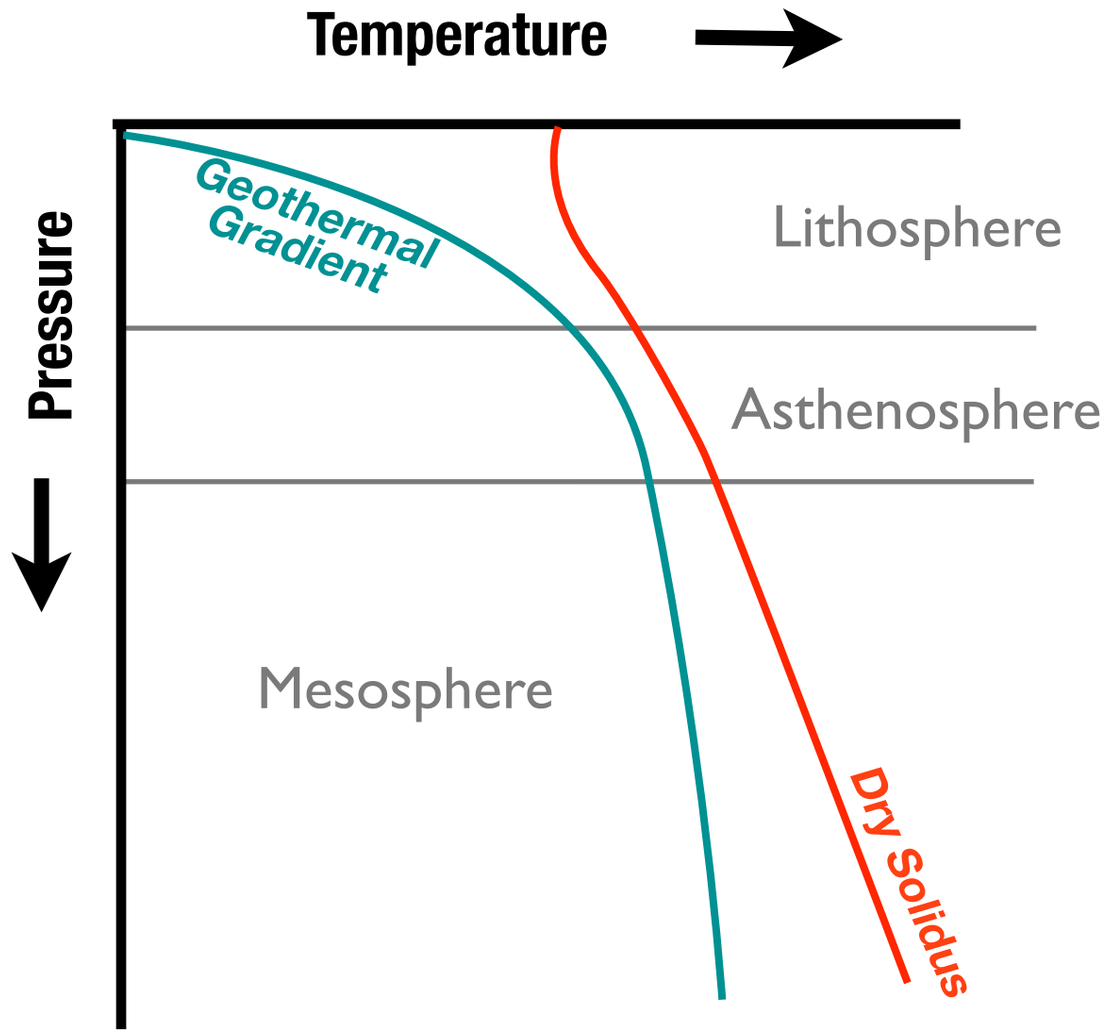
Gabbro

Peridotite

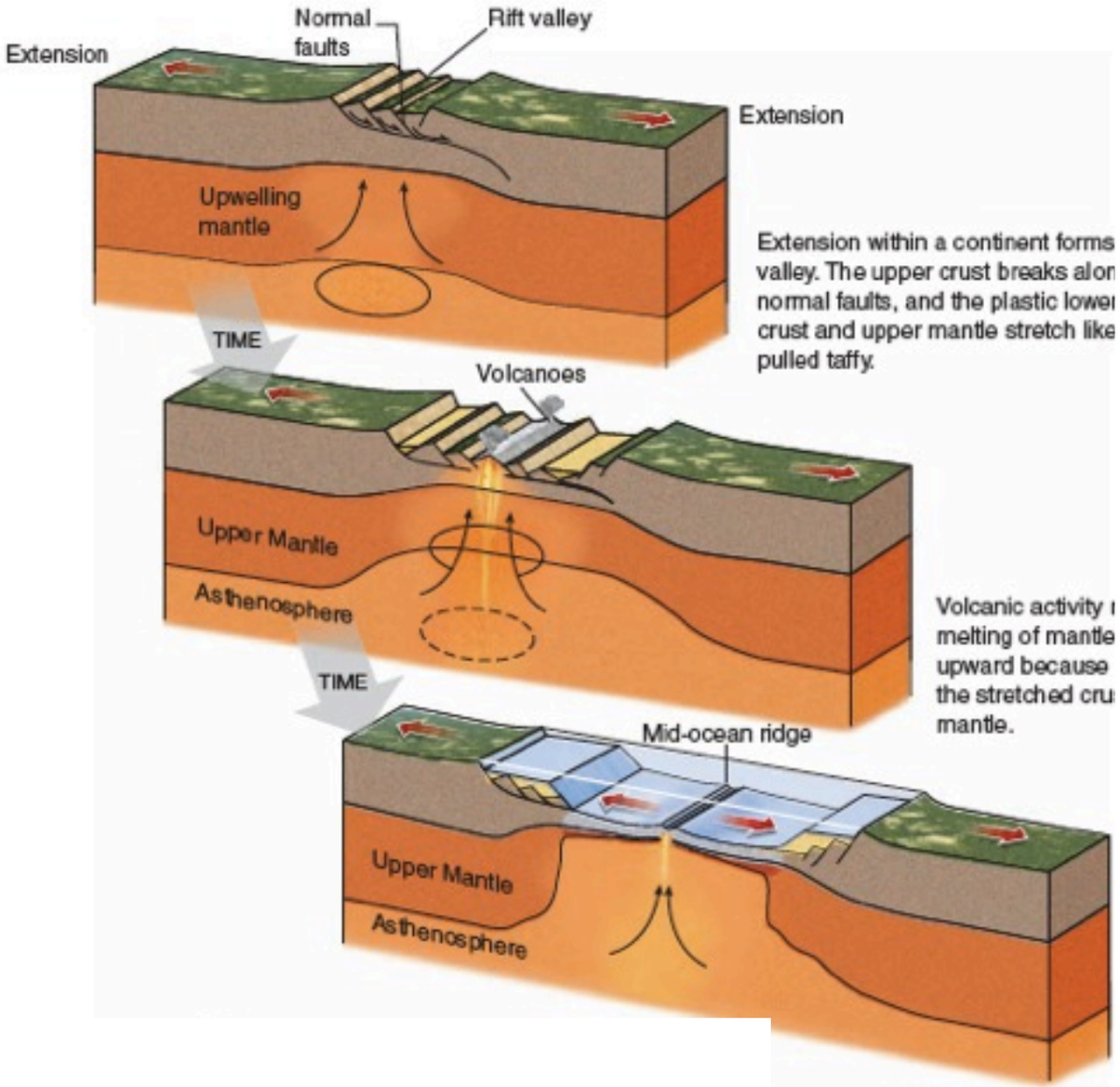
Magma Generation: Where Rocks Melt



Divergent Plate Boundaries

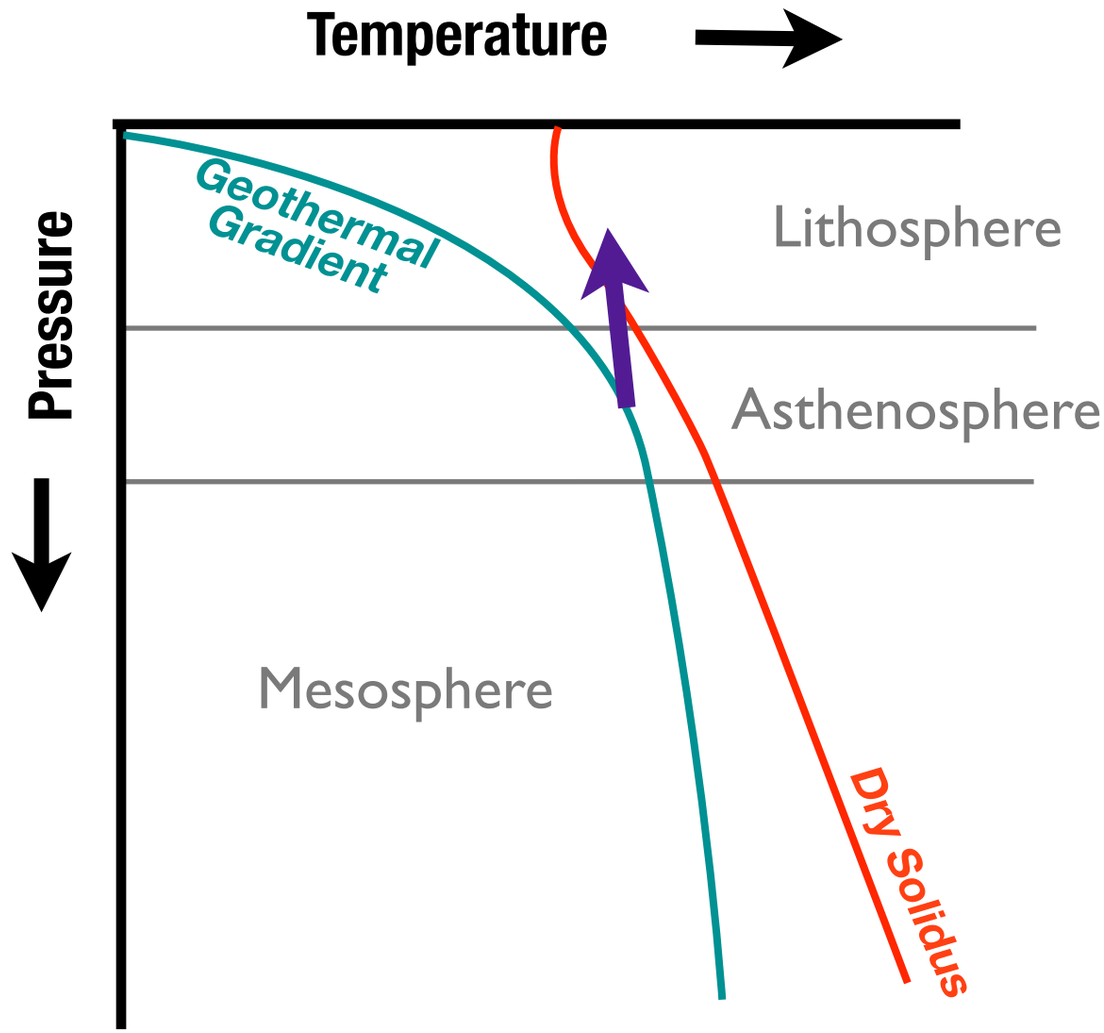


Magma Generation: Where Rocks Melt

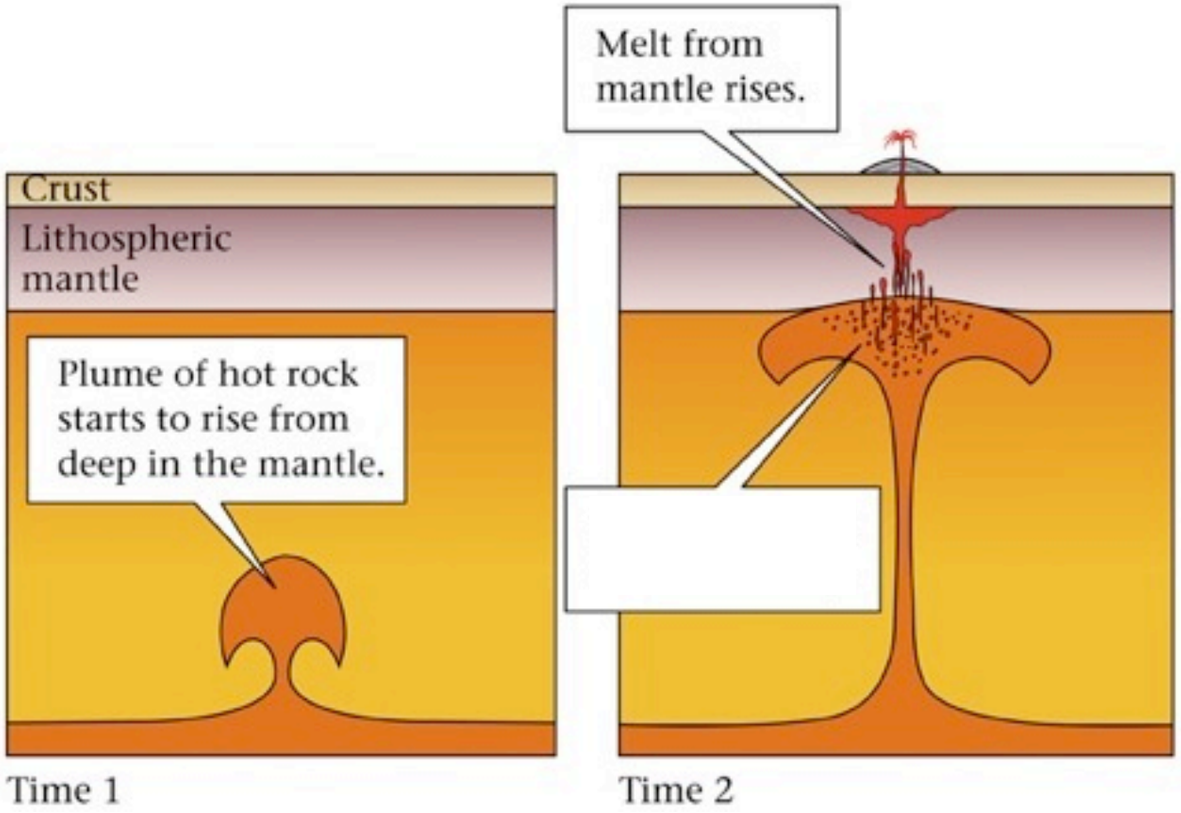


Divergent Plate Boundaries

