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Designation: Ontario Curriculum: Science and Technology

Earth and Space Systems: Grade 4 – Rocks, Minerals, and Erosion

Specific Expectations Addressed:

Understanding Basic Concepts – describe the difference between minerals (composed of the same substance throughout) and rocks (composed of two or more minerals);
– recognize that there are three classes of rocks: igneous, sedimentary, and metamorphic

Developing Skills of Inquiry, Design, and Communication – test and compare the physical properties of minerals (e.g., scratch test for hardness, streak test for colour);
– use appropriate vocabulary, including correct science and technology terminology, in describing their investigations and observations (e.g. use terms such as hardness, colour, lustre, and texture when discussing the physical properties of rocks and minerals)

Relating Science and Technology to the World Outside the School – identify the many uses of rocks and minerals in manufacturing, and in arts and crafts (e.g., china, iron fences, soapstone carvings, jewellery, coins)

Background:

Solid as a (Mineral) Rock!

Grade four students will really be "in their element" when they learn about rocks and minerals, because there are only ten elements that make up approximately 99 percent of the Earth's crust! Only ten elements that combine to form all the naturally occurring minerals which the earth and all its inhabitants require for life! (The composition of the Earth's crust, in weight percent order, contains the elements: oxygen, silicon, aluminum, iron, calcium, sodium, potassium, magnesium, hydrogen, titanium, and all other elements).Why are the *minerals* formed by these elements, and the *rocks* that the minerals form, so important?
Minerals are the building blocks upon which life and our modern societies depend. Our Earth produces vast amounts of resources – through its use of solar, wind, water and soil components. However, sometimes these resources aren't enough and "if it can't be grown, it's got to be mined". In other words, we need to tap into the non-renewable riches of the earth – its minerals and the rocks which contain them. Minerals are valued for everything from their beauty, rarity and hardiness as precious gemstones to their useful practicality in the pharmaceutical, manufacturing, construction and petroleum industries. Rocks house these minerals and also provide for many uses: as the foundation from which soil is produced; as naturally occurring major landforms and mountains; as building blocks for most of the great monuments of the past; and as the decorative stones of current architect and design.
What is the difference between a mineral and a rock? A mineral is a naturally occurring, inorganic solid with a definite chemical composition and crystal structure with specific colour and hardness. (It might be easy to remember that a diamond is a mineral in order to remember these specifics). A mineral may consist of only one of the abovementioned 10+ elements, for example, a diamond is composed only of carbon (one of the "other" elements); or a mineral may consist of several elements.
From this basis, we can define all rocks as composed of one or more minerals. A rock is *composed* of mineral(s) but is *not* a mineral. A rock, therefore, is an aggregate of one or more minerals which are all firmly locked together to form a hard solid. Instead of defining each rock as a specific individual, as we are able to do with minerals, rocks are classified into three basic rock families: igneous, sedimentary, and metamorphic rocks. These families are explained simply in the following activities, but the key differences are: igneous rocks are formed from the "ignis" or fire from the earth's core; sedimentary rocks are formed by sediments accumulated over time; and metamorphic rocks are either of the first two classes of rock that have metamorphosed with high temperature and pressure over time into different rocks.

Procedure:
Part 1

Understanding Basic Concepts – describe the difference between minerals (composed of the same substance throughout) and rocks (composed of two or more minerals);

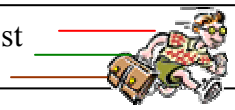
Developing Skills of Inquiry, Design, and Communication – test and compare the physical properties of minerals (e.g., scratch test for hardness, streak test for colour);
– use appropriate vocabulary, including correct science and technology terminology, in describing their investigations and observations (e.g. use terms such as hardness, colour, lustre, and texture when discussing the physical properties of rocks and minerals)

"Give it the Acid Test"– Testing for Minerals (carbonate minerals)

Materials Needed For Activity:

- rock samples gathered by students (including limestone and marble)
- vinegar
- bowl
- spoon or eye dropper
- magnifying glass

1) Fill bowl $^1/_3$ full of vinegar
2) Drop examples of the more "common" rocks, such as flint, granite, sandstone, into the vinegar (Ask students to observe what happens. Answer: rock sinks to bottom and there is no visible reaction).
3) Drop examples of "other" rocks, such as limestone or marble, into the vinegar (Ask students to observe what happens. Answer: Gas bubbles form, making the vinegar cloudy and bubbly on top. Therefore, these rocks contain minerals called carbonates.
4) To view this gas another way, use the spoon or eye dropper to drop vinegar onto dry rocks and observe with magnifying glass (Chalk, marble and limestone make vinegar fizz on top of rock)

