Lake Superior Rocks!

Geology of the Lake Superior Basin

Grade Level: 5 – 12

Activity Duration: 45 min – 1hr

Overview:
I. Classroom set-up
II. Geology Rocks!
III. Geo-theater
IV. Geology Timeline
V. Lake Superior Rocks!

Summary: Northern Minnesota has a dynamic geologic history born of oceans, fire, and ice. The rocks that we now see along the shoreline can help us to tell the story of what happened in this region. In this lesson students will actively develop an understanding of geology of the Lake Superior Basin through geo-theater, rock identification, geologic timeline exploration, and more!

Topic: rocks, minerals, natural history

Theme: Geological forces that created the Lake Superior basin are still visible today.

Goals: Students will identify geologic events that contributed to the formation of Lake Superior, by creating or acting out a timeline. Students will identify four common rocks found in the Lake Superior basin.

Objectives:

1. Students will identify the three rock groups.
2. Students will explain at least three geologic events that contributed to the formation of Lake Superior.
3. Students will place major geologic events of the Lake Superior basin in chronological order.
4. Students will identify four common Lake Superior Rocks.

Suggested Minnesota Science Standards

K-5th grade

0.2.1.1.1 – Physical Science, Matter
Sort objects in terms of color, size, shape, and texture, and communicate the reasoning for the sorting system.

1.3.1.3.1 – Earth and Space Science, Earth Structure and Processes
Group or classify rocks in terms of color, shape, and size.

1.3.1.3.3 – Earth and Space Science, Earth Structure and Processes
Identify and describe large and small objects made of Earth materials.

4.3.1.3.1 – Earth and Space Science, Earth Structure and Processes
Recognize that rocks may be uniform or made of mixtures of different minerals.

4.3.2.3.1 – Earth and Space Science, Earth Structure and Processes
Identify where water collects on Earth, including atmosphere, ground and surface water, and describe how water moves through the Earth system using the processes of evaporation, condensation, and precipitation.

5.1.1.1.4 – The Nature of Science and Engineering, The Practice of Science
Understand that different models can be used to represent natural phenomena and these models have limitations about what they can explain.

5.3.1.2.1 – Earth and Space Science, Earth Structure and Processes
Explain how, over time, rocks weather and combine with organic matter to form soil.

5.3.1.2.2 – Earth and Space Science, Earth Structure and Processes
Explain how slow processes, such as water erosion, and rapid processes, such as landslides and volcanic eruptions, form features of the Earth's surface.

Grades 6 – 12

8.3.1.2.1 – Earth and Space Science, Earth Structure and Processes
Explain how landforms result from the processes of crustal deformation, volcanic eruptions, weathering, erosion, and deposition of sediment.

8.3.1.2.2 – Earth and Space Science, Earth Structure and Processes
Explain the role of weathering, erosion, and glacial activity in shaping Minnesota's current landscape.

8.3.1.3.1 – Earth and Space Science, Earth Structure and Processes
Interpret successive layers of sedimentary rocks and their fossils to infer relative ages of rock sequences, past geologic events, changes in environmental conditions, and the appearance and extinction of life forms.

8.3.1.3.2 – Earth and Space Science, Earth Structure and Processes
Classify and identify rocks and minerals using characteristic including, but not limited to, density, hardness and streak for minerals; and texture and composition for rocks.

8.3.1.3.3 – Earth and Space Science, Earth Structure and Processes
Relate rock composition and texture to physical conditions at the time of formation of igneous, sedimentary and metamorphic rock.

9.3.1.1.1 - Earth and Space Science, Earth Structure and Processes
Compare and contrast the interaction of tectonic plates at convergent and divergent boundaries.

9.3.1.1.4 – Earth and Space Science, Earth Structure and Processes
Explain how the rock record provides evidence for plate movement.

9.3.1.3.1– Earth and Space Science, Earth Structure and Processes
Use relative dating techniques to explain how the structures of the Earth and life on Earth have changed over short and long periods of time.