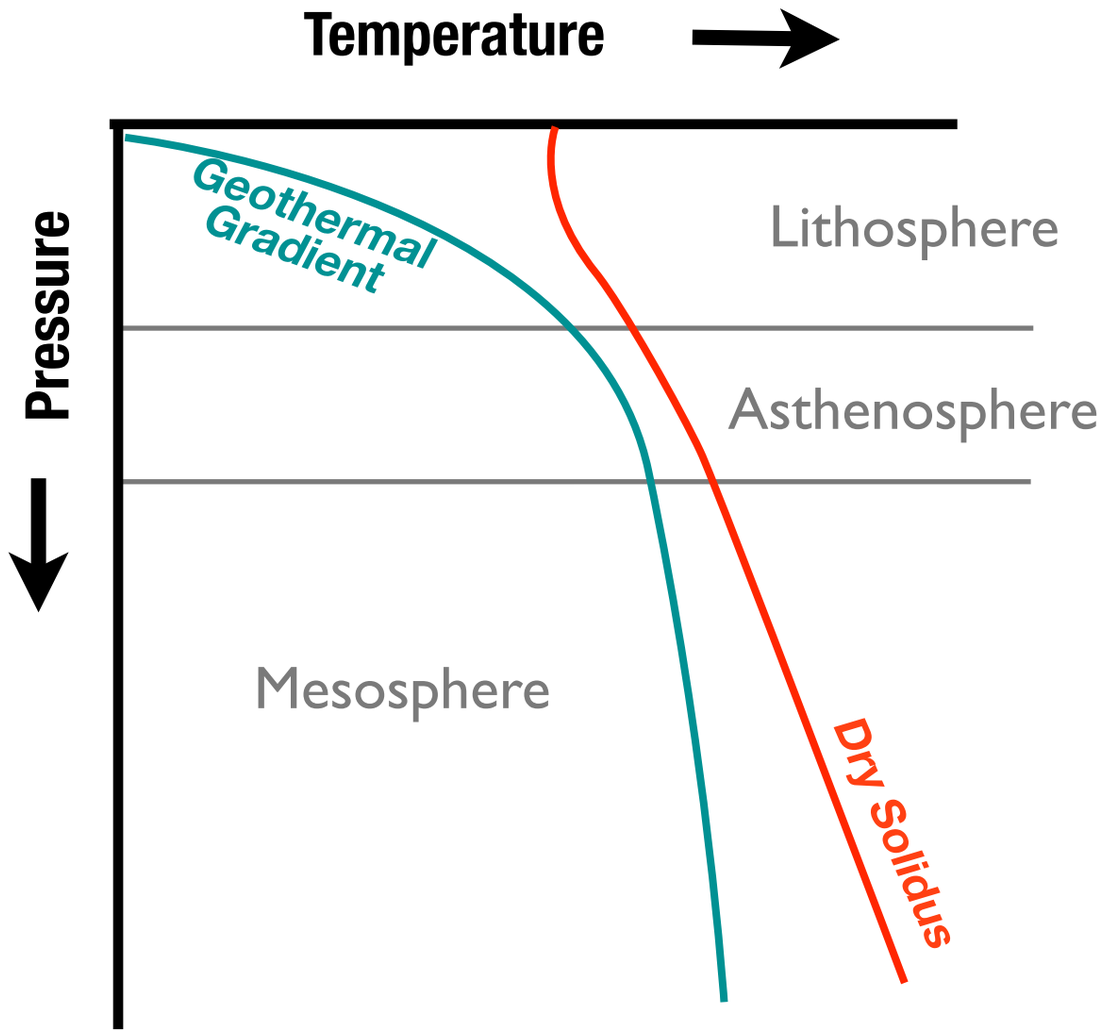
Decompression Melting



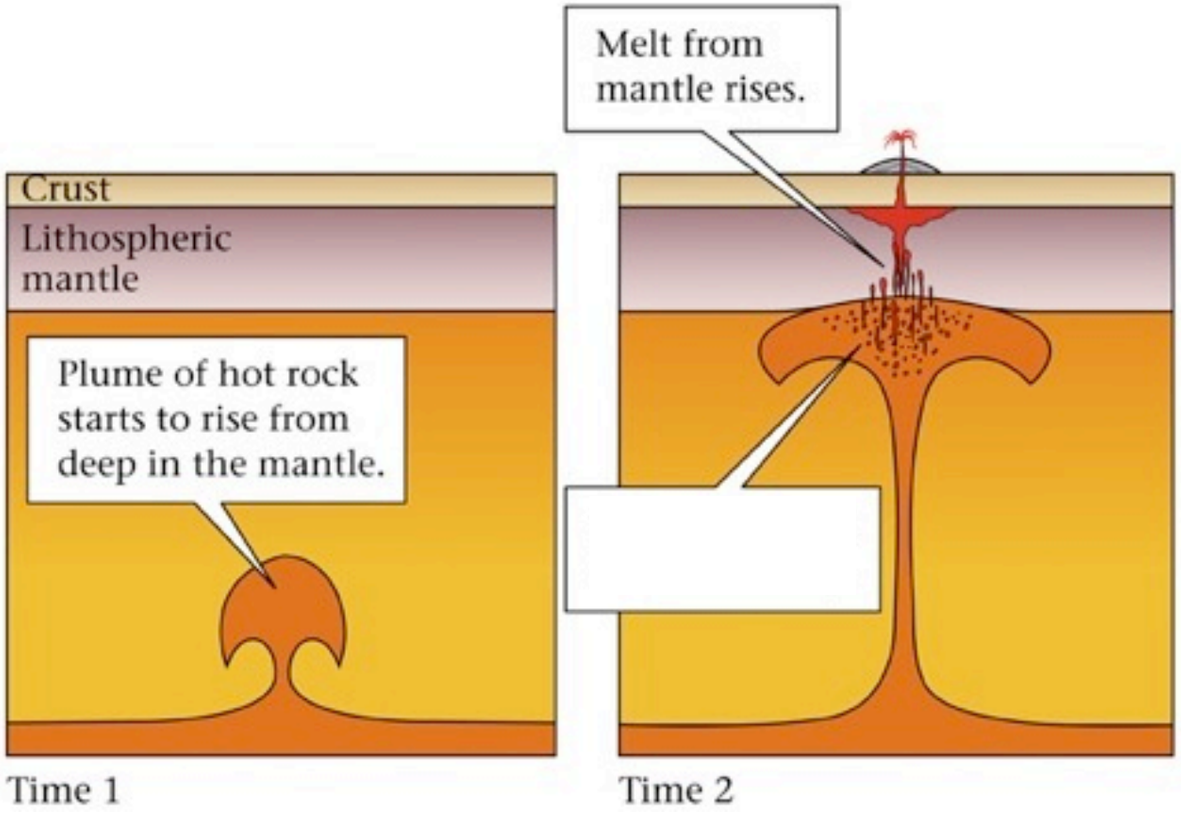
Magma Generation: Where Rocks Melt



Hot Spots

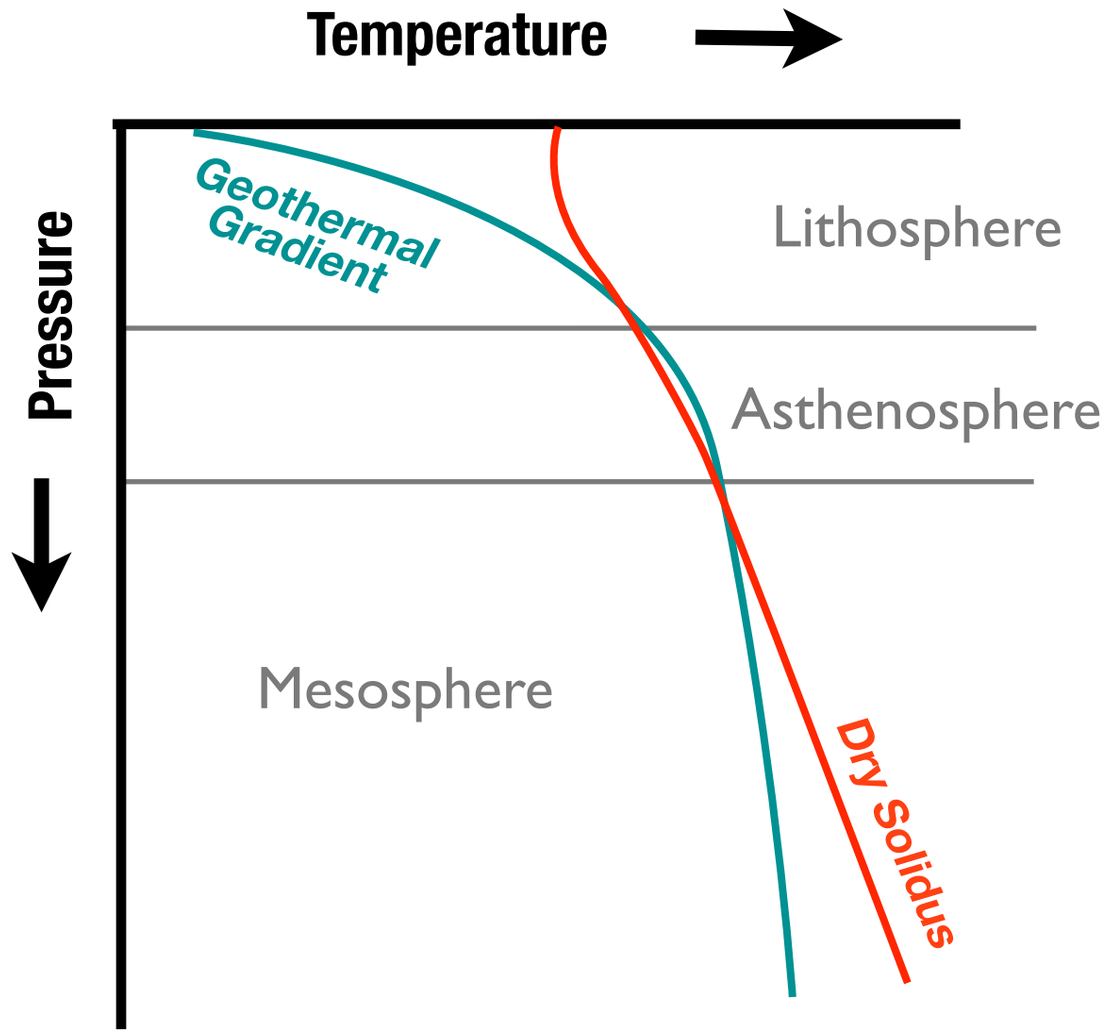


Magma Generation: Where Rocks Melt

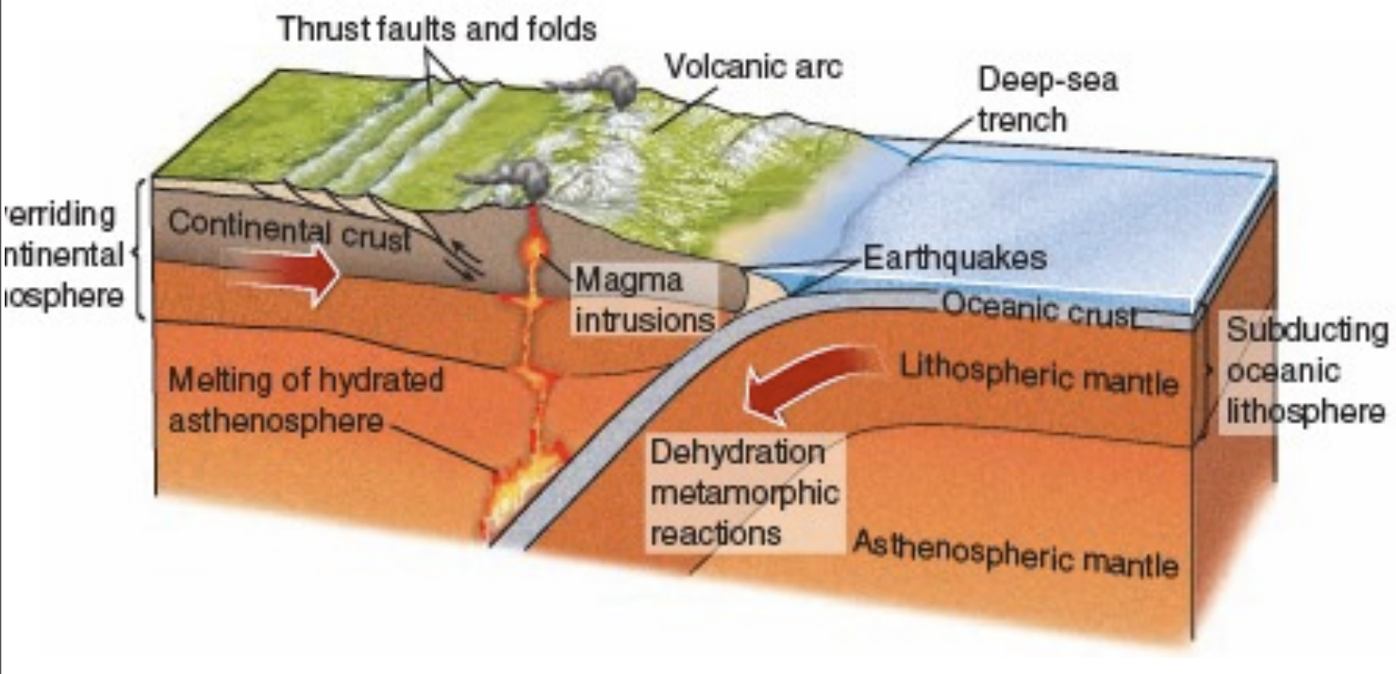


Hot Spots

