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# Physical Geology

## SYLLABUS AND MODEL CURRICULUM

### COURSE DESCRIPTION

Physical geology is a high school level course, which satisfies **Ohio Core** science graduation requirements of **Ohio Revised Code Section 3313.603**. This section of Ohio law requires a three-unit course with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

Physical geology incorporates chemistry, physics and environmental science and introduces students to key concepts, principles and theories within geology. Investigations are used to understand and explain the behavior of nature in a variety of inquiry and design scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications.

### SCIENCE INQUIRY AND APPLICATION

During the years of grades 9 through 12, all students must use the following scientific processes with appropriate **laboratory safety techniques** to construct their knowledge and understanding in all science content areas:

- Identify questions and concepts that guide scientific investigations;
- Design and conduct **scientific investigations**;
- Use technology and mathematics to improve investigations and communications;
- Formulate and revise explanations and models using logic and evidence (critical thinking);
- Recognize and analyze explanations and models; and Communicate and support a scientific argument.

## COURSE CONTENT

The following information may be taught in any order; there is no ODE-recommended sequence.

### MINERALS

- Atoms and elements
- Chemical bonding (ionic, covalent, metallic)
- Crystallinity (crystal structure)
- Criteria of a mineral (crystalline solid, occurs in nature, inorganic, defined chemical composition)
- Properties of minerals (hardness, luster, cleavage, streak, crystal shape. fluorescence, flammability, density/specific gravity, malleability)

### IGNEOUS, METAMORPHIC AND SEDIMENTARY ROCKS

- 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, Mohorovicic discontinuity, crust)
  - Magnetic reversals and Earth's magnetic field
  - Thermal energy within the Earth
  - Extrusive (volcanic activity, volcanoes: cinder cones, composite, shield)
  - Bowen's Reaction Series (continuous and discontinuous branches)
- Metamorphic
  - Pressure, stress, temperature and compressional forces
  - Foliated (regional), non-foliated (contact)
  - Parent rock and degrees of metamorphism
  - Metamorphic zones (where metamorphic rocks are found)
- Sedimentary
  - The 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
  - Division of sedimentary rocks and minerals (chemical, clastic/physical, organic)
  - Depositional environments
  - Streams (channels, streambeds, floodplains, cross-bedding, alluvial fans, deltas)
  - Transgressing and regressing sea levels

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## EARTH'S HISTORY

- 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

## PLATE TECTONICS

- Internal Earth
  - Seismic waves
    - S and P waves
    - Velocities, reflection, refraction of waves
  - Structure of Earth **(Note: specific layers were part of grade 8)**
    - Asthenosphere
    - Lithosphere
    - Mohorovicic boundary (Moho)
    - Composition of each of the layers of Earth
    - Gravity, magnetism and isostasy
    - Thermal energy (geothermal gradient and heat flow)
- Historical review **(Note: this would include a review of continental drift and sea-floor spreading found in grade 8)**
  - Paleomagnetism and magnetic anomalies
  - Paleoclimatology
- 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

## EARTH'S RESOURCES

- Energy resources
  - Renewable and nonrenewable energy sources and efficiency
  - Alternate energy sources and efficiency o Resource availability
  - Mining and resource extraction
- Air
  - Primary and secondary contaminants o Greenhouse gases
- Water
  - Potable water and water quality
  - Hypoxia, eutrophication
- Soil and sediment
  - Desertification
  - Mass wasting and erosion
  - Sediment contamination

## GLACIAL GEOLOGY

- 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

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## CONTENT ELABORATION: MINERALS

This unit builds upon the middle school Earth and Space Science strand (beginning in grade 6), where common minerals are tested, minerals are defined and minerals are classified. In addition, the chemistry sections of the physical science syllabus support both mineral properties and crystalline structures (chemical compositions and bonding).

The emphasis at the high school level is to relate the chemical and physical components of minerals to the properties of the minerals. This requires extensive mineral testing, investigations, experimentation, observation, use of technology and models/modeling. The focus must be learning the ways to research, test and evaluate minerals, not in memorization of mineral names or types.

Properties such as cleavage and hardness must be connected to the chemical structure and bonding of the mineral. In addition, the environment in which minerals form should be part of the classification of the mineral, using mineral data to help interpret the environmental conditions that existed during the formation of the mineral.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning and to develop summative assessment of student learning of science.