Mineral Colour Streak Test 

Materials Needed For Activity:

- local rock samples gathered by students, plus hematite, pencils, white chalk
- white or off-white ceramic tile and black / dark coloured tile (for white streaks)
- library books / charts / field guide books containing mineral information
- Teacher's Appendix A : Ontario Rocks and Minerals Streak Test Colour Guide
- Handout #1 "Streak Test Science"

1) Designate student pairs or small groups : use their own collection of 4 "unique" samples and one tile
2) Turn tiles face down, with rough side facing up
3) Decide on which order the rocks will be given the Streak Test and place them in that order
4) Take the first sample and rub a straight line, or streak, down the length of the tile (Students should see a streak of colour (even white), or colours , on the tile)
5) Return rock to its place in the ordered line-up and continue to perform the streak tests in order
6) Perform a streak test on the hematite and the "obvious" pencil and white chalk (Hematite has a red streak and the "obvious" black pencil streak is caused by the mineral graphite; white chalk is gypsum)
7) Record your results on Handout #1

HANDOUT #1: Streak Test Science **Name:** _____

Record your observations here for your Mineral Streak Test.

	ROCK #1	ROCK #2	ROCK #3	ROCK #4	Hematite	Pencil	White Chalk
COLOUR OF ROCK or item							
SHAPE OF ROCK or item							
TEXTURE OF ROCK or item							
STREAK TEST COLOUR/s							
CAN YOU NAME THE MINERAL?							

Minerals are _____ (natural / unnatural), solid, non-living substances which are metallic or nonmetallic. Each mineral has its own shape or colour that makes it _____ (the same as / different from) other minerals.

Every mineral is made up of _____ (many / one) type of "ingredient" or substance.

All _____ (rocks / rock 'n' roll stars) are made of one or more minerals.

A Streak Test produces _____ (sounds / colours) that provide a clue about what type of _____ (minerals / fossils) are present in a rock sample.

Minerals are_____ (renewable / nonrenewable) resources that people use every day. Everything is made of minerals. We need to use them wisely.

Hard as Rock! Scratch Test for Hardness

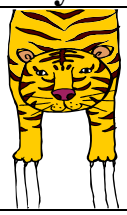
Materials Needed For Activity:

- collection of 4 “unique” samples gathered by students
- small bowls of water
- nail brushes / small scrub brushes
- pennies
- small baby food jars / jam jars
- steel nail or tool files
- sandpaper

1) Designate student pairs or small groups : use their own collection of 4 “unique” samples
2) Clean the rock samples using the water bowls and scrub brushes
3) Scratch two rock samples together. Can one rock scratch the other? It is therefore HARDER because it contains minerals which are harder than the minerals in the other rock.
4) Scratch each rock with a fingernail. On the Mohs’ Scale for rating hardness, a fingernail has a hardness of just over 2. If students can make a scratch on a certain rock sample, it has a hardness of 2 or less.
5) Record these numbers on Handout #2. A “PASS” ✔ is scored when the rock is scratched.
6) Set aside the rocks which were hardness of 2 or less from the fingernail scratching
7) Scratch the remaining rocks with a penny. On the Mohs’ Scale for hardness, a coin has a hardness of about 3. If students can make a scratch on a certain rock sample using a coin, it has a hardness of less than 3.
8) Record these numbers on Handout #2
9) Set aside the rocks which were hardness of 3 or less from the penny scratching
10) Continue the scratch tests using the glass jars, steel files, and the sandpaper**.** Glass has a hardness of between 5 and 6; steel files have a hardness of 7; and sandpaper has a hardness of 8.
11) Record all results and observations on Handout #2

HANDOUT #2: Scratch Test Science **Name:** _____

Record your observations here for your Mineral Scratch Test.

	**ROCK SAMPLE #1**	**ROCK SAMPLE #2**	**ROCK SAMPLE #3**	**ROCK SAMPLE #4**
Passed ✔ FINGERNAIL scratch test Hardness of 2 or less				
Passed ✔ PENNY scratch test Hardness of 3 or less				
Passed ✔ GLASS scratch test Hardness of 5/6 or less				
Passed ✔ STEEL FILE scratch test Hardness of 7 or less				
Passed ✔ SANDPAPER scratch test Hardness of 8 or less				

In 1822, a scientist named Friedrich Mohs made a list of 10 common minerals and ranked them from 1 to 10 for hardness. A hardness of 1 is the _____ (softest / hardest) and a hardness of 10 is the _____ (softest / hardest).

A diamond is the hardest natural _____ (ring / mineral). It will scratch all other minerals with its hardness of _____ (1 / 10).