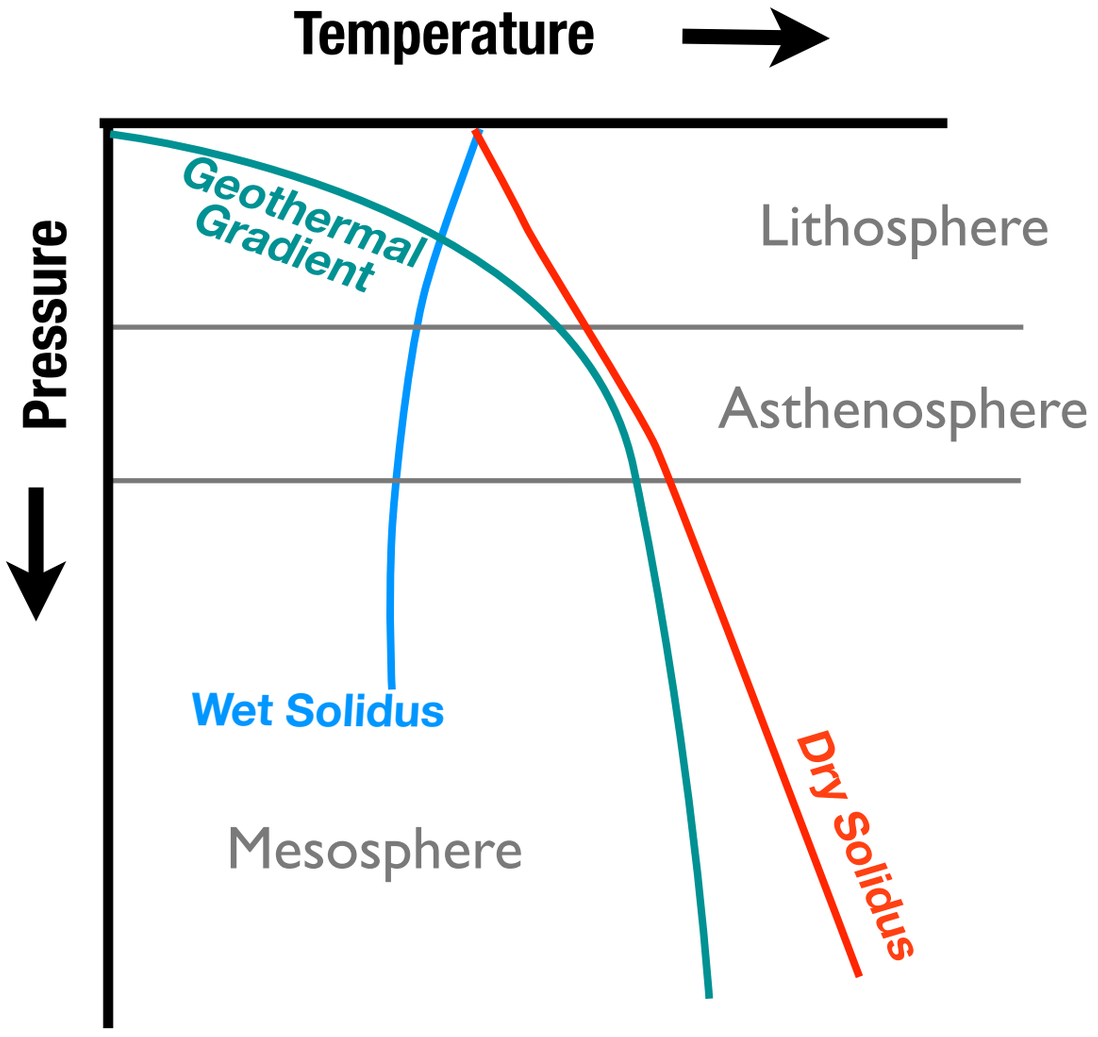
Addition of Heat



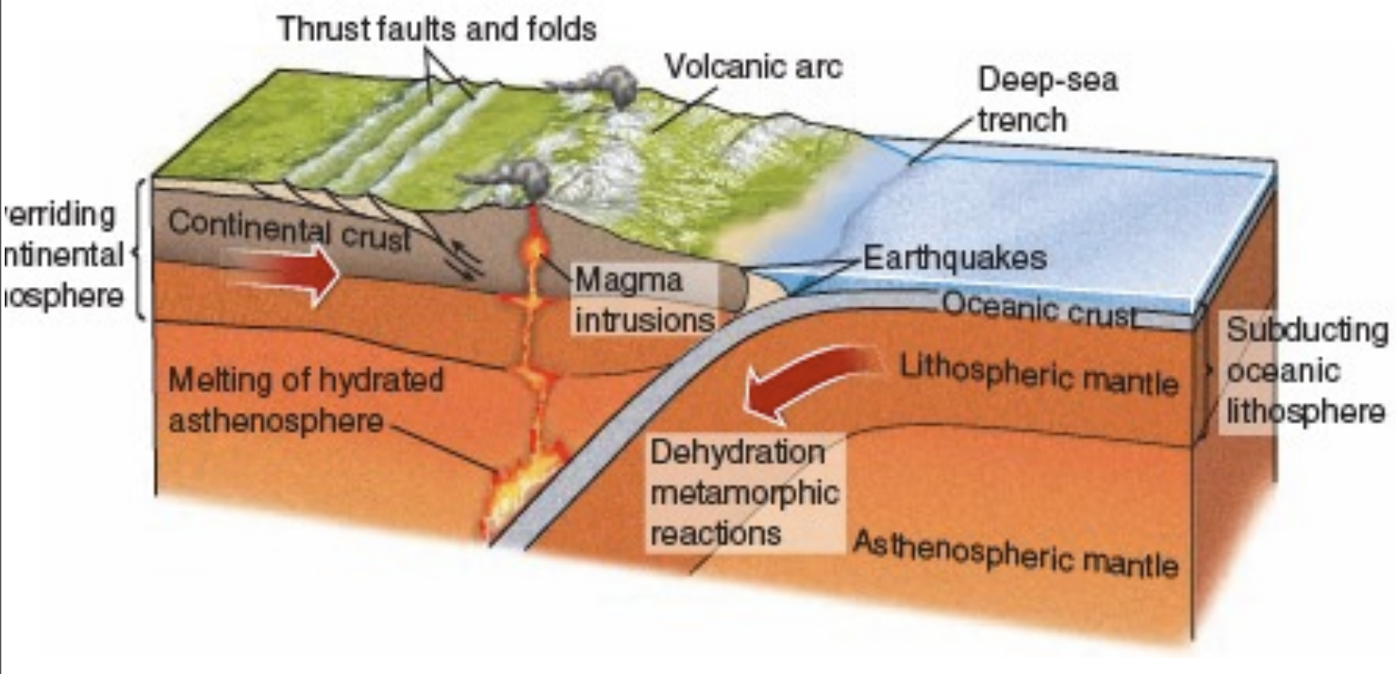
Magma Generation: Where Rocks Melt



Subduction zones

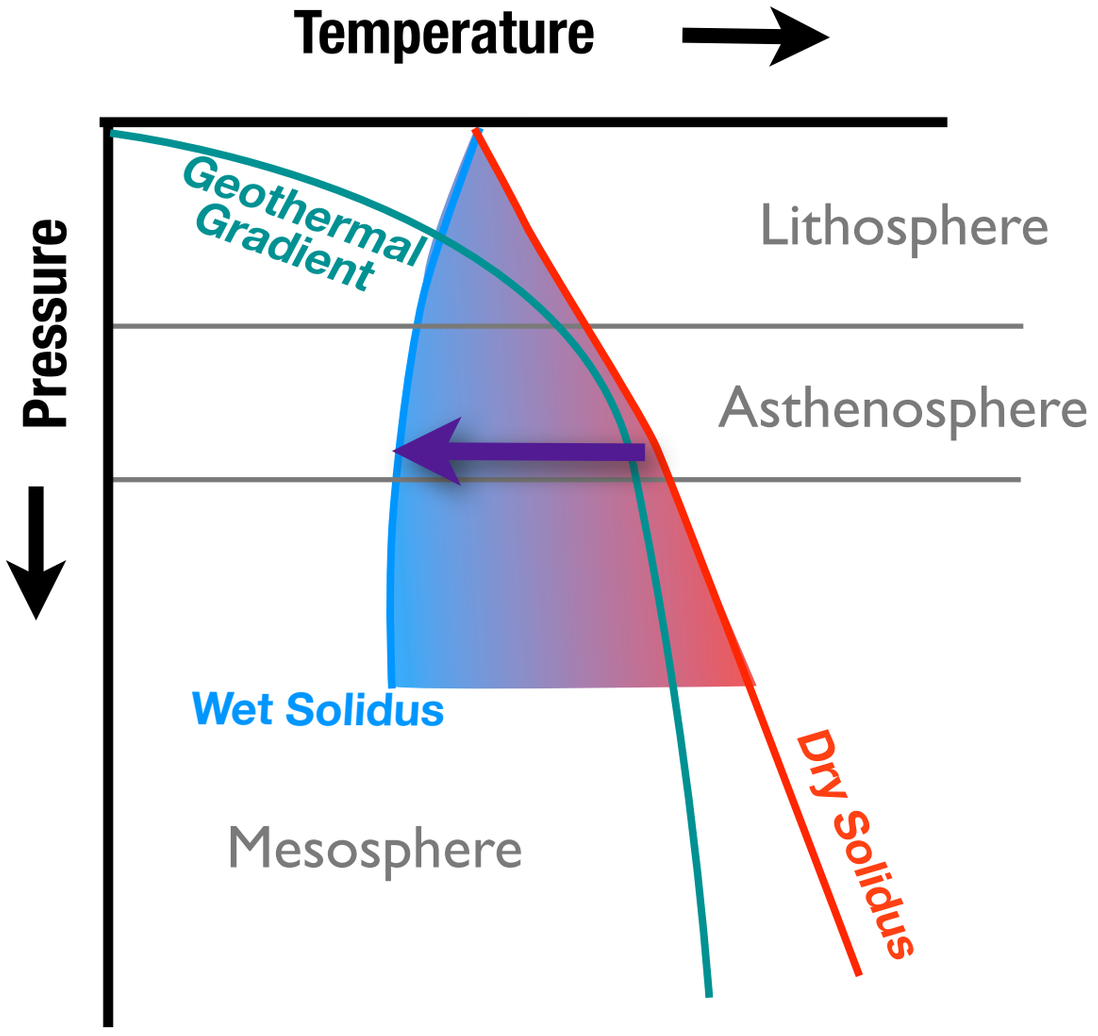


Magma Generation: Where Rocks Melt



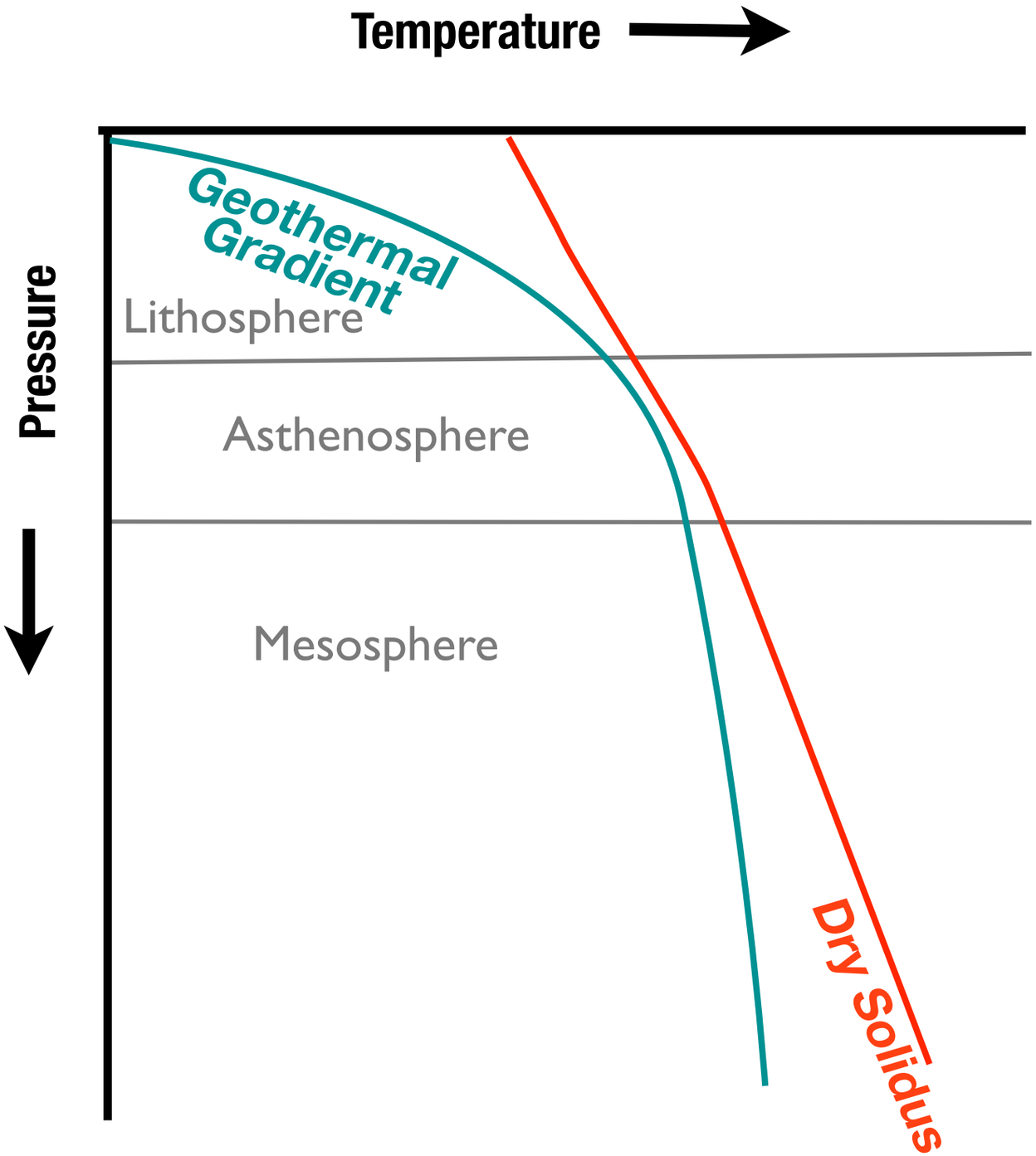
Subduction zones

Addition of Volatiles (water)

