SMA Saskatchewan Mining Association

The Rock Cycle Journey and Mineral Deposits

Overview

Students will use observation, inference, and data collection skill to discover that the rock cycle, like the water cycle, has various phases and does not necessarily move linearly through those phases Students will make the connection between rock type, mineral deposit type and processes as they travel through the rock cycle.

Source: The original idea for this lesson comes from a lesson by DLESE Mountain Building Teaching Box. It has been adapted for Saskatchewan schools by the SMA.

Duration: one – two classes

Materials:

- Rock Cycle Journey Paper dice
- Rock Cycle Journey Station and Mineral Deposits cards
- Student Data Table
- Mineral Deposits Chart
- Student Rock Cycle Journey Summary
- Student Cartoon Sheet
- Saskatchewan Rock Kit (optional): see Resources
- Keepers of the Earth: “Tunka-shila, Grandfather Rock”; “Old Man Coyote and the Rock”

Prior Knowledge:

Before attempting these activities students should have some understanding of the following:

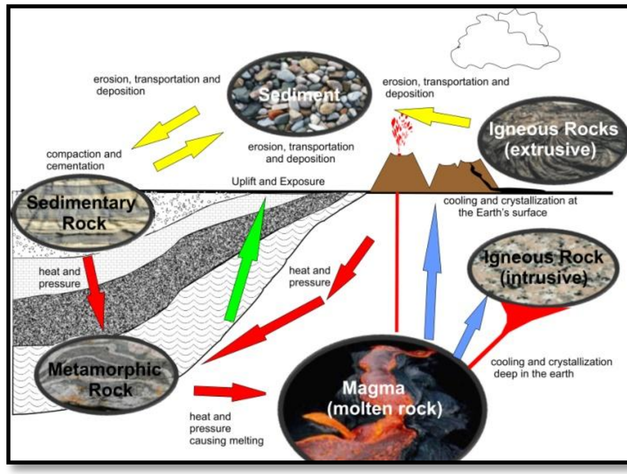
- Metamorphic, Sedimentary and Igneous rocks

Note to Teachers:

In this activity, rock cycle phases (igneous, sedimentary and metamorphic), processes, such as melting, cooling (crystallization), weathering, erosion, burial, deformation, heating, and information about Saskatchewan mineral deposits are located at 11 different stations. Each station has a “die” – a box that is labeled on each of its six sides. The sides of the dice are marked to reflect the relative likelihood of materials actually moving through the phase.

Instructional Methods:

- Simulation



Learning Outcomes and Indicators

Grade 7: Earth’s Crust and Resources

EC7.1 analyse societal and environmental impacts of historical and current catastrophic geological events, and scientific understanding of movements and forces within Earth’s crust.

b. Provide examples of past theories and ideas, including cultural mythology, that explain geological phenomena such as volcanic activity, earthquakes, and mountain building. (Extension 1.)

EC7.2 Identify locations and processes used to extract Earth’s geological resources and examine the impacts of those locations and processes on society and the environment. [SI, DM, CP]

d. Identify locations of Saskatchewan’s primary mineral resources (e.g., potash, gold, diamond, salt, uranium, copper, and graphite) and their primary uses.

EC7.3 Investigate the characteristics and formation of the surface geology of Saskatchewan, including soil, and identify correlations between surface geology and past, present, and possible future land uses. [DM, SI] g.

c. Construct a visual representation of the rock cycle (e.g., formation, weathering, sedimentation, and reformation) and relate this representation to the surface geology of Saskatchewan and Canada.

Earth Science 30

Lithosphere

ES30-LS2 Examine the processes that lead to the formation of rocks and minerals.

a. Differentiate the three main rock groups (i.e., sedimentary, igneous and metamorphic) by their processes of formation, including the roles of time, heat and pressure.

ES30-LS3 Investigate the processes and technologies used to locate and extract mineral resources and fossil fuels locally, provincially and globally.

b. Identify the location, method of extraction, uses and economic impact of major fossil fuel and mineral (e.g., gold, diamond, rare earth elements, copper, zinc, kaolin, coal, potash, uranium, salt, and sodium sulphate) resources.

c. Investigate how the location of major mineral and fossil fuel resources in Saskatchewan are influenced by their depositional setting and geologic history including depth of deposit and geological stability/instability. (indirectly)

Source: **Saskatchewan Evergreen Curriculum**

Other:

As a result of this lesson, students will be able to:

- Identify the various phases of the rock cycle.
- Explain that Saskatchewan mineral deposits occur in specific rock types and as a result of processes identified in the rock cycle

Big Picture Questions

1. **Where do Saskatchewan's mineral deposits fit into the Rock Cycle?**

Background Information

James Hutton (1726—1797), the 18th-century founder of modern geology came up with the concept of the rock cycle. The main idea is that rocks are continually changing from one type to another and back again as they are weathered, eroded, and compacted at the earth's surface and subjected to heat and pressure and are melted at depth when forces on the earth cause them to sink back into the mantle. A continuous cycle.