### VISIONS INTO PRACTICE

This section provides examples of tasks that students may perform; this includes guidance for developing classroom performance tasks. It is not an all-inclusive checklist of what should be done, but is a springboard for generating innovative ideas.

- Use crystal or atomic models to illustrate the crystal structure of common minerals. Relate the structure of the model to a specific quantifiable property (e.g., cleavage or hardness). Demonstrate and explain results to the class.
- Demonstrate (through specific testing, data collection, analysis and research) the relationship between mineral use, chemical formula, chemical bonds and the properties of the mineral. Document findings in writing.
- Research a specific mineral. Research questions should include: *Where can the mineral be found (globally)? What environmental conditions must exist? How long does it take to form crystals? How is the mineral extracted? What is the mineral used for? What hazards, precautions, safety issues pertaining to the mineral or the extraction of the mineral exist? What is the economic value of the mineral? Are there any laws that may pertain to the mineral or the extraction of the mineral?* Document the data in a scientific research paper or a poster session.
- Design and conduct an experiment to test specific properties of a mineral that has a unique use (e.g., a quartz battery or gypsum wallboard). Document process and findings in a scientific lab report.

### INSTRUCTIONAL STRATEGIES AND RESOURCES

This section provides additional support and information for educators. These are strategies for actively engaging students with the topic and for providing hands-on, minds-on observation and exploration of the topic, including authentic data resources for scientific inquiry, experimentation and problem-based tasks that incorporate technology and technological and engineering design. Resources selected are printed or Web-based materials that directly relate to the particular Content Statement. It is not intended to be a prescriptive list of lessons.

- Geology.com provides information on current events in all topic areas of geology, including resources and uses of resources, including minerals, at **http://geology.com/**.
- The U.S. Geological Survey provides mineral resources and information that can support the teaching of minerals at the high school and college level at **http://minerals.usgs.gov/minerals/**.
- The Mineralogical Society of America offers training, workshops, data and resources to support learning about minerals and geology. Find out more at **http://www.minsocam.org/**.
- The Digital Library for Earth Systems Education offers resources from a number of sources, such as *National Geographic*, government agencies and other scientific agencies. Grade 9-12 resources are provided at **http://www.dlese.org/library/query.do?q=&s=0&gr=02**.
- The College Board provides a document with Earth science recommendations for grades 6-12 (beginning on page 21). Essential questions and scientific applications are included in this document to encourage investigation and scientific inquiry. In addition, connections to other topics and subjects are suggested to add relevancy and interest for the student. Find it at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**.

### COMMON MISCONCEPTIONS

- Carleton College lists a number of geologic misconceptions for high school and college-age students at **http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html**.
- NASA provides common misconceptions for all ages about the Earth and geology at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.
- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.

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## DIVERSE LEARNERS

Strategies for meeting the needs of all learners including **gifted students, English Language Learners** (ELL) and students with **disabilities** can be found at the **Ohio Department of Education site**. Resources based on the Universal Design for Learning principles are available at **www.cast.org**.

## CLASSROOM PORTALS

Annenberg offers ideas about teaching high school level environmental science using an integrated Earth systems approach at **http://www.learner.org/resources/series209.html**.

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## CONTENT ELABORATION: IGNEOUS, METAMORPHIC AND SEDIMENTARY ROCKS

This unit builds upon the middle school Earth and Space Science strand (beginning in grade 6). Sedimentary, igneous and metamorphic rocks are introduced, rocks and minerals are tested and classified, plate tectonics, seismic waves and the structure of Earth are studied, and the geologic record is found (including the evidence of climatic variances through Earth's history). In the middle school Life Science strand, fossils and depositional environments are included as they relate to the documented history of life in the geologic record. In the physical science syllabus, support for waves, thermal energy, currents, pressure and gravity are presented.

At the high school level, geologic, topographic, seismic and aerial maps must be used to locate and recognize igneous, metamorphic and sedimentary structures and features. Technological advances permit the investigation of intrusive structures and the interior of Earth. Connections between the minerals present within each type of rock and the environment formed are important. The processes and environmental conditions that lead to fossil fuel formation (**Note: this links to the energy resources section below**) must include the fossil fuels found in Ohio, nationally and globally.

Bowen's Reaction Series must be used to develop an understanding of the relationship of cooling temperature, formation of specific igneous minerals and the resulting igneous environment. The focus is on knowing how to use Bowen's Reaction Series, not to memorize it. Virtual demonstrations and simulations of cooling magma and crystallization of the igneous minerals found on the series can be helpful in conceptualizing the chart.