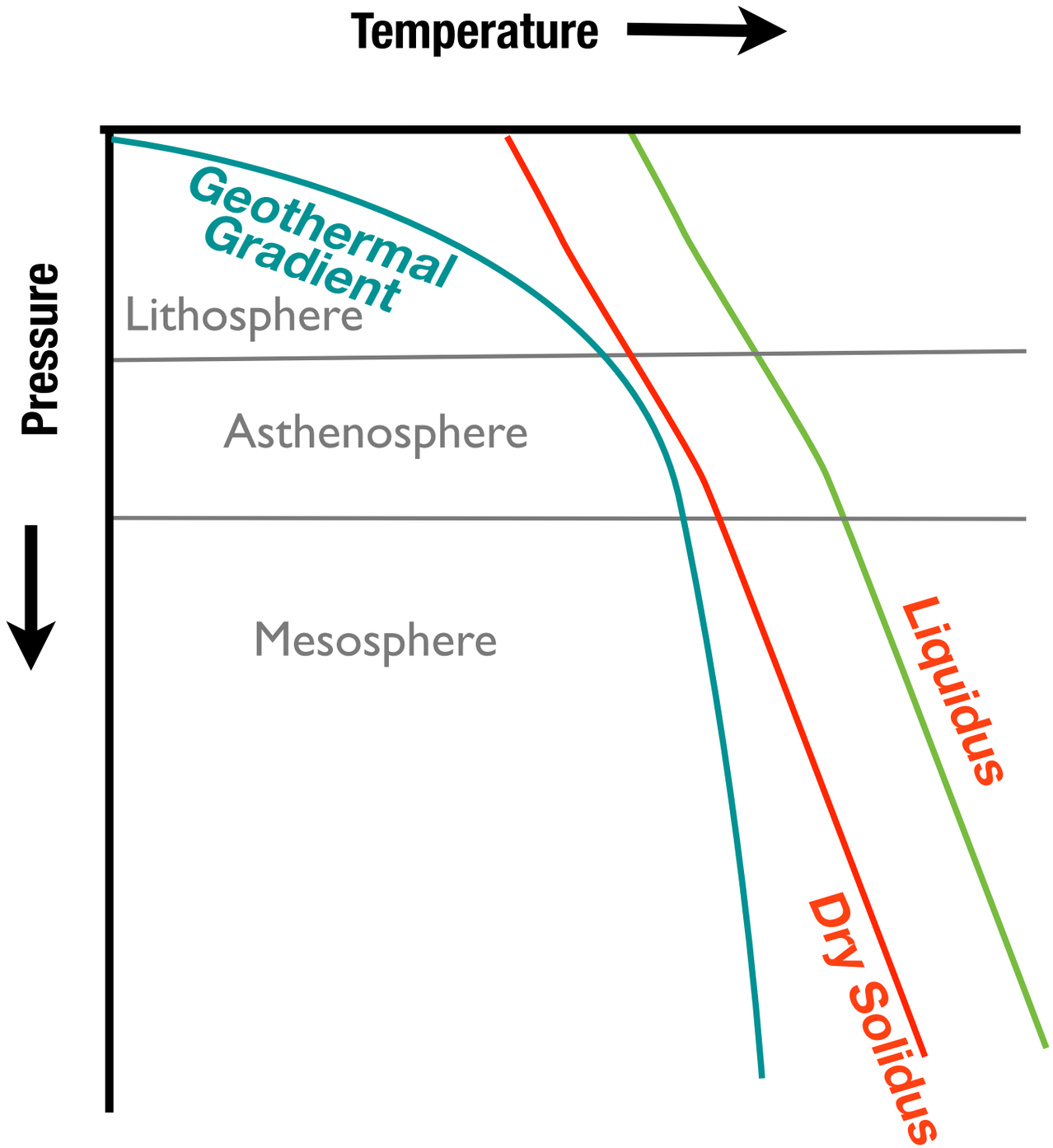


Partial Melting

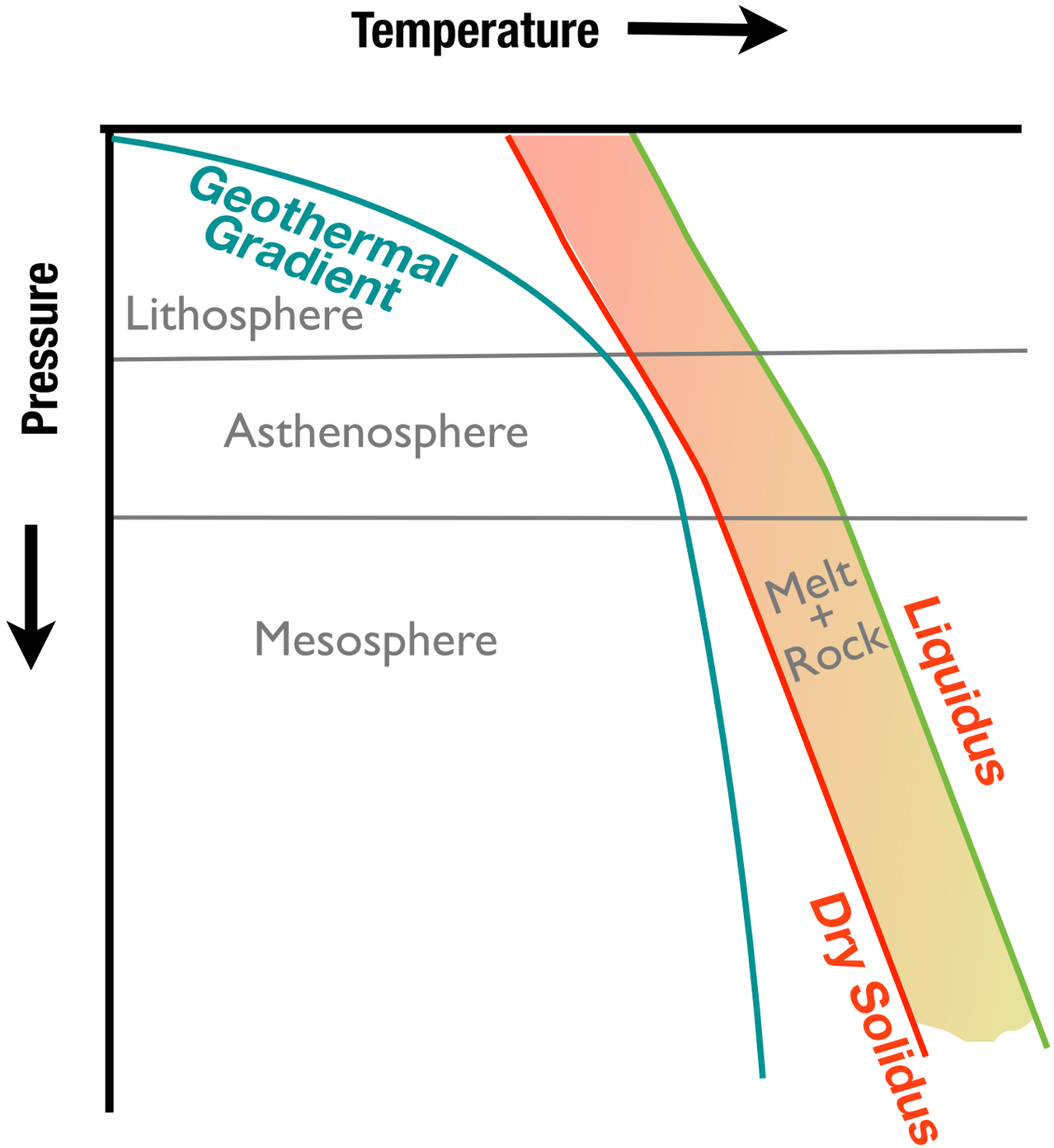
Partial Melting



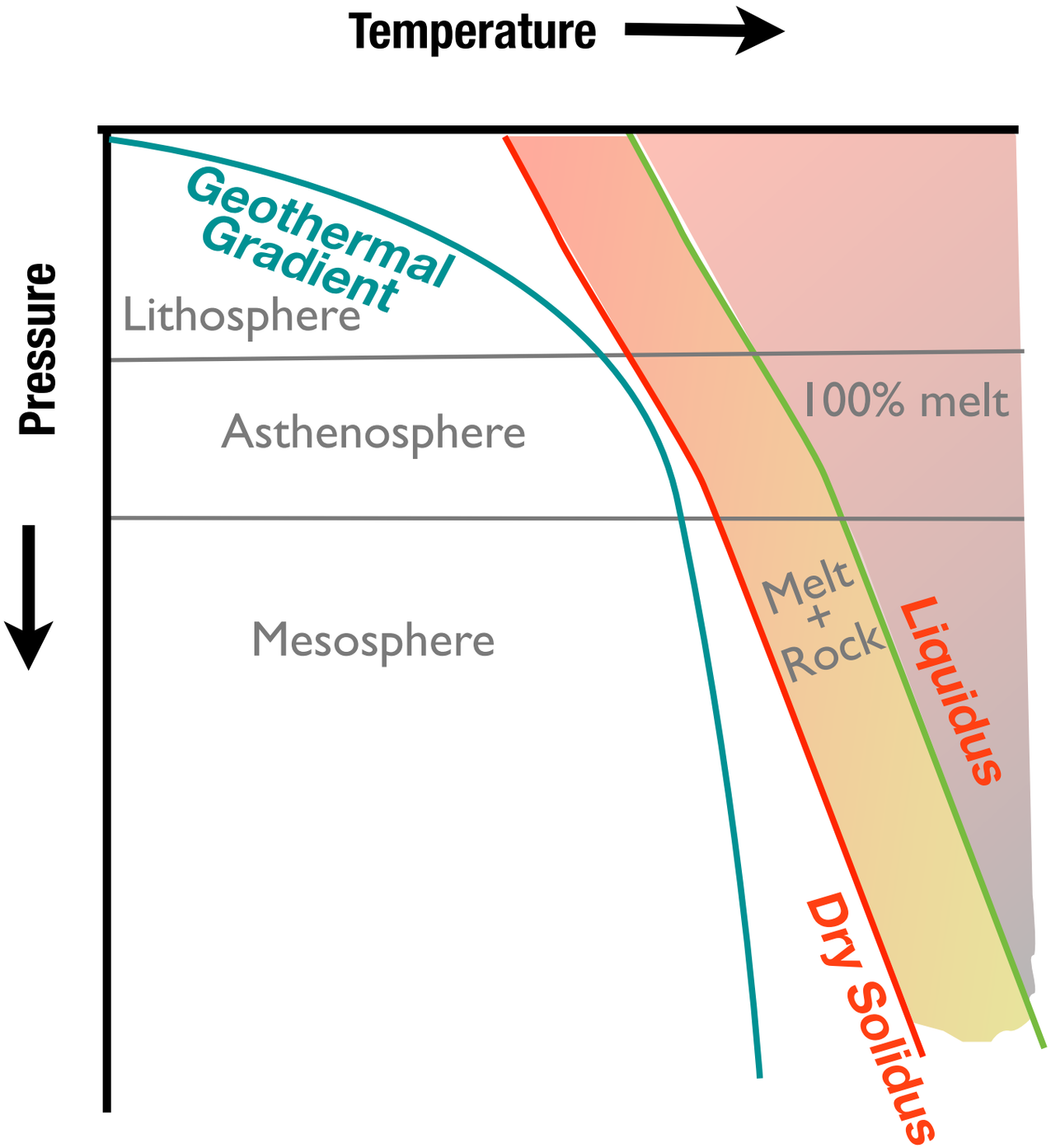
Partial Melting



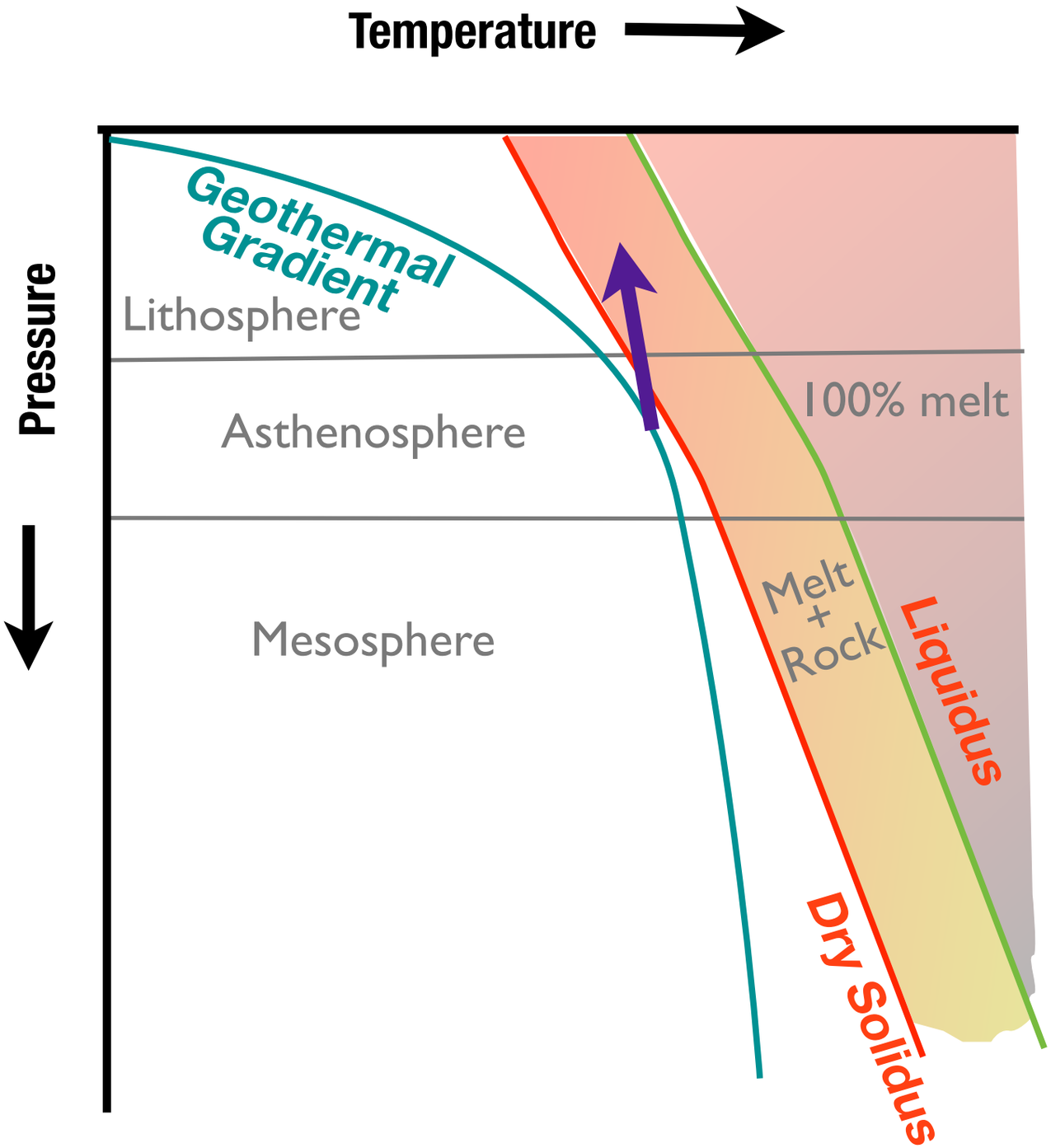
Partial Melting



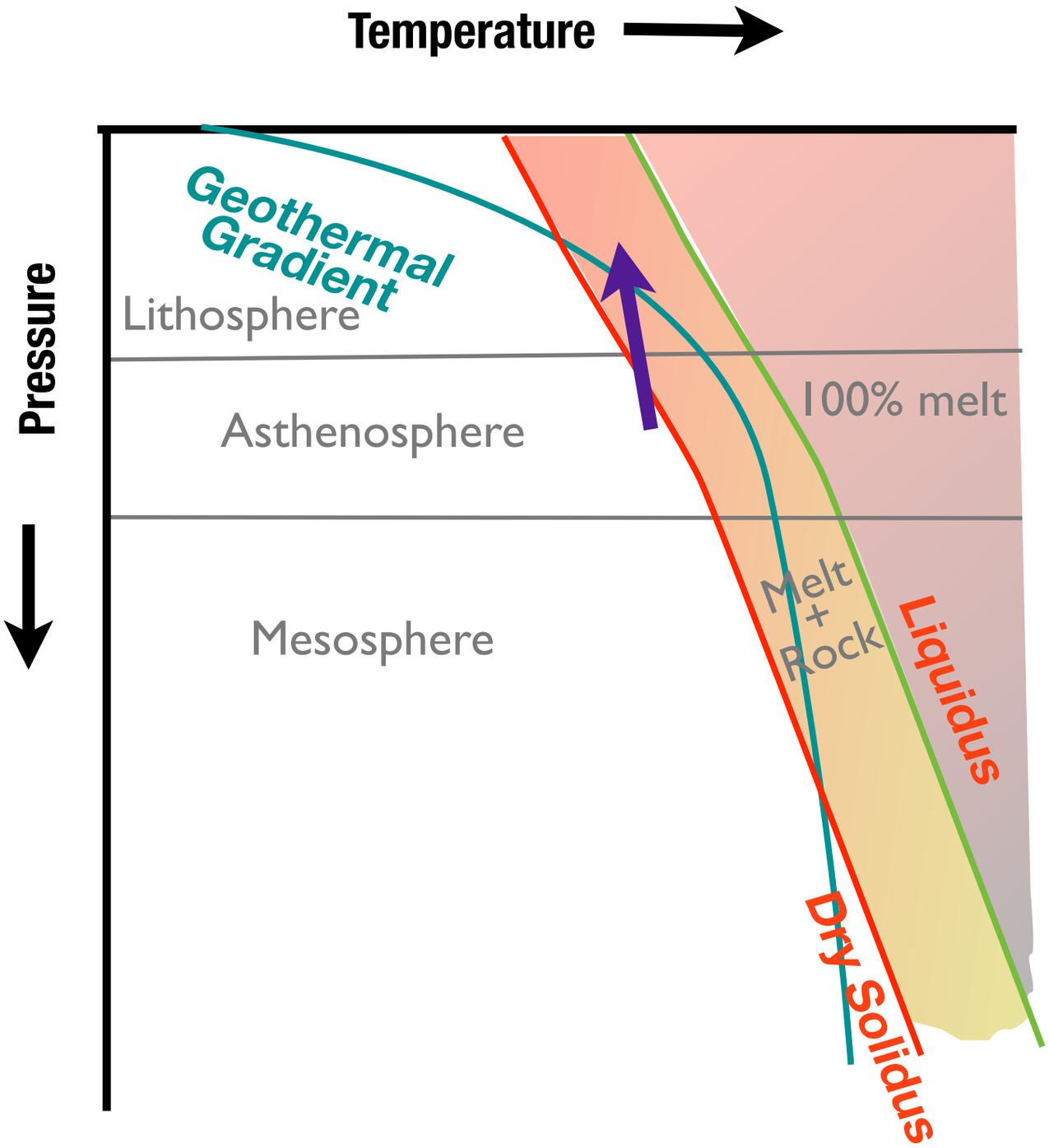
Partial Melting



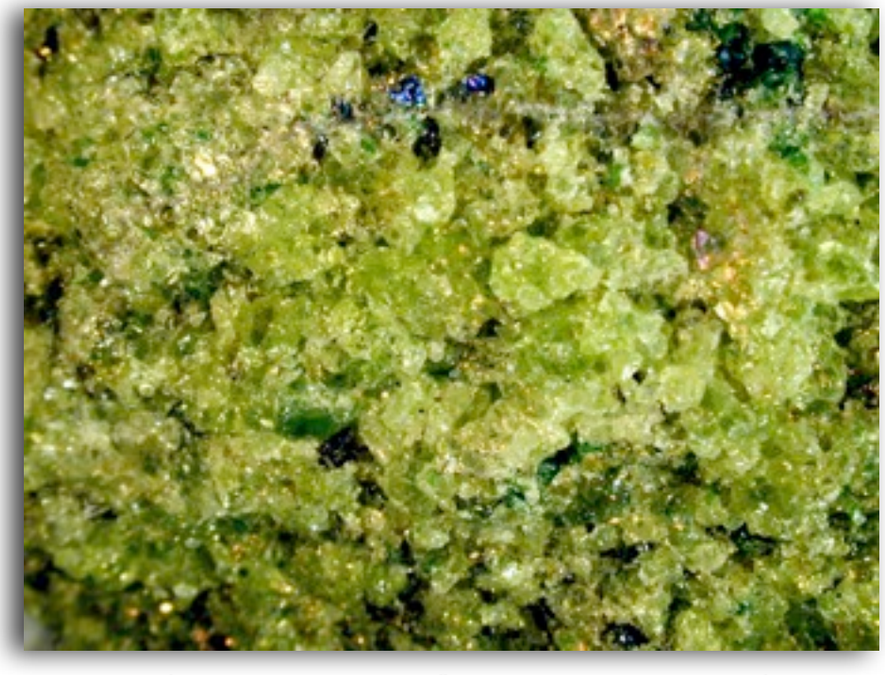
Partial Melting



Partial Melting

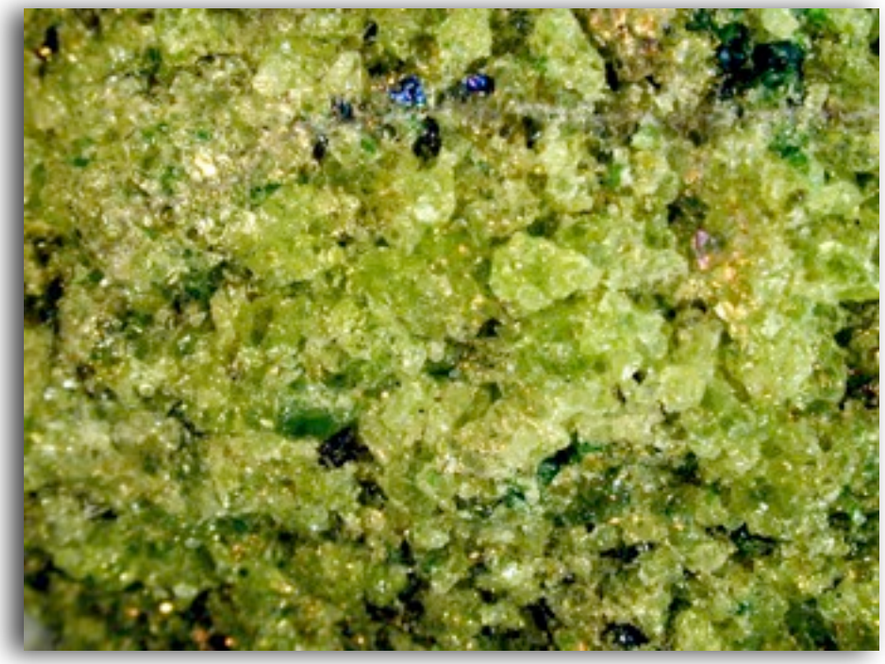


Partial Melting of the Asthenosphere



Ultramafic Mantle
Peridotite (<40% silica)

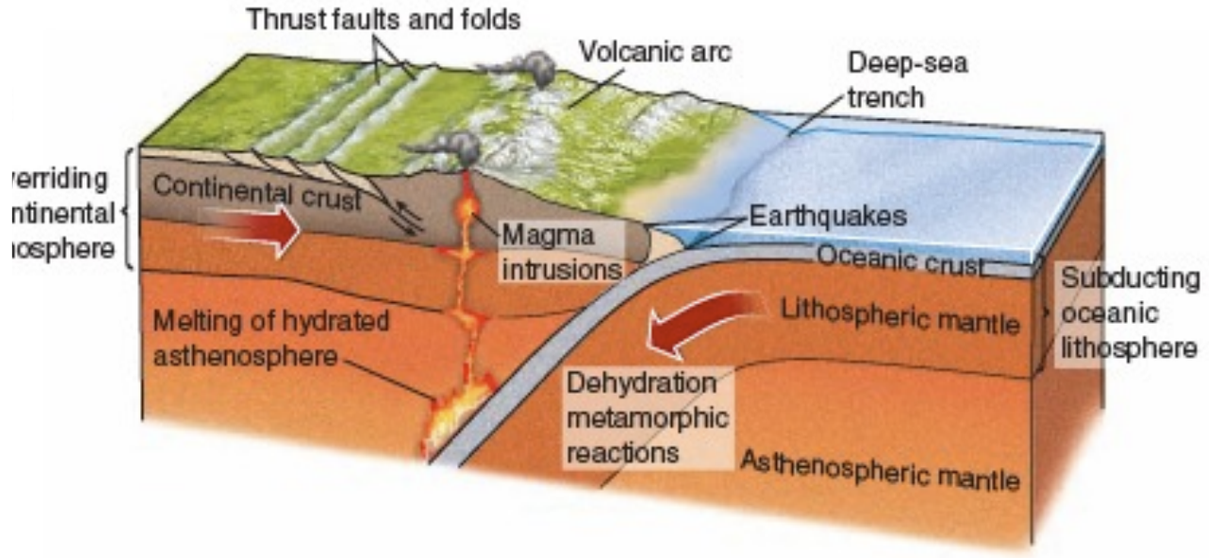
Partial Melting of the Asthenosphere



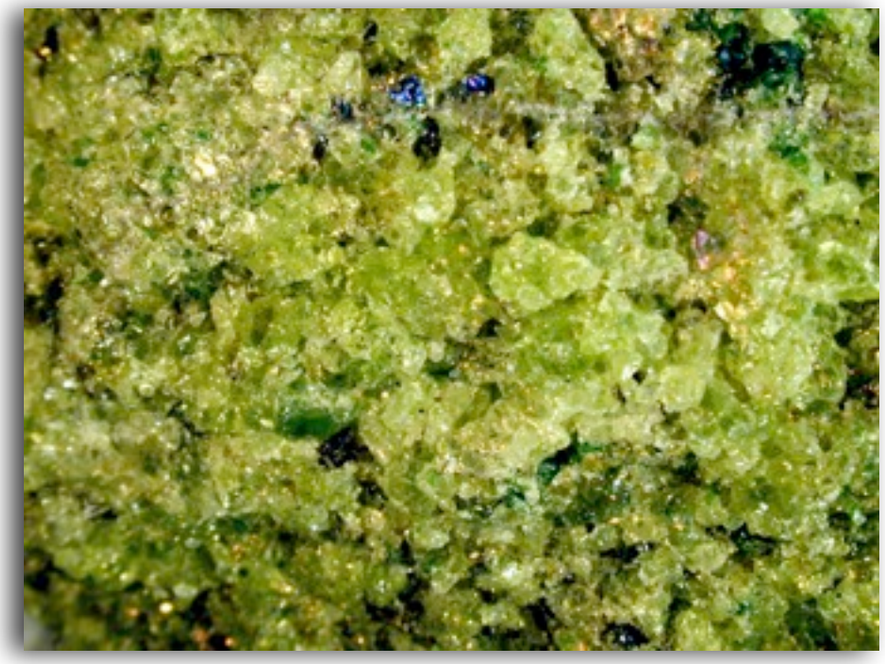
Ultramafic Mantle Peridotite (<40% silica)

Partial melting

