GEOLOGY COURSE FOR ARKANSAS HIGH SCHOOLS

Geology Course Outline (1 Year)

(First Nine Weeks)

1. **Maps**
    - Latitude and longitude
    - Map distances.
    - Topographic map – elevation, symbols, contours lines, profiles, landforms and water flows
    - Rock types, time periods, and faults
    - Compass readings
    - Map interpretation skills.
    - Remote sensing
    - GPS
2. **Matter and Minerals**
    - Classify a substance with symbol and formula
    - Use periodic table and reactive or non-reactive metals, nonmetal, or gases
    - Water as a solvent
    - Identify characteristics of all minerals
    - Model of an atom
    - Models of crystals.
    - Identify mineral samples and describe them
    - Gems as minerals

(Second Nine weeks)

3. **Rocks and the Rock Cycle**
    - Describe intrusive and extrusive igneous rocks.
    - Identify common igneous
    - Identify plutonic bodies
    - Identify sedimentary rocks
    - Identify common metamorphic rocks
4. **Geologic History, Geologic Time, Life on Earth**
    - Earth is at least 4 billion years old
    - Evolution of Earth - geosphere, the hydrosphere, the atmosphere, and the biosphere.
    - Fossils provide evidence for life forms
    - Examine the fossil record
    - Mutations, variations, and natural selection
    - Mass extinctions
    - Evaluate *evolution* in terms evidence
    - Evidence for plate
    - Relative and absolute dating.

- Geologic timetable
- Relative age of various fossils in sedimentary rock
- Rock strata and superposition

(Third Nine Weeks)

5. **Plate Tectonics**
    - Divergent, convergent, and transform in plate boundaries.
    - Evidence for plate tectonics
    - Convection currents and plate tectonics.
    - Volcanoes and earthquake.
    - Faults.
    - Anticline and syncline.
    - Convection cells within mantle
    - Hot spots
6. **External Landform Morphology**
    - Landforms in deserts, glaciers, shorelines, and rivers.
    - Groundwater
    - Stream and river discharge
    - Erosion, transportation, and deposition.
    - Watershed and drainage patterns.
    - River's age and velocity, shape, depth, and discharge.
    - River suspension, saltation, and bedload
    - Meanders, point bars, cut bank, and cutoffs
    - Floodplain, stream channel, levee
    - River deltas.

(Fourth Nine Weeks)

7. **Geology of Arkansas**
    - Geology history of Arkansas
    - Geology surface
    - Mining areas in Arkansas.
    - Minerals and their usages.

Strands and SLE's taken from 2005 Biology and Environmental Science Frameworks

Strand 1: Nature of Science

Standard 10: Students shall demonstrate an understanding that science is a way of knowing.

NS.10.B.1	Explain why science is limited to natural explanations of how the world works
NS.10.B.2	Compare and contrast *hypotheses*, *theories*, and *laws*
NS.10.B.3	Distinguish between a scientific *theory* and the term "*theory*" used in general conversation
NS.10.B.4	Summarize the guidelines of science: ▪ *explanations* are based on observations, evidence, and testing ▪ *hypotheses* must be testable ▪ understandings and/or conclusions may change with additional empirical data ▪ scientific knowledge must have peer review and verification before acceptance

Strand: Physical Dynamics

Standard 1: Students shall understand the physical dynamics of Earth

PD.1.ES.1	Describe the structure, origin, and evolution of the Earth's components: • atmosphere • biosphere • hydrosphere • lithosphere
PD.1.ES.2	Relate eras, epochs, and periods of Earth's history to geological development
PD.1.ES.3	Determine the relative and absolute ages of rock layers
PD.1.ES.4	Categorize the type and composition of various minerals
PD.1.ES.5	Explain the processes of the rock cycle
PD.1.ES.6	Describe the processes of degradation by weathering and erosion
PD.1.ES.7	Describe tectonic forces relating to internal energy production and convection currents
PD.1.ES.8	Describe the relationships of degradation (a general lowering of the earth's surface by erosion or weathering) and tectonic forces: • volcanoes • earthquakes
PD.1.ES.9	Construct and interpret information on topographic maps
PD.1.ES.10	Describe the characteristics (geology) of each of the natural divisions of Arkansas: • Ozark Plateau • Arkansas River Valley

