Purdue University Extension

4-H-987

M178

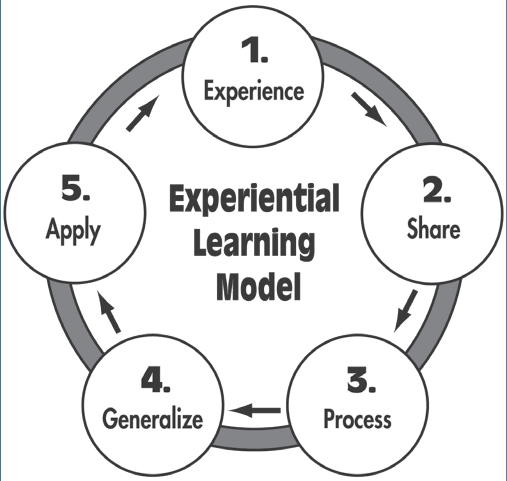
# GEOLOGY

## Level 3

# 4-H Geology Project Manual

## Note to 4-H Member

Learning about geology is fun and may help you choose a career. "Geology" exists all around you, wherever you live. The Indiana *4-H Geology* curriculum was written for youth who enjoy studying about Earth processes and want to learn more. The first two manuals introduced you to basic geology concepts with a focus on rocks, fossils, minerals, and basic Earth processes. *Level 3* introduces more advanced geology topics. And now, rather than giving you all the information you need, you are expected to be more active in your learning. This is achieved by 4-H member activity-based self study.




Pfeiffer, J.W., & Jones, J.E., "Reference Guide to Handbooks and Annuals"
© 1983 John Wiley & Sons, Inc.
Reprinted with permission of John Wiley & Sons, Inc.

The topics in this manual are introduced with a brief overview. A number of activities are then suggested to help you further explore the topics that most interest you. This approach is often called the *Experiential Learning Model*. The focus is "learning by doing." You will learn by reading, researching, and asking questions about the focus topic. Your study will be directed to help you **experience** a learning activity, **reflect** on what you did, **generalize** what you learned, and then think about how you can **apply** what you learned to other situations. This model is shown as a cycle because learning about one topic often leads to more questions that you will want to study. Each activity is followed by questions to help you complete this cycle.

You can find geology resources at rock shows, online, in your local library or school library, or at book stores and museums. This is a good time to expand your geology reference library to include books that have topics of special interest to you. See the "Resources" section at the back of the manual for suggestions.

**Authors:** Natalie Carroll, George Aldred, Wanda Aldred, Wes Beck, Trish Brutus, Kenneth Eck, Dale Fadely, and Catherine Maddox.

**Reviewers:** Linda Cook, and Pamela Rogers

**Editor:** Rebecca J. Goetz.

**Designers:** Cassi Halsema, Nicholas Peetz, and Jessica Seiler.

# Table of Contents



## Note to Parents and Project Leaders

The *4-H Geology* curriculum offers many educational experiences, from collecting and identifying rocks to learning how the Earth was formed. Parents and project leaders should be supportive of their children's interests, but high school aged youth should be taking the primary responsibility for their learning. The helper's guide has a variety of information to help adults work much more effectively with youth. These include:

- Ages & Stages – This article gives a summary of the general youth developmental stages and gives ideas of what to expect.
- Learning Styles for Youth – This article discusses how youth learn by different methods.
- Experiential Learning – This article gives tips on how to make the most of any activity by teaching with a variety of learning styles.

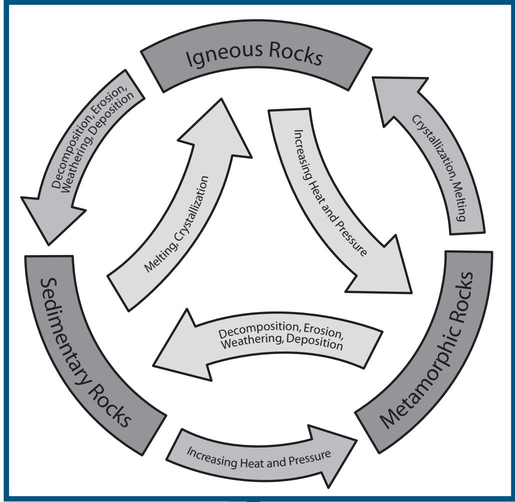
## Goals of This Publication

The *4-H Geology, Level 3* manual encourages youth to

- use resources beyond this manual for in-depth study of geology topics of interest,
- keep accurate records (field notes, journal),
- expand on their understanding of and appreciation for Earth science, and
- educate others about geology through exhibits, presentations, action demonstrations, and mentoring younger 4-H members.

# Review

The *4-H Geology Level 1 and 2* manuals introduced you to rocks, fossils, minerals, and basic Earth processes. You should be familiar with the basic concepts described below before beginning your *Level 3* work. If these topics are not familiar to you, it is recommended that you review the *Level 1 and 2* manuals or find information about these topics in a library or on the Internet.




## Level 1 topics

- Rocks and the rock cycle
- Equipment for rockhounds
- Minerals
- Fossils

## Level 2 topics

- Further study and identification of rocks, fossils, and minerals
- Geologic time
- Glaciers
- Journaling
- Field trips

# Safety

Always be aware of possible hazards when you are collecting rocks, fossils, and minerals. Safety suggestions:

- Don't collect alone.
- If you are not collecting on your own property, you must get permission from the property owner or manager before collecting specimens.
- Wear solid shoes and long pants.
- Wear safety glasses or goggles when breaking specimens.
- If you are collecting on a hillside, make sure there is no one below you.
- Be aware of where you are, what you are doing, and what others around you are doing.
- Always be conscious of your surroundings and potential dangers.
- Think Safely, Think Safety – at all times!

# Your Field Journal

A field journal is a great place to keep a record of what you have learned and where you found your specimens. Notes that are carefully recorded let you recall things you see and hear years after the occurrence. Developing the habit of writing down your observations takes effort, but it is worth the work.

Use a notebook or bound journal for your field journal. Notes should be recorded in waterproof ink (drafting or embossing ink) or with a Sharpie®. Pencils may also be used, but may smudge, and you may be tempted to change your notes. Resist that temptation. It is important to not change the notes you take in your geology journal. If you make a mistake in your journal, just draw a line through it once. It is good to get into the habit of signing the bottom of each page of your geology notebook.

Enter your personal information at the front so your book can be returned, should it be misplaced. Your notes can be recorded in any style as long as they are clear to you. Report the date and location of your observations. Be as specific as you can with the location, including legal land descriptions or the distance and direction to the nearest crossroads. Topographic maps or Internet maps are important tools. A **global positioning system (GPS)** unit can be a great help in defining the exact location where you found a particular specimen. When collecting fossils, record as much information as you can. Search the literature to find the period, time, formation, etc. The Indiana Geological Survey has resources that can help you find this information.

### Your Journal

Your journal is your personal geology diary.

Create the journal that you can use and want to keep.

Your geology journal is the best place to record geology information. Your notes are a record of what you noticed the day that you were in the field. Take notes about the geology specimens and formations that you see and geology events that you attend. Events may include visiting a rock show, museum, a program at a state park, or even a fossil dig.

The *Level 2* manual has additional information about field journals.

# Rocks, Minerals, Fossils

In the *4-H Geology Level 1 and 2* manuals you began to learn about rocks, minerals, and fossils. Now, you will continue learning on your own by focusing on a specific topic. Choose one of the topics below and study all you can about it. You can find information on the Internet, in your local library; at bookstores, museums, rock and mineral shows; and from others who have studied these topics. Keep notes in your journal about what you learned and where you learned it. The “Resources” section can help you get started, but don’t stop there.

## Activity 1. Personal Research

Choose one of the following topics and learn all you can about it. Study the topic by reading and researching as much as you can. The “Resources” section of this manual has many suggestions for where to start your search. See “Appendix A” for research suggestions. Visit geological sites if you can. Remember to take pictures and make notes in your field journal.