< 10% asthenospheric melting occurs at plate boundaries



Partial Melting of the Asthenosphere



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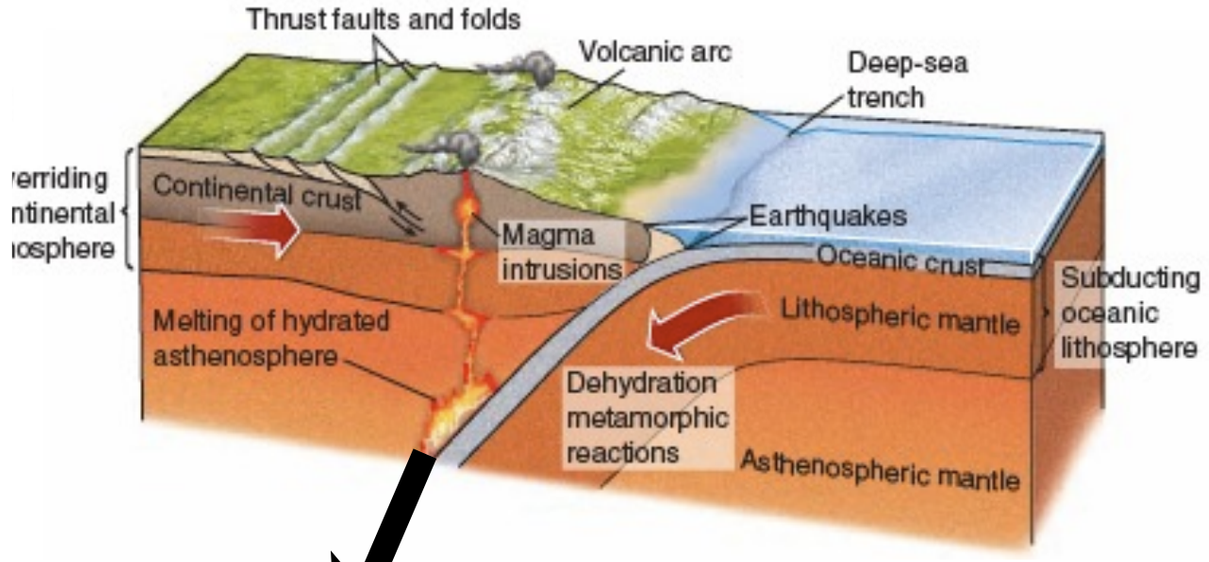
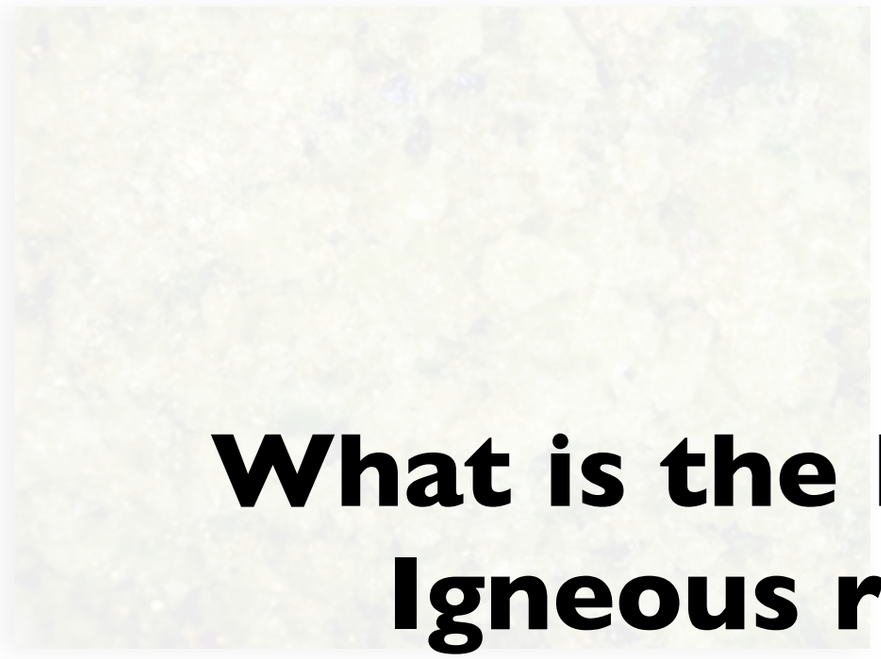


The Magma Produced is Mafic in Composition (Basaltic) and contains **45-55% silica**

No Crystals

Partial Melting of the Asthenosphere



Ultramafic Mantle
Peridotite (<40% silica)

Partial melting

<10% asthenospheric melting occurs at plate boundaries

What is the Most Common volcanic Igneous rock found on Earth?

The Magma Produced is Mafic in Composition (Basaltic) and contains **45-55% silica**

No Crystals

If you were to take <u>3 apples</u> from this bowl of fruit and put them into a second bowl,

A) the concentration of oranges would be increased in the initial bowl.

B) you would have one bowl that is concentrated in apples and one bowl that is less concentrated in apples.

C) you will have created two different bowls of fruit with unique ratios of apples to oranges that are both different in apple concentration from each other as well as different from the bowl you began with.

D) All of the above.

E) Only A and B are correct

If you were to take 3 apples from this bowl of fruit and put them into a second bowl,

A) the concentration of oranges would be increased in the initial bowl.

