Mineral Basics & Properties WORKSHEET A

Answer Key & Notes to Educator

You will explore rocks, minerals, and crystals.

STOP 1 Find the large wall interactive periodic table ("Minerals are Elementary!")

Minerals are made of elements. These elements form bonds that hold a mineral together.

Look at a diagram of the periodic table (on the wall to the left of the screen). It shows the diversity of atoms that can make up minerals. How many elements do you recognize? *Answer may vary*

Explore the wall interactive to combine different atoms to make different kinds of minerals. Record the name and the chemical formula of one mineral that you formed: *Sample answer: Forsterite (Mg_2SiO_4)*

STOP 2 Go to the "Crystal Basics" area of the hall

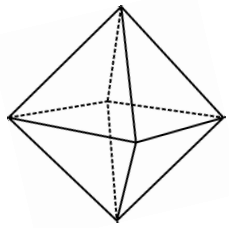
The arrangement of atoms affects the structure of a crystal. **In the "Crystal Systems" section** (on the right), **look at the line drawings and touchable models**. They represent the unit cells of the minerals on the wall above them. A unit cell is the microscopic basic building block of a mineral's crystal structure. **Look at the minerals on the wall.** What connections do you observe between these minerals and their unit cells?

Sample answer: some minerals show the same shape as the unit cells; others are harder to see

STOP 3 Go to the "Mineral Basics" area of the hall, "What Is a Crystal?" section (left)

In Stop 1, you explored how atoms bond together to form minerals. In Stop 2, you saw how the atoms form unit cells. Here, in Stop 3, you'll see how unit cells repeat and bond together to form crystal shapes.

Each kind of mineral has a unique, repeating three-dimensional (3-D) shape. **Look at the colorful plastic stick-and-ball model.** It shows how a unit cell repeats over and over again to form a mineral's crystal shape. One magnesium (Mg) atom, two aluminum (Al) atoms, and four oxygen (O) atoms bond together to form the mineral spinel ($MgAl_2O_4$). This combination, repeated, forms an octahedral shape.



octahedron

Examine both the plastic model and the real crystal. What do the model, the crystal, and the octahedron have in common?

Answers may vary

STOP 4 Explore the rest of "Mineral Basics" (center and right sections)

In the "What Is a Rock?" section, examine the granite rock (#1). Describe what you see and feel:

Sample observations: The rock feels rough, bumpy, and cold. It feels solid and looks heavy.

The mineral grains in this rock are tiny. They are different sizes, shapes, and colors.

Look at the four objects below the granite rock (#2–5). What are they? How are they related to the granite?

Sample answer: Each is about the same size as the granite. But they're not rocks. They are minerals.

These are the same four kinds of minerals as the tiny mineral grains that make up the granite rock.

Next, explore the "What Is a Mineral?" section.

Compare these minerals. What do they have in common?

Sample similarities: solid, cold

How are they different?

Sample differences: varying sizes, shapes, and colors

Pick your favorite mineral. Draw it:

Think about all that you have seen so far. What is the relationship between a rock, a mineral, and a crystal? Support your answer with your observations.

A rock is a solid that is made of one or more mineral grains. For example, a granite rock is made up of four different minerals. A mineral is a naturally occurring solid that comes in many colors, shapes, and sizes. Minerals have a regularly repeating crystal structure and defined chemical composition.

EXPLORE MORE

1. **Go to the "Minerals Properties and Uses"** area to see what makes minerals useful to humans.
2. **Visit the Hall of Gems.** People use tools to turn rough crystals into cut and polished crystals we call gems. To be used in jewelry, the ideal gem must have certain properties. For example, it must be hard enough to resist scratching and durable enough to resist breaking.

Igneous Environments

WORKSHEET B1

Answer Key & Notes to Educator

You will explore rocks, minerals, and crystals that form in igneous environments.

STOP 1 Find the two giant geodes near the hall entrance

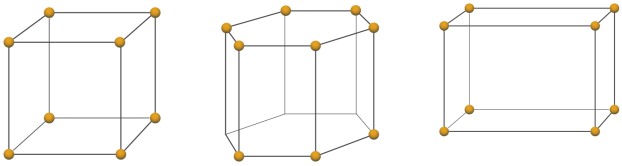
Pick one of the giant geodes and observe it. How would you describe the geode and its crystals to someone who has never seen them?

Sample descriptions: very tall geode; outside is dark gray, inside is hollow; the inside wall is lined with layers of crystals, including light brown, white, and purple ones; the top layer are purple crystals

Compare a few of the purple quartz crystals. Do you see a **repeating 3-D shape**?

