

# Physical Geology

## Minerals

### 1 Atoms and elements PG.M.1

Complexity a

a Identify parts of an atom (e.g., protons, neutrons, electrons). PG.M.1.A

Complexity b

b Identify a diagram or model of an atom. PG.M.1.B

Complexity c

c Identify that all matter is made of atoms. PG.M.1.C

Learning Progression

- Build or recognize a model of an atom including protons, neutrons or electrons. PG.M.1.LP.A
- Identify that protons have a positive charge, neutrons are neutral, and electrons have a negative charge. PG.M.1.LP.B
- Recognize that valence electrons are in the outside layer of an atom. PG.M.1.LP.C
- Identify the valence electrons on a drawing or model on an atom. PG.M.1.LP.D
- Place labels (protons, neutrons, electrons) on a drawing of an atom. PG.M.1.LP.E
- Select the diagram that shows an atom from a set of drawings. PG.M.1.LP.F
- Engage with models or various visual representations of an atom. PG.M.1.LP.G

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## 2 Chemical bonding (ionic, covalent, metallic) PG.M.2

Complexity a

- a Represent a chemical compound with a ball-and-stick model or chemical formula. PG.M.2.A

Complexity b

- b Recognize that a model (ball-and-stick or molecular geometries) or chemical formula represents a chemical compound. PG.M.2.B

Complexity c

- c Identify that two elements combine to form a compound. PG.M.2.C

Learning Progression

- Use an atomic model and/or video to investigate that atoms interact to achieve 8 valence electrons (view the product). PG.M.2.LP.A
- Recognize that different atoms react in different ways (ionic and covalent bonding). PG.M.2.LP.B
- Recognize an ion as an atom that has gained or lost valence electrons (which changes their electrical charge). PG.M.2.LP.C
- Recognize that ionic bonding is an attraction between oppositely charged ions. PG.M.2.LP.D
- Recognize that in covalent bonding atoms share valence electrons so that each have 8. PG.M.2.LP.E
- Identify common minerals that are bonded ionically and covalently. PG.M.2.LP.F
- Recognize that an atom's reactivity is based on its valence electrons. PG.M.2.LP.G
- Identify the valence electrons on a drawing or model on an atom. PG.M.2.LP.H
- Recognize that valence electrons are in the outside layer of an atom. PG.M.2.LP.I
- Engage with a model of an atom to locate the valence (outermost) electrons. PG.M.2.LP.J

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## 3 Crystallinity (crystal structure) PG.M.3

Learning Progression

Complex and advanced learning standards in Ohio's New Learning Standards are not included in the extended standards.

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#### **4 Criteria of a mineral (crystalline solid, occurs in nature, inorganic, defined chemical composition) PG.M.4**

Complexity a

- a Match minerals with rock types in which they are commonly found. PG.M.4.A

Complexity b

- b Identify a common mineral in a common rock. PG.M.4.B

Complexity c

- c Recognize that minerals can be found in rocks. PG.M.4.C

Learning Progression

- Use a crystal growing kit to illustrate how crystals form. PG.M.4.LP.A
- Examine a variety of rocks and note the size of the crystals in the structure. PG.M.4.LP.B
- Watch videos that show how minerals are formed in a variety of rocks. PG.M.4.LP.C

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#### **5 Properties of minerals (hardness, luster, cleavage, streak, crystal shape, fluorescence, flammability, density/specific gravity, malleability) PG.M.5**

Complexity a

- a Sort minerals by cleavage, streak, hardness and fracture. PG.M.5.A

Complexity b

- b Identify hardness and fracture as two characteristics to identify a mineral. PG.M.5.B

Complexity c

- c Match minerals by properties (e.g., cleavage, streak, magnetism). PG.M.5.C

Learning Progression

- Investigate a sample rock and determine its identity by testing its properties. PG.M.5.LP.A
  - Match a sample rock to its origin given a set of characteristics (e.g., using pictures, maps, illustrations, etc.). PG.M.5.LP.B
  - Manipulate rocks to identify textural characteristics of each. PG.M.5.LP.C
  - Engage with rocks by feeling the surface of each. PG.M.5.LP.D
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## Igneous, Metamorphic and Sedimentary Rocks