	• Ouachita Mountains • Coastal Plain • Mississippi Alluvial Plain (Delta) • Crowley's Ridge
PD.1.ES.11	Describe the physical and chemical properties of water
PD.1.ES.12	Compare and contrast characteristics of the oceans: • composition • physical features of the ocean floor • life within the ocean • lateral and vertical motion
PD.1.ES.13	Investigate the evolution of the ocean floor
PD.1.ES.14	Investigate the stratification of the ocean:
PD.1.ES.15	Predict the effects of ocean currents on climate

Strand: Physical Dynamics

Standard 1: Students shall understand the physical dynamics of Earth.

PD.1.ES.16	Explain heat transfer in the atmosphere and its relationship to meteorological processes: • pressure • winds • evaporation • precipitation
PD.1.ES.19	Describe the cycling of materials and energy: • nitrogen • oxygen • carbon • phosphorous • hydrological • sulfur

Strand: Heredity and Evolution

Standard 6: Students shall examine the development of the *theory* of *biological evolution.*

HE.6.B.1	Compare and contrast Lamarck's explanation of *evolution* with Darwin's *theory* of *evolution* by *natural selection*
HE.6.B.2	Recognize that *evolution* involves a change in allele frequencies in a *population* across successive generations
HE.6.B.3	Analyze the effects of *mutations* and the resulting *variations* within a *population* in terms of *natural selection*
HE.6.B.4	Illustrate *mass extinction* events using a time line
HE.6.B.5	Evaluate *evolution* in terms of evidence as found in the following:

	• fossil record • *DNA* analysis • *artificial selection* • morphology • embryology • viral *evolution* • geographic distribution of related *species* • *antibiotic* and *pesticide resistance* in various organisms

Additional Strands Created for Geology

Strand 1: Students shall demonstrate an understanding that science is a way of knowing.

G.1.1. Recognize how scientific processes produce valid, reliable results,
- consistency of explanations with data and observations,
- openness to peer review,
- full disclosure and examination of assumptions,
- testability of hypotheses, and
- repeatability of experiments and reproducibility of results.

G1.2. Uses scientific reasoning and valid logic to recognize
- faulty logic,
- cause and effect,
- the difference between observation and unsubstantiated inferences and conclusions, and
- potential bias.

G.1.3 Compare and contrast science with some of the other ways of knowing about our World (Comparison of the Ways of Knowing http://users.aristotle.net/~asta/science.htm)

Strand 2: The student will develop map interpretation skills for topographic and geologic features.

G.2.1 Determine latitude and longitude of specific map points.
G.2.2 Determine scaled map distances.
G.2.3 Determine elevations of specific points from a topographic map.
G.2.4 Recognize basic topographic map symbols from a legend/key.
G.2.5 Construct a 3-D representation of a topographical map or construct contour lines from a 3-D model.
G.2.6 Construct a profile from a topographic map.
G.2.7 Identify landforms and direction of stream flow using a topographic map.
G.2.8 Interpret basic rock types, time periods, and faults from geologic maps.
G.2.9 Determine and measure compass readings from selected sites.
G.2.10 Identify practical applications for map interpretation skills.
G.2.11 Investigate methods of remote sensing for measuring and monitoring the earth's crust.
G.2.12 Use a GPS instrument to identify latitude, longitude, and elevation of a location.

Strand 3: The student will explore matter and how it relates to the formation of minerals.

G.3.1 Classify a substance as being made of atoms or molecules given its chemical symbol or formula.
G.3.2 Select groups of elements as being reactive or non-reactive metals, nonmetal, or gases, given the periodic table.
G.3.3 Recognize that water is the major solvent that releases minerals from the earth.
G.3.4 Evaluate the benefits and drawbacks of man’s use of mineral resources given a scenario.
G.3.5 Identify characteristics of all minerals (e.g., naturally occurring, inorganic, solid, definite structure, and composition).
G.3.6 Recognize or create a representative model of an atom, using the periodic table.
G.3.7 Build models of the six major crystal systems.