### Rocks

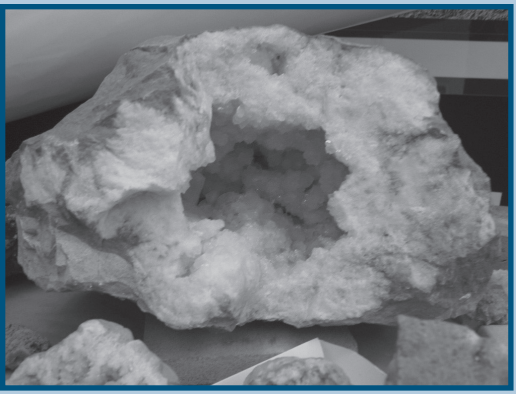
- Study the formation of rock layers.
- Study environmental influences on geologic formations.
- Study the creation of folds or faults.
- Study differences between extrusive and intrusive igneous rocks.
- Study Indiana bedrock.
- Study differences between foliated and non-foliated metamorphic rocks.

### Minerals

- Study a specific mineral family (for example: carbonates, sulfides, silicates).
- Study a crystal system (for example, a different mineral that has a hexagonal crystal system). Note that there are six basic crystal systems and specific forms within each system.
- Study one mineral of the native elements (for example: copper, gold, silver, platinum, carbon, lead, sulfur). Tell where it is found, how it occurs, etc.
- Study why some minerals will have fluorescence under long and/or short wave light. Include color photographs of your fluorescent

minerals under fluorescent light if possible, to show the difference between how they look in natural and fluorescent light.

- Study mineral colors and explain what causes different colors.
- Study minerals used to produce fertilizer (for example: potash/potassium, phosphate, sulfur, nitrogen) and explain what properties they have that make them important soil amendments.
- Study ore minerals that provide metals.
- Study minerals mined as byproducts (for example: iron, copper, uranium).
- Study ways quartz forms – explain how two pieces of quartz can have the same chemical and physical composition, but look very different.
- Study limestone.
- Study several different mineral characteristics: luster, streak, cleavage, color, fracture, opacity, magnetic properties, or electrical properties.



## Fossils

- Focus on a specific animal or plant that might have lived during a specific time-period in Indiana.
- Study a phylum during a specific time (era, period, etc.). Describe the environment that its members lived in, the plants and animals that occurred, etc.
- Tell what an index fossil is. Why is it important?
- Study the evolution of a species.
- Study the formation of a specific type of fossils.
- Study one of the following: sharks, ginkgo tree, coral. Explain why these are sometimes called “living fossils.”
- Study how fossils are preserved and explain the process that causes the fossilization of the plant or animal.
- Study tracks, burrows, or other signs of past life.

## Other

- Study how plate tectonics affected Indiana.
- Study subduction plate movement (causing earthquakes and volcanoes).

- Study a specific volcanic event (for example: Mount St. Helens).
- Study a specific earthquake event (for example: San Francisco, 1906, or New Madrid, 1811-12).
- Study Indiana faults (for example: Mt. Carmel)
- Study quarries, quarry equipment, and/or underground coal mines.
- Work with your project leader to come up with your own topic.

## Think about It!

What topic did you choose? Explain why you chose it.
What was your best resource for this topic?
Why is this topic important?

## Mentoring

Another way to expand your own knowledge is to share your geology knowledge with other 4-H members by mentoring. When you mentor another person you become the teacher. You may find that you'll learn as much as your students!

## Activity 2. Mentoring

Introduce a younger 4-H member to the geology project. Talk to your local geology leader or your county Extension Youth Educator about the possibility of working with other 4-H members at a meeting or workshop. Or, you can talk to one of your former teachers about doing a presentation in their class to introduce students to the fascinating world of geology. Start with the information and an activity from the *4-H Geology Level 1 or 2* manuals. Prepare a presentation using the lesson plan outline (see sidebar).

Keep track of the time you spend preparing and working with the 4-H members. Ask someone to take photographs of your presentation (and of you working with the youth) for your records.

## Think about It!

How would you rate your mentoring experience?
Would you like to do it again?
What did you learn that you could use in your life?

### Lesson Plan Outline

Activity title:

General (overall) objective:

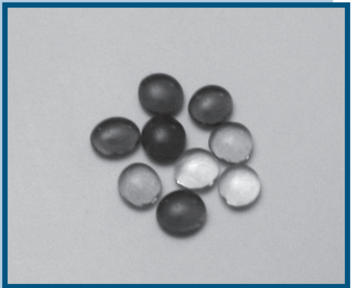
Specific objectives:

Time for activity:

Procedure:

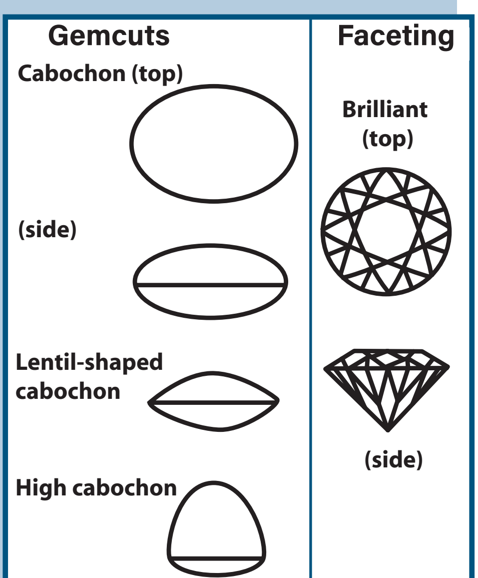
Materials needed:

Resources for more information:



### Fun Fact

The cabochon is the oldest and simplest gemcut. The cabochon must be used for a star or cat's eye to be visible and it is often the best cut for the opal, moonstone, or colorful opaque gems. Facet cuts include the brilliant (most common), square or rectangular, triangular, diamond-shaped, and trapezoidal. The brilliant cut requires a flat top and sides sloping outward to the girdle (the broadest part of the stone). The sides slope inward under the girdle to a tiny flat surface at the bottom. There are generally 32 facets above the girdle and 24 facets below.




## Tumbling

Mechanized tumbling is one of the most recently developed methods of stone polishing. The process of tumbling stones is similar to the natural process that occurs in a stream bed, except the rate of tumbling is controlled and speeded up considerably. Making a polished stone takes time, from ten days to two weeks. Indiana does not have the best stones for polishing, but cherts (flints), quartzites and some granites and fossils polish well. The general steps in polishing a stone are: choose and prepare the stones, tumble in coarse grit, tumble in intermediate grit, tumble in fine grit, tumble to polish, and clean up. Properly polished stones will have the same appearance when they are dry as when they are wet.

"Appendix B. Polishing Stones" has more detailed information about stone polishing.

## Activity 3. Making a Polished Stone

Create your own polished stones following the directions that come with your tumbler.

### Think about It!

What was the most difficult part of making polished stones? What will you do with them?

## Lapidary

Lapidary is the art of preparing gemstones to be used in jewelry settings. It includes cutting, polishing, and engraving of precious and semiprecious stones or gems. Lapidary is an ancient art; craftspersons and shops have been around for more than 6,000 years. The term **gem** refers to minerals and stones used in jewelry or other ornamental settings. Pearls (made by mollusks), amber (resin from trees), and white coral (made by sea creatures) are also considered gems. The value of a gem is determined by its hardness, color, brilliance, rarity, beauty, and demand, and by the skill of the lapidary craftsperson. The lapidary craftsperson will determine the type of cut to be used on a given gemstone after considering its hardness, transparency, index of refraction, and the initial shape of the stone. Cuts give the gem a number of symmetrical plane surfaces, which are called **facets**.

The easiest way to learn lapidary is to find a mentor so you can watch someone else do it. You can learn a lot by watching someone else go through the steps of cutting and polishing a stone. This can also help you decide if you are interested in purchasing your own equipment and decide what pieces of equipment you want. Equipment varies greatly, from homemade machines to commercially manufactured equipment. Much of the commercial equipment is expensive, but if you have the tools and shop space, the kit and parts can be secured for home assembly rather inexpensively. Ask your Youth Extension Educator for help in finding a lapidary mentor. "Appendix C. Lapidary" has more detailed information about making stones for jewelry.

## Activity 4. Lapidary

Practice and hone your lapidary technique by making polished flats, nodule halves, spheres, and carvings.

### Think about It!

What was the most difficult part of lapidary?
What will you do with gemstones you worked on?

## Activity 5. Making Stone Jewelry

Learn how to make your own jewelry. Cut, shape, and mount three stones in a jewelry setting.

### Think about It!

What was the most difficult part of making jewelry?
What will you do with it?