The *Rock Cycle Diagram* shows the many ways that old rocks can be recycled as new rocks. Nearly all of the earth's crustal material originates from the flow of molten magma from deep within the Earth. Magma becomes Igneous rock upon cooling. If it solidifies slowly deep within the Earth's crust, it forms plutonic rock such as granite. If it reaches the surface and erupts from a volcano, it solidifies quickly into volcanic rock such as basalt. The processes of weathering, erosion, transportation and deposition (in rivers, lakes and oceans) can convert any pre-existing rock into a sediment and finally a new sedimentary rock. Increased heat and pressure due to deep burial cause the growth of new minerals and possibly partial melting, converting any pre-existing rock into a metamorphic rock. Complete melting converts metamorphic rocks into magma, which may form a new igneous rock (Geological Highway Map).

Not all rocks to go through each step in the cycle. For instance, a sandstone may be weathered breaking up into small fragments, the fragments are transported and deposited eventually to be lithified as another sedimentary rock.

Mineral deposits are associated with particular rock types and processes. Sometimes a mineral can occur in several rock types but the processes in the formation of the deposit will differ. For example:

In Saskatchewan, we have deposits of uranium occurring in sandstone, as well as the in the underlying gneiss. The process by which uranium is deposited in both rocks is the same. Hot, oxidizing, uranium-rich fluids migrated through the rocks and precipitated uranium upon hitting a reducing environment. The smaller pegmatite-hosted uranium deposits also found in the basement gneiss, have a different origin. Quartz, feldspar, tourmaline, and uranium rich magma was injected into fractures in the Earth's crust, where it slowly cooled in a final stage of granitic pluton emplacement.

Potash was deposited as a sedimentary rock by crystallization of potassium-rich brines at the bottom of an ancient sea. Coal formed when vegetation rotting in a swamp was buried and subjected to pressure and increased temperature. Coal is also a sedimentary rock.

The elements, copper and zinc commonly occur as sulfide minerals in igneous rocks. Gold occurs as a natural element finely disseminated in igneous rocks or in quartz veins in Saskatchewan.

Vocabulary

deposit	extrusive
Igneous rock	intrusive
magma	mine
metamorphic rock	sedimentary rock

The Activity

Teacher Preparation:

1. Cut out each die pattern and the signs for each station. Assemble dice by folding along lines and taping the edges together.

2. Set up the eleven stations in the classroom – one for each die and matching cards (Station title and Mineral Deposits). Each card has the number of the station and the name of the phase or rock type printed on it. Each die also has the name and number of the station on it.

3. Copy and cut out the Mineral Deposits information sheets for each station. Have at least 30 copies of each slip per station. Not all students will reach every station but some may visit twice and may stay at the station for several turns. Place tape or glue beside the information slips.

4. If you have rock samples you could place a corresponding sample at the appropriate station.

The Activity:
Rock Cycle Journey and Mineral Deposits

1. Explain to the students that they are going to do an activity to learn more about rocks and what happens to them.

2. Review with the students the rules in the instructions before starting the activity.
   a. Orient the students to the activity by instructing them to think of themselves as a mineral grain, or a tiny piece of rock moving through a rock cycle.
   b. Go through the sample data table.
   c. Hand out the Rock Cycle Journey table for each student to complete on their journey.

3. Have the students choose a station to start at. Spread the students out so that each station has approximately the same number of students to begin with.

4. Students begin by taking turns rolling the die at their station and following the directions to either "go to" another station or "stay put". If they stay put they go to the back of the line and wait their turn to roll again.

   For example, rock material may remain in a molten state inside the earth for long periods of time. To show this, the die at station # 10, "Magma," has four sides that say "magma (stay as you are)" and only two sides that say "cooling and hardening." If you roll the "magma (stay as you are)" side of the die, you will stay at station #10 and roll again when it is your turn. If you roll one of the sides that say "cooling and hardening" you would move to station #9, the "Cooling and Hardening (crystallization)" station.

Remind the students to be careful with the die.