G.3.8 Recognize that the crystal form of minerals depends upon atomic size, method of bonding, and the environment.

G.3.9 Identify mineral samples using simple property tests (hardness, luster, streak, cleavage/fracture, specific gravity, and other special properties) and a mineral table.

G.3.10 Explore the role of gems as minerals and their value to man.

G.3.11 Create a presentation on minerals including a description (specific gravity, crystalline system, chemical formula, physical properties, etc,) an illustration, mining techniques, occurrences, and uses.

Strand 4: The student will investigate the three rock classes and the rock cycle.

G.4.1 Distinguish between intrusive (plutonic) and extrusive (volcanic) igneous rocks.

G.4.2 Identify common igneous rocks (e.g., granite, rhyolite, basalt, gabbro, obsidian, pumice) using physical properties and a table.

G.4.3 Identify plutonic bodies (e.g., sill, dike, batholith, and laccolith).

G.4.4 Understand sedimentary processes.

G.4.5 Distinguish between clastic vs. non-clastic and detrital vs. chemical.

G.4.6 Identify sedimentary rock features such as stratification, fossils, graded bedding, ripple marks, and mudcracks.

G.4.7 Identify basic sedimentary rocks (e.g., sandstone, shale, limestone, coquina, coal, conglomerate) using physical properties and a table.

G.4.8 Differentiate between foliated and non-foliated metamorphic rocks.

G.4.9 Compare and contrast regional and contact metamorphism.

G.4.10 Identify common metamorphic rocks (e.g., gneiss, marble, schist, slate, quartzite) using physical properties and a table.

Strand 5: The student will explore the geologic history of the Earth and evidence of life through time.

G.5.1 Recognizes that radiometric data indicate that Earth is at least 4 billion years old and that Earth has changed during that period.

G.5.2 Describes the characteristics of the evolution of Earth in terms of the geosphere, the hydrosphere, the atmosphere, and the biosphere.

G.5.3 Recognize that fossils contained in sedimentary rock provide evidence for life forms, changes in those life forms, and environmental changes.

G.5.4 Examine the fossil record to determine the environmental adaptations of organisms.

G.5.5 Analyze the effects of *mutations* and the resulting *variations* within a *population* in terms of *natural selection*

G.5.6 Illustrate *mass extinction* events using a time line

G.5.7 Evaluate *evolution* in terms of evidence as found in the following:

- fossil record
- *DNA* analysis
- *artificial selection*
- morphology
- embryology

G.5.8 Cite and explain the evidence for plate tectonics (e.g., fossil record, mountain ranges, rock strata, paleomagnetism, paleoclimates, and configuration of the continents.).

G.5.9 Compare and contrast the mechanisms for determining the advance of geologic history: relative and absolute dating.

G.5.10 Construct and interpret a geologic timetable for the evolution of Earth and the history of life.

G.5.11 Differentiate the relative age of various fossils in sedimentary rock, given a diagram of rock strata.

G.5.12 Interpret the sequence of rock strata using superposition, cross cutting relationships, inclusions, the fossil record, and absolute data techniques.

Strand 6: The student will relate the theory of plate tectonics to the evidence for continental drift and seafloor spreading

G.6.1 Identify geologic features associated with divergent, convergent, and transform (continental and oceanic) plate boundaries.

G.6.2 Identify the evidence for plate tectonics using paleomagnetism, fossil record, continental boundaries, and hot spots.

G.6.3 Describe how convection currents drive plate tectonics.

G.6.4 Associate volcanoes and earthquake activity with plate boundaries using a map.

G.6.5 Distinguish among reverse, normal, and strike-slip faults.

G.6.6 Distinguish between anticline and syncline.

G.6.7 Label illustrations of movement of convection cells within mantle and their relationship to convergent and divergent plate boundaries.