Which shape do you think it might be? Circle it:

Answer: hexagonal



cubic hexagonal orthorhombic

STOP 2 Go to the "Igneous Environment" video

Watch the video. What interesting things did you learn about this environment? How do different conditions in this environment form different kinds of minerals? Draw or write about it:

Answers may include:

- *igneous rocks form when magma cools and hardens*
- *molten rock around a volcano cools at different rates*
- *above ground, lava cools over days and forms smaller crystals*
- *below ground, magma cools over millions of years, so crystals can grow larger*

STOP 3 Go to the "Cooling Above and Below" case

A rock's observable traits—such as color, texture, shape, and crystal size—are clues to how it formed.

Extrusive Igneous Rocks (#1–7)

Observe and compare these rocks. What traits do they have in common?

Answers may include: smaller grain size

What do these traits tell you about the conditions under which these rocks formed?

Answers may include:

smaller grain size is a clue that these rocks formed and cooled quickly

Intrusive Igneous Rocks (#11–19)

Observe and compare these rocks. What traits do they have in common?

Answers may include: larger grain size

What do these traits tell you about the conditions under which these rocks formed?

Answers may include:

larger grain size is a clue that these rocks had more time to grow

STOP 4 Putting it all together: Go back to the giant geode

Observe the geode again and read the panels. Under what conditions do you think the geode and its crystals formed? Support your inference with your observations and what you learned in Stops 2 and 3.

Answers may include: the rock and the crystals are bigger so they might have taken longer to form; this shows that they may have formed deeper underground, where they had more time to grow bigger

EXPLORE MORE

1. **In nearby cases,** look for other minerals that formed in igneous environments. Observe their shapes, textures, and other traits. What do these clues tell you about how they form?
2. **Play the "What is a Mineral?" interactive game** to explore the traits that make a mineral a mineral.

Pegmatitic Environments

WORKSHEET B2

Answer Key & Notes to Educator

You will explore rocks, minerals, and crystals that form in pegmatitic environments.

STOP 1 Find and observe large beryl crystals

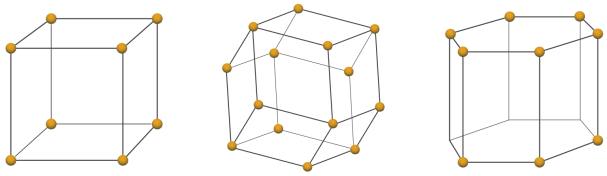
Pick one of the beryl crystals and observe it closely. How would you describe it to someone who has never seen it?

Sample answers: four crystals of different sizes (one is much taller and wider); mostly flat and smooth sides; colors include beige, pale green, light orange; looks very solid and dense

Compare the three smaller beryl crystals.
Do you see a **repeating 3-D shape**?

Which shape do you think it might be? Circle it:

Answer: hexagonal



cubic dodecahedron hexagonal

STOP 2 Go to the "Pegmatitic Environment" video

Watch the video. What interesting things did you learn about this environment? How do different conditions in this environment form different kinds of minerals? Draw or write about it:

Answers may include:

- *Pegmatites grow underground in leftover magma, after granite forms*
- *H_2O is concentrated in leftover magma, impeding crystallization*
- *A few crystals grow large, using up materials in the magma*
- *Different crystals form from the remaining ingredients*

STOP 3 Go to the "Simple Pegmatites" and "Complex Pegmatites" cases

A rock's observable traits—such as color, texture, shape, and crystal size—are clues to how it formed.

Simple Pegmatites

Observe and compare these rocks. What traits do they have in common?

Answers may include: colors are mostly beige, some pale purple, teal, black; large crystal size

What do these traits tell you about the conditions under which these rocks formed?

Answers may include: rare elements were not present during crystal formation

Complex Pegmatites

Observe and compare these rocks. What traits do they have in common?

Answers may include: a wide range of colors, including both pale and vibrant (pink, yellow, green, blue, brown, black); large crystal size

What do these traits tell you about the conditions under which these rocks formed?

Answers may include: rare elements that concentrated in the magma led to the formation of the wide range of colorful minerals, from paler colors to more vibrant colors

STOP 4 Putting it all together: Go back to the large beryl crystals

Observe the beryls again and read the panels. Under what conditions do you think the beryls formed? Support your inference with your observations and what you learned in Stops 2 and 3.

Answers may include: these large crystals grew big using up materials from magma; they rare elements, like beryllium, that concentrated in the magma that led to this pale color

EXPLORE MORE

1. **In nearby cases,** look for other minerals that formed in pegmatitic environments. Observe their shapes, textures, and other traits. What do these clues tell you about how they form?
2. **Play the "What is a Mineral?" interactive game** to explore the traits that make a mineral a mineral.

Metamorphic Environments WORKSHEET B3

Answer Key & Notes to Educator

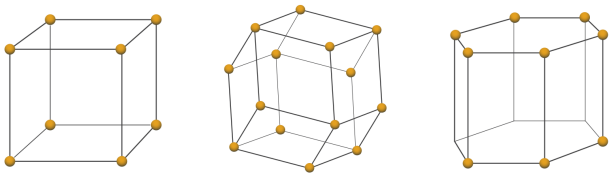
You will explore rocks, minerals, and crystals that form in metamorphic environments.