The magnetic properties of Earth must be examined through the study of real data and evidence. The relationship of polar changes, magnetic stripping, grid north, true north and the north pole must be included in the study of Earth's magnetic properties.

While the ocean is included within the sedimentary topic, it can be incorporated into other topics. Features found in the ocean must include all types of environments (igneous, metamorphic or sedimentary). Using models (3-D or virtual) with real-time data to simulate waves, tides, currents, feature formation and changing sea levels to explore and investigate the ocean fully is recommended. Interpreting sections of the geologic record to determine sea level changes and depositional environments, including relative age is also recommended.

Technological advances must be used to illustrate the physical features of the Earth, including the ocean floor. Interpreting geologic history using maps of local cross-sections of bedrock can be related to the geologic history of Ohio, the United States and the Earth.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning and to develop summative assessment of student learning of science.

### VISIONS INTO PRACTICE

This section provides examples of tasks that students may perform; this includes guidance for developing classroom performance tasks. It is not an all-inclusive checklist of what should be done, but is a springboard for generating innovative ideas.

- Use a geologic cross-section (or conduct a field investigation) for a specific location to analyze/interpret geologic history (rock type, formation, fossils or minerals present) and environmental conditions (including volcanic activity and/or transgressing and regressing sea levels). Share findings (can be a model, presentation or graphic) with the class.
- Identify specific geologic features using LANDSAT or other remote sensing data. Identify the factors required to create the specific features. Document findings graphically and in writing in a scientific journal, portfolio or e-portfolio.
- Create a map, model or lab investigation to illustrate a specific ocean current using real-time data. Relate the oceanic current to the Coriolis effect, density changes and physical features that exist. Present or demonstrate the product to the class. Defend and explain process and result.
- Design an investigation or experiment to demonstrate the magnetic reversals and the resulting magnetic striping that occurs at oceanic ridges. Document the process and result in writing, discuss or present to the class.
- Create a topographic, soil or geologic map of the school or community using actual data collected from the field (can use GPS/GIS readings, field studies/investigation, aerial maps or other available data to generate the map). Present final map in a poster session, with data used in the development of the map and the analysis of the data.
- Design and conduct a field study in a local area to locate fossil evidence that can help interpret the geologic history of the area (when combined with other rock evidence). Document the fieldwork and steps of the investigation in a scientific journal. Share the analysis of the data and the interpretation of the geologic history with the class through a presentation, portfolio, e- portfolio or poster session.

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## INSTRUCTIONAL STRATEGIES AND RESOURCES

This section provides additional support and information for educators. These are strategies for actively engaging students with the topic and for providing hands-on, minds-on observation and exploration of the topic, including authentic data resources for scientific inquiry, experimentation and problem-based tasks that incorporate technology and technological and engineering design. Resources selected are printed or Web-based materials that directly relate to the particular Content Statement. It is not intended to be a prescriptive list of lessons.

- The Digital Library for Earth Systems Education offers resources from a number of sources, such as *National Geographic*, government agencies and other scientific agencies. Grade 9-12 resources are provided at **http://www.dlese.org/library/query.do?q=&s=0&gr=02**.
- The Ohio Department of Natural Resources' Project Wet offers training and resources for K-12 teachers that promote deep understanding about all aspects of water and the interconnectedness of all of Earth's spheres (Earth Systems). Training and workshop opportunities can be found at **http://www.dnr.state.oh.us/tabid/3501/Default.aspx**.
- The College Board provides a document with Earth Science recommendations for grades 6-12 (beginning on page 21). Essential questions and scientific applications are included in this document to encourage investigation and scientific inquiry. In addition, connections to other topics and subjects are suggested to add relevancy and interest for the student. Find it at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**.

## COMMON MISCONCEPTIONS

- Carleton College lists a number of geologic misconceptions for high school and college-age students at **http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html**.
- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.
- NASA provides common misconceptions for all ages about the Earth and geology at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.

## DIVERSE LEARNERS

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## CLASSROOM PORTALS

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## CONTENT ELABORATION: EARTH'S HISTORY

This unit builds upon the middle school Earth and Space Science strand (beginning in grade 6), sedimentary, igneous and metamorphic rocks are introduced, rocks and minerals are tested and classified, plate tectonics, seismic waves and the structure of Earth are studied, and the geologic record is found (including uniformitarianism, superposition, cross-cutting relationships and the evidence of climatic variances through Earth's history). In the middle school Life Science strand, fossils and depositional environments are included as they relate to the documented history of life in the geologic record. In the physical science syllabus support for radiometric dating, seismic waves, thermal energy, pressure and gravity are presented.