## Activity 6. Decorating with Stones

Use your lapidary skills to add polished stones to three items such as: vases, rings, earrings, cuff links, bracelets, tie clasps, buckles, or necklaces.

### Think about It!

What items do you like to make most?
What would you like to learn to do?
Do you think that lapidary may be a lifelong skill for you? Why or why not?

## Miniatures (Thumbnails and Micromounts)

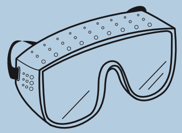
Rock and mineral collections can become large and difficult to store. Collecting miniatures can reduce the space needed to store your collection and generally cost less to obtain. You can usually find small specimens along with larger ones. You can use something as simple as a magnifying glass or as expensive

### Size of Specimens

1. Museum – large
2. Cabinet – smaller than museum
3. Miniatures – 2-3 inches, good collection size
4. Thumbnail – fits in a 1.25-inch cube
5. Micro – you need magnification to see characteristics

### Fun Fact

Some collectors will mount specimens in any size box and define them as micros because the material must be viewed with magnification to be fully appreciated. Others argue that no skill is required to mount large specimens in large containers. **However, it would be a mistake to ruin a perfect specimen to reduce it to a smaller size.**



## Safety Reminder

Wear safety glasses or goggles when breaking specimens.

and elaborate as a binocular microscope for magnification. High intensity lights provide adequate illumination for most viewing. Miniatures should fit in a box that is three inches in diameter or less. Boxes that are 1 inch x 1.5 inches x 1 inch, or smaller, are generally referred to as micromounts. Micros are permanently mounted mineral specimens that require magnification (10-35x) and illumination for proper observation.

• Selection of specimens – Pick a beautiful, well crystallized or interesting example. It is especially good if the specimen exhibits special mineralogical features such as habit, twinning, or growth features. You need to show the important features and basic characteristics of the specimen. **Matrix** specimens that fill more than half of the box are ideal. Damaged or broken material should be removed prior to mounting, if possible.

• Cleaning specimens – Mineral specimens should be cleaned prior to mounting and placing in the box. Most cleaning involves the removal of dust, dirt, grease, iron stain, lichens, and/or algae. Dust and dirt may be blown (using your breath, a syringe, hair dryer, or canned air) or brushed off, picked with a pointed tool, vacuumed, washed, or any combination of these methods. Before washing, however, check that the mineral is not soluble in water. Iron stains may be removed with oxalic acid. Lichens and algae should be treated with ammonia.

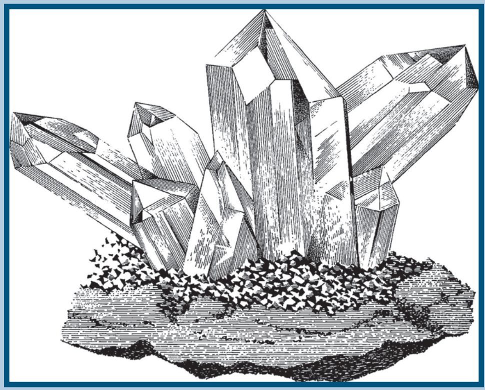
• Drying – A temporary storage box for drying specimens may be made by placing Styrofoam in a box to protect your specimens.

• Reducing the size of the specimens – You may need something to break the specimens. Mechanical breakers can be made or purchased and vary in size. A simple pair of diagonal cutters may be all that is necessary to snip off the edges of the matrix of some specimens, while others may need a hammer and chisel or a hydraulic breaker, c-clamp, or vise. Be careful! Carborundum grinding wheels can be used to cut away excess material or to form a flat surface for easier mounting. A diamond saw may be required for some trimming.

• Mounting specimens – Small individual crystals or specimens are usually mounted on a base or pedestal (“pegged”). A number of common materials may be adapted for such mounting depending upon the size and durability of the specimen. These include: corks, balsawood, matchsticks, toothpicks, wooden dowels, insect pins, and thumbtacks. A variety of glues or pastes may be used for fastening the pedestals and specimens.

Note, however, that Elmer's glue has the advantage since it can be soaked off with water, if you ever wish to change the mounting. Mounting a delicate specimen onto a pedestal without damage requires patience and practice. Practice mounting a few discarded minerals first so you develop the dexterity to manipulate the specimen with your hands and tweezers. As you handle more specimens, you will develop the techniques that work best for you. Magnifiers can help you see what you are doing when working with small specimens. There are magnifiers that clamp on eyeglasses, magnifier "lamps," and binocular magnifiers that you wear on your head like a sun shade. You can also purchase magnifying glasses (reading glasses) in many discount stores.

• Placement and labeling – Place your mounted specimen into an appropriate-sized box. Miniature boxes are often lined with black paper or painted on the inside with a flat black enamel such as Testor's "PLA," which is used on plastic models. The black color furnishes excellent contrast for the mounted crystals and specimens. A permanent label should be attached to each box. The label must contain the name of the specimen and the locality where it was found. You may position the label at any place on the box as long as it does not interfere with viewing the specimen. Always keep a label with each specimen. A specimen left unlabeled for a few days may be difficult to identify.
**Note**: Minerals are fragile. They should not be touched once they are mounted.



• Storage – Because of their small size, miniatures can be easily protected from light and dust in cardboard boxes. As your collection grows, it may become necessary to purchase or construct a storage cabinet. See the "Resources" section for display box plans.

## Activity 7. Miniatures

Mount five of your own miniatures for display.

### Think about It!

What was the most difficult part of making miniatures?

What will you do with them?

# Indiana Geology

## Topography

Indiana's **topography** and **physiography** vary across the state. The northern part of the state is fairly flat due to glaciers that once covered this part of the state. The southern portion of the state has a more complex terrain, caves, and **karst** areas. At one time, much of northwest Indiana was covered in wetlands, and the rest of the state was covered with hardwood forests. Now, however, farms, homes, and cities dominate the landscape, particularly in the north. You can learn more about the topography of the state by studying topography maps. Computer-based 3-D topography maps are becoming more popular and more widely available. Visit the United States Geological Survey (USGS, www.usgs.gov) or the Indiana Geological Survey (igs.indiana.edu/) for more information about topographic maps.

## Activity 8. Indiana Physiographic Regions

List the major Indiana physiographic regions: hills, valleys, plains (includes prairies), lowlands (flat but not wet), highlands, and wetlands. Visit geological sites if you can. Remember to take pictures and make notes in your field journal.

### Think about It!

How have Indiana's physiographic regions changed over time? What environmental consequences might these changes cause?

## Geologic Histories of Selected State Parks

Indiana has parks located across the state. Each park has its own physiographic history and features. They are great places to get a glimpse of what Indiana looked like years ago and to learn more about geology.

## Activity 9. Indiana State Parks

Plan a visit to one or more of the state parks in Indiana. Visiting Indiana's state parks can show you the different types of topography of the state. Decide when you will go, what route you will take, how far it is from your home to the state park, and what you want to see. If you are able to stay for more than one day, or if the park is far from your home, plan where you will stay, etc. If you actually take this trip, record in your field journal your mileage, costs, and information about the state park you visited and its geology. **Note:** do not pick up any natural items in the state park (plants, rocks, etc.), as they are protected. Leave them for others to enjoy.

### Think about It!

Did you enjoy planning your trip to a state park?
Were you able to go?
What did you learn from this experience?

## Activity 10. Indiana Geologic Sites

Research an Indiana geologic site. Learn as much as you can about what caused the particular formation and how it has changed over time (if it has). Visit the site, if possible. Take pictures and make notes in your field journal about what you saw. If you have access to a Global Positioning System (GPS) unit, include the coordinates. Collect any written materials available about the site. Explain the geologic process that formed the feature. **Note**: the *4-H Geology Level 2* manual describes some interesting sites in "Indiana Geology."

# Activity 11. Indiana's State Parks

Match the parks listed below with the descriptions that match them most closely. You can use the "Resources" section to find more information about the parks. (The Indiana Geological Survey and the Department of Natural Resources have information about each of Indiana's state parks.) Visit some geological sites if you can. Remember to take pictures and make notes in your field journal.

**a. Brown County State Park**
**b. Charlestown State Park**
**c. Clifty Falls State Park**
**d. Indiana Dunes State Park**
**e. McCormick's Creek State Park**
**f. Mounds State Park**
**g. Pokagon State Park**
**h. Shades State Park**
**i. Spring Mill State Park**
**j. Turkey Run State Park**

1. _____ The last glacier formed the park and surrounding counties as it melted 10-15 thousand years ago. Many glacial features are found in the park, including kettle depressions, Kettle Lake, end moraines, glacial **erratics**, kames, and eskers.