STOP 1 Find and observe a giant rock slab with garnet crystals

How would you describe this rock slab and its garnets to someone who has never seen them?

Sample answers: very tall; surfaces of wider sides are flat and smooth; mostly lighter gray with darker gray spots; throughout the slab, there are dark red round shapes surrounded by very dark gray circles of various sizes; very solid, with some small cracks

Compare a few of the garnets.
(Tip: Also look at ones in a nearby case titled "Garnets: Beautiful, Durable, Useful")



cubic dodecahedron hexagonal

Do you see a repeating 3-D shape?
Which shape do you think it might be? Circle it: *Answer: dodecahedron*

STOP 2 Watch a video about metamorphic environments and explore nearby specimens

Watch the video. What interesting things did you learn about this environment? How do different conditions in this environment form different kinds of minerals? Draw or write about it:

Answers may include:

- *Mountain chains are thickened sections of Earth's crust, piled up by the collision of tectonic plates*
- *Within mountains, the weight from overlying rock generates heat and pressure, causing the texture and mineralogy of rocks to change (the deeper below ground, the higher the pressure and temperature)*
- *Different minerals form at different depths*

STOP 3 Go to the "Metamorphism Great and Small" case

A rock's observable traits—such as color, texture, shape, and crystal size—are clues to how it formed.

Contact Metamorphism (#1–18)

Observe and compare these rocks. What traits do they have in common?

Answers may include: dense; most have just one or two colors; coarse texture; mineral crystals are mostly grainy or in same direction

What do these traits tell you about the conditions under which these rocks formed?

Answers may include: rocks in the crust are heated and changed by magma intrusion

Regional Metamorphism (#19–34)

Observe and compare these rocks. What traits do they have in common?

Answers may include: dense; most have multiple colors; the mineral crystals within each rock look more chaotic, appearing in different directions

What do these traits tell you about the conditions under which these rocks formed?

Answers may include: rocks were changed by pressure and temperature when they were buried during mountain formation

STOP 4 Putting it all together: Go back to the giant rock slab with garnet crystals

Observe the giant rock slab with garnet crystals again and read the panels. Under what conditions do you think they formed? Support your inference with your observations and what you learned in Stops 2 and 3.

Answers may include: the garnets in the slab are the result of metamorphic reactions at about 1,500°F (800°C) and pressure 8,000 times greater than atmospheric pressure, combined with growth-enhancing fluid from a nearby fault

EXPLORE MORE

1. **In nearby cases,** look for other minerals that formed in metamorphic environments. Observe their shapes, textures, and other traits. What do these clues tell you about how they form?
2. **Play the "What is a Mineral?" interactive game** to explore the traits that make a mineral a mineral.

Hydrothermal Environments WORKSHEET B4

Answer Key & Notes to Educator

You will explore rocks, minerals, crystals that form in hydrothermal environments.

STOP 1 Find and observe the stibnite

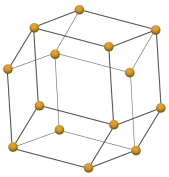
Observe this stibnite and its crystals. How would you describe it to someone who has never seen it?

Sample answers: long, thin crystals jutting out in different directions; shiny, dark gray; smooth, sharp

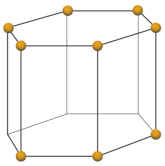
Compare a few of the stibnite crystals.
Do you see a **repeating 3-D shape**?

Which shape do you think it might be? Circle it:

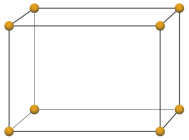
Answer: orthorhombic



dodecahedron



hexagonal



orthorhombic

STOP 2 Go to the "Hydrothermal Environment" video

Watch the video. What interesting things did you learn about this environment? How do different conditions in this environment form different kinds of minerals? Draw or write about it:

Answers may include:

- *Hot water is a medium for the formation of minerals*
- *Water fills tiny cracks and pores in rocks that make up Earth's crust*
- *In many hydrothermal environments, water is heated by magma*
- *As the water heats up, it rises through cracks in the rocks; colder water moves in to replace it, triggering circulation*
- *Water transports dissolved materials into cracks and pockets*
- *As enriched water cools, minerals crystallize*
- *Over time, the chemical composition of the water changes, and different minerals form*

STOP 3 Go to the "Veins and Pockets of Crystals" case

A rock's observable traits—such as color, texture, shape, and crystal size—are clues to how it formed.

Crystals That Grew In Veins (#1–14)

Observe and compare these crystals. What traits do they have in common?

