

GEOLAB

DESIGN YOUR OWN: MODEL CRYSTAL FORMATION

Background: The rate at which magma cools affects the grain size of the resulting igneous rock. Observing the crystallization of magma is difficult because molten rock is very hot and the crystallization process is sometimes very slow. Other materials, however, crystallize at lower temperatures. These materials can be used to model crystal formation.

Question: How do minerals crystallize from magma?

Materials

clean, plastic petri dishes	thermometer
saturated alum solution	paper towels
200-mL glass beaker	water
magnifying lens	hot plate
dark-colored construction paper	

Safety Precautions

WARNING: The alum solution can cause skin irritation and will be hot when it is first poured into the petri dishes. If splattering occurs, wash skin with cold water.

Procedure

1. Read and complete the lab safety form.
2. As a group, plan how you will change the cooling rate of a hot solution poured into a petri dish. Each group member should choose a petri dish in a predetermined location to observe during the investigation. Make sure your teacher approves your plan before you begin.
3. Place a piece of dark-colored construction paper on a level surface where it will not be disturbed. Be sure to put the paper in all of the predetermined locations. Place the petri dishes on top of the paper.
4. Using the glass beaker, obtain about 150 mL of saturated alum solution from your teacher. The temperature should be about 95°C to 98°C, just below boiling temperature.
5. Carefully pour some of the solution into each petri dish so that it is half full. Use caution when pouring the hot liquid to avoid splatters and burns.



6. Every 5 min for 30 min, record your observations of your petri dish. Make drawings of any crystals that begin to form.

Analyze and Conclude

1. **Compare** your methods of cooling with those of other groups. Did some methods appear to work better than others? Explain.
2. **Examine** your alum crystals. What do the crystals look like? Are they all the same size? Do all the crystals have the same shape?
3. **Draw** the most common crystal shape in your science journal. Compare your drawings with those of other groups. Describe any patterns that you see.
4. **Deduce** what factors affected the size of the crystals in the different petri dishes. How do you know?
5. **Infer** why the crystals changed shape as they grew.
6. **Compare and contrast** this experiment with magma crystallization.
7. **Evaluate** the relationship between cooling rate and crystal formation.

SHARE YOUR DATA

Peer Review Visit glencoe.com and post a summary of your data. Compare and contrast your results with those of other students who have completed this lab.

BIG Idea Igneous rocks were the first rocks to form as Earth cooled from a molten mass to the crystalline rocks of the early crust.

Vocabulary

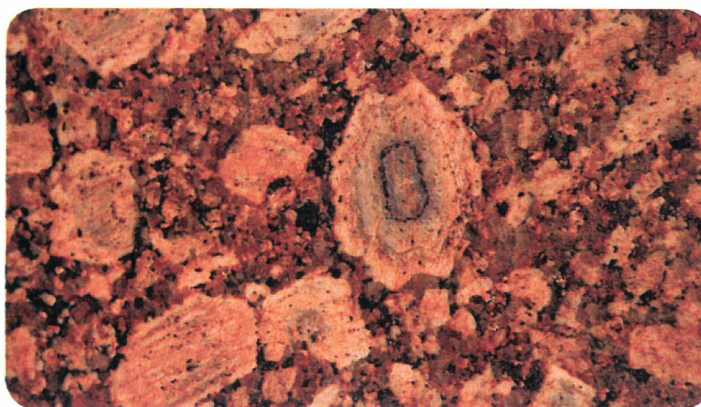
Key Concepts

Section 5.1 What are igneous rocks?

- Bowen's reaction series (p. 114)
- fractional crystallization (p. 115)
- igneous rock (p. 112)
- lava (p. 112)
- partial melting (p. 114)

MAIN Idea Igneous rocks are the rocks that form when molten material cools and crystallizes.

