	Topic/Objective CHAPTER: 5/6	NAME:
	Igneous Rx	Pd: 1 2 4 5 other
		DATE

Essential Question

How to identify Ign Rx?

Cue: Review: Thoughts: Main idea	NOTE Taking AREA:
Igneous	↳ Igneous Rx (Ign) forms from the cooling of Magma / Lava
Most Abundent	↳ most abundant Rx found mainly underground. not the most common
2 ways To I.D. them.	1. Rate of cooling (Temperature)
	a. Plutonic
	1. Slowly cooling
	↳ deep underground
	↳ Time for Crystals (Xstal) to grow ... Large-grains
	↳ easily visible
	* INTRUSIVE (Phaneritic)
	b. Volcanic
	2. Fast cooling
	↳ on or near surface
	↳ NO/Little Time for Xstal growth
	↳ Fine-grained
	* EXTRUSIVE (Aphanitic)

NOTES CONTINUE ON OTHER SIDE

Topic/Objective CHAPTER:	NAME:
	DATE

Cue: Review: Thoughts: Main Idea

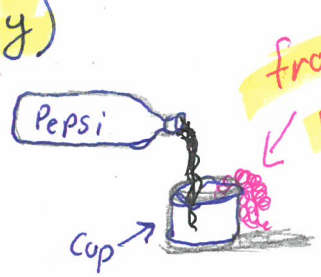
other Cooling

Air holes Trapped

Choc. Chip Cookie.

NOTE Taking AREA:

Cool so fast that it turns to glass or Foam (Frothy)



glassy Rx e.g. Obsidian

If air is trapped inside the Rx it can make "Bubbles"

A.K.A. Vesicular

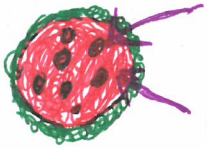
e.g. Pumice (Frothy); Scoria (Lava Rx)

↳ That Floats

↳ sinks

Porphyry

↳ start to cool slowly then cool rapidly



seeds (Phenocrysts)

melon (ground mass)

SUMMARY:

Topic/Objective CHAPTER: 5

Ign Rx

NAME:

Pd: 1 2 4 5 other

DATE

Essential Question

how do I identify Ign Rx?

Cue: Review: Thoughts: Main Idea

NOTE Taking AREA:

classification

Identify differ types of Ign Rx

2. Composition of the Rx
   - ↳ minerals that make up Ign Rx.
   - ↳ "Color" — Form*

"Color"

4 different Types

1. Light in Color
   - ↳ Felsic
     - ↳ contains lots of Silica
     - ↳ Si & O → like quartz
     - ↳ Na, Al, K also has
     - ↳ Not very dense; flows Slowly

Felsic

i.e. →

Rx e.g ⇒ Granite Rhyolite

2. Dark in color
   - ↳ Mafic
     - ↳ contains lots of Fe & Mg (Ferromagnesiam) less silica
     - ↳ very dense; flows quickly

Mafic

i.e. →

Rx e.g → Basalt Gabbro

Amphibole (Hornblende)

Olivine Pyroxene

NOTES CONTINUE ON OTHER SIDE

	Topic/Objective CHAPTER:	NAME:
		DATE

Cue: Review: Thoughts: Main Idea

NOTE Taking AREA:

3. medium
   - ↳ Intermediate
   - ↳ contains more silica than mafic but less than Felsic
   - ↳ Ave. dense ; flows like oil

Intermediate

i.e. Rx e.g → Andesite Diorite

K-feldspar (Turns things pink/red)

Ca-Na feldspar

→ as Calcium core is rapidly cooling

Ca = blue Na = green

as one decrease the other increases

Zonal Xstal

Ca 100%	Ca 75%	Ca 50%	Ca 25%	Ca 0%
Na 0%	Na 25%	Na 50%	Na 75%	Na 100%

4. Really Dark -
   - ↳ ULTRA MAFIC
   - ↳ contains lots of Fe & Mg
   - ↳ Flows ~~Very~~ rapidly ; dense

Ultra Mafic

i.e. Rx e.g → Peridotite (Kimberlite)

A.k.a. diamonds.