2. _____ This park contains some of the largest and finest examples of 2,000 year old earthworks (Adena) in Indiana and the Midwest. Through partial excavations and archaeological surveys of these and other mound sites, it was discovered that a stratified society existed. The society was composed of hunter-gatherers; traders traveling hundreds, perhaps thousands, of miles; and religious rulers who kept track of solar and celestial events at the mounds.

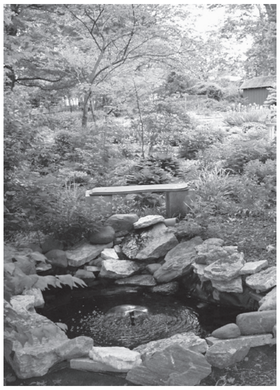
3. _____ Limestone, formed from the coral life found in ancient seas, has eroded to form a deep canyon. Waterfalls provide essential oxygen for healthy creek life. Deep sinkholes alternate with connecting ridge areas to create tiered native plant communities. Wolf Cave and the Twin Bridges show the power of stream erosion and seepage to carve a short, winding, narrow passage through a ridge. Glacial melt waters were the architects for the spectacular limestone erosion that created the canyon features and Wolf Cave.

4. _____ This park is remarkable for its varied topography, including gently rolling highlands, heavily wooded and steep ravines, Devonian fossil outcroppings, and karst sinkholes. The Fourteenmile Creek valley is one of the oldest unglaciated stream valleys in Indiana. Even though this valley was unglaciated, melt water from glaciers north of the park helped carve out its current depth and width. The park has a well-known geologic formation called Devil's Backbone. It is a unique ridge formed as two different bodies of water, Fourteenmile Creek to the north and the Ohio River to the south, cut through bedrock to form its steep sides.

5. _____ The property's karst features are unique to south central Indiana. The karst landscape helped to shape the flora and fauna of the area. This park is home to a natural area known as a "karst sinkhole plain," a landscape of sinkholes covered by a mixed mesophytic forest type. It contains at least three, rocky, shallow, fast-flowing streams that originate from cave entrances and run to the lake. These streams provide excellent habitat for many aquatic animals that require cold, fast-flowing creeks.

6. _____ Ancient history is frozen in time by the cliffs of sandstone at the park. The exposed bedrock tells many stories of times long past: stories of mighty rivers, of swamp forests, of ancient seas and creatures long dead. The canyons and cliffs were shaped during the time of the glaciers and continue to provide homes for relict plants such as eastern hemlock and Canada yew.

7. _____ The landscape of this park reveals natural processes at work for millions of years. The receding Wisconsin Glacier paused about 16,000 years ago near present-day Valparaiso and deposited rocks and soil of glacial till in a ridge of rolling hills called the Valparaiso Moraine. Between the moraine and the present shoreline of Lake Michigan is a series of similar lower ridges, further evidence of the glacier's remodeling activities. Stretching from the Valparaiso Moraine to the beach, these ridges of moraines and dunes mark the shores of a once larger lake that shrank by stages after the glaciers disappeared. (The ridges may not be visible due to vegetation.) As the glacier melted, plants colonized in its wake. The strange environment called Pinhook Bog was once part of this massive glacial system. Formed from an ice chunk marooned by the retreating glacier some 14,000 years ago, the bog is now filled with sphagnum moss and hosts unusual vegetation, from deciduous evergreens to insect-eating plants and delicate orchids.



8. _____ The scenic hills were carved from sedimentary rocks that formed about 300 million years ago when southern Indiana was covered by a shallow inland sea. Sand, silt, and mud from highlands to the northeast were carried into this sea by ancient river systems and were deposited in a vast delta complex. The area has experienced many geological changes. The deposits hardened into sandstone, siltstone, and shale that are known as the Borden Group of rocks. Later, the sea cleared, and thick bed of limestone was deposited over these rocks. Following regional uplift, the rocks were exposed to weathering and erosion. After that, hundreds of feet of these ancient rocks were stripped away by the streams of those times, and the scenic hills and valleys of this area were eventually formed. Where more resistant sandstones protected the underlying rocks, much more prominent hills like Weed Patch Hill, Hohen Point, and others were formed.

9. _____ The geologic history of the falls and the gorge below goes back to the time when glacial ice extended approximately to the location of the present Ohio River. The eroding power of Big Clifty Creek helped form the gorge. As the stream cut through the rock, soft shale and thin limestone of the Ordovician period were literally cut from beneath the more resistant and thicker rocks now forming the cliffs and the lips of many scenic waterfalls in the park.

10. _____ The geology of this park offers a great view into the past. The exposed bedrock is called Mansfield sandstone. Deposits formed during the Carboniferous Period, when the buildup of sand at the mouth of the ancient Michigan River was slowly compacted and cemented into solid rock. Due to the swampy environment of the area, coal was eventually formed and mined here in the late 1800s and early 1900s. During the Pleistocene Epoch, the sandstone bedrock was carved into today's familiar canyons and formations by the eroding action of glacial meltwaters. The Punchbowl is an example of a pothole that was scoured out by glacial erratics caught in swirling backwash. Erratics are pieces of bedrock from Canada that were carried here by the glaciers. Some of the larger erratics, or boulders, can still be seen in Boulder Canyon and smaller ones, pebbles, in Sugar Creek. In the last few hundred years, the wind and water erosion of the sandstone has continued at a slower pace.

*Activity continued on the next* page.

## Think about It!

How many of the state parks were you able to match without resorting to a reference?

How many of these parks have you visited?

What geologic formations at one of these state parks are you most interested in seeing?

## Think about It!

Where did you find your best resources describing the geologic site that you studied?
Were you able to visit it?
Have you started your own geologic reference book?
If so, what other sites would you like to visit?

## Activity 12. Indiana Geology Research

Choose one of the following Indiana geology topics to investigate. Each general topic is followed by a list of suggested sub-topics to help you focus your research in a specific area. Study the topic by reading and researching as much as you can. You may be able to visit sites that will help you learn more about Indiana geology. Take pictures and keep notes in your field journal, if you do visit a related site. The "Resources" section of this manual has many suggestions for where to start your search. See "Appendix A. Research Suggestions."

• Geological industry in Indiana – Bedford Stone, crushed stone, glass manufacturing, the petroleum industry, gypsum production

• Coal – block, cannel, chemical properties, coal balls, coal gasification, coal liquefaction, composition, distribution in Indiana, history of coal mining in Indiana, low-sulfur coal, methods of mining coal, peacock coal, physical properties, surface-mined land in Indiana, underground coal mining in Indiana

• Dimension stone – Salem Limestone, microfossils, carving and sculpture, milling, quarrying, venerable veneer

• Geomorphology of an Indiana site – Anderson Falls, Bear Creek Canyon, Portland Arch, Bluespring Caverns, Bluffs of Beaver Bend, Squire Boone Caverns, Brown County State Park, Cataract Falls, Clifty Falls State Park, Eagle Creek Reservoir, Glacial Lake Flatwoods, Hanging Rock, Harrison Spring, Hemlock Cliffs, Indiana's Karst Topography, Jug Rock Barrens, Kentland Dome, Klintar, Knobstone Escarpment, Lost River, Marengo Cave, McCormick's Creek, Mineral Waters and Health Resorts, The Ohio River, Pine Hills Nature Preserve, Pokagon State Park, Sand Dunes, Seven Pillars of the Mississinewa, Shades State Park, Spring Mill State Park, Standing Rocks, Turkey Run State Park, Turtle Rock, Versailles State Park, Williamsport Falls, Wyandotte Cave

• Historical geology of Indiana – Bonneyville Mill, whetstones, Burton Tunnel, mineral wool, glass sand industry, lime kilns, natural cement, New Harmony, pioneer brickmaking, Portland cement, Tunnel Mill, salt mineral waters

• Indiana industrial minerals – Indianite, ore deposits, lightweight aggregate, marl, natural molding sand, New Albany Shale, peat moss, sand and gravel, zinc, cement

• People in Indiana geology – Willis S. Blatchley, Edward Travers Cox, Richard Owen, Maurice Thompson, David Dale Owen

• The Pleistocene Ice Age in Indiana

• Research and map of modern-day glaciers – Alaska, Glacier National Park in Montana

• Geode, mineral, or fossil sites

### Think about It!

What did you learn from your research?

