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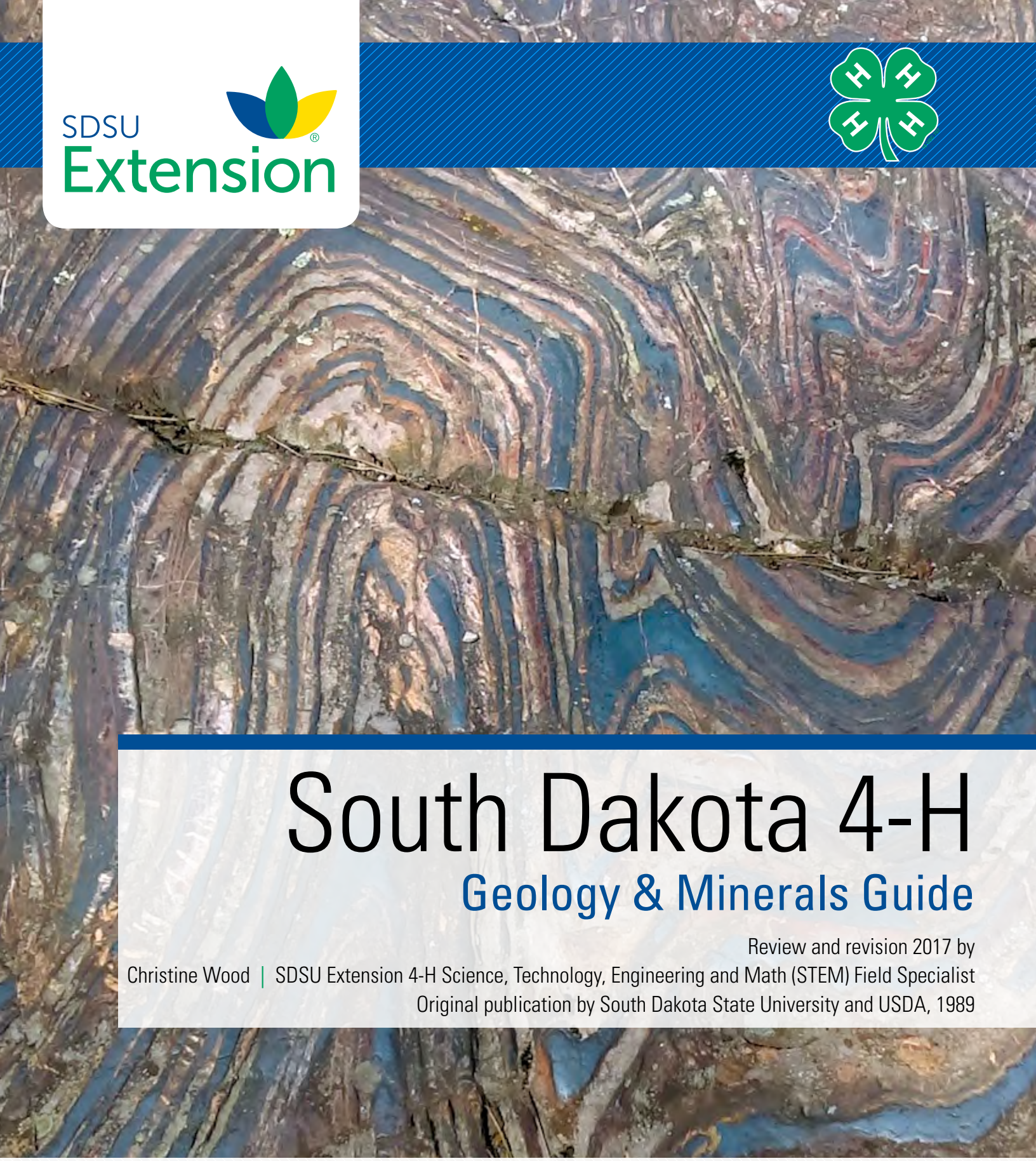

South Dakota 4-H

Geology & Minerals Guide

Review and revision 2017 by
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Folded banded iron formation (hematite and quartz) at the Soudan Mine, Minnesota
Photo courtesy of Dr. Brennan Jordan

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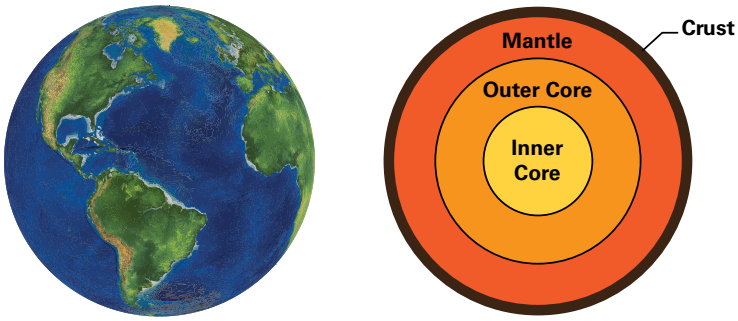
What is Geology?