### **1 Igneous • Mafic and felsic rocks and minerals • Intrusive (igneous structures: dikes, sills, batholiths, pegmatites) • Earth's interior (inner core, outer core, lower mantle, upper mantle, Mohorovičić [Moho] discontinuity, crust) • Magnetic reversals and Earth's magnetic field • Thermal energy within Earth • Extrusive (volcanic activity, volcanoes: cinder cones, composite, shield) • Bowen's Reaction Series (continuous and discontinuous branches) [PG.IMS.1](#)**

Complexity a

- a** Compare how different environments change the type of igneous rock that is formed. [PG.IMS.1.A](#)

Complexity b

- b** Describe the properties of igneous rocks. [PG.IMS.1.B](#)

Complexity c

- c** Identify environments in which igneous rocks are formed. [PG.IMS.1.C](#)

Learning Progression

- Look at samples of igneous rock (e.g., granite, basalt), identify differences and recognize that they were formed in different environments. [PG.IMS.1.LP.A](#)
- Identify that granite makes up much of continental crust and basalt makes up much of our ocean floors. [PG.IMS.1.LP.B](#)
- View images or videos of volcanoes at various locations (e.g., edges of continents, mid-ocean spreading centers, hotspots). [PG.IMS.1.LP.C](#)
- Recognize that the cooled lava from volcanoes forms igneous rock (e.g., Hawaii). [PG.IMS.1.LP.D](#)
- View videos of volcanoes erupting. [PG.IMS.1.LP.E](#)

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**2 Metamorphic • Pressure, stress, temperature, and compressional forces • Foliated (regional), nonfoliated (contact) • Parent rock and degrees of metamorphism • Metamorphic zones (where metamorphic rocks are found) PG. IMS. 2**

Complexity a

- a Compare how different environments change the type of metamorphic rock that is formed. PG. IMS. 2. A

Complexity b

- b Describe the properties of metamorphic rocks. PG. IMS. 2. B

Complexity c

- c Identify environments in which metamorphic rocks are formed. PG. IMS. 2. C

Learning Progression

- Look at samples of metamorphic rocks and the rocks they formed from (e.g., slate from shale, marble from limestone), note the differences and similarities PG. IMS. 2. LP. A
- Recognize that heat and pressure cause things to change. (e.g., examine a slice of white bread (crust removed), describe its properties, roll and squish it into a small ball, describe how its properties have changed, relate this to metamorphic rocks changing from other existing rocks (heat and pressure from your hand). PG. IMS. 2. LP. B

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**3 Sedimentary • Division of sedimentary rocks and minerals (chemical, clastic/physical, organic) • Depositional environments PG. IMS. 3**

Complexity a

- a Compare how different environments change the type of sedimentary rock that is formed. PG. IMS. 3. A

Complexity b

- b Describe the properties of sedimentary rocks. PG. IMS. 3. B

Complexity c

- c Identify environments in which sedimentary rocks are formed. PG. IMS. 3. C

Learning Progression

- Predict what would happen if lots of pressure squeezed the sediments (they would cement together). PG. IMS. 3. LP. A
- Describe locations where sedimentary rocks can form (e.g., deserts, oceans). PG. IMS. 3. LP. B
- Build a model of the formation of sedimentary rock (e.g., shake sand and dirt in a jar of water, let it sit and describe what happens (settles to the bottom), relate this to sediments falling to the bottom of an ocean). PG. IMS. 3. LP. C

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**4 Ocean • Tides (daily, neap, and spring) • Currents (deep and shallow, rip and longshore) • Thermal energy and water density • Waves • Ocean features (ridges, trenches, island systems, abyssal zone, shelves, slopes, reefs, island arcs) • Passive and active continental margins • Transgressing and regressing sea levels • Streams (channels, streambeds, floodplains, cross-bedding, alluvial fans, deltas) PG. IMS. 4**

