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Ores to Minerals

Lesson 4
Mineral Structures

LESSON PLAN

Standards Alignment, Learning Objectives, Materials List,
Step-by-Step Instructions, Teacher key, Vocabulary Bank, Differentiation Suggestions

In this lesson, the teacher will present direct instruction on crystalline structure, mineral properties, and the importance of refined minerals in everyday life. Students will observe the geometry of specific crystals and test their hardness.

Standards

AP® Environmental Science Standard: 5.9 Impacts of Mining - LEARNING OBJECTIVE-EIN-2.K: Describe natural resource extraction through mining.

Next Generation Science Standard: HS-ESS3-1 - Construct an explanation based on evidence for how the availability of natural resources [and/or the] occurrence of natural hazards...have influenced human activity.

Learning Objective

Students will identify the inherent crystalline structures found in minerals and determine their shape.

Materials

1. Student Worksheet
2. Student Slides
3. Glue or tape
4. Scissors
5. Crystal System Cut-Outs and Their Labels sheet
6. Crystal samples, especially quartz (optional)
7. Magnifying glass (optional)

Step-by-Step Instructions

Getting Started:

1. Print the "Crystal System Cut-Outs and Their Labels" sheet on cardstock if possible. Provide students with the Student Worksheet.

Introduction:

2. Present the Student Slides to review the learning objectives. If available, show students examples of crystals you have on hand and ask students to note their varying crystal system shapes. Have students anticipate what the names of these shapes might be. Tell students that they will be able to identify some crystal system shapes after this lesson.
3. Present the slides as you discuss the shared characteristics of minerals and introduce minerals as inherently crystalline in nature. Proceed through the slides to introduce the structure of crystals, unit cells, crystal lattices, and various crystal system shapes. If possible, use a sample of hexagonal pyramidal quartz as an example while presenting the slides.
4. Instruct students to complete the Student Worksheet as you work through the slides.
5. Pass out scissors and glue or tape and instruct students to cut out the crystal system shapes and organize them with their labels.
6. (Optional) Once students have correctly identified the crystal system shapes, you may either end the lesson or you may provide students with a magnifying glass and samples of crystals and ask them to sort the samples by the shape of their crystal systems, and have students sketch them on the student worksheet in the "Example" column of Table 1. Another option is to ask students to find digital images of crystals that exemplify each crystal system and give their names as examples.

Teacher Key

Table 1

Shape	a, b, c	α, β, γ	Figure	Axes & Definitions	Example (Optional)
Cubic	a = b = c	$\alpha = \beta = \gamma = 90°$		All three axes are equal in length and intersect at 90-degree angles.	Halite, pyrite, diamond, galena
Tetragonal	a = b ≠ c	$\alpha = \beta = \gamma = 90°$		All three axes meet at 90-degree angles where two of the axes are equal in length, and the third is longer or shorter.	Zircon
Orthorhombic	a ≠ b ≠ c	$\alpha = \beta = \gamma = 90°$		All three axes meet at 90-degree angles, but all have different lengths.	Topaz, sulfur
Hexagonal	a = b ≠ c	$\alpha = \beta = 90°$ $\gamma = 120°$		Three equal axes are positioned at 120 degrees to each other in one plane, and a fourth axis is at a 90-degree angle to that plane.	Calcite, quartz, apatite
Rhombohedral	a = b = c	$\alpha = \beta = \gamma \neq 90°$		All axes are equal in length and all angles are equal, but no angles are equal to 90 degrees.	Calcite, dolomite, tourmaline
Monoclinic	a ≠ b ≠ c	$\alpha = \gamma = 90°$ $\beta \neq 90°$		Three axes are of unequal lengths where two of them intersect at a 90-degree angle and the third axis forms an angle with the plane of the other two that is not 90 degrees.	Gypsum, feldspar (most), azurite
Triclinic	a ≠ b ≠ c	$\alpha \neq \beta \neq \gamma \neq 90°$		Three axes of unequal lengths intersect at angles that are not 90 degrees.	Rhodonite, feldspar (few), turquoise

Conclusion Questions

How are minerals useful for people? Minerals are used in renewable energy sources such as solar panels and wind turbines as well as the batteries used to store that energy. Also, medical implants, cell phones, satellites, and fireworks use minerals. There are other uses in manufacturing, such as making ceramics, plastics, and paper. Also, minerals are necessary for the human body to function and to make vehicles for transportation.
Are all crystals minerals? Why or why not? Not all crystals are minerals because some organic (once-living) things can have a crystalline structure and be considered crystals.
Are all minerals crystals? Why or why not? All minerals are crystals because generally minerals have a regular, repeating pattern of unit cells that form a crystal lattice with an identifiable crystal system.
What is the difference between a unit cell, a crystal lattice, and a crystal system? A unit cell is the smallest part, consisting of the atoms that make a repeating pattern. A crystal lattice shows the 3D pattern of how the unit cells are connected. A crystal system refers to a classification of crystals based on their symmetry.
Which crystal systems involve all 90-degree angles? Cubic, tetragonal, and orthorhombic
Which crystal systems involve axes or lengths that are all equal? Cubic and rhombohedral
Which crystal systems involve axes that are all unequal lengths? Orthorhombic and triclinic

Vocabulary Bank

- **Chemical formula** - A shorthand way to describe the composition of a substance by listing its elements and their quantities
- **Crystal lattice** - The 3D representation of repeating unit cells
- **Crystal system** - A classification scheme used to categorize crystals based on their symmetry
- **Crystalline structure** - A structure of atoms that are held together in an orderly three-dimensional arrangement
- **Crystallography** - The branch of science that studies the arrangement and bonding of atoms in crystalline solids and their geometric structures
- **Cubic** - A crystal structure with all three axes equal in length and intersecting at 90° angles
- **Hexagonal** - A crystal structure with four axes, where three equal axes are positioned at 120o to each other in one plane, and a fourth axis is at a 90o angle to that plane
- **Inorganic** - Substances that are non-living or derived from non-living things
- **Monoclinic** - A crystal structure with three axes of unequal lengths where two of them intersect at a 90° angle while the third axis forms an angle with the plane of the other two that is not 90°
- **Organic** - Substances that are living or derived from living things
- **Orthorhombic** - A crystal structure with three axes that meet at 90° angles but all have different lengths
- Rhombohedral - A crystal structure where all axes are equal in length and all angles are equal but no angles are equal to 90°
- **Tetragonal** - A crystal structure with three axes that meet at 90° angles where two of the axes are equal in length, and the third is longer or shorter
- Triclinic - A crystal structure with three axes of unequal lengths that intersect at angles that are not 90o
- Unit cell - The simplest repeating unit of atoms in a crystal

Differentiation Suggestions

- Adjust Amount: Reduce the amount of vocabulary terms.
- Use a Cooperative Learning Strategy: Add a Think-Pair-Share or similar activity when introducing the sample crystals and asking students to guess their shapes.
- Scaffold Support:
  - Provide or allow aids, like additional text or images.
  - Provide sentence frames such as, "I believe this crystal system shape is..."
- Reduce Cognitive Load: Limit the amount of text you include in each slide.
- Ongoing Check-Ins: Regularly check in with groups to provide feedback and support, ensuring all students participate and understand the task.
- Use translation technology or a bilingual dictionary.
- Read the text aloud.