Elements, minerals, and rocks are the building blocks of Earth. It is through the observation and study of these items that geologists are able to explore the physical body of Earth as well as other planets and moons. Through physics, chemistry, astronomy, zoology, botany, and other sciences geologists can develop and understanding of Earth's history, climate changes, precious metals and gems, past life (fossils), natural resources (water, natural gas, oil, etc.), and natural hazards (volcanoes, earthquakes, etc.).

Building Blocks of Earth



When you look at Earth, it appears to be mostly water; however, water is only found on the surface. Earth's surface is comprised of 70% water; the remaining 30% is the continental land masses. Underneath the water, plants, and soil, the Earth's crust is comprised of a rock layer that is thickest under the continents and thinnest under the oceans. The crust is divided into large tectonic plates that are responsible for earthquakes, volcanoes, and mountain ranges.

The next layer is the mantle consisting primarily of silicate rocks which are composed of magnesium and iron. These rocks move as they are exposed to heat causing movement of the plates of the crust. The mantle encapsulates the core of the Earth which is made up of two separate molten rock components. The solid inner core is made of a nickel-iron alloy and it is surrounded by the liquid outer core of nickel-iron alloy.

Elements

An element is a chemically pure substance that cannot be broken down into a simpler substance by non-nuclear reactions. Elements combine together to form the various compounds found all around us. While there are many different elements, most of the rock of the Earth's crust is composed of just eight: oxygen, silicon, aluminum, iron, calcium, sodium, potassium, and magnesium. These eight elements combine together in a countless number of combinations through different mixtures and different processes to form the many different minerals on Earth (more than 4,000!).

Clay minerals create "popcorn" texture of sedimentary rocks at the Badlands, South Dakota
Photo courtesy of Dr. Brennan Jordan

Minerals

Minerals are comprised of one or more elements and thus have a definite chemical composition and uniform structure at the molecular level. These characteristics give the mineral distinct physical properties that assist with its identification. To be a mineral, it must meet five requirements:

- Naturally occurring – Not made by humans
- Solid
- Definite chemical composition
- Ordered internal structure

Each mineral has a unique set of physical properties that can be used to identify it. Some properties that can be tested include:

- Color – though it can vary for many minerals is still a useful simple observation
- Streak – color of mark made when scratched on an unweathered surface (usually unglazed porcelain)
- Hardness – can be determined utilizing a scratch test and Mohs scale of hardness
- Luster – appearance of surface when viewed under reflected light
- Specific Gravity – ratio of weight of substance to equivalent volume of water
- Cleavage – tendency to split in definite directions, yielding a smooth surface
- Fracture – character of a surface produced when mineral is broken in any direction other than along cleavage plane
- Magnetism – does it have magnetic properties?

Rocks

A rock is a hard, naturally occurring combination of one or more minerals compacted or combined together. They are classified according to the processes that formed them, their mineral and chemical and particle size. There are three classes of rocks: igneous, sedimentary, and metamorphic.

Igneous Rock. Igneous rocks get their name from the Latin word ignis, meaning "fire." Igneous rock is formed from melted rock from the interior of the earth, called magma (underground) or lava (above ground), which has cooled and solidified.

Sedimentary Rock. Sedimentary rocks are formed through the accumulation and cementation of fragments of earlier rocks, minerals, and organisms. The particulate matter is compacted under moderate pressures and temperatures. There are 3 classes of sedimentary rocks: clastic, chemical, and organic.

Clastic. These sedimentary rocks are formed by mechanical weathering of rocks. Examples include sandstone, siltstone, and shale.

Chemical. When dissolved materials precipitate from solution these sedimentary rocks are formed. Some examples include rock salt, iron ore, and some limestone.

Organic. These sedimentary rocks form from accumulation of plant or animal debris. For example, calcium is found in shells, bones, and teeth. These bits of calcium can pile up and accumulate into a layer of 'organic' sedimentary rock. Examples include coal and some limestone.