In this experiment, our class scratched _____ (rocks / tiles) to test the hardness of the _____ (fibers / minerals) that they are made up of.

Procedure:
Part 2

Understanding Basic Concepts – describe the difference between minerals (composed of the same substance throughout) and rocks (composed of two or more minerals);

Developing Skills of Inquiry, Design, and Communication – use appropriate vocabulary, including correct science and technology terminology, in describing their investigations and observations (e.g. use terms such as hardness, colour, lustre, and texture when discussing the physical properties of rocks and minerals)

An Ingenious Method for creating Igneous Rock 

Materials Needed For Activity:

- white sugar
- water
- milk
- butter
- bicarbonate of soda
- saucepans
- wooden spoon
- measuring cup and spoons
- stove top / Bunsen burner
- freezer
- wax paper
- baking tray
- oven gloves

A

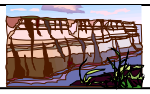
1) Heat 500g of sugar in one or two centimetres of water in the saucepan
2) Continue to heat the mixture in the pan until it turns brown but not black and then add 1 tbsp milk
3) Take the pan off the heat source
4) Let cool for one hour. (Once cooled, class should be able to observe tiny grains in the fudge mixture)
5) When completely cooled, let students handle the mixture. Ask for textural observations. After students' descriptions, inform class that this concoction is similar to a type of rock called **GRANITE**. (Granite is an igneous rock that was made deep inside the Earth. Igneous rock starts off as the fiery-hot melted magma; magma either erupts from volcanoes or cools underground becoming igneous rock. Granite cooled inside the earth very slowly and allowed its inner crystal structure to expand. These crystals have a grainy texture like our fudge mixture).

B

1) Grease baking tray with wax paper and butter
2) Leave tray in the freezer for at least one hour; remove using oven mitts and set aside
3) Heat 500g of sugar in one or two centimetres of water in a clean saucepan
4) Stir this mixture with the spoon while it heats and the water evaporates
5) Be sure that the sugar doesn't burn and blacken, but just turns golden brown
6) Pour the hot mixture on to the cool tray
7) Ask students for observations after 10 minutes. It should form a thin, glassy, brittle sheet of "toffee". When completely cooled, let students handle the creation. Ask for textural observations. After students' descriptions, inform class that this creation is similar to a type of rock called **OBSIDIAN**. (Obsidian is an igneous rock that also started off as fiery-hot melted magma that cooled underground. However, obsidian cools very quickly and doesn't have time to form crystals. Thus, it is like smooth black glass.)

C

1) To make **PUMICE**: repeat procedure B but add bicarbonate of soda to the hot mixture just before pouring it on the baking tray. This will make tiny bubbles of gas in your hot magma mixture, just like when hot lava containing a lot of gas pours out of underwater volcanoes forming pumice rock.

(Making) Sedimentary Rock is Elementary, my dear Watson! 

Materials Needed For Activity:

- tall clear glass beaker
- large clump of non-hardening modelling material
- long sundae / iced tea spoon
- coarsely crushed graham crackers
- chocolate chips
- small white marshmallows
- carob chips or caramels
- small coloured marshmallows
- rubber gloves
- old plastic tub
- plaster of Paris
- water
- fork
- fine pebbles
- sand
- earth
- newsprint

A

1) Teacher : Press bottom edge of beaker very firmly into the clump of modelling material, making sure that jar will remain propped up or sitting on an angle of approximately 45º
2) Without touching the side of the beaker, slowly spoon a few scoops of graham crackers into the bottom, forming a layer about 2cm thick
3) Continue adding layer after layer of: white marshmallows, carobs/caramels, coloured marshmallows, chocolate chips and then begin again starting with the graham cracker layer. The different layers, or STRATA, should be of varying depths and should be clearly visible as distinct layers
4) Carefully remove your strata jar from the clay and hold it upright. Now, the differently coloured and textured layers are visible like the different layers of **SEDIMENTARY ROCK** (Once igneous rock has been exposed to the elements – water, wind, ice, plant roots, and acid secretions – it becomes broken into smaller pieces. These pieces are called sediment. They are transported by these same elements to different areas where they gradually accumulate, layer by layer, and then are compacted into sedimentary rock)

B

1) Teacher: Wearing rubber gloves make plaster of Paris in plastic tub. Stir.
2) Before the plaster hardens, mix your small pebbles, sand and earth into tub mixture. Stir thoroughly.
3) Set this **CONGLOMERATE SEDIMENTARY ROCK** mixture aside for approximately 10 minutes, until it begins to harden. (Conglomerates are sedimentary rocks which contain large sediments like large pebbles that are cemented together by sand)
4) Designate student pairs or small groups and place a small lump of rounded “rock” mixture onto their newsprint pieces to dry
5) Ask students to observe the texture, colour of their conglomerate rocks as they dry
6) Once completely hard and dried out, ask students to hold these rocks and describe their hardness

Melt-in-your-Mouth Metamorphic Rock! 