9.3.1.3.2 – Earth and Space Science, Earth Structure and Processes
Cite evidence from the rock record for changes in the composition of the global atmosphere as life evolved on Earth.

Environmental Literacy Scope and Sequence

Benchmarks:

- Social systems and natural systems are made of parts. (preK-2)
- In social and natural systems that consist of many parts, the parts usually influence each other. (3-5)
- Social and natural systems can include processes as well as things. (6-8)

Concepts addressed: abiotic factors, properties, change and constancy, cycles, scale, stratification, climate, geomorphism

Materials

File Folder
- Lesson Plan
- Background Information
- Geo-Theater Script
- Geology Timeline Script

Map of Lake Superior
Geo-Theatre
- Two pieces of crust with Velcro connected in center
- Lava (red and yellow strips of material)
- Rain (pom-poms)
- Wind (pinwheel)
- Water (blue fabric)
- Glacier bulldozer
- Paper or sponge for rocks

Geology Timeline
- Clothesline 45 feet long
- Clothes pins marked with geologic events

Mineral Cards
- Large Pictures (4)
- Mica (9)
- Feldspar (9)
- Quartz (9)
- Silica (9)

Lake Superior Rocks
- Lake Superior rock containers (12)
- Lake Superior Rock ID Charts (12)
- *Rock Picker's Guide to the North Shore* (12)

Classroom Set-Up

The Geo-Theater, crystal formation demonstration, and rock type game all require a large space. Consider playing these games in a gym, or moving desks to the edge of your classroom. Almost all of this lesson could be adapted to teach outside.

Procedure

I. Introduction

Show the students the map of Lake Superior. Ask the students:

- How Lake Superior formed?
- How did Lake Superior get here?
- Was it always here?
- Has it been here a long time?
- How did all of the water get here?

The earth can tell amazing stories in its rocks and are the key to understanding the past. We can look at the way Lake Superior appears today as *geologists* (scientists who study rock and minerals) to better understand how it formed long ago. Today we are going to learn more about Lake Superior geology and the history of this region.

II. Geo-Theater (see laminated script cards in file folder)

How did Lake Superior form? How did all the water get here? Was it always here? Has it been here a long time?

We are going to act out the history of this area! A long time for us may be 50 or 100 years, but when we think of GEOLOGIC time, we really need to stretch our brains out, way out, to a billion years ago (1.1B), when our story starts.

Recruit 9 volunteers, briefly explain their roles to them, and put their costumes on prior to beginning.

Crust: 2 volunteers (one to hold crust piece on each end)
Lava: 1 volunteer (red scarves)
Rain: 1 volunteer (blue pom poms)
Rocks: 1 volunteer (bag of crushed paper)
Glacier: 1 volunteer (bulldozer)
Lake Superior: 1 volunteer (visor and fishing pole)
Lake level: 2 volunteers (hold one end of the blue fabric)

Read the script below (laminated cards are in the file folder) and describe the actions to the actors that are written in italics.

Dramatically introduce Geo-theater. *Lights! Camera! Action!*

<u>Stage One:</u>
Three billion years ago (or a long, long time ago), the earth resembled a big pot of chicken dumpling soup. The dumplings were the core of the new continents. They were a rock called granite (Send in the crust volunteers). One of these granite dumplings popped up in what is now the North Shore of Lake Superior. Another popped up in what is now the South Shore. They formed mountains over 25,000 feet high.

<u>Stage Two:</u>
Then the continent began to split in half, right where Lake Superior is today. The continent pulled apart in a mighty rift (Have the crust volunteers pull the crust apart to split it in two pieces). Lava poured out of the rift until it was 20,000 feet thick (Have lava volunteer come out of space between the two pieces of the crust). As the lava cooled it turned into a type of rock called basalt (Have lava volunteer freeze into rock). Basalt makes up most of the cliffs and rocky shoreline of the North Shore of Lake Superior. This formed a huge valley, about 200 miles long and 100 miles wide (Have crust volunteers lift the edges of the crust to make it taller).