Complexity a

- a** Use data to see how the sea level changes with the tides in a given location. PG. IMS. 4. A

Complexity b

- b** Describe how the tides are controlled by the moon. PG. IMS. 4. B

Complexity c

- c** Identify a reason for a change in sea level. (e.g., tides, currents, waves, etc.). PG. IMS. 4. C

Learning Progression

- Given a tide table, identify the pattern (amount of time) that occurs between high and low tide and high tide to next high tide. PG. IMS. 4. LP. A
  - Watch videos on ocean currents (e.g., NASA, NOAA, Bill Nye) to look at patterns; understand that ocean currents move materials around the ocean and affect the climate on Earth. PG. IMS. 4. LP. B
  - View time lapse videos of tides in the ocean, recognize that the water level changes due to the tides. PG. IMS. 4. LP. C
  - Recognize that tides are controlled by the gravitational attraction between the moon and Earth. PG. IMS. 4. LP. D
  - Engage by watching convection in a tub of water to observe how temperature differences make water move in currents (heat a tub of water under one side only, sprinkle in pepper and watch the circulation pattern). PG. IMS. 4. LP. E
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## Earth's History

### **1 The geologic rock record • Relative and absolute age • Principles to determine relative age • Original horizontality • Superposition • Cross-cutting relationships • Absolute age • Radiometric dating (isotopes, radioactive decay) • Correct uses of radiometric dating • Combining relative and absolute age data • The geologic time scale • Comprehending geologic time • Climate changes evident through the rock record • Fossil record** [PG.EH.1](#)

#### Complexity a

- a** Describe how technology assists in determining the age of rocks (e.g., radiometric dating). [PG.EH.1.A](#)

#### Complexity b

- b** Identify that in a cross-section of rock, the layer on top is the youngest layer and the layer on the bottom is the oldest (assuming no geological process has shifted the layers). [PG.EH.1.B](#)

#### Complexity c

- c** Identify changes across layers (crosssection) of rocks. [PG.EH.1.C](#)

#### Learning Progression

- Explain that radiometric dating traces radioactive materials in the rock to determine age. [PG.EH.1.LP.A](#)
  - Recognize that there are a variety of methods to determine the age of rock. [PG.EH.1.LP.B](#)
  - Given a cross section of rock determine the relative age in an undisturbed section. [PG.EH.1.LP.C](#)
  - Model the formation of rock layers and relate the age of the layers to the Law of Superposition. [PG.EH.1.LP.D](#)
  - Identify the layers that can be seen within a cross section (e.g., highway cut, Grand Canyon). [PG.EH.1.LP.E](#)
  - Engage with a model of a cross section of a highway cut or rock layers. [PG.EH.1.LP.F](#)
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## Plate Tectonics

### 1 Internal Earth • Seismic waves • S and P waves • Velocities, reflection, refraction of waves [PG.PT.1](#)

Complexity a

- a Analyze which earthquake was larger based on a seismographic report or readout. [PG.PT.1.A](#)

Complexity b

- b Describe how a Richter scale is used as a tool to measure the seismic waves of an earthquake. [PG.PT.1.B](#)

Complexity c

- c Recognize that a Richter scale is a tool used to measure intensity of earthquakes. [PG.PT.1.C](#)

Learning Progression

- Recognize that the “wiggles” on the seismograph represents energy waves traveling through Earth. [PG.PT.1.LP.A](#)
- Given two seismograms choose the one that represents a stronger earthquake. [PG.PT.1.LP.B](#)
- Compare seismograms, recognize that large “wiggles” mean more shaking of the ground. [PG.PT.1.LP.C](#)
- Recognize that the Richter scale uses numbers to describe the strength of earthquakes (larger numbers are 10 times stronger than the number before). [PG.PT.1.LP.D](#)
- Recognize that earthquakes have different strengths. [PG.PT.1.LP.E](#)
- Watch video footage of small and large earthquakes. [PG.PT.1.LP.F](#)

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### 2 Structure of Earth (Note: specific layers were part of grade 8) • Asthenosphere • Lithosphere • Mohorovičić (Moho) boundary • Composition of each of the layers of Earth • Gravity, magnetism and isostasy • Thermal energy (geothermal gradient and heat flow) [PG.PT.2](#)

Learning Progression

Complex and advanced learning standards in Ohio’s New Learning Standards are not included in the extended standards.