Metamorphic Rock. Metamorphic means "changed form." Any rock type subjected to intense pressures or extreme heat while buried within the earth's crust can be completely changed into metamorphic rocks. The process of metamorphism transforms them into denser, more compact rocks.

Fossils - Fossils are the naturally preserved remains, or the representation of remains, of animals, plants, or other organisms that lived in the geological past. These are most often found in sedimentary rock. Trace fossils result from the activities or presence of creatures and plants. Examples of these traces include footprints, burrows, fecal matter, and root tunnels. At the larger end of the scale, fossils include bones, the largest belonging to dinosaurs. Fossils are clues to the past. Scientists use fossils to develop a history of the earth and its plants and animals.

Where to start?

Goals and Objectives

You do not need to be an experienced scientist to study and appreciate geology – many of the most important geological discoveries have been made by young people. 4-H Geologists can begin their journey through exploring their backyard, going hiking, and visiting museums to learn more about land forms, rocks, minerals, animals, weather, and plants.

Through the 4-H Geology project, youth will:

- Learn the differences between rocks and minerals and how to classify
- Develop an appreciation of geological history
- Begin to understand the importance that rocks and minerals have in our daily lives
- Begin to understand the enormous amount of time that it has taken nature to develop the landscape around us
- Develop an appreciation of past cultures and their contribution to the present
- Understand today's plant and animal life as compared to earlier eras
- Collect and preserve these fragments of history so that others that follow will also be able to appreciate the past

Opportunities

Volcanology students in the South Dakota School of Mines field camp in Iceland study young rhyolite and basalt lava flows
Photo courtesy of Dr. Brennan Jordan

The 4-H Geology project area provide youth with learning experiences as well as opportunities to showcase what they have learned. Some of the opportunities youth have to experience learning about Geology are through:

- Going on field trips and tours
  - SD School of Mines Museum of Geology in Rapid City, SD
  - The Mammoth Site in Hot Springs, SD
  - Jewel Cave National Monument in Custer, SD
  - Petrified Forest in Piedmont, SD
  - Petrified Wood Park in Lemmon, SD
- Visiting rock shops and rock shows, learn about cutting and polishing, and learn commercial uses of rocks and mineral
- Check out the South Dakota Geological Survey Bookstore in Vermillion, SD
- Collecting samples of rocks, minerals, fossils, and artifacts.
- Collecting as many of your own specimen as possible. However, it is permissible to trade, sell and buy specimens to complete your collection
- Reading literature about Geology to learn more about specimen
- Identifying, classifying, labeling and indexing all specimens collected
- Visiting museums and study the rocks, minerals and fossils you found on exhibit

Youth can then showcase their learning by:

- Giving presentations or demonstrations on project activity
- Developing an educational poster
- Creating an educational display
- Preparing and exhibiting collections so others may learn and benefit from the experience

Resources

One of the best way for youth to learn about their geological finds is for them to dive into literature about geology. Some resources they might consider are:

- *Fossils, Rocks and Time* by Lucy E. Edwards and John Pojeta Jr. http://pubs.usgs.gov/gip/fossils/
- *Geology for Kids – The Study of Our Earth*; chapter two –Earth, Rocks and Landforms http://www.kidsgeo.com/geology-for-kids/0019-inside-of-earth.php
- *Our Changing Continent* by John S. Schlee http://pubs.usgs.gov/gip/continents/
- *Roadside Geology of South Dakota* by Paul Gries, Mountain Press, 1996
- *Rock Hounds* – Discover How Rocks are Formed! http://www.fi.edu/fellows/fellow1/oct98/create

How to Develop Collections

Collecting geological samples is a great way to display skill and knowledge gained through the 4-H Geology project. As you build your collection you will: collect, keep records, clean, identify, and display your specimens. You may consider using shoe boxes, baking pans, plastic storage boxes, or egg cartons to store your specimen as your collection grows; however, these will NOT be allowed as display cases for fair exhibits.

Where to Find Samples?

Geological specimens can be found anywhere but some of the best places to find specimens are in quarries, rock out croppings, steep banks, gravel and sand pits, creek or stream bottoms, along the shores of some lakes or rivers. Level country and open fields provide poor opportunities to find specimen.

The South Dakota Geological Survey (http://www.sdgs.usd.edu/)has a repository of good information on rocks, minerals and fossils. Publication E-05, Rocks and Minerals of South Dakota should assist with planning your field trips for collecting as they show numerous locations of deposits.