- Magma consists of molten rock, dissolved gases, and mineral crystals.
- Magma is classified as basaltic, andesitic, or rhyolitic, based on the amount of silica it contains.
- Different minerals melt and crystallize at different temperatures.
- Bowen's reaction series defines the order in which minerals crystallize from magma.



Section 5.2 Classification of Igneous Rocks

- basaltic rock (p. 118)
- extrusive rock (p. 118)
- granitic rock (p. 118)
- intrusive rock (p. 118)
- kimberlite (p. 123)
- pegmatite (p. 122)
- porphyritic texture (p. 120)
- texture (p. 119)
- vesicular texture (p. 120)

MAIN Idea Classification of igneous rocks is based on mineral composition, crystal size, and texture.

- Classification of igneous rocks is based on three main characteristics.
- The rate of cooling determines crystal size.
- Ores often occur in pegmatites. Diamonds occur in kimberlites.
- Some igneous rocks are used as building materials because of their strength, durability, and beauty.



Vocabulary Review

The sentences below are incorrect. Make each sentence correct by replacing the italicized word or phrase with a vocabulary term from the Study Guide.

1. Gases escape from *magma* as it flows out onto Earth's surface.
2. *Mohs scale of hardness* describes the order in which minerals crystallize.
3. *Lava* forms deep beneath Earth's crust.

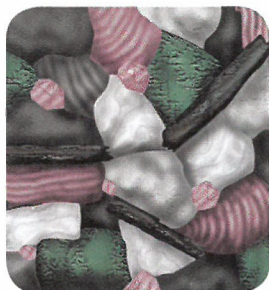
Complete the sentences by filling in the blank with the correct vocabulary term from the Study Guide.

4. An igneous texture characterized by large crystals embedded in a fine-grained background is called a _____.
5. Igneous rocks that form under conditions of fast cooling are said to be _____.
6. Light-colored rocks with large crystals are said to be _____.

Understand Key Concepts

7. Which is the first mineral to form in cooling magma?
 - A. quartz
 - B. mica
 - C. potassium feldspar
 - D. olivine

Use the diagram below to answer Question 8.



8. Which process is occurring in the diagram?
 - A. fractional separation
 - B. crystal separation
 - C. fractional crystallization
 - D. partial melting

9. Which minerals are associated with the right-hand branch of Bowen's reaction series?
 - A. olivine and pyroxene
 - B. feldspars
 - C. mica and feldspars
 - D. quartz and biotite
10. Which magma type contains the greatest amount of silica?
 - A. basaltic
 - B. andesitic
 - C. rhyolitic
 - D. peridotite
11. Which does not affect the formation of magma?
 - A. volume
 - B. temperature
 - C. pressure
 - D. mineral composition
12. Which extrusive rock has the same composition as andesite?
 - A. granite
 - B. basalt
 - C. obsidian
 - D. diorite

Use the figure below to answer Question 13.



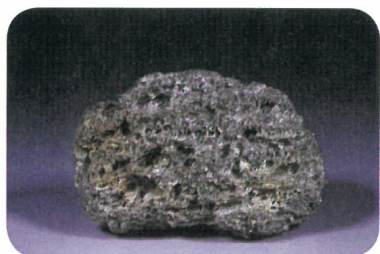
13. Which process formed this rock?
 - A. slow cooling
 - B. fast cooling
 - C. very fast cooling
 - D. slow, then fast cooling
14. Which type of ultrabasic rock sometimes contains diamonds?
 - A. pegmatite
 - B. kimberlite
 - C. granite
 - D. rhyolite

15. What effect does a fast cooling rate have on grain size in igneous rocks?
 - A. It forms fine-grained crystals.
 - B. It forms large-grained crystals.
 - C. It forms light crystals.
 - D. It forms dark crystals.
16. What term describes igneous rocks that crystallize inside Earth?
 - A. magma
 - B. intrusive
 - C. lava
 - D. extrusive
17. Which minerals are most common in granite?
 - A. quartz and feldspar
 - B. plagioclase feldspar and amphibole
 - C. olivine and pyroxene
 - D. quartz and olivine

Constructed Response

18. **List** some uses of igneous rocks in the construction industry.
19. **Explain** how and why the plagioclase feldspar in basaltic rocks differs from that in granitic rocks.