At the high school level, the long-term history of Earth and the analysis of the evidence from the geologic record (including fossil evidence) must be investigated. Using actual sections of the geologic record to interpret, compare and analyze can demonstrate the changes that have occurred in Ohio, in North America and globally.

The emphasis for this unit is to explore the geologic record and the immensity of the geologic record. The analysis of data and evidence found in the variety of dating techniques (both absolute and relative), the complexity of the fossil record, and the impact that improving technology has had on the interpretation and continued updating of what is known about the history of Earth must be investigated. Geologic principles are essential in developing this level of knowledge. These principles must be tested and experienced through modeling, virtually, field studies, research and in-depth investigation.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning and to develop summative assessment of student learning of science.

### VISIONS INTO PRACTICE

This section provides examples of tasks that students may perform; this includes guidance for developing classroom performance tasks. It is not an all-inclusive checklist of what should be done, but is a springboard for generating innovative ideas.

- Research a specific geologic time period. Document, using specific evidence and data, the environmental conditions, climate organisms that existed (through fossil evidence), orogenies, continental placement, etc. Present findings orally or in writing.
- Investigate the geologic history beneath the school or community using field data, geologic research (published by scientists or through a government agency) and/or bedrock geology maps and reports. Represent findings in a scientific research paper that includes graphics and data analysis or a 3-D model (can be virtual).
- Create a chart or table (can be virtual) to document the pattern of climate change that has occurred throughout geologic time using evidence from the rock record. Use published scientific data (that can be verified and validated) to document periods of climate fluctuation. Evaluate patterns and cause and effect that may be evident in the research. Share the graphic with the class. Discuss and defend the analysis and interpretation.
- Calculate, given the half-life and relative amounts of original isotope and daughter product in a rock sample, the estimated age of the sample (College Board Standards, 2010).

### INSTRUCTIONAL STRATEGIES AND RESOURCES

This section provides additional support and information for educators. These are strategies for actively engaging students with the topic and for providing hands-on, minds-on observation and exploration of the topic, including authentic data resources for scientific inquiry, experimentation and problem-based tasks that incorporate technology and technological and engineering design. Resources selected are printed or Web-based materials that directly relate to the particular Content Statement. It is not intended to be a prescriptive list of lessons.

- The University of Maine offers a scientific case study of a specific glacier, including quantifiable data that documents measurable changes each year, at **http://climatechange.umaine.edu/Research/projects/byrdglacier.html**.
- The OSU Byrd Polar Research site offers numerous educational resources that are related to glacial geology and climate change at **http://bprc.osu.edu/**.
- The College Board provides a document with Earth Science recommendations for grades 6-12 (beginning on page 21). Essential questions and scientific applications are included in this document to encourage investigation and scientific inquiry. In addition, connections to other topics and subjects are suggested to add relevancy and interest for the student. Find it at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**.

### COMMON MISCONCEPTIONS

- Students may have misinformation and misconceptions that pertain to climate change. To address this, it is important to provide evidence of climate change throughout Earth's history and current data to document temperature changes (surface and oceanic). Data and other resources to help with teaching climate change can be found at **http://www.epa.gov/climatechange/index.html**.
- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.
- Carleton College lists a number of geologic misconceptions for high school and college-age students at **http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html**.

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- There are numerous misconceptions regarding Earth's history. Providing scientific data and research for students is essential in addressing them. Carleton College offers a number of strategies and resources that can be used to address Earth history misconceptions at **http://serc.carleton.edu/introgeo/earthhistory/geotime.html**.
- NASA provides common misconceptions for all ages about the Earth and geology at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.

## DIVERSE LEARNERS

Strategies for meeting the needs of all learners including **gifted students, English Language Learners** (ELL) and students with **disabilities** can be found at the **Ohio Department of Education site**. Resources based on the Universal Design for Learning principles are available at **www.cast.org**.