Topic/Objective CHAPTER: 5	NAME:
Ign Rx	Pd: 1 2 4 5 other
	DATE 3065

Essential Question

What are the Classification for Ign Rx

Cue: Review: Thoughts: Main idea

NOTE Taking AREA:

by: Wendy Van Norden

video youtube: Igneous Rx classification

All igneous Rx form from the cooling of Magma or Lava

- Magma → found underground
- Lava → found on ⊕ surface

How Ign Rx form

1.) Cooling Rate

- one of the MOST important
- Rx cooled underground then crystal → Xstal have time to form.
  - Result: Large visible Xstal

- Rx cooled on the surface
  - Xstal do not have time to form.
  - Result: small or none will form

Porphyry

Special cooling Rate

e.g. melon (ground mass) seed (Phenocrysts)

PORPHYRITIC

i.e. Choc. Chip cookie

Vesicular

- gas Trapped inside Rx Then escaped creating holes

holes

NOTES CONTINUE ON OTHER SIDE

	Topic/Objective CHAPTER:	NAME:
		DATE

Cue: Review:
Thoughts: Main Idea

NOTE Taking AREA:

EXTRUSIVE

Rhyolite

INTRUSIVE

Granite

2) Texture

A. Glassy
↳ no x-stal present due to rapid cooling e.g. Obsidian

B. Aphanitic (Volcanic) on surface
↳ Fine-grained (small)
↳ small or very little x-stal visible
↳ cooled quickly
e.g. Rhyolite (Pink color)

C. Phaneritic (Plutonic) underground
↳ Coarse-grained (large)
↳ large x-stal are visible
↳ cooled slowly
e.g. Granite (multi-color)

D. Pegmatite
↳ very coarse-grained (Really large)

MINERAL composition

Felsic: Fel = feldspar, quartz, Al
Sic = Silica ~~Any~~; Very low.
Light in color

SUMMARY:

Intermediate: e.g. Andesitic
: light & Dark

MAFIC: Mg & Fe heavy, dense Rx
Dark color
eg: BASalt : ocean crust

Ultra mafic:
eg: peridotite, olivine, Kimberite → diamonds

Topic/Objective CHAPTER: 5/6

Ign Rx

NAME:

Pd: 1 2 4 5 other

DATE 4 of 5

Essential Question

How does Magma form

Cue: Review: Thoughts: Main Idea

NOTE Taking AREA:

Ign Rx Formation

↳ Ign Rx formation depends on the composition of magma
  ↳ which is often a slushy mix of molten Rx, dissolved gases, & mineral crystals
  ↳

3 Types of magma

Basaltic (42-52%) Andesitic (granitic) Rhyolitic

* Silica affects melting temperature & impacts how quickly magma flows.

Magma can be formed either by:

1. melting of Earth's crust
2. melting w/in the mantle.
   ↳ this is about 60 to 200 km below ⊕ surface [37 to 124 miles]

NOTES CONTINUE ON OTHER SIDE

	Topic/Objective CHAPTER:	NAME:
		DATE

Cue: Review: Thoughts: Main Idea	NOTE Taking AREA:
4 factors involved in formation of magma	*1. Temperature ~1400°C = 760°F ↳ increases w/depth ↳ A.K.A. geothermal gradient ↳ is just 1 condition needed to melt minerals into magma 2. Pressure ↳ increases w/depth due to the overlying Rx. ↳ This increases the Rx melting point 3. H_2O content (%) ↳ Rx often contain a small amount of H_2O ↳ As H_2O content increases Melting Pt decreases 4. mineral content ↳ different minerals melt at different points ↳ Rocks Rich in Fe & Mg melt @ higher temp ↳ Rx rich in Si & O melt @ lower temp ↳ as part of the Rx melts/other part does not melt. this is known as:
SUMMARY:	Partial Melting ↳ different melt into magma @ different temperature △ it's composition.
Partial Melting	