Answers may include: more stripy; crystals are in same directions; overall more solid and less empty space between crystals

What do these traits tell you about the conditions under which these rocks formed?

Answers may include: minerals grew mostly in the same direction, indicating that they grew outward from a flat surface

Crystals That Grew In Pockets (#15–26)

Observe and compare these crystals. What traits do they have in common?

Answers may include: spherical; different minerals in center than surface; crystals pointing towards an empty space in center

What do these traits tell you about the conditions under which these rocks formed?

Answers may include: minerals grew toward the center, indicating that it formed in a cavity with a curved surface

STOP 3 Putting it all together: Go back to the stibnite

Observe the stibnite again and read the panels. Under what conditions do you think the stibnite crystals formed? Support your inference with your observations and what you learned in Stops 2 and 3.

Answers may include: crystals formed as water transported dissolved materials into cracks in the rocks; they likely grew on a flat surface, creating something that looks like a vein

EXPLORE MORE

1. **In nearby cases,** look for other minerals that formed in hydrothermal environments. Observe their shapes, textures, and other traits. What do these clues tell you about how they form?
2. **Play the "What is a Mineral?" interactive game** to explore the traits that make a mineral a mineral.

Weathering Environments

WORKSHEET B5

Answer Key & Notes to Educator

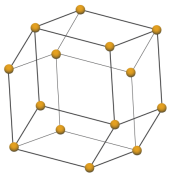
You will explore rocks, minerals, and crystals that form in weathering environments.

STOP 1 Find and observe the Singing Stone

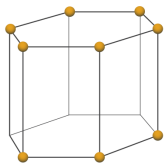
Observe this rock. How would you describe it to someone who has never seen it?

Sample answers: a huge block of rectangular-shaped rock; very rough, uneven surface with lots of wavy lines and holes; colors include blue, light green, and light and dark brown

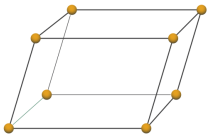
The blue mineral in this rock is called azurite. Find and compare this mineral in a nearby case titled "An Enriching Process" (# 16, 18).



dodecahedron



hexagonal



monoclinic

Do you see a repeating 3-D shape?

Which shape do you think it might be? Circle it: *Answer: monoclinic*

STOP 2 Go to the "Weathering Environment" video

Watch the video. What interesting things did you learn about this environment? How do different conditions in this environment form different kinds of minerals? Draw or write about it:

Answers may include:

- *Rain falls and seeps into the ground*
- *Rainwater is slightly acidic*
- *Leached Zone: As water descends, it strips metals and other elements from soil and rocks, leaving behind a leached zone*
- *Oxidized Zone: The leached water continues to descend; it reacts with sulfides to form an oxidized zone of colorful minerals*
- *Enriched Sulfides Zone: Below the water table, water fills tiny pores in rock; in this zone, the leached water reacts with sulfides to produce enriched sulfides, dense deposits of metal ores*
- *Primary Sulfides Zone: Beyond the reach of the leach water, minerals remain unchanged*

STOP 3 Go back to the "An Enriching Process" case

A rock's observable traits—such as color, texture, shape, and crystal size—are clues to how it formed.

	Observe and compare the minerals. What traits do they have in common?	What do these traits tell you about the conditions under which these rocks formed?
Leached Zone (# 1–10)	*Observations may include: darker colors (black, browns); variety of interesting shapes (bubbly, drips)*	*Answers may include: water containing dissolved gasses oxidizes sulfide minerals at the surface of an exposed ore body, forming sulfuric acid and removing soluble metal ions*
Oxidized Zone (# 11–21)	*Observations may include: lots of different colors (green, blue, white, pink, brown); some are shiny*	*Answers may include: as water enriched in acids, metals, and oxygen descends, it reacts with existing minerals to form colorful oxide, sulfate, and carbonate minerals*
Enriched Sulfide Zone (# 26–36)	*Observations may include: much duller colors (gray, beige, browns); looks rough*	*Answers may include: below the water table, where oxygen levels are low, water enriched with metals from above precipitate enriched sulfide minerals*

STOP 4 Putting it all together: Go back to the Singing Stone

Observe the Singing Stone again and read the panels. Under what conditions do you think this rock formed? Support your inference with your observations and what you learned in Stops 2 and 3.

Answers may include: this rock contains bright green malachite and deep blue azurite; these minerals formed in the oxidized zone, when acidic, copper-rich fluids from the breakdown of copper sulfides flowed through cracks in the original limestone, dissolving the calcium carbonate minerals in the rock and depositing azurite, malachite, and some iron oxides

EXPLORE MORE

1. **In nearby cases,** look for other minerals that formed in weathering environments. Observe their shapes, textures, and other traits. What do these clues tell you about how they form?
2. **Play the "What is a Mineral?" interactive game** to explore the traits that make a mineral a mineral.