## CLASSROOM PORTALS

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## CONTENT ELABORATION: PLATE TECTONICS

This unit builds upon the middle school Earth and Space Science strand (beginning in grade 6). Sedimentary, igneous and metamorphic rocks are introduced, rocks and minerals are tested and classified, plate tectonics (including the history and evidence for plate tectonics), seismic waves and the interior structure of Earth and the geologic record are found. In the middle school Life Science strand, fossils and depositional environments are included. In the physical science syllabus, support for density, convection, conductivity, motion, kinetic energy, radiometric dating, seismic waves, thermal energy, pressure and gravity are presented.

At the high school level, Earth's interior and plate tectonics must be investigated at greater depth using models, simulations, actual seismic data, real-time data, satellite data and remote sensing. Relationships between energy, tectonic activity levels and earthquake or volcano predictions, and calculations to obtain the magnitude, focus and epicenter of an earthquake must be included. Evidence and data analysis is the key in understanding this part of the Earth system. For example, GIS/GPS and/or satellite data provide data and evidence for moving plates and changing landscapes (due to tectonic activity).

The causes for plate motion, the evidence of moving plates and the results of plate tectonics must be related to Earth's past, present and future. The use of evidence to support conclusions and predictions pertaining to plate motion is an important part of this unit.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning and to develop summative assessment of student learning of science.

### VISIONS INTO PRACTICE

This section provides examples of tasks that students may perform; this includes guidance for developing classroom performance tasks. It is not an all-inclusive checklist of what should be done, but is a springboard for generating innovative ideas.

- Research and investigate a specific area of ongoing plate movement. Create a presentation (can be virtual) that uses graphics and/or a 3-D model to document the evidence of movement, rate of movement, prediction for future movement and hazards that may exist due to movement. Collect and analyze authentic scientific data for each part of the research/investigation. Data and data analysis must be included in the documentation.
- Investigate contemporary methods of evaluating risk from plate movement (including earthquake and volcanic eruptions). Analyze earthquake and volcano data to identify patterns that can lead to predictability. Document the research in a scientific journal, portfolio or e- portfolio.
- Collect real-time data to document tectonic activity in the United States. Highlight the areas of greatest activity and compare to Ohio activity. Determine ways to harness energy from these areas (research and document existing methods in these areas). Present or discuss findings to the class.
- Construct representations of Earth's systems where convection currents occur, identifying areas of uneven heating and movement of matter (College Board Standards, 2010). Use remote sensing or real-time data to determine these zones. Document findings in a scientific report or journal.

### INSTRUCTIONAL STRATEGIES AND RESOURCES

This section provides additional support and information for educators. These are strategies for actively engaging students with the topic and for providing hands-on, minds-on observation and exploration of the topic, including authentic data resources for scientific inquiry, experimentation and problem-based tasks that incorporate technology and technological and engineering design. Resources selected are printed or Web-based materials that directly relate to the particular Content Statement. It is not intended to be a prescriptive list of lessons.

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### COMMON MISCONCEPTIONS

- Carleton College lists a number of geologic misconceptions for high school and college-age students at **http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html**.
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## DIVERSE LEARNERS

Strategies for meeting the needs of all learners including **gifted students**, **English Language Learners** (ELL) and students with **disabilities** can be found at the **Ohio Department of Education site**. Resources based on the Universal Design for Learning principles are available at **www.cast.org**.

- EarthComm offers a program that uses many different strategies to reach students of all learning levels at **http://www.agiweb.org/earthcomm/**The teaching of environmental science through relating the classroom to the real world is essential for many learners.

## CLASSROOM PORTALS

Annenberg offers ideas about teaching high school level environmental science using an integrated Earth systems approach at **http://www.learner.org/resources/series209.html**.

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## CONTENT ELABORATION: EARTH'S RESOURCES

This unit builds on the Earth and Space Science content from elementary school, when renewable/nonrenewable energy, soils, the atmosphere and water are introduced, to grades 6-8 when Earth' spheres, Earth's resources and energy resources are found and then to biology and physical science (in particular water, air, chemistry and energy topics) syllabi at the high school level.

At the high school science level, renewable and nonrenewable energy resources topics investigate the effectiveness and efficiency for differing types of energy resources at a local, state, national and global level. Feasibility, availability and environmental cost are included in the extraction, storage, use and disposal of both abiotic and biotic resources. Modeling (3-D or virtual), simulations and real-world data must be used to investigate energy resources and exploration. The emphasis must be on current, actual data, contemporary science and technological advances in the field of energy resources.