University of South Dakota students sketching and describing geologic relationships in banded iron formation at the Soudan Mine, Minnesota Photo courtesy of Dr. Brennan Jordan

Selecting specimens should be done with care. Keep in mind that your collection is an assortment of samples. Rocks should be about fist-sized. Mineral specimens about 2-inches in diameter. Crystals, fossils, and artifacts will vary in size. Near perfect specimen are always much more valuable but difficult to find.

Citizenship & Safety

- Do not collect rocks from national or state parks and monuments without permits – be careful to only collect the things you have permission to collect.
- Take only what you need for your own collection, leave what you can't use.
- Keep our natural environments beautiful. If you pack it in, pack it out.
- Respect the rights of landowners and lessees. Make sure you have permission to collect on private land, including mines.
- Refill all holes when digging for specimen
- Be extremely careful around old mines, especially mine shafts.
- Respect the weather. Carry plenty of food and water. Be aware of changing weather conditions and possibilities of storms.
- Never hike or collect alone. Know where you are, how to get back safely, and whom to call in an emergency.
- If you see something that was made by people—anything from arrowheads to old bottles—you should leave it alone and ask the landowner what to do. Sometimes these are associated with old homesteads, ceremonial sites, or even burial sites, and should not be disturbed. You may be the first person to find such a site. If you do find something like this, you should act like a CSI detective. Don't walk through, dig, or disturb a site. Make notes, take pictures, get GPS information, and notify the landowner as soon as possible. You may have found an important archaeology or history site. Remember that it belongs to the landowner, and that you are helping everyone by being responsible for site protection.

Equipment you will need

Tools

- Small picks or probes for small rocks and fossils. If you can gently remove specimens without a pick or hammer, do so to minimize disruption and damage.
- Geologist's Pick or Mason's Hammer (a carpenter hammer is too brittle) – Breaking rocks, prying small chucks, or working out minerals requires the use of a tempered hammer and some skill. A flat-faced hammer works for breaking and trimming rocks. Use light well placed blows to avoid ricocheting fragments.
- Cold Chisel (all metal) - for Cutting Rock
- Magnifying Glass – Determining crystal size and mineral content can be done utilizing a magnifying glass with a power of 8x or 12x.

University of South Dakota students learning how to use clinometers to estimate the angle of a fault (notice offset in rock layers) in the Badlands, South Dakota
Photo courtesy of Dr. Brennan Jordan

- Pocketknife – The hardness of rocks and minerals can be tested utilizing a pocketknife. Pocketknives can also assist with digging in soft rocks or dirt.

Personal Protective Equipment (PPE)

- Goggles – As you hammer or chisel at rocks, the potential of fragments flying exists. You and anyone accompanying you should wear protective lenses to prevent these fragments from entering your eyes.
- Gloves – Collecting samples puts your hands at risk for scrapes, cuts, and bruises; which can be prevented or lessened by good gloves
- First Aid Kit – extremely important!

Field Guide

Suggested Field Guides

- Peterson First Guide to Rocks and Minerals
- Peterson Guide to Rocks and Minerals
- Golden Press Pocketbook 'Rocks and Minerals' by Zim
- Golden Press Pocketbook 'Fossils' by Zim

Other

- Compass/Map/GPS – As you explore, be aware of your surroundings and knowledgeable of how you
- Field Bag for Collection – A lightweight sturdy bag will be required for carrying collected samples.
- Old Newspapers or Small Paper Sack – Before placing specimens into your bag for carrying, you should protect them by wrapping them in newspaper or cloth.
- Notebook and Pencil – Always record notes of where and when you located your various specimen. You can use a map to chart sampling locations or a GPS to record the longitude and latitude.
- Label – be sure to label your specimens right away. As specimen are collected label them with a number (you can wrap them in a piece of paper marked with the number, use masking tape, or place each specimen in their own container with a notecard) and indicate the number and corresponding details within your notebook. Indicated the location and date of the find within your notebook

Record Keeping

Record keeping is the most important portion of any geological exploration. Be sure to have a notebook handy and record the following about each specimen:

- Specimen number (number them in according to the order you found them)
- Date collected or purchased
- Location of the find (at a minimum the state, country, and approximate distance from nearest town)
- Type of sample
- Description or name of specimen
- Observations about the specimen
- Observations about the location (note any topographic and/or geographic features of the area; plants in area; other rocks)

Cleaning

A brush or probe may be used to carefully remove surface weathering, moss, or lichen. A fine brush can be used to gently remove soil and debris from the sample; however, take care as some rocks can be damaged by brushing to harshly. Cold or lukewarm water can be used to clean specimens, but be careful since some minerals dissolve in water. Never use hot water since it can cause some minerals to crack or break. Allow specimens to air dry.