<u>Stage Three:</u>
Due to rain, wind, and freezing and thawing (Have rain volunteer "rain" and have the rest of the class make wind noises) some of the old granite mountains eroded

down into the valley covering the basalt with sand and gravel (Have lava volunteer get up and have rock volunteer dump rocks in the space between the two pieces of crust). In the eastern part of the lake, shallow seas migrated in. The sand on the bottom of these seas built up over time and hardened into a rock called sandstone.

Stage Four:
Then it got really cold, and continental glaciers poured out of Hudson Bay. The glaciers went right down the middle of the rift valley and scooped out all the loose rock. The glaciers carried the loose rock many miles away (Have glacier volunteer push the rocks out of the space between the two pieces of crust using the bulldozer).

Stage Five:
When the glaciers began to melt, fresh water filled the huge hole it carved (Have glacier "melt" and move out of the way. Then have the Lake Superior volunteer come in wearing the visor and holding the fishing pole). This huge lake at one point was 600 feet higher than today's Lake Superior. This higher lake was called Glacial Lake Duluth (Have lake level volunteers come in and stand next to crust volunteers – you can tell the class that the level of Glacial Lake Duluth is where Skyline Drive is today). The lake level went up and down a lot (Have lake level volunteers move the lake level up and down). Finally, about 4,000 years ago (or a long time ago) the lake level settled into its current level (Have lake level volunteers stay at one height).

Stage Six:
As time goes by waves pound the shoreline of Lake Superior and smooth out the rocks, forming many interesting beaches (Have lake level volunteers make waves). The currents carry sediment around the shoreline and create sandbars that are up to seven miles long (Park Point).

And that brings us to Lake Superior as we know it today…
Let's give our volunteers a huge round of applause! Collect the props from the volunteers as they sit back down.

Discussion/Review
Have students briefly recall the important events in Lake Superior's formation.
For example:

- What happened due to the rifting?

- Can you name some causes of weathering/erosion?
- What main force transported our soil further south?
- Where did the water come from to fill the lake?

III. Geology Timeline

*** You may want to organize the clothes pin in order before the demonstration***

After watching or acting out the "geo-theater" it is also important to understand how much time has passed. The geology timeline helps students understand how much time is considered when talking about rock formation and the rock cycle. In this activity students will have an opportunity to see how much time has passed since the first rocks were formed here on earth.

Have two volunteers hold the clothes line out across a space where all students can see. Ask the students what this line might represent? 100 years? 50 years?

Explain that one end of the clothes line represents "today" and the other end represents 4.6 billion years ago (BYA). That is a lot of time! Have the students guess when and where different events (whether human or geologically related) would be on the clothesline. Work your way from 4.6 BYA to present day, adding clothes pins in the following order (a print out of this order is in the file folder)

1. *"First Rocks"—The hot lava from inside of the earth erupted and cooled. Some rocks cooled more quickly than others, making smaller or larger crystals.*

2. *"Oceans in Minnesota"—The area now known as Minnesota used to be a shallow, warm sea. This caused pockets rich in iron deposits.*

3. *"Rift" or "Mid-Continental Rift"—The earth crusts sits upon several different plates that are slowly pushing and pulling each other. This motion is referred to as "Plate Tectonics" and cause mountain ranges and deep trenches on the earth. A mid-continental rift occurred in what is now known as Minnesota causing deep trenches, lava flows, and small mountains.*

4. *"Erosion and Sandstone"—Softer rocks and minerals cannot tolerate wind, rain, and weather as much as harder, more durable minerals. Sandstone, a very*

common rock found in Minnesota, is a great example of a soft rock that minimizes and erodes away quickly when exposed to harsh conditions.