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### 3 Historical review (Note: this would include a review of continental drift and sea-floor spreading found in grade 8) • Paleomagnetism and magnetic anomalies • Paleoclimatology [PG.PT.3](#)

Learning Progression

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**4 Plate motion (Note: introduced in grade 8) • Causes and evidence of plate motion • Measuring plate motion • Characteristics of oceanic and continental plates • Relationship of plate movement and geologic events and features • Mantle plumes** [PG.PT.4](#)

Complexity a

- a** Describe how the continents used to be connected in one super continent of Pangaea and have moved due to tectonic forces. [PG.PT.4.A](#)

Complexity b

- b** Recognize that the shape of the continents is evidence of plate motion (e.g., they fit together like puzzle pieces). [PG.PT.4.B](#)

Complexity c

- c** Identify the crust as the location of the continental plates. [PG.PT.4.C](#)

Learning Progression

- Recognize that plate motion has caused the continents to shift. Use video footage of Hawaii to illustrate this type of activity. [PG.PT.4.LP.A](#)
  - Use cut outs of the modern continents, try to fit them together like a puzzle, understand that the fact they fit is evidence they were once joined. [PG.PT.4.LP.B](#)
  - Review maps of Earth's continents over the past 300,000 years to identify changes. [PG.PT.4.LP.C](#)
  - Recognize that the surface of Earth has changed. [PG.PT.4.LP.D](#)
  - Identify the name of the previous supercontinent as Pangaea. [PG.PT.4.LP.E](#)
  - Watch a video of a flower blooming or a glacier moving in real time and in fast motion, recognize that sometimes movement is too slow to see. [PG.PT.4.LP.F](#)
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## Earth's Resources

### **1 Energy resources • Renewable and nonrenewable energy sources and efficiency • Alternate energy sources and efficiency • Resource availability • Mining and resource extraction** [PG.ER.1](#)

Complexity a

- a** Identify factors to consider before mining for mineral resources (e.g., cost, pollution, effects on wildlife). [PG.ER.1.A](#)

Complexity b

- b** Identify the effect that mining for a mineral resource has on an area. [PG.ER.1.B](#)

Complexity c

- c** Recognize that minerals are a resource. [PG.ER.1.C](#)

Learning Progression

- Provide pictures of mining sites and describe the changes to the environment. Describe how those changes impact wildlife. [PG.ER.1.LP.A](#)
- Understand that renewable means more can be made in a short period of time. [PG.ER.1.LP.B](#)
- Understand that nonrenewable means that once it is used there is no way to get more in a reasonable time frame. [PG.ER.1.LP.C](#)
- Recognize that minerals are a nonrenewable resource. [PG.ER.1.LP.D](#)
- Recognize that minerals are extracted through mining. [PG.ER.1.LP.E](#)
- Recognize that minerals are used in our everyday materials. [PG.ER.1.LP.F](#)
- Observe and manipulate various minerals. [PG.ER.1.LP.G](#)

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## 2 Air • Primary and secondary contaminants • Greenhouse gases PG.ER.2

Complexity a

- a Describe how greenhouse gas effects the atmosphere. PG.ER.2.A

Complexity b

- b Identify a cause and effect of specific air pollution problem (e.g., smoke from a factory causes haze in the air). PG.ER.2.B