After cleaning you will want to place a spot of white enamel paint about half the size of a dime on the rock. Place the enamel on the side of the sample that will not be seen when displayed. After the paint is dried, write the number on the spot with a Pigma Micron pen (can be found at most craft stores).

Identification & Classification

University of South Dakota students examining the San Andreas fault in California.
Photo courtesy of Dr. Brennan Jordan

Proper identification of the specimen is critically important and can be extremely challenging for beginning geologists. Your first resource to refer to when identifying rocks and minerals is the field guide. With field guide in hand, you will be able to compare the physical properties of a mineral to descriptions and pictures in your guide. Most common minerals can be identified by their physical properties. These properties are color, streak, transparency, luster, hardness, cleavage, fracture, specific gravity, and crystal form.

Utilize the knowledge of your geology project leader or advisor. He or she can guide you in proper identification. Seek out assistance from local resource people such as a science teacher or local rock hound. And don't forget about the many resources that can be found on the internet.

It is absolutely necessary to identify your specimens accurately!

Identification is best made by the physical characteristics of rocks and minerals (reference your chosen field guide). Color, hardness, streak, specific gravity, cleavage and possibly crystal form all aid in identification. Geologists at state universities, museums or geological survey centers will help identify difficult specimens. Local rock club members also can be of assistance.

One step beyond identification, classification shows you the relationship between rocks and minerals. You sort your specimens into rocks – minerals – crystals – fossils – artifacts.

> Minerals – These collections may be exhibited as a combined collection of minerals or may be exhibited as classified mineral collections: Rock-forming, Minerals, Major Metallic Minerals, Minor Metallic Minerals, non-metallic Minerals and/or Gem Minerals.

Rocks – Your rock collections will need to be broken down into the following classes:

- Igneous: Rocks formed at high temperatures from molten materials
- Sedimentary: rocks formed by action of water, wind or organic agents
- Metamorphic: rocks that have been altered by heat, pressure, or chemical addition

Crystals – These collections may be exhibited as one group of a variety of crystals or they can be classified into any of the six major crystal systems: cubic, tetragonal, hexagonal, orthorhombic, monoclinic, and triclinic.

Fossils – These collections may be classified into Animal (vertebrate, or invertebrate), Plants, Insects, or a combination of the three classifications

Labeling & Displaying

Begin with the placement of a circular piece of white tape or a spot of quick-drying enamel on the specimen in an inconspicuous place. A number is given to the specimen and indicated in the catalog or specimen index file.

Guidelines for Exhibits

For guidelines on public presentations, and educational posters please see the State Fair Book.

For county and state fair 4-H display exhibits:

- All specimen are properly cleaned and arranged for maximum showmanship.
- Display specimens should be somewhat small – approximately 2 inches in size. The collection will display better if the samples are about the same size. If you find spectacular, large mineral samples or fossils, keep these the way you find them.
- All specimen must have identification number visible – indicating they have been catalogued.
- Labeling of specimen in an exhibit should be shown as lot description (found in State Fair book).
- Collections should be displayed in an 18" x 24" x 3 ½" inch wood box with a Plexiglass cover (Figure 1). While handy for storing specimens at home, the following items are NOT acceptable for displays: shoe boxes, baking pans, plastic storage boxes, or egg cartons.
- Each specimen is to be mounted and labeled in the exhibit box. Boxes will be displayed in an upright position (not flat), so make sure your specimens are firmly fastened to the floor of the box.