Relating Earth's resources (energy, air, water, soil) to a global scale and using technology to collect global resource data for comparative classroom study is recommended. In addition, it is important to connect industry and the scientific community to the classroom to increase the depth of understanding. Critical thinking and problem-solving skills are important in evaluating resource use and conservation.

Smaller scale investigations, such as a field study to monitor stream quality, construction mud issues, stormwater management, nonpoint source-contamination problems (e.g., road-salt runoff, agricultural runoff, parking lot runoff) or thermal water contamination can be useful in developing a deeper understanding of Earth's resources.

Earth Systems must be used to illustrate the interconnectedness of each of Earth's spheres (the hydrosphere, lithosphere, atmosphere and biosphere) and the relationship between each type of Earth's resources.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning and to develop summative assessment of student learning of science.

### VISIONS INTO PRACTICE

This section provides examples of tasks that students may perform; this includes guidance for developing classroom performance tasks. It is not an all-inclusive checklist of what should be done, but is a springboard for generating innovative ideas.

- Design and build (virtual, blueprint or 3-D model) an *Eco-House* that uses green technology and allows the house to be *off-grid*. Designate a specific location and research/evaluate the different options that would be efficient and effective for that area. Present the final product (with complete explanation and defense of choices/options) to the class.
- Design an experiment to determine the amount and size of particulate matter in the air at the school or community. Analyze the results using information from the Environmental Protection Agency and the Department of Health (e.g., lung diseases, including emphysema and asthma). Locate specific Ohio data for comparative analysis. Report class findings and recommendations orally or in written form to school administrators.
- Investigate local contamination issues. Research existing laws that apply, recommend ways to reduce or prevent contamination (based on scientific data and research), invite community speakers/professionals and collect samples (water, soil, air) to test. Document findings, determine a way to share findings with the community and present to an authentic audience.
- Research and collect specific data for a mass wasting or desertification event (can be present day or historical). Research questions should include: *What factors led to the event? What was the result of the event (how was each of Earth's spheres impacted)? What data is present (analyze data and draw conclusions)? What laws are related to the event? How can this be prevented in the future?* Record the results graphically or in a scientific report.

### INSTRUCTIONAL STRATEGIES AND RESOURCES

This section provides additional support and information for educators. These are strategies for actively engaging students with the topic and for providing hands-on, minds-on observation and exploration of the topic, including authentic data resources for scientific inquiry, experimentation and problem-based tasks that incorporate technology and technological and engineering design. Resources selected are printed or Web-based materials that directly relate to the particular Content Statement. It is not intended to be a prescriptive list of lessons.

- NOAA provides real-time data for many of its projects and research missions at **http://www.noaa.gov/sciencemissions/bpoilspill.html**.
- *Science News* and *Science Daily* offer information highlighting science in the news that can be used for class discussions. The information is updated weekly or bi-weekly and provides references and resource sites for more in-depth discussion. Visit **http://www.sciencenews.org/** and **http://www.sciencedaily.com/**

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- Geology.com provides information on current events in all topic areas of geology, including resources and uses of resources, at **http://geology.com/**
- NSTA provides learning modules called "SciPacks" that are designed to increase teacher content knowledge through inquiry-based modules. Find a module addressing Earth's resources and humans at **http://learningcenter.nsta.org/products/scipacks.aspx**
- The Ohio Department of Natural Resources' Project Wet offers training and resources for K-12 teachers that promote deep understanding about all aspects of water and the interconnectedness of all of Earth's spheres (Earth Systems). Training and workshop opportunities can be found at **http://www.dnr.state.oh.us/tabid/3501/Default.aspx**.
- The College Board provides a document with Earth Science recommendations for grades 6-12 (beginning on page 21). Essential questions and scientific applications are included in this document to encourage investigation and scientific inquiry. In addition, connections to other topics and subjects are suggested to add relevancy and interest for the student. Find it at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**.
- Project Wet's *Healthy Water, Healthy People* water quality educators guide offers ideas and resources for teaching all aspects of water and water contamination issues. Ideas for field monitoring, research projects and student investigations as well as teacher training are available at **http://www.projectwet.org/water-resources-education/water-quality-education/**.

### Career Connection

In designing and building an *Eco-House*, students will include Ohio-based businesses and companies in their presentation. They will identify companies who manufacture qualifying materials, design suitable structures, and construct buildings that meet the specifications. Students will conduct career interviews, workplace visits, and navigate company websites to collect data and information. The explanations for choosing each company will be included in their presentation.