5. *"Dinosaurs"—The earth's climate has fluctuated significantly over the span of geological time. There have been scientific discoveries made that dinosaurs once roamed this land.*

6. *"Early Humans"—At this point in geological time humans were discovered to be living and surviving earth.*

7. *"Glaciers"—Lake Superior and the surrounding area were once covered in a mile thick glacier. This time period helped shape the landscape we see here today. Signs of glaciation can still be seen in rocks near the shore. The heavy glacier trimmed the mountains found up both the south and north shore of Lake Superior.*

8. *"Fluctuation" –The water level or Lake Superior has gone up and down during its rather short life. At one point the shore of Lake Superior was where "Skyline Drive" is now today.*

Event	Time (millions of years ago)	Distance from 'Today'
First rocks on earth	4000	39 feet
Oceans present in what is now MN, Iron deposits	1800	20 feet
Mid-continental rift	1100	11 feet
Erosion and sandstone deposits	1000	10 feet
Dinosaurs, what is now MN located near tropics	300	3 feet
Early humans	2	0.25 inches
First glaciers begin	1.6	0.2 inches
Lake Superior lake level fluctuate	.05 - .09	0 inches

What does the timeline tell us about Lake Superior? It is relatively young!

IV. What is a rock?

Ask the students to think about the last time they visited the shore of Lake Superior. What did they find there? Have they ever skipped a rock into the lake? Did they ever stop to think about the rock they were tossing in the water and where if might have come from? Did they ever stop to think about what the rock is made of?

Definitions:
Mineral – a pure substance with a unique crystal structure
Rock – a mixture of many different minerals

Rocks are made up of different minerals. Different combinations of minerals create different types of rocks. The amount of time that a rock has to cool can also affect the final outcome. Rocks that have a longer cooling time have larger and often times more visible mineral crystals. Rocks that have a quicker cooling time may have less visible minerals.

Cookie Analogy:
Ask the students to raise their hand if they like cookies. Have a few students share their favorite type of cookie. What makes these cookies different from another? The ingredients! Some cookies have chocolate chips or peanut butter or white chocolate! Cookies are just like rocks! Rocks are made up of a number of ingredients, too. Rock ingredients are called minerals.

Ask the students if they have ever baked cookies? Do all cookies get baked at the same temperature? Do all cookies get baked for the same amount of time? No! Some cook at cooler temperatures and different cookies require different cook times. Just like cookies, rocks form at different temperatures! Minerals can be formed into different rocks by the amount of time they had to cool.

We are going to play a game that can help us better understand rock formation.

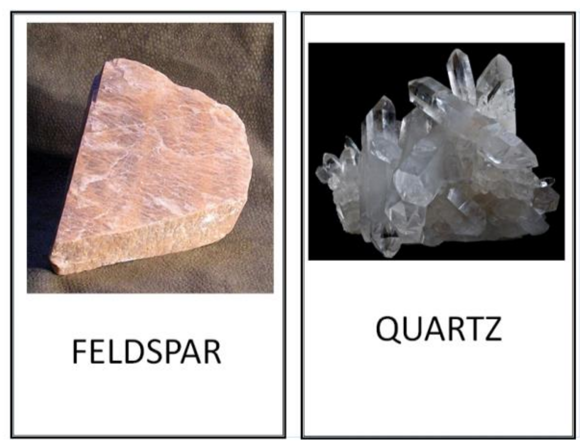
Rock Formation Game:
Mix up the cards so there is an equal amount of each mineral to pass out to the students.

1. Show the students the different mineral cards. Explain that these are the minerals that make up many common rocks in the Lake Superior Basin. Remember: minerals are the ingredients that make up rocks!

2. Pass out one card to each student. Be sure that they conceal their mineral so no one else can see which card they have.

3. Have the students stand up and spread out around the room. Be sure that they keep their minerals cards hidden from each other.

4. Explain that they are going to create a rock in the classroom. Tell them that when you say "go" they will need to find the other matching minerals without using their voices. Tell them when you say "stop" they must stop where ever they are—even if they didn't find all the other matching minerals.