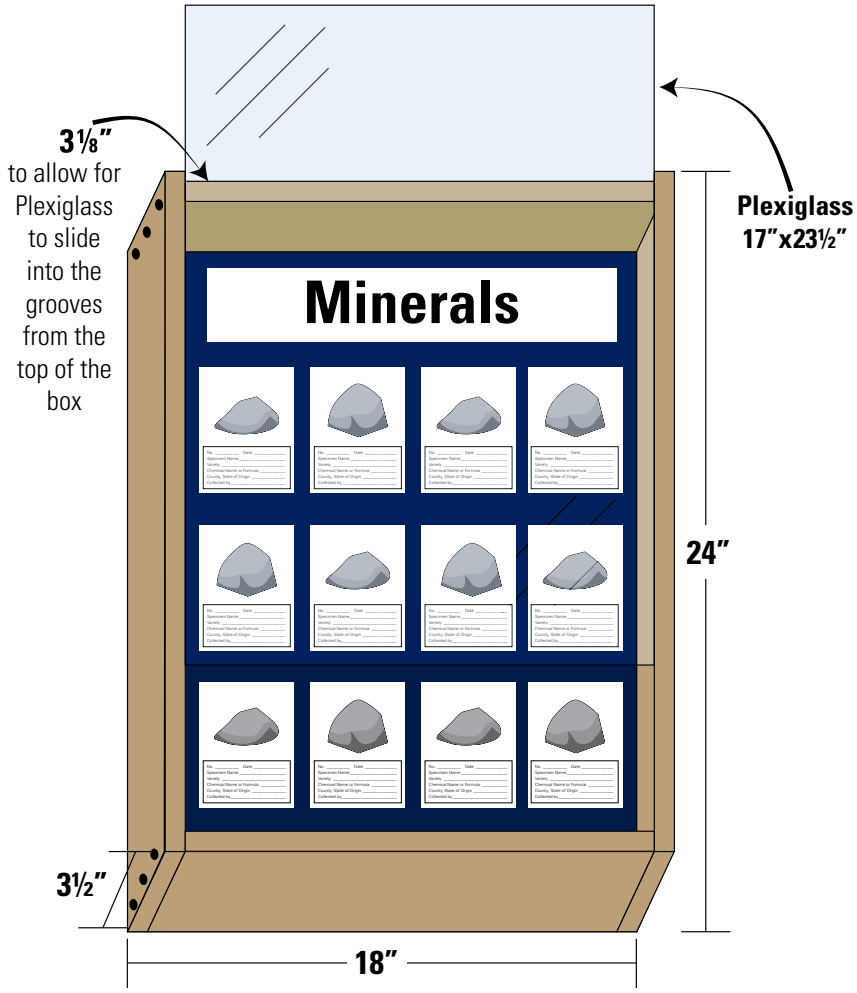


Figure 1: Geology Display Case

Materials needed:

1. Bottom ¼" x 18" x 24" plywood or ⅛" x 18" x 24" tempered masonite
2. Two side pieces of pine ¾" x 3½" x 24" groove to accept cover ¼" x ⅛"
3. One end piece of pine ¾" x 3½" x 16½" groove to accept cover ¼" x ⅛"
4. One end piece of pine ¾" x 3⅛" x 16½"
5. One cellotex or celling tile ½" x 16½" x 22". Cover bottom so pins will stick.
6. One piece of cloth or felt to cover bottom, about 18" x 24".
7. One plexiglass for cover ⅛" or more x 17" x 23½"

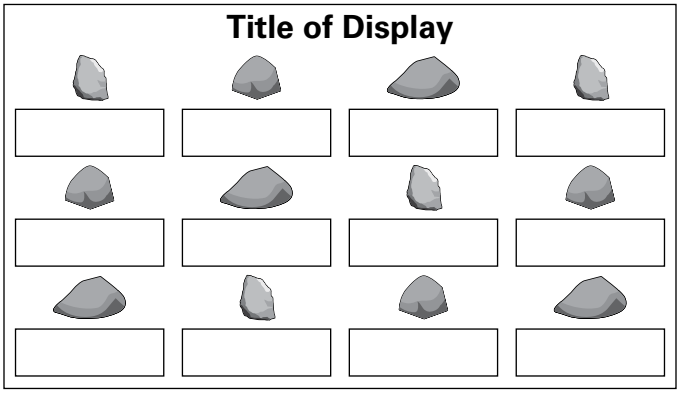
Display Box Suggestions

In order to be able to easily remove your specimen from the display case, consider mounting the specimen on a small piece of cardboard or cardstock (half of an unlined 3.5 index card is good for most specimen). Glue your specimen firmly to it about 1/3 of the way down the card to leave room for the label. Be careful that no extra glue is showing. You can utilize a glue gun or Elmer's Glue, but be sure to allow it to fully dry in a flat position. Proof-read and glue labels on the bottom 1/3 of the card.

Be sure to give your box a title to indicate the type of Geology collection you are exhibiting (use lot name). Arrange the box in a neat and logical fashion. Put large, heavy specimens at the bottom of the box. Use a straight edge to ensure rows are straight. Use short pins to secure the cards and labels down (be sure to push them all the way in).