Use the photos below to answer Questions 20 and 21.



20. **Draw** a flowchart documenting the formation of the holes in this sample of vesicular basalt.
21. **Speculate** on the reasons that samples of pumice are able to float in water.

22. **Illustrate** how fractional crystallization changes the composition of magma, using the formation of iron-rich olivine to illustrate the point.
23. **Apply** the concepts of temperature and crystallization to explain why magma is often described as a slushy mixture of crystals and molten rock.

Use the table below to answer Questions 24 and 25.

Rock Composition				
Mineral	Mineral Percentage			
	Rock 1	Rock 2	Rock 3	Rock 4
Quartz	5	35	0	0
Potassium feldspar	0	15	0	0
Plagioclase feldspar	55	25	0	55
Biotite	15	15	0	10
Amphibole	25	10	0	30
Pyroxene	0	0	40	5
Olivine	0	0	60	0

24. **Analyze** the data in the table, and explain which rock is most likely granite.
25. **Incorporate** Use the data for Rock 4 and the fact that it is fine-grained to determine the name of Rock 4.

Think Critically

26. **Compare** obsidian and granite to explain why granite is more easily carved into statues and monuments.
27. **Evaluate** this statement: It is possible for magma to have a higher silica content than the rock that forms from it.
28. **Apply** what you know about mineral hardness to explain why stainless steel knives do not harm granite cutting boards.

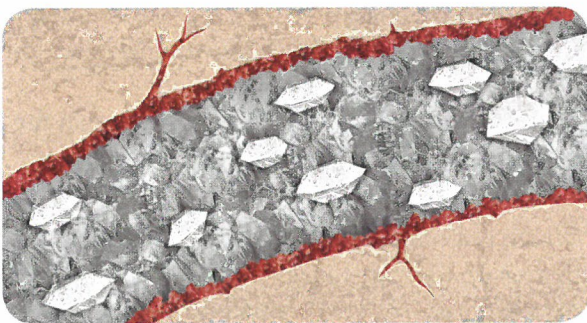
29. **Infer** Kimberlites are the source of most diamonds. Infer why scientists study kimberlites to learn more about Earth's mantle.
30. **Assess** Rocks generally consist of minerals. When molten rock is chilled rapidly, it becomes a glass. Volcanic glass is an extrusive igneous rock. Assess whether this rock contains minerals. Explain your answer. [Hint: Recall the definition of a mineral from Chapter 4.]
31. **Infer** why rocks that are composed of minerals that crystallize first according to Bowen's reaction series are unstable and break down quickly at Earth's surface.
32. **Hypothesize** what the Palisades Sill would look like if the magma that formed it was granitic in composition.

Concept Mapping

33. Use the following terms to create a concept map showing the relationship among position in Earth's crust and mantle, crystal size, and rock type: *fast, slow, slowest, intrusive, extrusive, magma, lava, granite, rhyolite, basalt, gabbro, obsidian, and pumice.*

Challenge Question

Use the diagram below to answer Question 34.



34. **Determine** The diagram shows a cross section of the Leopard Lode, an igneous rock unit in Wyoming. Determine the formation history of this rock unit.

Additional Assessment

35. **WRITING in Earth Science** Building stone is expensive. Suppose you are selling kitchen countertops that look like granite, but consist of a less-expensive synthetic material. List the specific characteristics of granite that your customers would look for in the imitation granite.



Document-Based Questions

Data obtained from: Gerya, T.V., et al. 2003. Cold fingers in a hot magma: numerical modeling of country-rock diapirs in the Bushveld Complex, South Africa. *Geology* 31 (9): 753.