G.6.8 Correlate plate movement by plotting movement of hot spots through time.

Strand 7: The student will investigate landforms created by many different surface processes and their relationships to various sources of energy in the Earth System.

G.7.1 Describe the landforms associated with deserts, glaciers, shorelines, and rivers.

G.7.2 Describe the nature of groundwater and define the elements of groundwater features.

G.7.3 Discuss stream discharge using the Tennessee River or local stream system as an example.

G.7.4 Describe the fluvial processes of erosion, transportation, and deposition.

G.7.5 Illustrate various drainage basin models and identify different types of drainage patterns.

G.7.6 Relate the characteristics of a river's age with respect to its velocity, channel shape, depth, and discharge.

G.7.7 Explain the processes by which a stream erodes and transports its load (suspension, saltation, and bedload).

G.7.8 Identify meanders, point bars, cut bank, and cutoffs using a map (e.g., lower Mississippi, Arkansas, White, and Red Rivers).

G.7.9 Define a floodplain and describe the behavior of a stream channel and natural levee formation during a flood.

G.7.10 Describe the formation of river deltas.

Strand 8: The student will investigate geology of Arkansas and the relationships between surface geology and land-use and environmental problems.

G.8.1 Describe the geology history of Arkansas

G.8.2 Describe the geology surface of the various regions in Arkansas and compare their environmental problems created by their surface features and land-use.

G.8.3 Local mineral mining areas in Arkansas.

G.8.4 Describe the major minerals and rock in Arkansas and their usages.

The Nature of Science

- Science is the method of explaining the natural world. Science presumes that the objects and events in the universe occur in consistent patterns that are comprehensible through careful, systematic study. The testing of various explanations of natural phenomena for their consistency with empirical data is an essential part of the methodology of science.
- Science is limited to explaining natural phenomena through the use of empirical evidence; therefore it cannot provide answers to personal or religious beliefs, superstitions, myths or ultimate explanations.
- The primary goal of science is the formation of theories (explanations) and laws, which are terms with very specific meanings.
- Scientific explanations are called "theories." In ordinary speech, "theory" is often used to mean "guess" or "hunch," whereas in scientific terminology, a theory is a set of universal statements that explain some aspect of the natural world**.** A scientific theory is held with a high degree of confidence and is supported by enough physical evidence to make its abandonment unlikely.

How Science Works

- Scientists test hypotheses (A testable statement or prediction about the natural which can be supported by experiment or observation) by conducting observations or experiments from which they collect data, analyze the data and write up their results for publication.
- Scientists must publish their results and evidence in scientific journals for peer review.
- Peer review leads to attempts to replicate and verify the results. If the results are verified this may lead to further observations and experiments.
- Some scientists may review these findings and work of other scientists to further develop or refine theories and in infrequent cases development new theories.
- Laws are generalizations of universal relationships related to the way that some aspect of the natural world behaves under certain conditions is often stated in a form of a mathematical equation.
- Theories are well-substantiated explanation of some aspect of the natural world that explains facts, laws, inferences, and tested hypotheses. Theories do not become laws even with additional evidence; they explain laws. However, not all scientific laws have accompanying explanatory theories.
- Well-established laws and theories must be internally consistent and compatible with the best available evidence, must be successfully tested against a wide range of applicable phenomena and evidence, must possess appropriately broad and demonstrable effectiveness in further research, and must have the potential to lead to new knowledge and have predictive power.
- The body of scientific knowledge changes as new observations and discoveries are made. Theories and other explanations change. New theories emerge, and other theories are modified or discarded. Throughout this process, theories are formulated and tested on the basis of evidence, internal consistency, and their explanatory power.
- Scientific knowledge is simultaneously reliable and tentative. Having confidence in scientific knowledge is reasonable while realizing that such knowledge may be

abandoned or modified in light of new evidence or re-conceptualization of prior evidence.