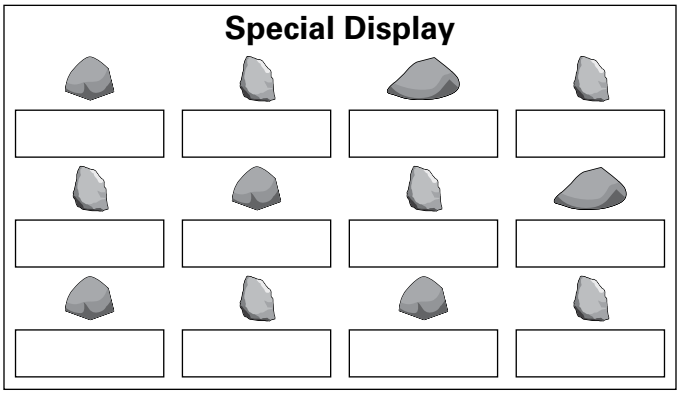
Educational Display

Using any or all of the following: fossils, minerals, crystals, jewelry, or lapidary specimens. Twelve specimens in exhibit. Label each according to its classification (specifics found under each display lot below). Displays should be adequately titled to catch attention of viewer and describe display type. Displays must be accompanied by a project booklet providing background information on each specimen.



Display Lots

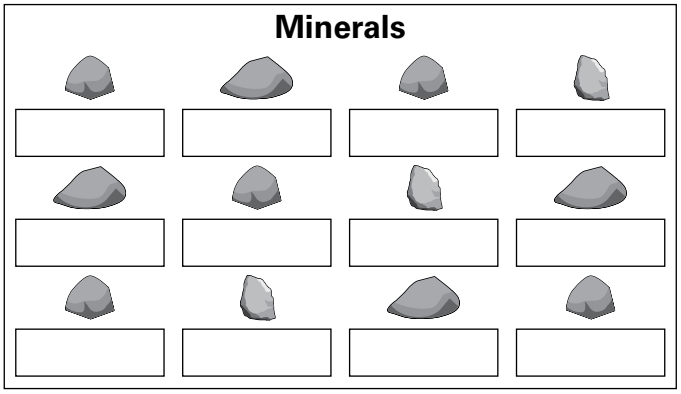
Special Collection – This exhibit must contain 12 labeled specimens of any one or combination thereof: fossils, rocks, minerals, jewelry, crystals, or lapidary. Each Specimen should be labeled according to directions for that particular type of collection (see collection types below).



Mineral Collection – The recommended size of each specimen in this collection should not exceed 2 inches in diameter. This collection is to consist of 12 specimens. Each specimen is to be labeled as indicated. May be exhibited as a group of various minerals or shown in various classifications.

Label Should Include:

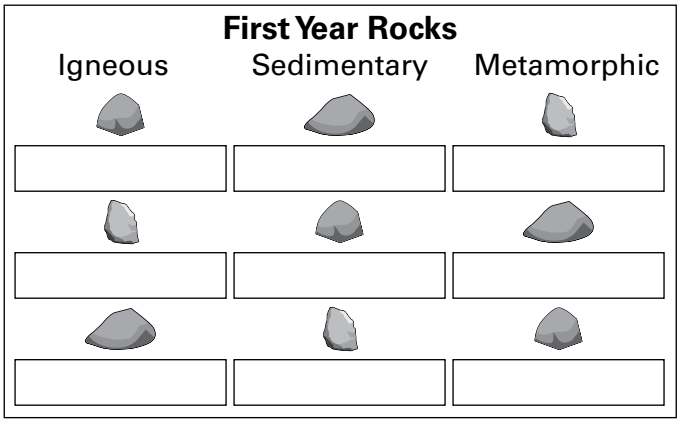
No. _____ Date _____
Specimen Name_____
Variety _____
Chemical Name or Formula _____
County, State of Origin _____
Collected by_____



First Year Rock Collection – This collection should consist of 2 igneous, 2 sedimentary, and 2 metamorphic rocks. Suggested minimum size 2 inches in diameter, maximum sized to be the size of average fist.