Topic/Objective CHAPTER: 5	NAME:
Ign Rx	Pd: 1 2 4 5 other
	DATE 5 of 5

Essential Question

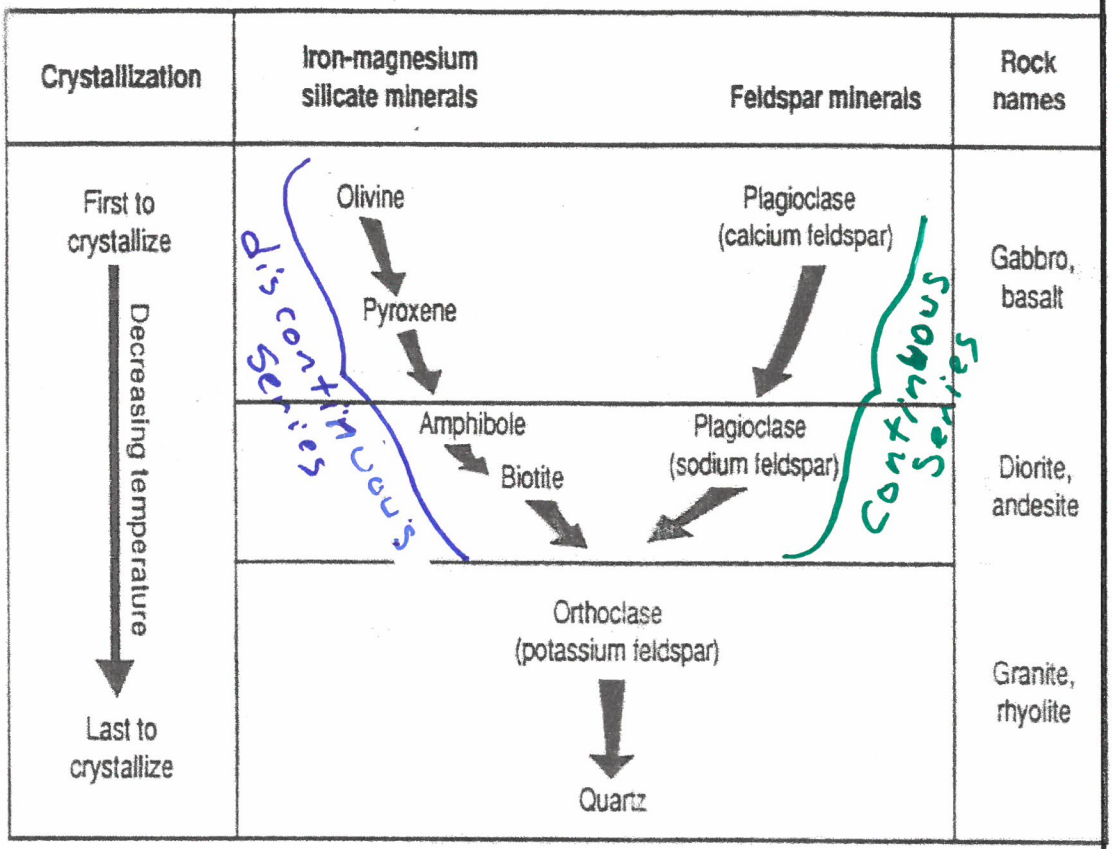
What is Bowen's Reaction Series?

Cue: Review: Thoughts: Main Idea

NOTE Taking AREA:

CRYSTALLIZATION

This chart represents the order in which different minerals crystallize from a cooling magma or lava to form igneous rocks. Both mineral names and the rocks they form are shown. Use the chart to answer the questions.



↳ Norman L. Bowen was a canadian geologist who demonstrated that as magma cools & crystallizes, minerals form in predictable patterns in a process known as the:

Bowen's Reaction Series

NOTES CONTINUE ON OTHER SIDE

	Topic/Objective CHAPTER:	NAME:
		DATE

Cue: Review: Thoughts: Main Idea	NOTE Taking AREA:
Discontinuous Series	↳ left side ↳ goes in steps in which Rich Fe-Mg minerals undergo abrupt change as magma cools
Continuous Series	↳ Right side ↳ shows how plagioclase Feldspar under goes a continuous △ from Ca-Rich to Na-Rich
Fractional crystallization	↳ 1ST minerals to crystallize are the Last minerals that melt

SUMMARY:

