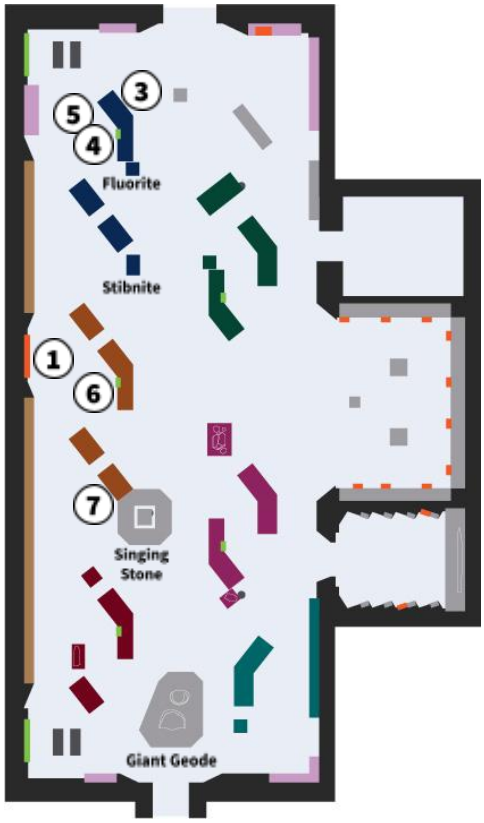
Student Worksheet

Answer Key & Notes to Educator



STOP 1 Find the periodic table interactive

Make minerals by combining atoms of different elements!

STOP 2 Select one of four specimens (labeled on map)

- ▢ **Fluorite**
- ▢ **Stibnite**
- ▢ **Singing Stone**
- ▢ **Giant Geode**

How would you describe it and its crystals to someone who has never seen them?

Answers will vary.

STOP 3 Go to the "How Water Transports Minerals" case

Read the text panel (left). What makes it possible for water to dissolve minerals, transport elements, and deposit minerals? Draw or write about it.

Answers may include:

- *A water molecule is "polar." Its positively charged sides (H^+ ions) and a negatively charged side (O^{2-} ion) make it possible for water to disrupt the chemical bonds in minerals and dissolve them.*
- *Once dissolved, the elements from the minerals can be carried elsewhere by water.*

Observe specimen #35. What does the order of the two mineral layers show about (1) how the minerals formed, (2) their solubility, and (3) water temperature?

Answers may include:

The layers show:

• The purple amethyst quartz (bottom layer; lower solubility) crystallized first, when the water temperature was higher.

• The white calcite (top layer; higher solubility) crystallized second, as the water temperature decreased and the concentrations of the elements that form calcite increased.

Observe specimens #14–22. These nine minerals are organized from most soluble in water at moderate temperature (top) to least (bottom). What is the relationship between solubility, water, and chemical bonds?

Answers may include: Some minerals dissolve in water more readily than others, a property called solubility.

Minerals with high solubility have weaker chemical bonds that are broken more easily by water.

Solubility is also affected by temperature and fluid composition.

STOP 4 Go to the "Hydrothermal Environment" video

Watch the video.

What role does water play in the formation 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 (elements) into cracks and pockets*
- *As enriched water cools, minerals crystallize*
- *Over time, the chemical composition of the water changes, and different minerals form*

STOP 5 Go to the "Veins and Pockets of Crystals" case

	Observe the minerals in each section. What physical traits do they have in common?	What do these traits tell you about the role of water in the formation of these minerals?
Crystals That Grew In Veins (# 1–14)	*Observations may include: more stripy; crystals are aligned in same directions; overall more solid and less empty space between crystals*	*Answers may include: minerals grew mostly in the same direction, indicating that they grew outward from a flat surface as hot water deposited dissolved minerals*
Crystals That Grew In Pockets (# 15–26)	*Observations may include: spherical; different minerals in center than surface; crystals pointing towards an empty space in center*	*Answers may include: minerals grew toward the center, indicating that it formed in a cavity with a curved surface as hot water deposited dissolved minerals*

How might water have interacted with rock to form the specimens in this case?

Check all that apply.

- ▢ Chemical addition (adding elements)
- ▢ Chemical exchange (swapping elements)
- ▢ Deposition (depositing new minerals)
- ▢ Dissolution (removing minerals)
- ▢ Hydration (adding hydrogen and oxygen)

TIP: Learn about these interactions in the case: "**Hot Water Carries, Exchanges, and Deposit Minerals**" (to the right of the Hydrothermal Environments video in Stop 4)

STOP 6 Go to the "Weathering Environment" video

Watch the video.

In each zone, what role does water play in the formation 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; 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 7 Go to the "An Enriching Process" case

	Observe the minerals within each zone. What physical traits do they have in common?	What do these traits tell you about the role of water in the formation of these minerals?
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*

How might water have interacted with rock to form the specimens in this case?

Check all that apply.

- ▢ Chemical addition (adding elements)
- ▢ Chemical exchange (swapping elements)
- ▢ Deposition (depositing new minerals)
- ▢ Dissolution (removing minerals)
- ▢ Hydration (adding hydrogen and oxygen)

TIP: Learn about these interactions in the case: "**Hot Water Carries, Exchanges, and Deposit Minerals**" (to the right of the Hydrothermal Environments video in Stop 4)

STOP 8 Put it all together: Go back to the specimen you selected in Stop 2

Observe the specimen again.

How might water have interacted with rock to form this specimen?

- ▢ Chemical addition (adding elements)
- ▢ Chemical exchange (swapping elements)
- ▢ Deposition (depositing new minerals)
- ▢ Dissolution (removing minerals)
- ▢ Hydration (adding hydrogen and oxygen)

Support your inference with your observations (e.g. physical traits) and what you've learned in previous stops (e.g. water temperature, solubility, polarity, weathering processes).

Answers will vary