5. Information about Saskatchewan's mineral deposits is posted at each station. Have the students pick up a Saskatchewan Mineral Deposits "card" and tape/glue it into the correct column on the *Rock Cycle Journey Table*. If the student stays at the station for several tosses of the dice they can enter the symbol *"* to indicate the same information.

6. While at each station students **must record** (station # and what happened to them) on the ***Rock Cycle Journey Table*** for each roll of the die and its outcome on their data table even if they end up rolling it multiple times. (Minerals cards see Step 5.)
   See example *Rock Cycle Journey Table*.

Each step in the rock cycle can take as little as 200,000 years or as much as several million years. For this activity, count each roll of the die as 200,000 years. Students multiply the number of tosses of the die by 200,000 years to get the number of years spent in the rock cycle.

After the activity is over they will have a record of what happened.

Summary Activities (1 class)

7. Once the rock cycle journey has been completed have the students summarize their journey. Students could use the ***Rock Cycle Journey Summary Sheet*** *to help them create a story, essay, power point, poster, cartoon, animation, video.*

8. Have students complete the journal questions .

Assessment Method and Evidence

✓ Journal questions:

- Students will be able to list at least 3 Saskatchewan mineral deposits and the rocks they are hosted in.
- Students will be able to list the depositional processes involved in at least two of Saskatchewan's mineral deposits.
- Students will be able to explain the process of how a mineral could start out in an igneous rock, become part of a metamorphic rock and end up as a sedimentary rock.

✓ Activity Data Summary Sheet:

- Students will hand in the record of their journey through the rock cycle on a ***Data Summary Sheet***. The record of their journey is the basis of their summary story or cartoon.

✓Summary:

- Students will summarize their journey through the rock cycle (inferring transportation methods) as listed on their Data Sheet either in essay/story/cartoon/PowerPoint format. The summary will reflect their understanding of the cyclic nature of the rock cycle and the vast length of time for the geological process.
- Students will incorporate one or more Saskatchewan mineral deposits visited along the journey into their summary indicating their understanding that Saskatchewan's mineral deposits occur in a specific rock type.
- Advanced: Students may be able to synthesize the process of mineral deposition as it fits into their journey through the rock cycle. I.e.: Student stops in sedimentary rocks (coal deposit) then travels to Temperature and Pressure – student may suggest that the sedimentary rock he/she is travelling as may become a coal deposit.

Extension Activities

1. Grades 4 and 7: Read the First Nations legends Tunka-shila, Grandfather Rock" and "Old Man Coyote and the Rock". These stories relate to the rock cycle with the creation of volcanic rocks and the transport of boulders. Have the students relate the legends to what they know about the rock cycle. Questions: How did the big rock come to be sitting in the middle of the prairie? (Transported by glaciers/erosion). Are there any big rocks in your area? What animals used these rocks in the past? (Buffalo rubbing rocks).

At the end of the stories there is a discussion of the rock cycle and several other activities related to the rock cycle, rock types, and soil.

2. Have students research how one of Saskatchewan's mineral deposits has been formed.

3. After students have learned about plate tectonics have students hypothesize how their rock particle made the transitions between the phases. I.e. From sedimentary rock to melting could be subduction in a trench. What would cause erosion? (Uplift due to continental collision?)

4. Have students locate the Saskatchewan examples of Sedimentary, Igneous and Metamorphic rocks on a geology map.

Resources

DLESE Mountain Building Teaching Box. **The Rock Cycle.** Available at: (http://www.teachingboxes.org/mountainBuilding/index.jsp)

Geological Highway Map of Saskatchewan: Saskatchewan Geological Society Special Publication Number 15. Available to purchase at: http://www.sgshome.ca/publication_list

Caduto, M.J. and Bruchac, J. (1997). **Keepers of the Earth** Native American Stories and Environmental Activities for Children. Fulcrum Publishing, Golden Colorado. Pgs 57 – 63.

Northern Saskatchewan's Rock Cycle: **Northern Saskatchewan Geoscape poster: If Rocks Could Talk.** Available to download at: http://publications.gc.ca/collections/collection_2007/nrcan-rncan/M41-8-91E.pdf

Rogers, M.C., (2011). **Saskatchewan Descriptive Mineral Deposit Models** - Open File Report 2011-57. Available to

download at:
http://www.economy.gov.sk.ca/depositmodels

Saskatchewan Rock Kit: Saskatchewan Energy and Resources offers one set of 24 Saskatchewan rock samples to each school. To order a free rock kit, teachers should contact Geological Publications at 306-787-2528 or email **er.publications@gov.sk.ca** and provide the school name and mailing address.