5. Say "go" and allow the class 5-10 seconds to find the other minerals (this is initially not enough time to show quick cooling)

6. Say "stop." Have the different minerals raise their hands one group at a time. Did all the mineral cards get together? No! This is a great example of a rock that

cooled quickly. The minerals are not in groups making smaller crystals. Rocks that cool quickly have small crystals.

7. Say "go" and allow the class all the time they need to get into their mineral groups. Have the different mineral groups raise their hands one group at a time. Did all of the mineral cards get together this time? Yes! This is a great example of a rock that cooled with more time. The minerals were able to get into larger groups making larger crystals. Rocks that have more time to cool have larger crystals.

8. You can collect the cards and do this activity again or collect the cards and move onto the next activity.

What happened during the second round of this activity? What might that tell you about the time it takes for crystals to form in a rock? Would you expect to see more crystals that cool in a rock that had a lot of time to cool or a rock that had just a little time to cool?

V. Types of Rocks

Rocks provide the structural foundation for the earth's crust. The earth's crust is made up of dozens of different types of rocks, but each forms in one of these three ways:

1. Igneous – Draw a picture of a volcano or show the students a picture of a volcano. Rocks form when magma cools and hardens. These rocks are called *igneous rocks.* Some igneous rocks form underground when magma that is pushed up toward the crust cools and crystallizes before it reaches the surface.
   Igneous rocks:
   1. Are created through very hot volcanic forces
   2. Are often hard and durable
   3. Can include small bubbles frozen into shape

2. Sedimentary – Rocks are layered. Most of these rocks get their start as wind, ice, and water wear down rocks into bits of sand, soil, mud, pebbles, clay, and other loose sediment. As this sediment washes into rivers, lakes, and oceans, it piles up, layer

upon layer. Have several students come up and demonstrate layering by creating a "hand pile". Each hand represents a different layer of sediment. Over time, as the pressure on the bottom layer increases, the sediment lithifies, or turns to rock. Ask the students with their hands on the bottom of the pile if they feel the pressure building up. The sediment compacts and cements together to form solid rock. When rocks form in this way they are called *sedimentary rocks.*

Sedimentary rocks:

1. Are made up of lots of different pieces cemented together
2. Are usually rough and could be sandy feeling
3. Sometimes contains fossils

3. Metamorphic – Write the word "metamorphic" on the board. Ask the students if they know what it means. If they are not sure have them try to think of a word like it. If they need a hint say the word "butterfly". The students should be familiar with the word "metamorphosis". Ask them what "metamorphosis' means. Tell them that just like a caterpillar changes into a butterfly some igneous and sedimentary rocks change into different rocks because of extreme heat and pressure within the crust of the earth. These rocks are called *metamorphic rocks.*

   Metamorphic rocks:

   1. Have been subjected to lots of heat and pressure over the years
   2. Form new minerals from the ingredients of the parent rock
   3. Often include sparkly bits
   4. Often have streaks or spots (mineral layering)

VI. *Geology Rocks!* Rock Type Game

1. Choose a wide open area, gym or classroom with desks moved aside, or play outside (this is a great game to play outside).

2. Before game play begins, caution student to be careful as they form their groups. The leader can choose to eliminate players that are left over after all groups have been formed or move before 'Big Thaw' is called. A winner or group of winners can be named at the end. Alternately, the game can be played inclusively without elimination.

3. Review with students how rocks are formed, and name the three rock groups: igneous, metamorphic, and sedimentary. As the class describes how each rock group forms, have a group of students demonstrate each action.

4. Call out each geology term and have students practice forming groups. Gameplay begins, and students must form correct groups as quickly as they are called to avoid elimination. Call terms in no particular order and as many times as desired.