How can you apply what you learned?

## Agriculture

Indiana has a rich agricultural history. Agriculture is strong in Indiana because of the rich soils and favorable climate. Soil surveys contain information about the soils and the average depth to bedrock. Soil surveys contain information not only about the soil types in each county, but the best uses of each type of soil, erodibilty of the soil, and topography, as well as other geologic information. You can request a Soil Survey for your county from the Indiana Natural Resources Conservation Service (www.in.nrcs.usda.gov/) or your local Soil and Water Conservation District office.

## Activity 13. Indiana Agriculture

Choose one of the following topics to learn more about. Study the topic by reading and researching as much as you can. See "Appendix A. Research Suggestions." Visit geological sites if you can. Remember to take pictures and make notes in your field journal.

• Glaciation effects on Indiana soils – movement of soils and deterioration of materials, slopes

• How soil type and depth of soil affect crops grown

• How bedrock affects soil type

- Types of soils (major) in different parts of the state and types of crops that do best in these soils
- Different types of terrain in Indiana and types of crops that do best in each

### Think about It!

Why is an understanding of geology important to those involved in agriculture?

How might you apply what you learned about geology and agriculture in your life?

# U.S. and World Geology

The United States has a wide range of topography and physiography throughout the 50 states, from the coastlines to mountain ranges and prairies to the Great Lakes. There are many state and national parks where you can enjoy this scenic beauty first-hand.

## Activity 14. Topography and Physiography

Research U.S. topography and physiography (coasts, mountain ranges, prairie, the Great Lakes, etc.). Create your own U.S. map showing the different regions. See "Appendix A" for research suggestions.

### Think about It!

How does U.S. topography and physiography differ from what you can see in Indiana?

What would you most like to see in person? Why?

## Activity 15. U.S. and World Geologic Site

Study a U.S. or world geologic site of interest and write a report. Learn as much as you can about what caused the particular formation and how it has changed over time. Obtain pictures to add to your journal. Collect any written materials that are available about the site. See "Appendix A" for research suggestions. If you are able to visit one of these sites, be sure to take your own photos and keep notes in your field journal.

### Think about It!

What did you learn during your research?

Why is understanding geology in other states or other nations interesting to you?
How could you use the information that you gained in doing your research?
What would you like to see in person? Why?

## Activity 16. U.S. and World Geology Research

Choose one of the following U.S. geology topics to learn more about. Some topics have a list of suggested sub-topics to help you focus your research in a specific area. Study the topic by reading and researching as much as you can. The "Resources" section of this manual has many suggestions for where to start your search. See "Appendix A" for research suggestions.

- Computers in geology
- Continental drift
- Damsites
- Deserts
- Earth magnetism
- Earthquakes
- Faults
- Fluid inclusions
- Geochemistry/geophysics
- Geologic field mapping
- Geothermal energy
- Geysers
- Glaciers and glacial erratics
- Great Lakes
- Heavy minerals
- Hot springs
- Isotopes
- Landslides
- Meteorites and impacts
- Microanalyses by electrons
- Mineral resources and mining
- Oil and gas – deep drilling, early methods of transporting petroleum, cable-tool drilling rigs, geologists and geophysicists, marine or offshore drilling, origin, processing (pumping, refining, transportation), drilling (then and now)
- Palentology – focus on one of the following: brachiopods, bryozoa, callixylon, cephalopods, conodonts, corals, crinoids, cystoids and blastoids, eurypterids, gastropods, ice age

mammals, ostracods, pelecypods, sea urchins, sharks, sponges, Stelleroidea, trace fossils

- Pyrite
- Seismograph readings and earthquakes
- Spelunking (caving)
- Unconsolidated deposits
- Volcanic ash – Tioga Bentonite or other bentonites
- Underwater geology
- Well logs

## Think about It!

What did you study?
How could your new knowledge help you in your future?

# Geology Technology

Many geologic advances have been made in recent years because of technology. Computers allow the collection and analysis of vast amounts of data and assist in the creation of maps. Geographic Information Systems and Global Positioning Systems have helped to accurately locate and record geologic features.

**GIS (Geographic Information System)** combines traditional paper maps with computerized databases. GIS can help you examine the relationships among all the information layers on the maps in time and space, not just time.

**GPS (Global Positioning Systems)** include a network of satellites that broadcast a time-based location code. Handheld receivers use three satellites to locate exactly where you are on Earth.

**Remote Sensing (RS)** allows researchers to study something without touching it. Geophysics allows us to look into the Earth without digging using ground penetrating radar (GPR) resistivity, and electromagnetic (EM), seismic, and well logging.

The Indiana Geological Survey and the Indiana Department of Transportation have created a GIS atlas Web site at http://igs.indiana.edu/GISatlas. This Web site allows you to easily use GIS technology to make your own map. You can turn on the “layers” that you want to view. Those layers may include roads, rivers and streams, etc.

## Activity 17. Make Your Map

Make a map of your county using the IGS Atlas (http://igs.indiana.edu/GISatlas) and the following steps:

• Zoom down to your county.

• Choose the Reference folder (on the right hand side), under Map Layers.

• Choose Aerial Photos.

• Click on the layers that you want to view.

• Print your map at the most appropriate scale.

### Think about It!

How long did it take you to make your map?
How might you be able to use the skills you learned in other projects or studies?
How could the map database be used by professionals?

### Letterboxing and Geocaching (GPS)

A fun way to hone your map-reading, compass, or GPS (global positioning system) skills is to locate a "letterbox" or "geocache" in Indiana.

Letterboxing offers a fun way to explore your county and teach others, as well. You can set up a letterbox for your friends and then give them clues (often using compass directions) so they can find your letterbox. You will leave a special stamp there. Once they find it, they can stamp and date a paper or small notebook to show they were there. All you need to get started is a stamp, a small notebook, and a waterproof container. If you enjoy this game, you can find clues from all over the world on the Internet. Additional information is available at the Letterboxing North America Web site, www.letterboxing.org. Frequently asked questions are posted at: www.letterboxing.org/faq/faq.html

**Note:** Be sure to label your box to explain what it is and who left it. Otherwise, other people might think it is dangerous.

Geocaching is a treasure-hunting activity, similar to letterboxing, but using a GPS system and the Internet. You can find more information on the Geocaching Web site, www.geocaching.com. You can find the geocaches by zip code, state, or country. The Web site also features a "Frequently Asked Questions" section

### Follow the Rules

Sometimes people who participate in these activities (Letterboxing or Geocaching) are more interested in finding scenic or unusual places to hide their box and do not follow posted restrictions. This is one of the reasons that the U.S. National Park Service has prohibited the playing of this game on its properties (www.letterboxing.org/faq/faq.html). So, if you do decide to take up one of these hobbies, please respect the places that you visit and follow all rules and restrictions.

that is a big help for people new to geocaching. **Note:** Be sure to label your box to explain what it is and who left it or others might think it is dangerous.

### Activity 18. Make a Letterbox or Geocache

Hide five items in safe places. Label your boxes. Write clues using notable landmarks and a compass (letterboxing) or GPS coordinates (geocaching). Ask your parents, an adult helper, or friends to see if they can follow your clues.

#### Think about It!

Were people able to locate the items you hid?
Did they enjoy this game?
How could you expand this activity?
List some other ways that GPS coordinates can be used.

## Geologists

Many people have studied geology. Their work effects what we know today. Some of these people are listed below.

- Louis Agassiz (1807-1873), "The father of glaciology."
- Mary Anning (1799-1847), "The greatest fossilist the world has ever known."
- Rosalind Franklin (1920-1958), a crystallographer whose work helped explain the fine structures of coal, graphite, DNA, and viruses.
- Charles Lyell (1797-1875), considered the father of modern geological thought.
- James Parkinson (1755-1824), wrote *Organic Remains of a Former World.*
- James Hutton (1726-1797), wrote *Theory of the Earth,*1795.
- Inge Lehmann (1888-1993), a Danish seismologist was the first to suggest that the inside of the Earth's molten core may be solid.