Principles of Geology

Science has determined that the Earth is 4.6 billion years old and was formed at about the same time as the rest of our solar system. In the very beginning, the body of the newly forming planet was cool but soon began to heat up. The heat had been generated by the repeated high speed collisions of much smaller bodies of space rocks that continually clumped together as they collided to form this planet. Gravitational forces cause the heavier elements to move to the Earth's core. As the collisions tapered off the Earth cooled again and formed a thin crust on its surface. Water and atmosphere begin to form. Erosion and deposition began that created the layers of the Earth. A number of geological principles begin and continue today (http://en.wikipedia.org/wiki/Geology).

Plate Tectonics says that the Earth is broken into large plates. It is combination of two earlier ideas, continental drift and sea-floor spreading. The size and position of these plates change over time. The edges of these plates, where they move against each other, are sites of as earthquakes, volcanoes, and mountain building. Where the plates spread, we have new molten rock forming plate edges.

The Principle of Superposition states that a sedimentary rock layer in a tectonically undisturbed sequence is younger than the one beneath it and older than the one above it.

The Principle of Uniformitarianism states that the geologic processes observed in operation that modify the Earth's crust at present have worked in much the same way over geologic time.

The Principle of Original Horizontality states that sediments are deposited in flat layers

The Pinciple of Intrusive Relationships concerns crosscutting intrusions. In geology, when an igneous intrusion cuts across a formation of sedimentary rock, it can be determined that the igneous intrusion is younger than the sedimentary rock.

The Principle of Cross-cutting Relationships states that Faults are younger than the rocks they cut.

The Principle of Inclusions and Components states that, with sedimentary rocks, if inclusions (or *clasts*) are found in a formation, then the inclusions must be older than the formation that contains them.

The Principle of Faunal Succession is based on the appearance of fossils in sedimentary rocks. As organisms exist at the same time period throughout the world, their presence or (sometimes) absence may be used to provide a relative age of the formations in which they are found. The principle becomes quite complex, however, given the uncertainties of fossilisation, the localisation of fossil types due to lateral changes in habitat, and that not all fossils may be found globally at the same time.

Internet Resources

Rockhounding in Arkansas – Geology of Arkansas http://rockhoundingar.com/geology.html
Geology Map of Arkansas - http://www.state.ar.us/agc/argeomap.pdf
Geology of General Map Arkansas, Geology Commission - http://www.state.ar.us/agc/argeol.htm
Geology Specific Map of Arkansas - http://geology.about.com/library/bl/maps/n_statemap_AR1200.htm
Ouachita Mountains Fieldtrip - http://www.lgsweb.org/fieldtrip01.html
Economic Geology and Mineralogy of Central Arkansas - http://www.lgsweb.org/fieldtrip00.html
Paleozoic Rocks, Southeastern Ouachita Mountains, Arkansas - http://www.lgsweb.org/fieldtrip99.html
Hot Spring Field Notes - http://www2.nature.nps.gov/geology/parks/hosp/index.cfm
Buffalo River Field Notes - http://www2.nature.nps.gov/geology/parks/buff/index.cfm
Geology of War Eagle - http://comp.uark.edu/~sboss/edmap98.pdf
USGS http://www.usgs.gov/
Google Earth http://earth.google.com/
NASA World Wind http://worldwind.arc.nasa.gov/
GeoStor 5.0 for Arkansas http://www.geostor.arkansas.gov/Portal/index.jsp
Arkansas Earthquakes http://quake.ualr.edu/public/arkansas.htm
Minerals Uses http://www.scienceviews.com/geology/minerals.html

Labs

http://www.sciencecourseware.org/GLOL/
http://quake.ualr.edu/public/history.htm
http://tsunami.geo.ed.ac.uk/local-bin/quakes/mapscript/home.pl
http://welcome.to/geologycentral/
http://www.pbs.org/wnet/savageearth/animations/index.html

Possible Textbooks

In-Terra-Active, West Publishing
Essentials of Geology, Prentice Hall
Physical Geology, Glencoe/McGraw-Hill
Geology and *Essentials of Geology*, Houghton Mifflin