	Topic/Objective CHAPTER:	NAME:
	Ch5 Igneous Rock	Pd: 1 2 4 5 other
		DATE 6/5

Essential Question

What is and How Does Bowens Reaction series Work (YouTube video by Wendy Van Norden)

https://www.youtube.com/watch?v=scYPwhvlLVg

Cue: Review: Thoughts: Main Idea

Igneous RX

Texture xstal

Glassy

Fine grained

Coarse grained

VERY coarse

Texture color

Felsic (light)

Mafic (dark)

Intermediate

Ultramafic

Igneous Rx Classification

A) NORMAN L. BOWEN (N. L. Bowen)

1 1900's a Canadian geologist studied magma as it cooled

- ♦ He demonstrated that as magma cools, minerals from in predictable patterns.
- ♦ He then determined that specific minerals formed at specific temperature as magma cools:

**SEE OVERHEAD DIAGRAM*

2 This predictable pattern is called the Bowen's Reaction Series

- ♦ It illustrates the relationship between cooling magma & mineral formation
- ♦ **Bowen's Reaction Series** is a sequence in which minerals crystallize within a cooling magma.
  - (a) Crystallization occurs simultaneously on two branches if lithification rates are slow enough.
  - (b) Minerals found at the top of the chart (both left and right columns) form first during cooling.
  - (c) Other minerals form in progression (down the table) as temperature cools.

3 Bowen discovered 2 main patterns or branches of crystallization

- ♦ First pattern: **Discontinuous Branch**
  - (a) Olivine-Pyroxene-Amphibole-Biotite (all **ferro-magnesium** minerals) takes turns forming at specific temperatures on this branch.
  - (b) As the temperature progressively decreases, each takes elements remaining in the melt and steals from previously formed minerals to make new minerals.
    - Biotite is the last to form in this group, after which all iron and magnesium remaining in the melt are used up.
  - (c) Obviously, the available amount of iron and magnesium in the melt determines the amount of ferro-magnesium minerals formed.
  - (d) Characterized by an abrupt change of mineral type in the iron-magnesium groups
    - Left branch represents the Fe-rich minerals, which these minerals undergo abrupt changes during fractional crystallization
      - 1st Magma rich in Fe & Mg cools around 1800° C (3,272° F)
      - 2nd Olivine begins to crystallize first till the temperature drops to 1,557° C (2,835° F)
      - 3rd Then pyroxene begins to form, followed by amphiboles & then biotite
      - 4th Finally the remaining melt, enriched with silica & oxygen, crystallize, quartz forms

SUMMARY: CONTINUED on SECOND SHEET

	Topic/Objective CHAPTER:	NAME:
	Ch5 Igneous Rock	Pd: 1 2 4 5 other
		DATE

Essential Question

Cue: Review: Thoughts: Main Idea

Porphyry

Vesicular

Pyroclastic

Rx examples

- ◆ Second pattern: **Continuous Branch**
  - (a) Two flavor of Plagioclase minerals (containing calcium and sodium) form on this branch at the same temperature range as the Discontinuous Branch (Plagioclase is a mixture of Anorthite: $CaAl_2Si_2O_8$ and Albite: $NaAlSi_3O_8$).
  - (b) Characterized by a continuous, gradual change of mineral compositions if the feldspar group
    - ● Right branch represents the feldspar minerals, which undergo a continuous change of composition
      - 1st Magma cools the first feldspar to form are rich in calcium
        - a. Calcium-rich plagioclase minerals (anorthite) form first, robbing the melt of this element.
      - 2nd As cooling continues, Ca-rich feldspar change to Na-rich feldspar.
        - a. As less calcium remains within the melt more sodium elements are used to form a sodium-rich plagioclase (Albite).
        - b. Plagioclase is formed until all calcium and sodium is used up in the melt.
    - ◆ Remaining minerals are formed at lower temperatures (Fe/Mg/Ca/Na all used up by this time)
      - (a) Magma is now rich in silica, aluminum and potassium.
        - ● Orthoclase (potassium-aluminum) ($KAlSi_3O_8$) feldspar is now formed.
        - ● If water is present, muscovite may form.
        - ● Otherwise the remaining melt contains only silica, all other elements have been depleted, and finally forms quartz: SiO_3.
      - (b) Geologists hypothesize that under certain conditions, newly formed crystals are separated from magma, & the chemical reactions between the magma and the minerals stop.
        - ● **Crystal separation** can occur when crystal settle to the bottom of the magma body, & when liquid magma is squeezed from the crystal mush to form 2 distinct igneous bodies with different compositions
      - (c) In some magma bodies, the minerals form into distinct bands in the order in Bowen's reaction series
        - ● This results in a **layered intrusion**
        - ● Not sure how they form, scientist think that settling of crystals, flowing currents in the magma, & temperatures gradients within the magma chambers all play a part
        - ● **Layered intrusion** can be a valuable source of raw metals
          - 1st Some contain very high concentrations of elements such as platinum, chromium, nickel, & gold
            - a. Stillwater Complex in Montana is the only source of platinum in the United States
            - b. Platinum is a critical component in catalytic converters, which reduce the amount of pollutants that vehicles emit.