### Activity 19. Geologists

Study one of the geology pioneers listed above to find out about their work, life, and the concept they published. Write a report. You research should include when and where they lived, how well accepted their theories were, and any other interesting information that you can find.

# Careers in Geology

Since you are interested in geology, perhaps you should consider a career that would use the knowledge you are acquiring. You could become a geologist and study earth processes as a career.

There are many other careers that require knowledge of rocks, minerals, or fossils. Job positions that use this knowledge can be found in government or private sectors or in educational institutions. The list below will give you an idea of the variety of jobs that require an interest in and knowledge of geology. Of course, you could always volunteer to teach geology to youth through 4-H!

- Decision Makers: city planners
- Education: elementary, middle school, and high school science teachers often teach some geology; college faculty generally specialize and teach in a specific area; Extension educators may need to use their knowledge of geology
- Engineering: civil engineer, surveyor, cartographer, geographer, meteorologist
- Environment: consultant, marine scientist, oceanographer, hydrologist, hydrogeologist, hydrologic technician
- Lapidary Arts: faceter, gemologist, jeweler
- Mining: workers involved in mineral or oil exploration, mineralogist, mining engineer
- Physical Sciences: geochemist, geophysicist, nuclear technician, vulcanist, laboratory technician, archaeologist, paleontologist, mapper
- Utilities: workers involved with natural gas, petroleum, nuclear power, coal, electricity, water treatment

Research careers that interest you, so you can begin to prepare now. High schools and colleges may use the terms earth science, earth studies, or geosciences in place of geology. Find out how much education each job requires and if you must do an internship. Also, check to see where you would be likely to work and what the job prospects are. Because you can learn most about a job by talking to someone who does that job, try to find and interview someone in the career that interests you. If possible, shadow the professional on a workday to learn more about the job responsibilities. Record your findings and experiences in your field journal.

You can begin to explore careers in geology by completing some of the activities listed below. It is a good idea to keep any notes and observations you make in your geology journal so you can refer to them in the future.

## Undergraduate Study in Geology

You may be able to study geology at a college or university. Some schools may have a geology department, while others may have geology coursework. Visit IN.gov, Education and Training (http://www.state.in.us/ai/education/), to see if the college or university that you are interested in attending has geology courses.

## Activity 20. Career Investigation

Find a job listing (paper or Internet*) that requires a knowledge of geology. Using an online job search site, look for geology positions. Look at the type of educational requirements for each type of position. Also, look at the work experience required for each position. Complete the following (if given):

Job Title: ______________________________________________

Starting Pay: ______________________________________________

Qualifications Required**:______________________________________________

______________________________________________

Duties: ______________________________________________

______________________________________________

______________________________________________

Contact Information: ______________________________________________

______________________________________________

* The U.S. Geological Survey Web site, www.usgs.gov/, has a "jobs" section that includes job openings, student employment opportunities, and information about volunteering to help the environment.

** Keep in mind that choices you make now (for example, what courses you take in high school) will impact your ability to meet job qualifications. Math and science courses are required.

## Think about It!

What did you learn from the job listing?
How could your new knowledge help you in your future?

Consider types of summer jobs or internships you could do that would help prepare you for a career in a geology-related field. You might explore working for a local government office or nearby university to get some hands-on experience.

## Activity 21. Career Interview

Interview someone who needs an understanding of geology to do their job. This could be the State Geologist, a university professor, an environmental engineer, a mining engineer, a paleontologist, or a seismologist. Try to schedule a face-to-face interview with the individual. If that is not possible, you might be able to interview them by phone or e-mail. Before the actual interview, make a form that includes the following questions, leaving room for you to write their answers.

1. Name and position of the person being interviewed.
2. Date of interview.
3. What does the person do for a living?
4. Why did they choose the career they have?
5. What knowledge of geology do they need to do their job?
6. How did they learn what they need to know?
7. What advice do they have for someone who is interested in their job?

## Think about It!

What did you learn from your interview?
How could your new knowledge help you plan your future?

## Activity 22. Career Web Search

Visit Web sites listed in "Undergraduate Study in Geology" to find out what you need to do during your high school years to prepare for entering an undergraduate geology program.

## Think about It!

What did you learn from the Web sites about requirements for entering a geology program in college?
Did you look at any other college programs?
Why might it be important to look at college degree programs while you are still in high school?

## Activity 23. Internship Investigation

Once you have researched the careers in geology, think about summer jobs/internships you could do to help you train for those careers. Look for volunteer opportunities and internships with local government offices or universities that offer hands-on experience. This will help you decide if a geology-related career is really for you. It will also give you a very valuable experience.

## Think about It!

Were you able to find any information about internships?
Why might an internship be useful to you?

## Activity 24. Planetary Science

Search the Internet for information about NASA and the work it is doing in planetary science (e.g., NASA's Great Observatories: the Hubble Space Telescope, the Compton Gamma Ray Observatory, the Chandra X-ray Observatory, and the Spitzer Space Telescope). Visit sites with the extensions .gov (governmental) or .edu (education) as they are more reliable than those made by an individual.

**Answer the following questions.**

What is planetary science?

Why would understanding geology be important to a planetary scientist?

What geologic formations have been found on other planets?

What are planetary scientists looking for and what are they learning?

## Think about It!

What was the most interesting thing that you learned about planetary science? Why should we care? How might a knowledge of planetary science affect people who are not geologists?

## Expanding Your Geology Library

As you become more involved in geology, you should begin to build your own geology library. Identification books would be a good starting base. A soil survey of your county would provide a wealth of information and be a great addition to you geology library. Other resources that you might want to collect include textbooks, topographic maps (some show rock layers), and books about geologic history. It would be a good idea to get in contact with a geologic professional and ask her or him to recommend some books to add to your library.

## Web Sites

- American Association for the Advancement of Science – www.aaas.org
- American Association of Petroleum Geologists – www.aapg.org
- American Geological Institute – www.agiweb.org (see the link to the 44 geoscientific and professional associations)
- American Geophysical Union – www.agu.org
- Association for Women Geoscientists – www.awg.org
- American Federation of Mineralogical Societies – www.amfed.org
- Department of Earth & Atmospheric Sciences, Purdue University – www.purdue.edu/eas
- The Field Museum (in Chicago) – http://www.fieldmuseum.org
- Earth Science Week – www.earthsciweek.org
- Earth Science World – www.earthscienceworld.org
- Geocaching – www.geocaching.com
- The Geological Society of America – www.geosociety.org
- Geotimes – www.geotimes.org
- Indiana Children's Museum, Indianapolis – www.childrensmuseum.org
- Indiana clubs – http://amfed.org/mwf/indiana.htm
- Indiana Falls of the Ohio – www.fallsoftheohio.org
- Indiana Geological Survey – http://igs.indiana.edu/ and http://igs.indiana.edu/GISatlas
- Indiana GIS – www.in.gov/ingisi

- Indiana Natural Resource Conservation Service – www.in.nrcs.usda.gov/
- Indiana State Museum, Indianapolis – www.in.gov/ism
- Indiana State Parks & Reservoirs – www.in.gov/dnr/parklake
- Letterboxing North America – www.letterboxing.org
- Mid-America Paleontology Society, www.midamericapaleo.org/
- The Mineralogical Record – www.minrec.org
- National Geographic – www.nationalgeographic.com
- Rock and Gem Magazine – http://www.rockngem.com
- Smithsonian – www.si.edu
- United States Faceters Guild (gems and jewels) – www.usfacetersguild.org
- U.S. Geological Survey – http://www.usgs.gov
- Volcano World - http://volcano.und.edu

## Geology Societies

Visit the Midwest Federation of Mineralogical and Geological Societies Web site www.amfed.org/mwf/, and click on "Member Societies." Click on "Indiana." Contact an officer to find out more about their meetings, show dates, and other information.

## Museums with Geology Displays

The Indiana State Museum in Indianapolis – www.in.gov/ism

The Field Museum in Chicago – www.fieldmuseum.org

Royal Tyrrell Museum in Alberta – www.tyrrellmuseum.com (with a field station; about 50 miles north of the Montana border.)

Indiana Children's Museum – www.childrensmuseum.org

Many college and university geology departments will have collections that you can view. Most natural history museums also have geology displays.

## Publications

Visit the Web site, http://igs.indiana.edu/, or call (812) 855-7636 for a publication list from the Indiana Geological Survey (IGS).