Geology Term	Action
Igneous	Volcano: Groups of three people. Two hold hands and a third 'pops' up from in between, making eruption sounds
Metamorphic	Pressure: Groups of two, apply pressure by give bear hugs – or squeezing hands (gently)
Sedimentary	Layers: Groups of four people. Each person layers hands in middle, one on top of the other, huddle style
Glacier	Everyone freeze, stay still until 'Big Thaw' is called
Big Thaw	Players are unfrozen and may begin moving again.
Crystal	Groups of four form a 'square' facing away from each other, elbows linked

Wind, water, and ice are continually wearing away igneous, metamorphic, and sedimentary rocks and processes within the earth are creating new rocks every day. By studying rocks and how they "recycle", scientists can learn more about how the earth itself is changing, and how life has changed over time.

VII. Rock Detectives

Materials: Lake Superior rock containers, one per group; Lake Superior Rock ID charts; Rock Picker's Guide to the North Shore

Many different types of rock from many different time periods are exposed and can be seen around the Lake Superior shore. Now that we have learned about how Lake Superior formed and the 3 different types of rocks found on earth, what type do you think is most prevalent around Lake Superior? (*igneous*, sedimentary or metamorphic). Have the students think back to what they learned during the geo-theater.

Most that are found on cobble beaches around Duluth and along the North Shore are volcanic (igneous) rock. These rocks can be identified by focusing on the characteristics of common Lake Superior rocks. Some of the North Shore rocks have the same mineral ingredients, but look very different. As lava cools, its location relative to the surface of the earth can influence cooling time and crystal formation.

Lava that cooled quickly at the surface (extrusive) of the earth is less likely to form rocks that have visible crystals. On the other hand, lava that cools more slowly below the surface (intrusive), give minerals time to organize into visible crystal structures. Careful observation of color and texture can aide in rock identification.

1. Divide students into small groups. Provide each group with a Lake Superior Rock container.

2. Have students examine the rocks. Which rocks cooled quickly? *Ones with no visible crystals.* What factors could affect the rate of cooling? *Location (above or below surface of the earth) number of layers, climate etc.*

3. Encourage students to classify them into groups using whatever characteristics their group decides. Have each group explain how and why they grouped their rocks in that way.

4. Draw a blank Rock ID chart on the board. Explain that darker colored (or mafic) rocks in the Lake Superior region have more iron and magnesium. Lighter, reddish colored (or felsic rocks) have more quartz and feldspar.

5. Provide each group with a Rock ID chart (found inside the file folder) Have students place rocks and labels according to color, and appearance of crystals.

6. Rocks with the same mineral ingredients can cool at different rates, giving them a different appearance. Rhyolite and granite have the same mineral components, as do basalt and gabbro. Which cooled more slowly? *Gabbro and granite.*

Basalt

- Smooth, bluish-black with very small crystals (cooled quickly on surface)
- Very common

Gabbro

- Black
- Large crystals (cooled slowly underground)
- Not as common

Rhyolite

- Reddish
- Hard, smooth
- Tiny vesicles/holes (gas bubbles trapped in the lava as it solidified)
- Very small crystals (cooled quickly on surface)
- Very common

Granite

- Speckled/multicolored; flecks of color = large crystals (cooled slowly underground)

If there is time you can bring out a "mystery rock" (Lake Superior Agate). After everyone has seen the mystery rock have the students raise their hands if they know what type of rock it is. Before revealing the identity of the mystery rock, ask the students who are unsure of what type of rock it is how they could figure it out. Tell the students that it is a Lake Superior Agate. Pass around pictures of agates. Ask the students if they have an idea of how the agate formed? Explain how agates form to the group.

Lake Superior Rock Chart Key			Texture	
	Color		Coarse (Crystals visible)	Fine (small, barely visible crystals)
		Dark / Blackish	Gabbro	Basalt
		Reddish or speckled	Granite	Rhyolite

VIII. Review/Conclusion

Have students remain in the rock sorting groups.

Ask each group to draw a pictorial timeline of how Lake Superior was formed. Be sure to include the main events from the Geo-Theater and also identify when and where the four common rocks from the ID chart could be found. Ask the students questions about rock ingredients, rock formation, and rock types.

Alternately, create a large scale timeline as a class.