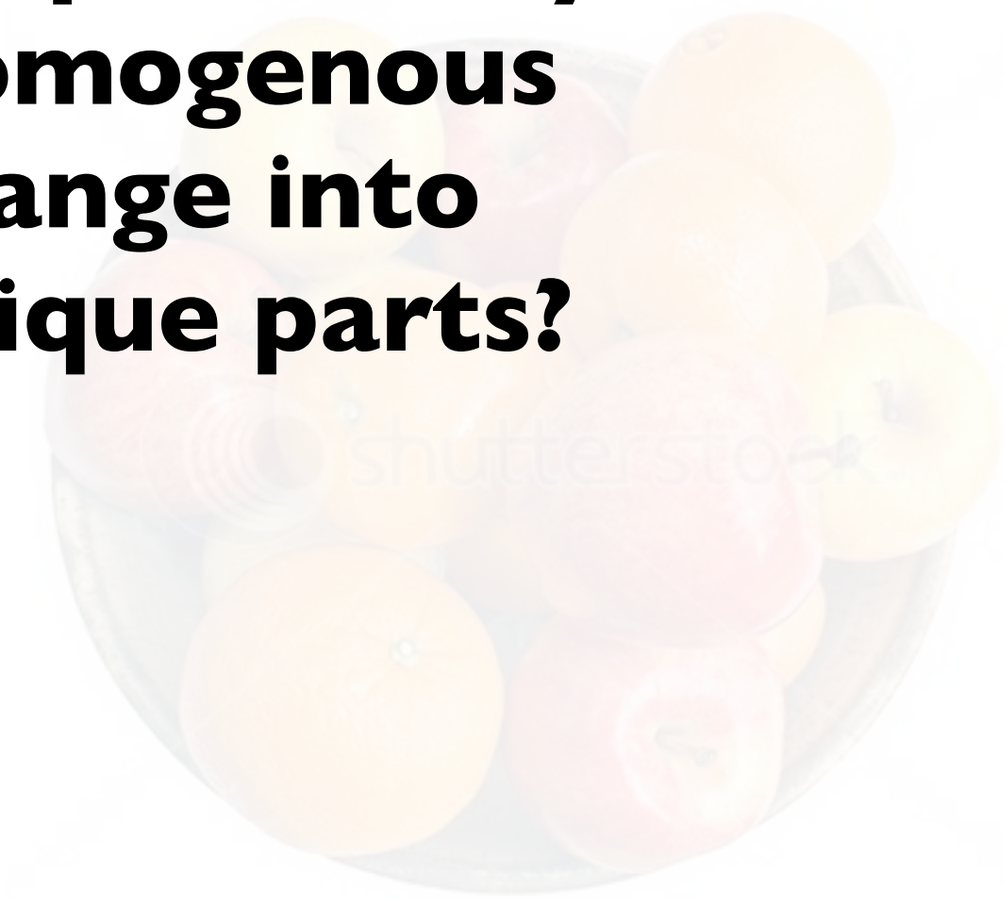
B) you would have one bowl that is concentrated in apples and one bowl that is less concentrated in apples.

C) you will have created two different bowls of fruit with unique ratios of apples to oranges that are both different in apple concentration from each other as well as different from the bowl you began with.

D) All of the above.

E) Only A and B are correct

What do we call the process by which we take a homogenous substance and change into compositionally unique parts?



Bowen's Reaction Series

Norman L. Bowen (1887 -1957)

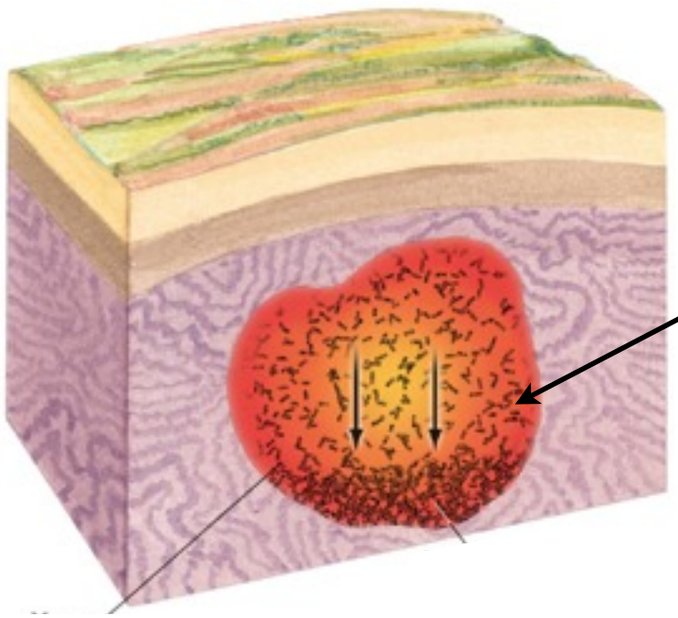
Bowen's experimental Igneous Rock Factory

"The Evolution of Igneous Rocks" (1928)

Magma Differentiation

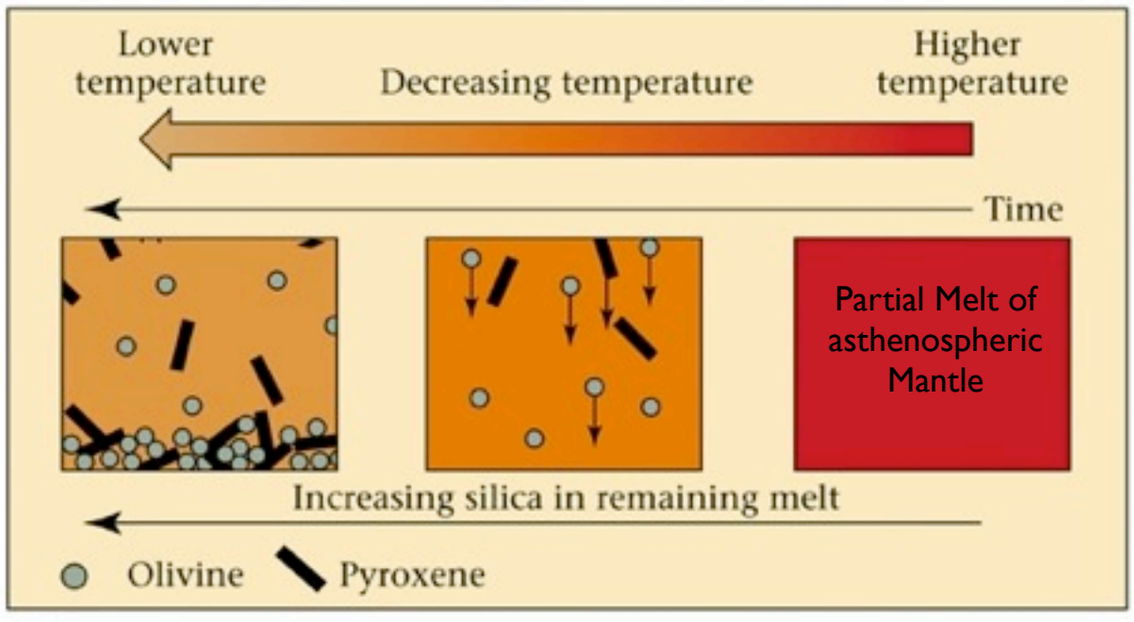
by

Fractional Crystallization



Magma Chamber

Increasing Silica



(b)

Temp. Comp.

Ultra-Mafic

Partial melt of Asthenospheric Mantle Peridotite

No Crystals

1300

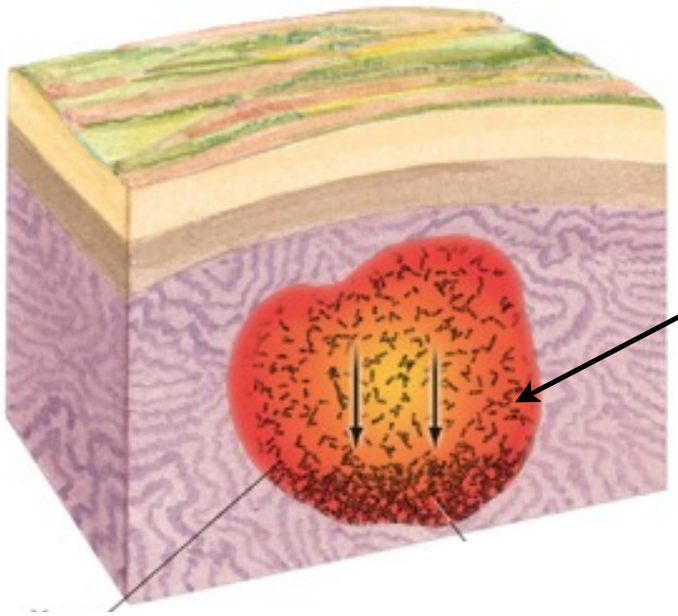
900

600

Magma Differentiation

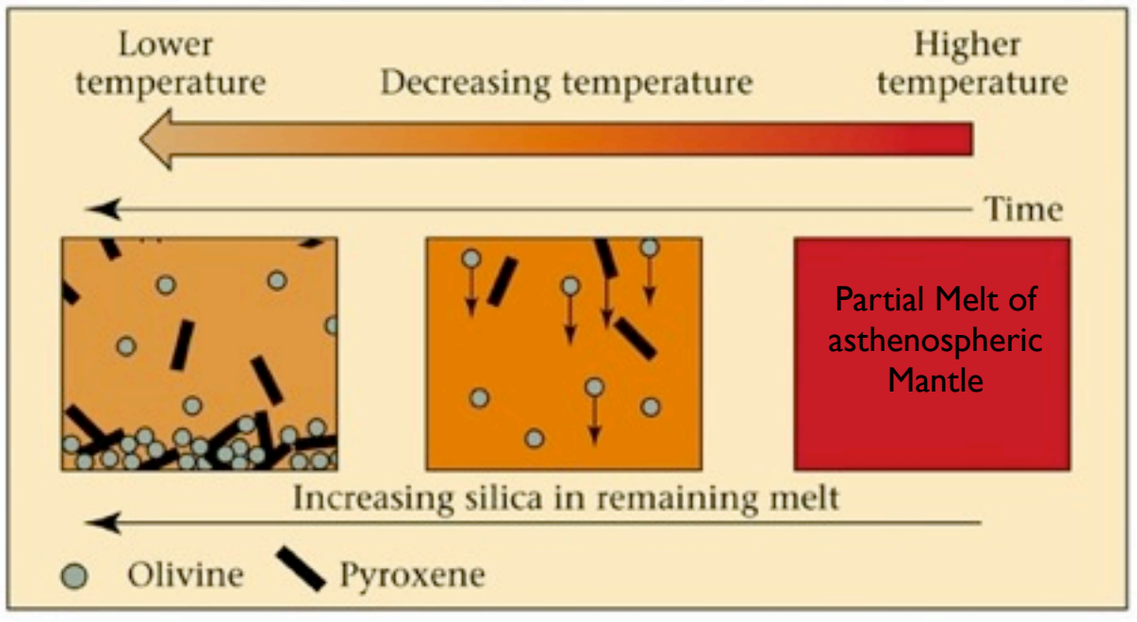
by

Fractional Crystallization



Magma Chamber

Increasing Silica



(b)

Temp. | Comp.