Box plans (for entomology and geology) are available under "Resources" at the Indiana 4-H Entomology Web site, www.four-h.purdue.edu/staff.home/natalie/Projects/entomology.

# Glossary

**Erratic –** a naturally occurring rock that doesn't match the indigenous bedrock (moved by glaciers)

**Facets –** cuts on a gem to make symmetrical plane surfaces

**Gems –** minerals, stones, pearls, amber, and white coral used in jewelry or other ornamental settings

**GIS (Geographic Information System) –** a computerized system used to input, store, and analyze spatially referenced information (GIS can help you examine the relationships among information sets by overlaying and utilizing database information linked to a particular geographic location.)

**GPS (Global Positioning System) –** the network of satellites that broadcast a time-based location code (These systems use satellites to locate exactly where you are on Earth.)

**Karst –** an irregular limestone region with sinks, underground streams, and caverns

**Matrix –** the fine-grained mass of material in a rock in which larger grains, fossils or crystals are embedded

**Physiography –** physical geography; regions or areas grouped and defined based on terrain, rock type, and geologic structure and history

**Remote Sensing (RS) –** a method of obtaining information about properties of an object or area without coming into physical contact with the object or area (RS can include aerial photographs, satellite data, spectral data, and radar.)

**Topography –** the graphic delineation, usually on maps or charts, of natural and features (terrain) of a place or region, especially to show their relative position and elevation

# Appendix A. Research Suggestions

Many of the activities in the Level 3 manual require you to learn all you can by doing research. These suggestions can help you organize your research:

• Collect information about your topic. Be sure to keep track of all your resources as you find them.

• Keep notes of what you learn and the resources (books, articles, personal contacts, etc.) that you use. Index cards work well for this. If you put one fact/graph/etc. on each card, it is easy to sort them into a logical order when you are organizing a notebook, paper, talk, or exhibit.

• Information on the Internet should come from a reputable source, such as *.edu (educational) or *.gov (governmental). If you use the Internet, be sure to give the entire URL for Internet resources, not a search engine address and the date you obtained the information.

• Organize the facts and information you found using drawings, charts, and graphs.

• Your project leader, teacher, parent, or other adult can help you with your research. Collect specimens to illustrate your study.

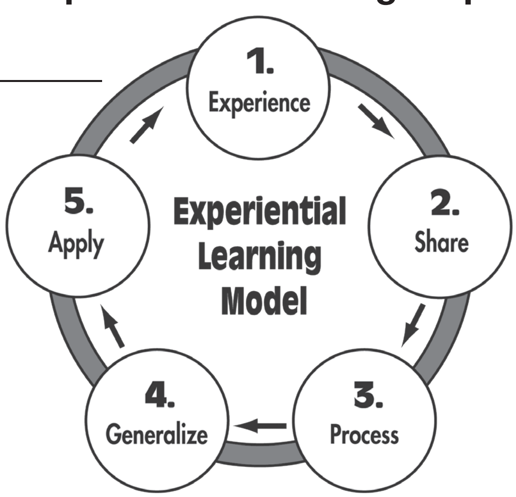
• Clearly state what you learned during your study.

## Experiential Learning Map

**Topic of Study**: ____________________

How is what I learned useful in another part of my life?

Why was it useful to learn about this topic?




Pfeiffer, J.W., & Jones, J.E., "Reference Guide to Handbooks and Annuals"
© 1983 John Wiley & Sons, Inc.
Reprinted with permission of John Wiley & Sons, Inc.

Resources I used:

What I did and what I learned:

## Experiential Learning

Complete the Experiential Learning map to explain:

- Your experience
- Your reflection
- How you can generalize what you learned
- How you can apply what you learned to other situations

# Appendix B. Polishing Stones

Polishing stones can be a lot of fun. You will need to purchase a tumbler and to read and follow the instructions given. The steps given below are general guidelines.

The hardness of the rock will determine the length of time the stones must be tumbled. In general, it takes three to five days in each of three sizes of grit (abrasive) and a final polish. The stones should be inspected daily to check the abrasive to see if there are enough sharp grains left to cut effectively. The general steps in polishing a stone are given below, but be sure to refer to your tumbler owner instructions for specifics.

1. *Stone Choice and Preparation* – Indiana does not have the best stones for polishing, but cherts (flints), quartzites, and some granites and fossils polish well. Your stones should be washed thoroughly with soap and water and sorted in groups of similar size and hardness. For example, do not mix 2-inch diameter stones with stones of 1⁄2-inch diameter. You can tumble stones of unequal hardness together, but you will need to be careful to remove the softer stones before they are ground away to nothing while the harder stones are finishing in a particular grit.

2. *Coarse grit* – The tumbler tank is filled to 50 to 60 percent capacity with stones. Water is added to cover the stones by 1/16 inch. The course grit (about 80) is then added at the rate of about 1 pound per 8 to 10 pounds of stones. Check that the machine is lubricated and the belts are tight. Record the weights of the stones, the amount of grit, and the time the tumbler is started. Observe your tumbler for a few minutes after starting it to be sure that everything is tight and sounds right before you leave the machine. Check the tumbler periodically.

!

### Tumbler Tip

It is easier to buy extra barrels, if you can, so you can have one for each grit. Be sure to label them.

## Tumbling Equipment

Hobby stores and some larger toy stores sell rock tumblers. Non-rotating tumblers are more expensive than rotating tumblers, but they offer some advantages that you might want to consider: they vibrate, so they are quieter than rotating tumblers; they do not need to be watched quite as closely; and the cover may be removed to watch the polishing taking place. Read the directions carefully before starting. You can obtain special polishing materials from rock shops, hobby shops, the Internet, or mail-order companies.

You might have more success with a cabochon-making machine with interchangeable discs (charged with diamond compound).

**Notes:**

• If it is necessary to shut the tumbler down for more than an hour, remove the stones or the mixture may harden and the stones may fracture when the tumbler starts again.
• Clean the barrel of your tumbler, your hands, and all the other materials that come in contact with the rocks after tumbling is completed at each grit level.
• Do not wash waste material down any house drains, as it will harden in the traps and require major plumbing repairs. Dispose of waste materials as directed in your tumbler instructions.

3. *Intermediate grit* – Fill the tumbler barrel to the halfway mark with the coarsely polished stones. Since the bulk of the stones may be reduced 15 to 20 percent during the coarse grinding, it may be necessary to add a few stones that are already smooth to bring the batch up to the correct level. Add intermediate grit (about 220) and water as before. It may help to add a tablespoon of baking soda to keep gas from forming inside the barrel. Some hobbyists omit this stage of the operation and go directly from coarse to fine grit. It is even possible to use one grit throughout the whole process by starting with coarse grit and wearing it out until it becomes fine enough to put a finishing surface on the stones. This is a very slow process, however.

**Note:** It is important not to chip or crack the stones from this point on.

4. *Fine grit* – Place some water in the barrel of your tumbler. Add the stones gently to the halfway mark. Put another tablespoon of soda and add the appropriate amount of fine grit (about 500). Do not add additional grit during the fine-grit tumbling. Let the grit wear out to a finer grit. Check the progress of this step closely. The stones may be ready for polishing any time between 72 to120 hours. If the stones do not polish well, it is probably because they were not handled properly during this step. Some hobbyists add an extra step using “super fine” grit (800-1200) to be sure that their stones are ready for polishing.

**Note:** Wash and inspect your stones. Remove any chipped or rough stones before polishing. Clean the tumbling barrel and stones carefully to be sure they are clean and free from grit and rough edges, so your stones don’t get scratched during the polishing step.

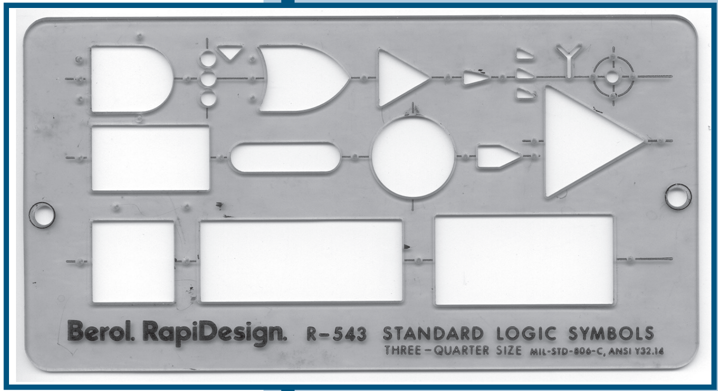
5. *Polish* – Place the stones carefully in the tumbler barrel. Add one cup of Spic and Span for every 6 pounds of stones (half the amount of grit you have been using). Put in 1⁄4 to 1 teaspoon of detergent to increase the effectiveness of the polishing powder. Slow the tumbler down by about 20 percent, if possible, or add a filler such as sawdust to slow down the tumbling action. This will help prevent breaking and scratching of the polished stones.