Complexity c

- c Identify an air contaminant. PG.ER.2.C

Learning Progression

- Identify greenhouse gases (e.g., carbon dioxide, water vapor) and how they can impact the atmosphere and environment. PG.ER.2.LP.A
- Use Google Earth to view a local area to determine what exists in an area and what products are produced and how that impacts an area (e.g., farms, housing developments, industries, nature reserves). PG.ER.2.LP.B
- Identify an effect of a primary and secondary contaminant. PG.ER.2.LP.C
- Identify sources of air pollution. PG.ER.2.LP.D
- Recognize when there is a change in the air (hot, cold, odor, scent, humid). PG.ER.2.LP.E
- Engage with the air by taking a deep breath and exhaling. PG.ER.2.LP.F

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### 3 Water • Potable water and water quality • Hypoxia, eutrophication PG.ER.3

Complexity a

a Describe why it is important to have clean drinking water. PG.ER.3.A

Complexity b

b Identify a water contaminant. PG.ER.3.B

Complexity c

c Identify a drinking water source. PG.ER.3.C

Learning Progression

- Sort water sources as potable and nonpotable. PG.ER.3.LP.A
- Describe characteristics of potable and nonpotable water or factors that make it potable/non potable. PG.ER.3.LP.B
- In your region, identify where your water originates. PG.ER.3.LP.C
- Recognize that the water used for drinking has to be processed to be used. PG.ER.3.LP.D
- Recognize that some water is potable and some is not. PG.ER.3.LP.E
- Identify various sources of water. PG.ER.3.LP.F
- Actively participate in a discussion about water that is good for drinking versus water that would not be. PG.ER.3.LP.G

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### 4 Soil and sediment • Desertification • Mass wasting and erosion • Sediment contamination PG.ER.4

Complexity a

a Describe how erosion can change an environment. PG.ER.4.A

Complexity b

b Identify a reason for erosion. PG.ER.4.B

Complexity c

c Define erosion as the movement of Earth's materials. PG.ER.4.C

Learning Progression

- Identify the agents of erosion. PG.ER.4.LP.A
  - Recognize a landform or area that resulted from erosion. PG.ER.4.LP.B
  - Examine before and after images of erosion. PG.ER.4.LP.C
  - Observe erosion (video) in action. PG.ER.4.LP.D
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## Glacial Geology

- 1 Glaciers and glaciation • Evidence of past glaciers (including features formed through erosion or deposition) • Glacial deposition and erosion (including features formed through erosion or deposition) • Data from ice cores • Historical changes (glacial ages, amounts, locations, particulate matter, correlation to fossil evidence) • Evidence of climate changes throughout Earth's history • Glacial distribution and causes of glaciation • Types of glaciers: continental (ice sheets, ice caps), alpine/valley (piedmont, valley, cirque, ice caps) • Glacial structure, formation, and movement** [PG.GG.1](#)

Complexity a

- a** Describe land features that were formed through either erosion or deposition from glaciers. [PG.GG.1.A](#)

Complexity b

- b** Identify land features in Ohio that were formed by glaciers. [PG.GG.1.B](#)

Complexity c

- c** Identify that glaciers consist mainly of ice. [PG.GG.1.C](#)

Learning Progression

- Use a map to trace the movement of glaciers globally for the last 20 years. [PG.GG.1.LP.A](#)
- Identify features on a map that are a direct result of glaciation (e.g., the Great Lakes, glacial grooves on Kelleys Island). [PG.GG.1.LP.B](#)
- Use pictures to identify the different kinds of glaciers (e.g., valley, piedmont, glaciers, cirque, tidewater). [PG.GG.1.LP.C](#)
- Look at a series of pictures from around Ohio, sort them into glaciated and unglaciated areas. [PG.GG.1.LP.D](#)
- Actively engage in an activity that demonstrates movement and effects of a glacier. Push a large ice cube across a container of sand, dirt and pebbles, to recognize that ice blocks (glaciers) can move materials. Push down to make the ice cube dig a hole in the sand, relate this to the formation of the Great Lakes. [PG.GG.1.LP.E](#)