Ultra-Mafic

1300

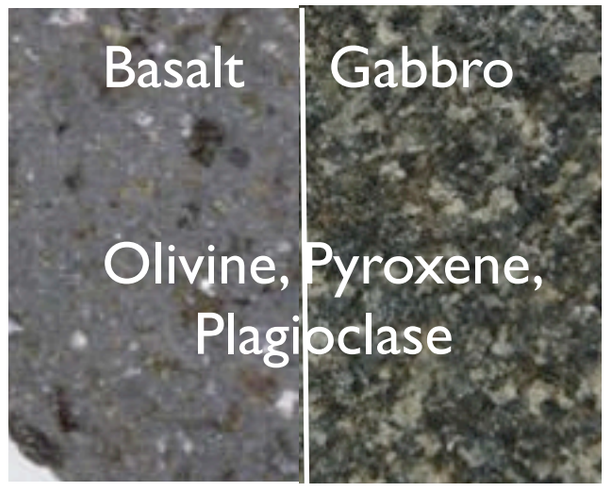
Mafic

900

600

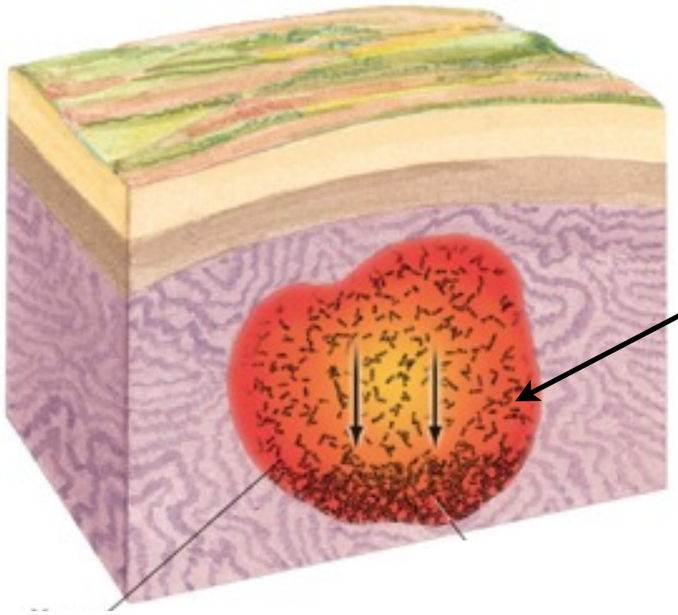
Partial melt of Asthenospheric Mantle Peridotite

No Crystals



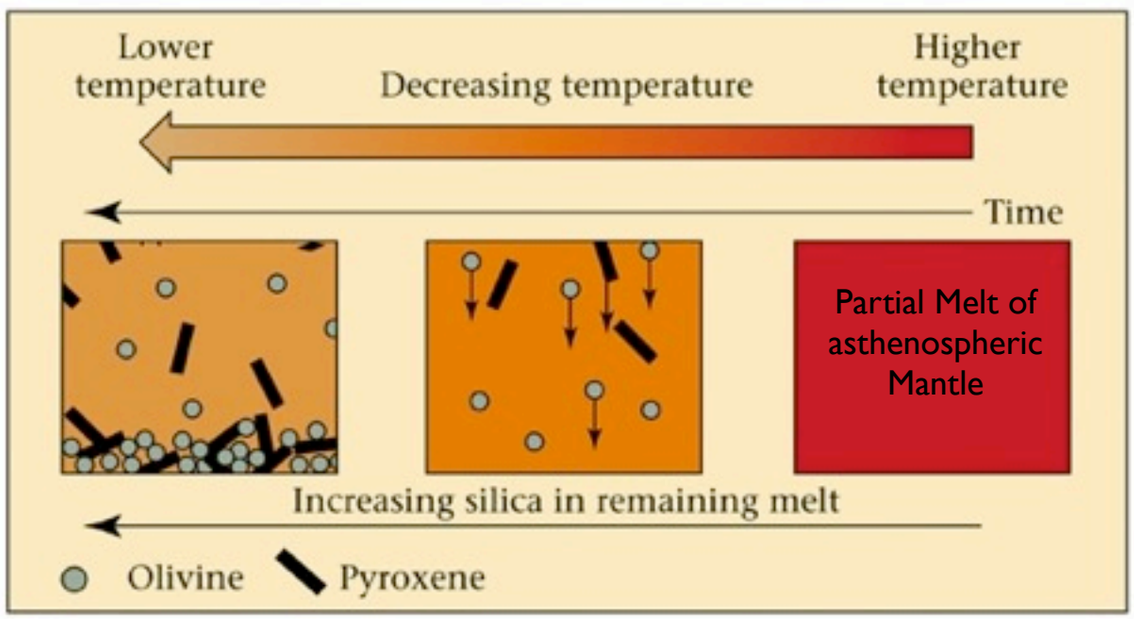
Magma Differentiation

by
Fractional Crystallization



Magma Chamber

Increasing Silica

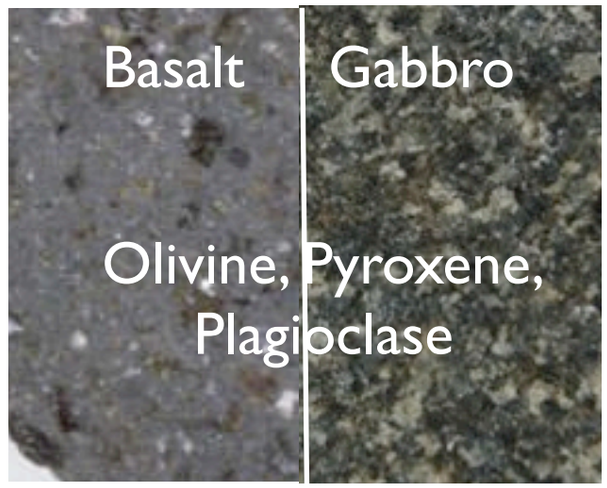


(b)

Temp.	Comp.
	Ultra-Mafic
1300	
	Mafic
900	
	Interm.
600	

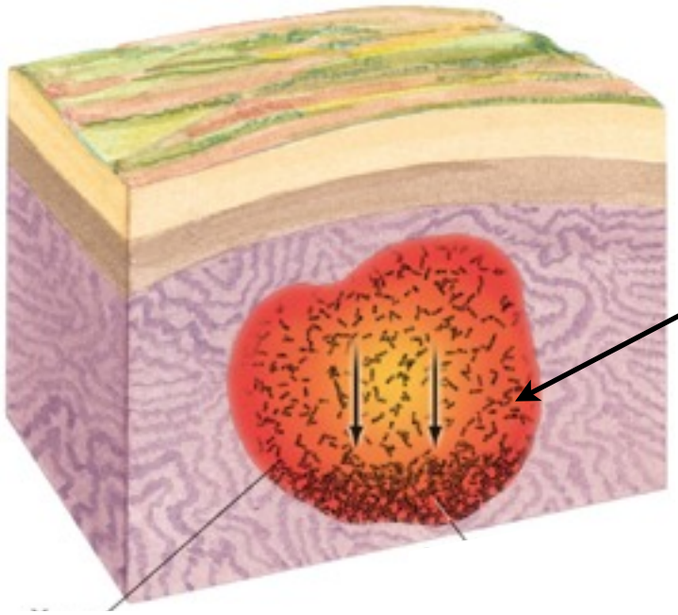
Partial melt of Asthenospheric Mantle Peridotite

No Crystals



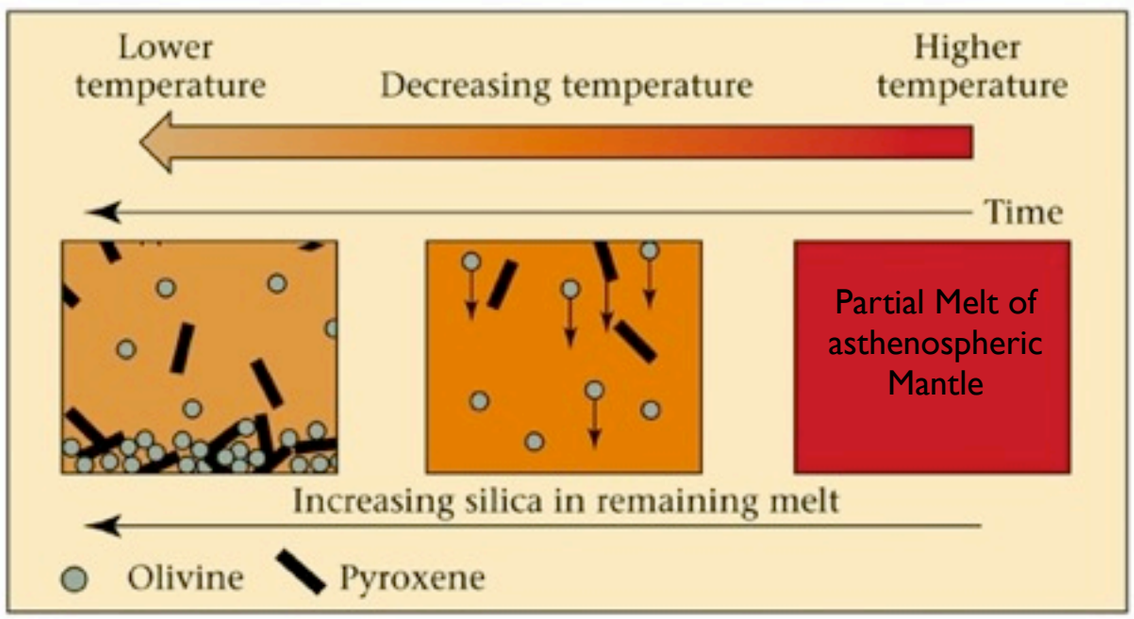
Magma Differentiation

by
Fractional Crystallization



Magma Chamber

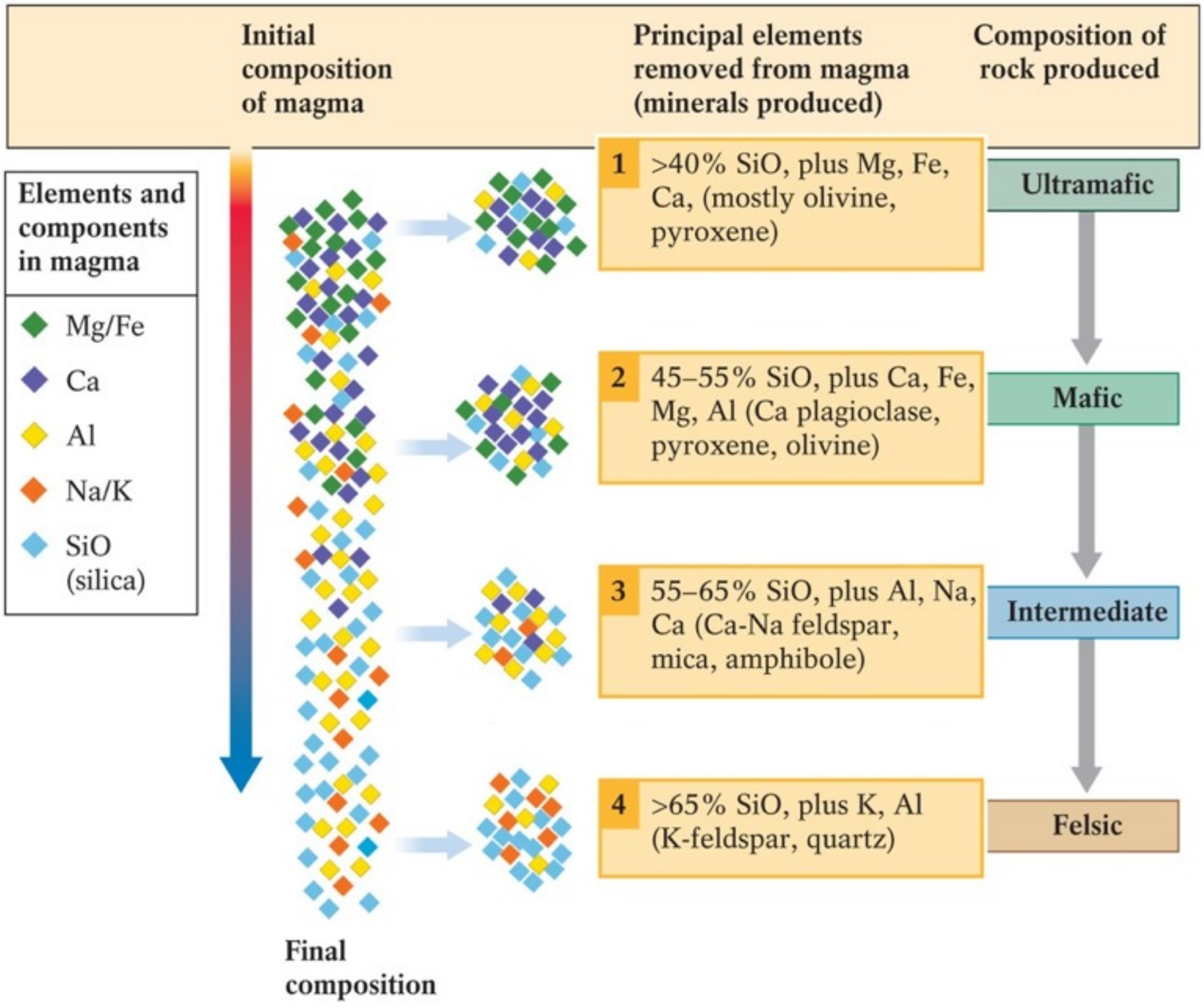
Increasing Silica



(b)

Temp.	Comp.	
	Ultra-Mafic	Partial melt of Asthenospheric Mantle Peridotite No Crystals
1300		
	Mafic	Basalt / Gabbro Olivine, Pyroxene, Plagioclase
900	Interm.	Andesite / Diorite Hornblende, Biotite Plagioclase
600	Felsic	Rhyolite / Granite Muscovite, Quartz, K-feldspar

Fractional Crystallization



MIT Experimental Petrology Lab

Experimental Setup

Run experiments at:

- 760 - 1200°C
- depths of 96-120 km
- 3 days - 2 weeks