The Bushveld Complex is the world's largest layered intrusion. It was injected as a hot, dense basaltic magma between overlying volcanic and underlying sedimentary rocks. Modeling of this event indicates that finger-shaped bodies of heated, metamorphosed sedimentary rocks subsequently intruded the overlying igneous layers. The model assumed the igneous rock properties shown in the table.

Igneous Rock Properties			
Rock Type	Density (kg/m ³)	T Solidus (°C)	T Liquidus (°C)
Granitic	2700 (solid) 2400 (molten)	675	925
Basaltic/ ultrabasic	3000 (solid) 2900 (molten)	950	1100

36. Compare and contrast the density of solid and molten rocks in this model.
37. Speculate about why the overlying rhyolitic rocks could not penetrate, or sink into, the basaltic magma.
38. Infer the meaning of the terms *liquidus* and *solidus*. At what temperature do the first crystals in granitic rocks melt?

Cumulative Review

39. What is a molecule? (Chapter 3)
40. Name a gemstone that consists of corundum. (Chapter 4)

Standardized Test Practice

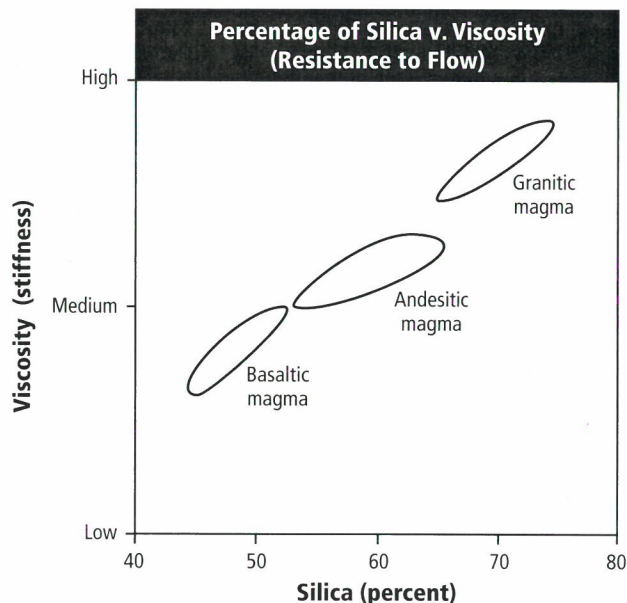
Multiple Choice

Use the table below to answer Questions 1 and 2.

Characteristics of Rocks			
	Color	Silica Content	Composition
Rock A	light	high	quartz and feldspars
Rock B	dark	low	iron and magnesium

- Rock A is most likely what kind of rock?
 - granitic
 - basaltic
 - ultrabasic
 - adesitic
- Which type of rock is Rock B?
 - granite
 - diorite
 - gabbro
 - pegmatite
- Which is most abundant in magma and has the greatest effect on its characteristics?
 - O
 - Ca
 - Al
 - SiO₂
- Which process describes how minerals form in predictable sequences?
 - partial melting
 - fractional crystallization
 - Bowen's reaction series
 - geothermal gradient
- Which is NOT a feature used for identifying minerals?
 - hardness
 - color
 - density
 - volume
- Which is distorted on a Mercator projection map?
 - shapes of the landmasses
 - areas of the landmasses
 - latitude lines
 - longitude lines