SUMMARY:

*Igneous Rx form from the cooling of Magma / Lava. They are classified in 2 ways. (1) How they cool: Above the G (**Aphanitic – (FINE=GRAINED)** or underground **Phaneritic – (COARSE=GRAINED)** . (2) Texture or color of minerals within. This can be Light, intermediate, Dark or Very Dark. There are other types of texture also.*

Topic/Objective CHAPTER: 5

Igneous Rx

NAME:

Pd: 1 2 4 5 other

DATE 10/5

Essential Question

How do I identify Ign Rx?

Cue: Review: Thoughts: Main Idea

Mr. Parr Song

Igneous

Most Abundant

2 ways to ID. Environment of Formation

Intrusive

Extrusive

NOTE Taking AREA:

Types of Rocks
↳ All Rocks are formed

↳ Igneous (Ign) Rx forms from the cooling of magma / Lava

* ↳ Most Abundant Rx

Identify differ types of Ign Rx

1. RATE of cooling (Temperature)
   1. Slowly
      ↳ means they are usually deep underground.
      ↳ Time for crystals (xstal) to grow ... Large-grains
      ↳ easily visible to see
      ↳ A.K.A. ⇒ Intrusive (Plutonic) (coarse)
   2. Quickly
      ↳ means they are usually found on/near ⊕ surface.
      ↳ NO time for xstal to grow
      ↳ Fine / small / hard to see-grains
      ↳ Extrusive (Volcanic)
      Ex → previous/past

2 Types of Magma

NOTES CONTINUE ON OTHER SIDE

Pahoe Hoe = Ropey

Aa =

Topic/Objective CHAPTER:	NAME:
	DATE

Cue: Review: Thoughts: Main Idea

NOTE Taking AREA:

Xstal are actually minerals growing

Texture

How minerals grow

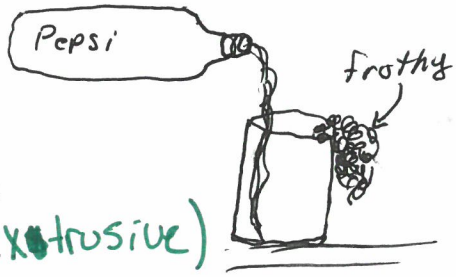
1. Large mineral grains
   - ↳ easily visible b/c it cooled slowly
   - ↳ Coarse-grain: Phaneritic
   - ↳ e.g. Granite (loc: mostly landmass)

Intrusive

2. Small (Fine) mineral grains
   - ↳ NOT easily visible b/c it cooled quickly
   - ↳ Fine-grain: Aphanitic
   - ↳ e.g. Basalt (loc: on Ocean floor)

Extrusive

3. NO-xstal form
   - ↳ None or very Fine
   - ↳ Glassy: or Frothy
   - ↳ e.g. Obsidian (extrusive)



4. Air holes or Bubbles
   - ↳ Vesicular
   - ↳ gas is trapped inside the Rx as it cools.
   - ↳ e.g. Pumice (Frothy) Scoria (Lava Rx) gas grill ↳ Floats

Vesicular

5. Both Coarse & Fine grains
   - ↳ Porphyry
   - ↳ starts to cool slowly then cools rapidly

Porphyritic

SUMMARY:

e.g. ↳