## COMMON MISCONCEPTIONS

- Carleton College lists a number of geologic misconceptions for high school and college-age students at **http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html**.
- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.

## DIVERSE LEARNERS

Strategies for meeting the needs of all learners including **gifted students**, **English Language Learners** (ELL) and students with **disabilities** can be found at the **Ohio Department of Education site**. Resources based on the Universal Design for Learning principles are available at **www.cast.org**.

## CLASSROOM PORTALS

Annenberg offers ideas about teaching high school level environmental science using an integrated Earth systems approach at **http://www.learner.org/resources/series209.html**.

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## CONTENT ELABORATION: GLACIAL GEOLOGY

This unit builds upon the fourth-grade introduction of Earth's surface (landforms and features, including glacial geology) and the middle school Earth and Space Science strand, with sedimentary, igneous and metamorphic rocks, sediment and soils, the geologic record and Earth's history, the cryosphere and the relationship of the analysis of ice cores in understanding changes in climate over thousands of years. Fossils and fossil evidence within the geologic record is found in the Life Science strand, building from second grade through high school biology.

Tracing and tracking glacial history and present-day data for Ohio, the United States and globally is an emphasis for this unit. Scientific data found in the analysis of the geologic record, ice cores and surficial geology should be used to provide the evidence for changes that have occurred over the history of Earth and are observable in the present day. New discoveries, mapping projects, research, contemporary science and technological advances must be included in the study of glacial geology.

Modeling and simulations (3-D or virtual) can be used to illustrate glacial movement and the resulting features. The focus should be on the geologic processes and the criteria for movement, not on memorizing the names of types of glaciers.

Field investigations to map and document evidence of glaciers in the local area (if applicable) or virtual investigations can help demonstrate the resulting glacial features and the impact that ice has had on the surface of Earth throughout history. Real-time data (using remote sensing, satellite, GPS/GIS, aerial photographs/maps) can help support this topic.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning and to develop summative assessment of student learning of science.

### VISIONS INTO PRACTICE

This section provides examples of tasks that students may perform; this includes guidance for developing classroom performance tasks. It is not an all-inclusive checklist of what should be done, but is a springboard for generating innovative ideas.

- Create a cross-section (virtual or drawn) or a 3-D model of a specific type of glacier and use the model or graphic to explain how the glacier moves to the class. Explain and defend data and evidence in the demonstration.
- Take a field trip to an area of Ohio that has visible glacial features. (Check the Ohio Department of Natural Resources, state parks and/or metro parks that have access to view glacial features throughout the state.) Compare the area to maps or satellite data or visit a scientific center that studies glaciers or glacial formation (e.g., the Byrd Polar Research Center) to see glacial core data and learn about glaciers from experts (what kind of data is collected and how it is analyzed). Document observations in a scientific journal or paper (including graphics where appropriate).
- Research the glacial history of a specific location using data from the rock record, contemporary field data (research conducted and published by scientists) and/or glacial features that can be documented (maps, virtual/aerial documentation, remote sensing data). Relate the history to contemporary evidence of changing climate. Present or discuss findings with the class.
- Design and conduct a field study in a local or a specific area within Ohio to collect and/or map evidence of glacial activity (e.g., collection of glacial erratics, photographic evidence of striations from glacial movement or glacial features). Using specific data, share and defend findings with the class.
- Using aerial photographs, LANDSAT data, surficial geology maps or topographic maps, recognize and identify different types of glaciers and glacier features. Document the types of glaciers graphically and in writing in a scientific journal, portfolio or e-portfolio.

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- The OSU Byrd Polar Research site offers numerous educational resources that are related to glacial geology and climate change at **http://bprc.osu.edu/**
- The College Board provides a document with Earth Science recommendations for grades 6-12 (beginning on page 21). Essential questions and scientific applications are included in this document to encourage investigation and scientific inquiry. In addition, connections to other topics and subjects are suggested to add relevancy and interest for the student. Find it at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**.
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## COMMON MISCONCEPTIONS

- Students may have misinformation and misconceptions that pertain to climate change. To address this, it is important to provide evidence of climate change throughout Earth's history and current data to document temperature changes (surface and oceanic). Data and other resources to help with teaching climate change can be found at **http://www.epa.gov/climatechange/index.html**.
- Carleton College lists a number of geologic misconceptions for high school and college-age students at **http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html**.
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