Materials Needed For Activity:

- Strata beaker of edible layers from the Sedimentary rock activity (above)
- Bunsen burner
- oven mitts
- access to freezer
- bread knife
- potato mashing utensil or spoon

1) Teacher: Using your Sedimentary Rock / Strata jar example from our prior activity, explain that **METAMORPHIC ROCK** is actually just sedimentary rock (or igneous rock) which has been buried very deep in the earth's crust. Once deep in the earth, it is exposed to the intense heat from the earth's core and it feels great pressure because of the heavy weight of the other rock and earth pressing down on it. Since the class already has a delicious looking "sample" of sedimentary rock, we'll use that to create our metamorphic rock. Ask a student to define the word "metamorphosis" from the dictionary.
2) Compress the mixture (as much as possible) in the jar using the potato masher or spoon
3) Place the beaker / jar over the Bunsen burner on a low flame until slightly warmed
4) Remove the jar from the heat (using the oven mitts) and again compress the mixture by applying downward pressure with the potato masher. Ask students why it is possible to compress it now
5) Replace the beaker on the Bunsen burner and repeat these steps until the marshmallows, chocolate chips, carob chips / caramels are melted but not burned
6) Set aside to cool. You've created metamorphic rock now that the sedimentary "rock" has compacted and changed (metamorphed) with pressure and heat. Ask students for descriptions and observations regarding the hardness, colour, texture of the new metamorphic rock.
7) To be able to eat this rock, place your cooled jar in the freezer until it has compacted enough that it will slide out of your overturned jar
8) Use the bread knife to chunk out pieces of Melt-in-your-Mouth Metamorphic Rock. Enjoy!

Procedure:
Part 3

Relating Science and Technology to the World Outside the School – identify the many uses of rocks and minerals in manufacturing, and in arts and crafts (e.g., china, iron fences, soapstone carvings, jewellery, coins)

"I Spy with My Little Eye, something that is…"

- game begins with classroom teacher distributing Handout #3, explaining only that it contains "clues" to play the game
- teacher begins game with a simple statement such as "I spy with my little eye, something that is made from iron and holding up something special"
- students guess what is present in their classroom that fits that description based on their "clues"
- in this case, the desk frames or chair legs that students are seated on is a good guess

Purpose:

- The purpose of this game is to help students realize the fundamental importance of mineral resources and rocks in their daily lives – everything comes from the earth!
- To illustrate the geologists' saying, "If it can't be grown, it's gotta be mined". In other words, if our products cannot be manufactured from plant or animal sources (organic sources) they must come from the ground / the earth in the inorganic form of minerals or rocks
- To challenge students to try to compose a list of items or products which are not earth-derived

Materials / Resources to Use:

- Students are encouraged to bring in examples of their mineral "discoveries": items which they can use to illustrate the fundamental importance of rocks or minerals as "building blocks". For example, an aluminum pop can is a very common object which is made of a very important, valuable mineral.

Teachers can explain to grade 4 students that aluminum makes up 7.5% of the weight of the earth's crust. That is a huge amount of aluminum, however most forms of aluminum are not suitable for processing into useful metallic aluminum at affordable costs. One form of aluminum oxide known as bauxite is suitable for efficient processing into metallic aluminum. It forms in tropical soils, and is fairly rare when we consider the human demand for aluminum products, i.e. aluminum foil, cans, cookware, building products such as aluminum siding, eavestroughing, power lines, cars parts, etc. Unfortunately, because it forms in soil, the extraction process of mining can be difficult, expensive and environmentally destructive if care is not taken.
There are several types of mining. *Surface mining* involves the removal of the overlying layer of soil, rock and vegetation to uncover the mineral deposits close to the earth's surface. While this type of mining can be quite destructive to the mine area, government regulations tightly control mining activity, mine wastes, and require the mining company to replace the topsoil and plant cover over the entire area once mining operations are complete. For mineral deposits deep below the surface of the earth, *subsurface mining* is used to dig deep vertical shafts into the mineral deposit, and then haul the ore to the surface.
Allow for discussion among grade 4 students to discuss the importance of balancing the need for mineral resources, the issues involved with extraction techniques and the need to protect the environment. (Hints: society cannot function without mineral resources, machinery uses fossil fuels, creates emissions and pollution; land is disturbed and erosion can occur; mine area rehabilitation can be difficult and expensive, etc.)
Aluminum cans are excellent examples of why mineral resources should be reused or recycled. Students will understand (now) why mining for "new" aluminum has many costs and how easy it is to simply recycle a pop can, for example, and save this valuable resource and the environment at the same time.