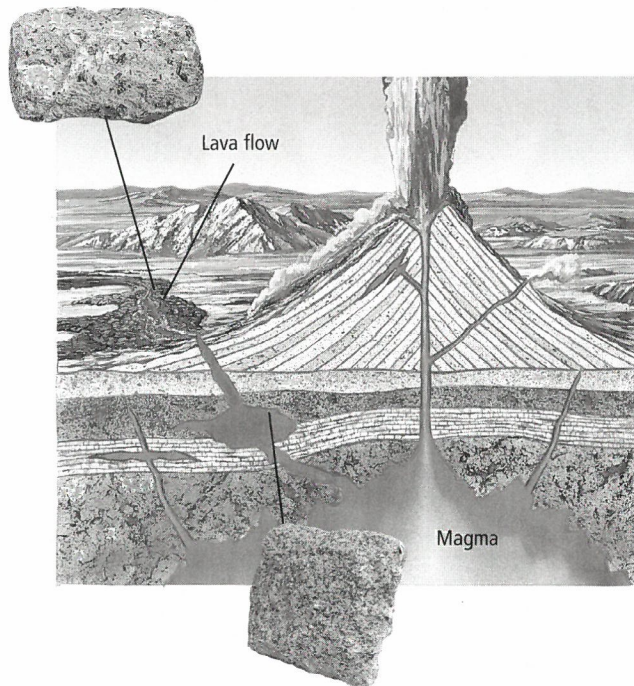
Use the graph below to answer Questions 7 and 8.



- What relationship can be inferred from the graph?
 - Magmas that have more silica are more viscous.
 - Magmas that have less silica are more viscous.
 - Magmas always have low viscosity.
 - There is no relationship between silica content and viscosity (resistance to flow).
- Which is a true statement about rhyolitic magma?
 - Rhyolitic magma is heavier than the other two types of magma.
 - Rhyolitic magma is lighter than the other two types of magma.
 - Rhyolitic magma flows more quickly than the other two types of magma.
 - Rhyolitic magma flows more slowly than the other two types of magma.
- Which is a combination of two or more components that retain their identities?
 - chemical
 - solution
 - mixture
 - element
- Which is the lightest of all atoms?
 - uranium atom
 - oxygen atom
 - carbon atom
 - hydrogen atom

Short Answer

Use the picture below to answer Questions 11–13.



11. Name the type of igneous rock located at the bottom of the picture, and state a common example of that type of rock and explain how this rock is formed.
12. Name the type of igneous rock located at the top of the picture and state a common example of that type of rock and explain how this type of rock is formed.
13. Contrast the formation of the two types of igneous rock.
14. What does it mean to say that minerals are naturally occurring and inorganic?
15. Why are some minerals classified as gems?
16. Why are both latitude and longitude lines necessary when identifying a location?

NEED EXTRA HELP?

If You Missed Question . . .	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Review Section . . .	5.2	5.2	5.1	5.1	4.1	2.2	5.1	5.1	3.2	3.1	5.2	5.2	5.2	4.1	4.2	2.1

Reading for Comprehension

Marianas Island Research

Billowing ash plumes, molten sulfur droplets, feisty shrimp feasting on fish killed by noxious gases, and red lava jetting from a vent are all part of the action recently filmed at an underwater volcano in the western Pacific Ocean. The images are the first ever direct observations of an active, submarine-arc volcano. Unlike volcanic activity at mid-ocean ridges, island-arc volcanoes can remain fixed over their magma sources for thousands of years, allowing them to sometimes grow above water level and become islands. The new studies at the Marianas Islands are giving scientists a firsthand look into this formation process. The volcano has been going through nearly constant low-level eruptions since at least 2004, when it was first observed, Embley says. It could potentially keep erupting for decades, giving scientists the opportunity to monitor its growth.

Article obtained from: Roach, J. "Deep-Sea Volcano Erupts on Film—A First" *National Geographic News*. 24 May 2006.

17. What are the benefits of the new studies at the Marianas Islands?
 - A. The studies give scientists a firsthand look into the formation process.
 - B. The studies reveal that the volcano could potentially keep erupting for decades.
 - C. The studies show life near the vent.
 - D. The studies are the first ever direct observations of an active submarine arc-volcano.
18. What can you infer from this passage?
 - A. Volcanoes constantly erupt at some level of intensity.
 - B. Volcanic activity occurs only at mid-ocean ridges.
 - C. Shrimp only eat fish killed by noxious gasses.
 - D. There are many active submarine volcanoes.