Label Should Include:

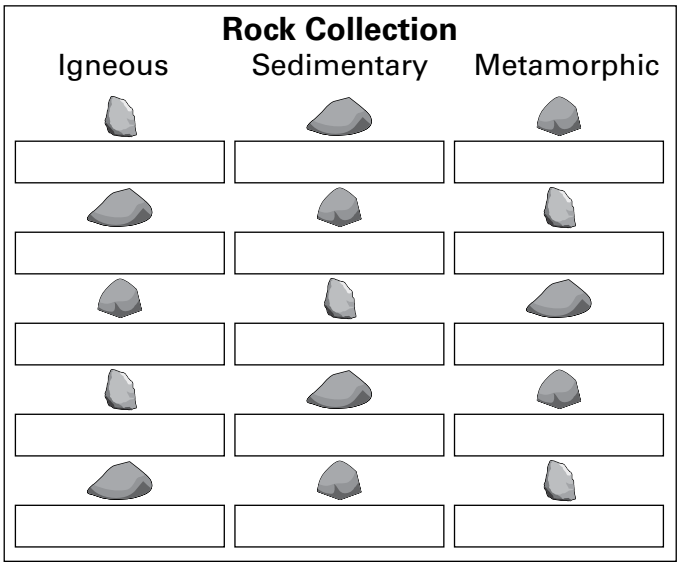
No. _____ Date _____
Name of Rock _____
County, State of Origin _____
Collected by_____



Rock Collection – This collection should consist of 5 igneous, 5 sedimentary, and 5 metamorphic rocks. Suggested minimum size 2 inches in diameter, maximum sized to be the size of average fist.

Label Should Include:

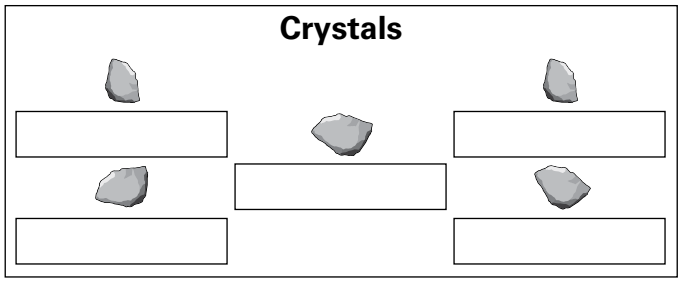
No. _____ Date _____
Name of Rock _____
County, State of Origin _____
Collected by_____



Crystal Collection – This collection should consist of 5 specimens. Crystal collection can include single crystals with or without matrix, twin crystals, or crystals with inclusions. Each Specimen to be properly labeled.

Label Should Include:

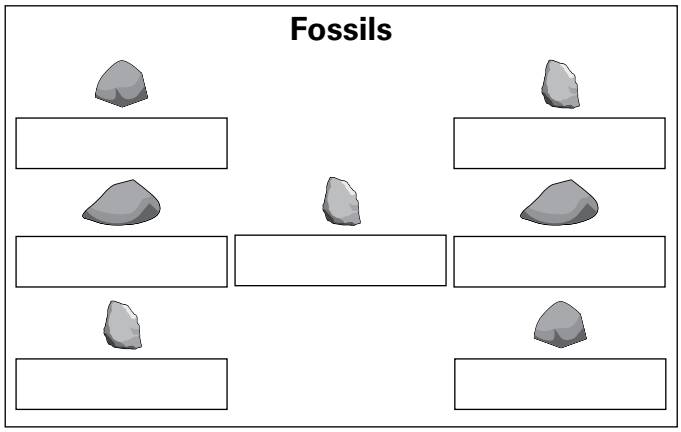
No. _____ Date _____
Name of Crystal _____
County, State of Origin _____
Collected by_____



Fossil Collection – The collection may consist of animal, plant or insect fossils in one collection. There are to be 7 specimens in this collection. Fossils can be classified into animal (vertebrate and invertebrate, plant, and insect collections if you so desire. Each fossil specimen shall be properly labeled.

Label Should Include:

No. _____ Date _____
Phylum _____
Class_____
Common Name _____
Period _____
County, State of Origin _____
Collected by_____



Jewelry and Metalcraft – Metalcraft refers only to articles intended for general ornamentation and/or service. Examples: vases, vanity boxes, etc. Jewelry refers only to articles intended for personal ornamentation and wear. Examples: rings, tie clasps, earrings, cuff links. A pair of matched earrings or cufflinks is considered one specimen.

Use of finished stones, fossils, or mineral specimens in all articles of metalcraft or jewelry is mandatory. All specimens must bear a label showing the name of the material used. Label need not refer to the metalcraft or jewelry unless exhibitor so desires. Five specimen are required for exhibit.

Label Should Include:

No. _____ Date _____
Specimen_____
County, State of Origin _____
Collected by_____
Made by_____