HANDOUT #3: Mystery Minerals

MYSTERY MINERALS

DID YOU KNOW…?
The mineral Titanium Oxide makes the centre of the OREO cookie bright white?!?

Can you SPY  **which minerals make which objects?**

MINERAL RESOURCE	OBJECT
Calcite (the main ingredient in limestone)	Cement
Clay (from sedimentary rock)	-Ceramic dishes -Pottery -China / Chinaware (a type of ceramic called porcelain)
Copper	Pennies
Diamond / Emerald / Ruby / Sapphire / Opal	Jewellery containing these gemstones
Gold or Platinum	Jewellery
Graphite (from metamorphic rock)	Pencil "leads"
Gypsum	-Drywall -Plaster of Paris -White chalk
Iron	Metal products made with iron: IN SCHOOL: (desk frames, chair legs, door frames, window frames, shelves, filing cabinets, light fixtures, door handles and locks, plumbing, taps, coat hangers, fences) ON YOU: zippers, belt hooks AT HOME: stainless steel knives, forks, spoons
Mercury	-Mercury thermometers -Insecticides
Nickel	-Silver coins: nickels, dimes, quarters, toonies -Stainless steel items
Petroleum	ALL plastics: some table/desk tops and trims, synthetic tiles, computer casing, telephone casings, toys, pencil boxes, etc. -Vinyl: chair coverings, flooring, items marked 3 -Synthetic fabrics (man-made fabrics) : could include carpet, rugs, curtains, polyesters, rayons, nylons, rubber, upholstery, curtains, etc.
Silica / Quartz Sand	-ALL objects containing GLASS: drinking glasses, eyeglasses, window panes, light bulbs, computer and television screens -Computer chips
Silver	-Jewellery -Black & White Pictures -Dental Fillings
Talc	Soapstone carvings
Tin	Pewter objects such as keepsake frames, boxes
Titanium	-Aircraft frames, engines -Golf club shafts

Teacher's Appendix A: Ontario Rocks and Minerals Streak Test Colour Guide

Note to Teachers: Geology is a complex science. The minerals listed in this appendix (Apatite*, Calcite, Chalcopyrite*, Dolomite, Fluorite*, Hematite*, Pyrite*, and Quartz) are all found in Ontario, with the minerals marked with an asterisk* being found in Northern Ontario, in the Canadian Shield.
You will notice that these minerals are found in many colours and it will be difficult to distinguish many of them without the aid of a good geology field book, a set of labeled samples from a collector or university, or a helpful website such as http://www.ontariominerals.com/index.html
In reference to the "Streak Test Science" Handout, which asks students to identify rocks based on the colour of the streak which their mineral contents leave behind, be open-minded and willing to research with the students. The students' samples will not likely be *easily* identified. Again, reference to geology field books, websites, and sample collections will help. Instead of trying to positively identify only ONE possible type of mineral, feel free to list numerous possibilities. This is a learning experience! Have fun! (Try a black / coloured tile?)

Apatite: $Ca_5(PO_4)_3$
Colour: Colorless, white, yellow, brown, red, pink, purple, blue, green, sometimes multicoloured
Streak: White **Hardness:** 5

Calcite: $CaCO_3$
Colour: Occurs in all colours, sometimes even multicoloured
Streak: White **Hardness:** 2-3

Chalcopyrite: $CuFeS_2$
Colour: Brass yellow to golden yellow. Tarnishes purple, blue, and red
Streak: Black with a slightly green tinge **Hardness:** 3 ½ to 4

Dolomite: $CaMg(CO_3)_2$
Colour: Colourless and transparent or white grey or greenish becoming yellowish brown or brown with increasing iron content also pink or rose
Streak: White **Hardness:** 3 ½ to 4

Fluorite: CaF_2
Colour: Occurs in all colours, even multicoloured
Streak: White **Hardness:** 4

Hematite: Fe_2O_3
Colour: Black, gray to silver gray, brown to reddish brown, red. May be iridescent.
Streak: Red to reddish brown **Hardness:** 5-6

Pyrite: FeS_2
Colour: Yellowish gray to gray
Streak: Black with a slightly green tinge **Hardness:** 6 – 6 ½

Quartz: SiO_2
Colour: Occurs in an infinite range of colors. Most commonly white, purple, brown, and colourless. Many specimens are multicolored or banded.
Streak: White **Hardness:** 7