6. *Final clean-up* – The final cleaning of the polished stones may be done either by hand or by using the tumbler. If you use the tumbler, be sure to use plenty of water to prevent breakage or scratching of the stones. Add enough detergent powder to make a heavy, soapy solution and tumble the stones for six to twelve hours. Properly polished stones will have the same appearance when they are dry as when they are wet.

# Appendix C. Lapidary

## Lapidary Equipment

You will need to trim, grind, sand, and polish your stone. Often one machine with different sanding disks for each operation is used. All grinding and sanding is done on wet wheels. Water may be dropped or sprayed on the wheels, or they may be allowed to rest in a shallow pan of water. As the wheels rotate, water will cover them and prevent the stones from becoming overheated. Stones can be cracked by too much heat. Grinding wheels should not be left sitting in water when not in use as they may crack or develop uneven spots. You'll need:



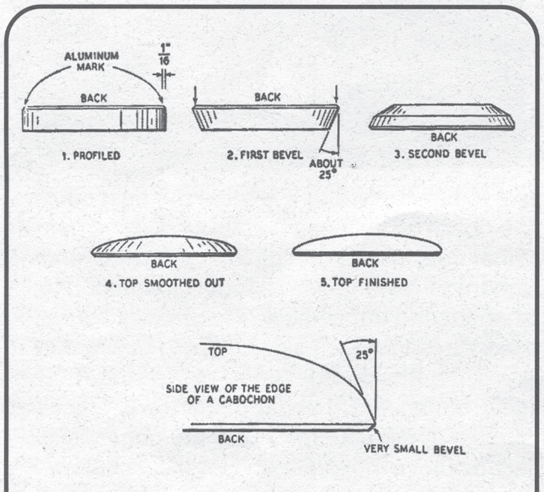

- A trim saw with a coolant tank and a diamond saw blade. The motor should be at least 1⁄4 horsepower (hp) and turn at least 1725 revolutions per minute (rpm).

- A grinder with a 1⁄4-hp motor and two grinding wheels, usually of silicon carbide, carborundum, or cast iron charged with abrasives at 100 grit and 220 grit. Water is usually dripped or sprayed on the wheels to cool the stone being worked. This requires a spray shield.

• A sander for finer cutting and shaping. You may use a rubber wheel with sanding grit in it or a belt and sander with wet/dry sandpaper. Grits of 400 and 600 are common.

• A leather polish wheel to use with tin oxide, cerium oxide, titanium oxide, or similar material. These polishes may be purchased from a hobby or lapidary shop in powder form and moistened with water to make a paste which is applied to the wheel.

The general steps in polishing a stone are given below, but be sure to read your equipment manuals carefully.

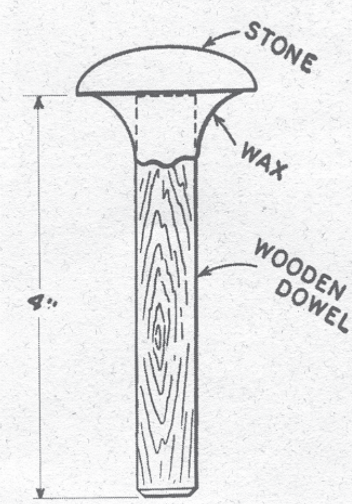


The Cabochon Cut

1. *Selecting material* – The only sources available for acceptable lapidary materials are found in hobby or rock shops or at rock and mineral shows. Materials will cost from a few cents to several dollars a slab. There is a great variety of materials that can be cut and polished into attractive stones. It is best to start with a slab of the less expensive material that has been cut to the desired thickness.

2. *Marking the slab* – Mark the shape of the stone to be cut on the back of your slab. Use an aluminum pencil or nail. A template should be used to mark the stone to assure a uniform guideline.

**Note:** The cabochon cut is an excellent choice to start with. It is the oldest and simplest cut. A flat stone is smoothed around the edges to form a disk. Two bevels are made and the back is smoothed out. Generally, the back is rounded to improve the appearance of the stone and to add weight.



dop

3. *Rough cutting* – Use the trim saw to cut the marked stone out of the slab in the approximate shape you want. An abrasive disk or metal disk infused with powdered diamonds or other abrasives is generally used. A margin of up to 1/8-inch should be left around your mark on the slab. This rough "oversized" stone is now ready to be prepared for grinding.

4. *Dopping* – A rough cut stone is usually "dopped" on a stick or dowel with dop wax (cementing agent) to make it easier to handle during the grinding, sanding, and polishing steps. A wooden clothes pin (without the metal spring) makes a good dop. Heat both the dop wax and the stone. The stone should be heated to the same temperature as the wax to avoid stress to the stone when the wax is applied. Dip the top of the dop stick into hot wax.

The wax will adhere to the stick. Then, place the dop stick with the wax on the bottom of the heated stone (be sure the stone is level) and allow it to cool. Do not allow any wax to adhere to the top surface of the stone. When it is cooled, the dop can be used to manipulate the stone during grinding, sanding, and polishing. Dops are removed by placing the dop and stone in the freezer. The specimen can easily be removed from the dop when cold.

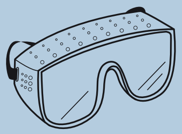
**Note:** An old electric iron can be used to melt the dop wax and heat the stone. The iron must be inverted and held in position so that the bottom of the iron is level. Experiment with the regulator to heat the wax just until it flows. Record the setting and time required to heat.

5. *Grinding* – Use the dop stick to hold your stone against a coarse grinding wheel (about 100-grit) to take off the excess rock evenly around your pattern. A supporting block with holes for the dop stick permits more precise control of the angle being ground. A medium grit wheel (about 220-grit) is used to shape and smooth the stone until there is an even border of about 1/16 inch around the pattern. This should remove the coarse grinding marks from the first grinding operation.

**Note:** The stone must be washed thoroughly in hot soapy water after each operation to remove any grit that may be on it. This is especially important between the sanding and polishing operations.

6. *Sanding* – The coarser (about 400-grit) rubber wheel or sander is used to further shape the stone and remove the marks left by grinding. The stone should be very close to its final size and shape before beginning this step. Finally, a fine rubber wheel or sander (about 600 grit) is used to remove the scratches from the previous sanding and to finish shaping the stone. The stone should be smooth and even with no “dips” or “flat” spots when the final sanding is completed.

7. *Polishing* – Polishing is the final step in making a fine stone. This may be done on a leather wheel using tin oxide as a polish or on a wooden or cloth wheel charged with fine abrasives such as rouge or Tripoli powder. The tin oxide is applied to the polishing side of the leather as a thin paste. If you have done all steps carefully, the polished stone should be bright and shiny. A well-shaped and polished stone is the mark of a skilled lapidary craftsman.



### Safety Reminder

Wear safety glasses or goggles when grinding stones.

# Geology Level 3

## Indiana 4-H Club Record

Name ______________________________ Grade ________ Year ________

Name of Club ______________________________ Year in Club Work ______

County ________________________ Township________________________

1. What did you enjoy most about the geology project this year? Why?

2. What were the most interesting things that you learned by taking the geology project?

4. How will knowing about geology help you in other areas (school, home, etc.)?

List the activities that you completed this year. Circle your favorite.

| Page | Title | What you learned |
|---|---|---|
| | | |

Signature of 4-H member ___________________________ Date __________

I have reviewed this record and made comments about the individual's progress and project completion.

Signature of Helper/Leader __________________________ Date __________

(You can copy or download this page from the 4-H Web site, www.four-h.purdue.edu)

# Notes

PURDUE UNIVERSITY | Extension

PURDUE UNIVERSITY | Extension

purdue.edu/extension

Find out more at
THE EDUCATION STORE
edustore.purdue.edu

EXPERT REVIEWED

An Equal Access/Equal Opportunity University

2007