Vocabulary

Deposit: A natural occurrence or accumulation of mineral material, as uranium, gold, coal, or potash ore.

Extrusive: Igneous rock that has been erupted in a molten state onto the surface of the Earth. Extrusive rocks include lava flows and pyroclastic material such as volcanic ash.

Igneous: Rock or mineral that solidified from molten or partly molten material, i.e., from a magma;

Intrusive Rock: Rock formed from magma that solidified without reaching the earth's surface.

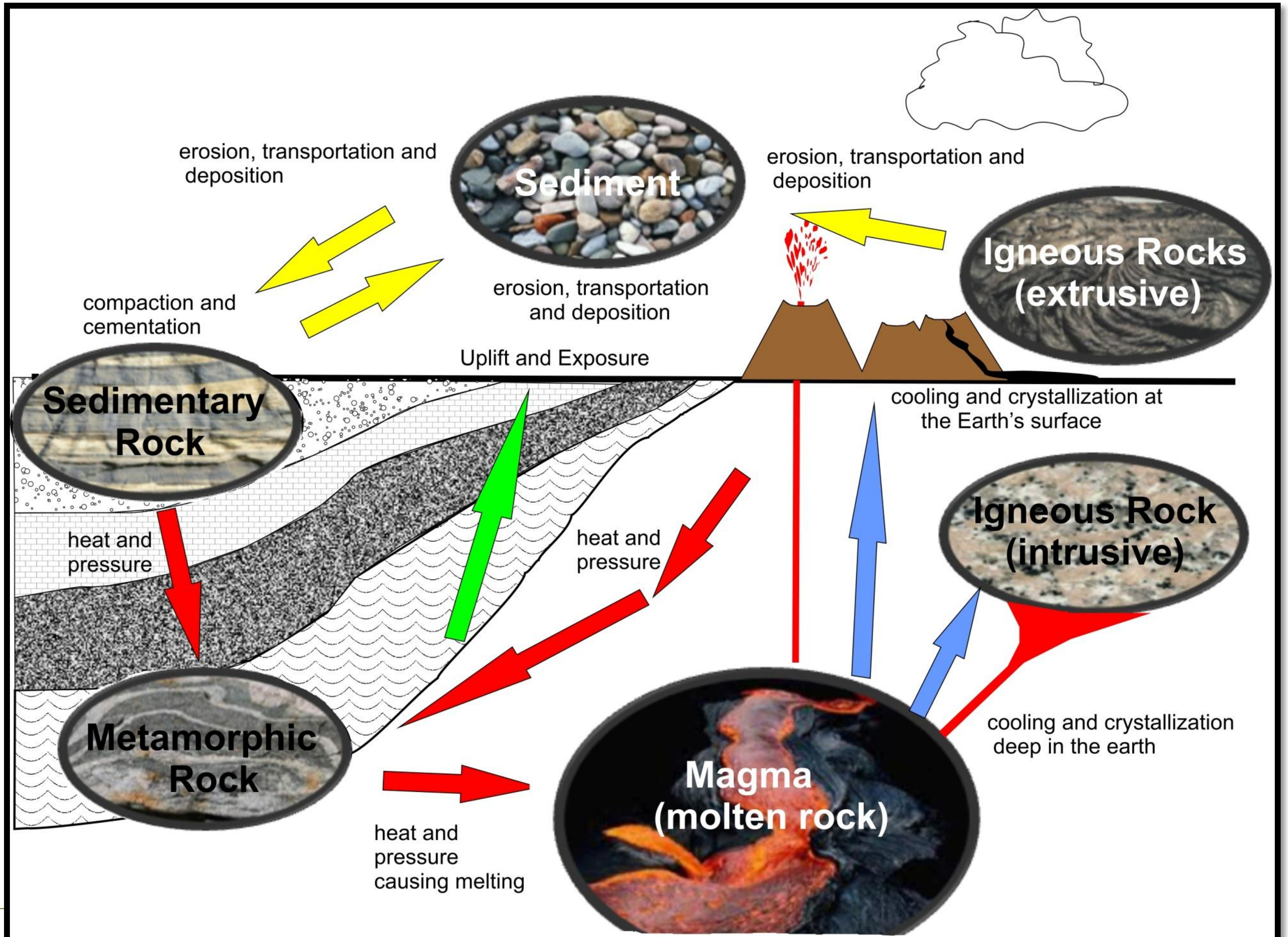
Magma: Naturally occurring molten rock within the earth from which igneous rocks are formed.

Metamorphic Rock: Any rock, which has been altered by heat or intense pressure, causing new minerals to be formed and new structures in the rock.

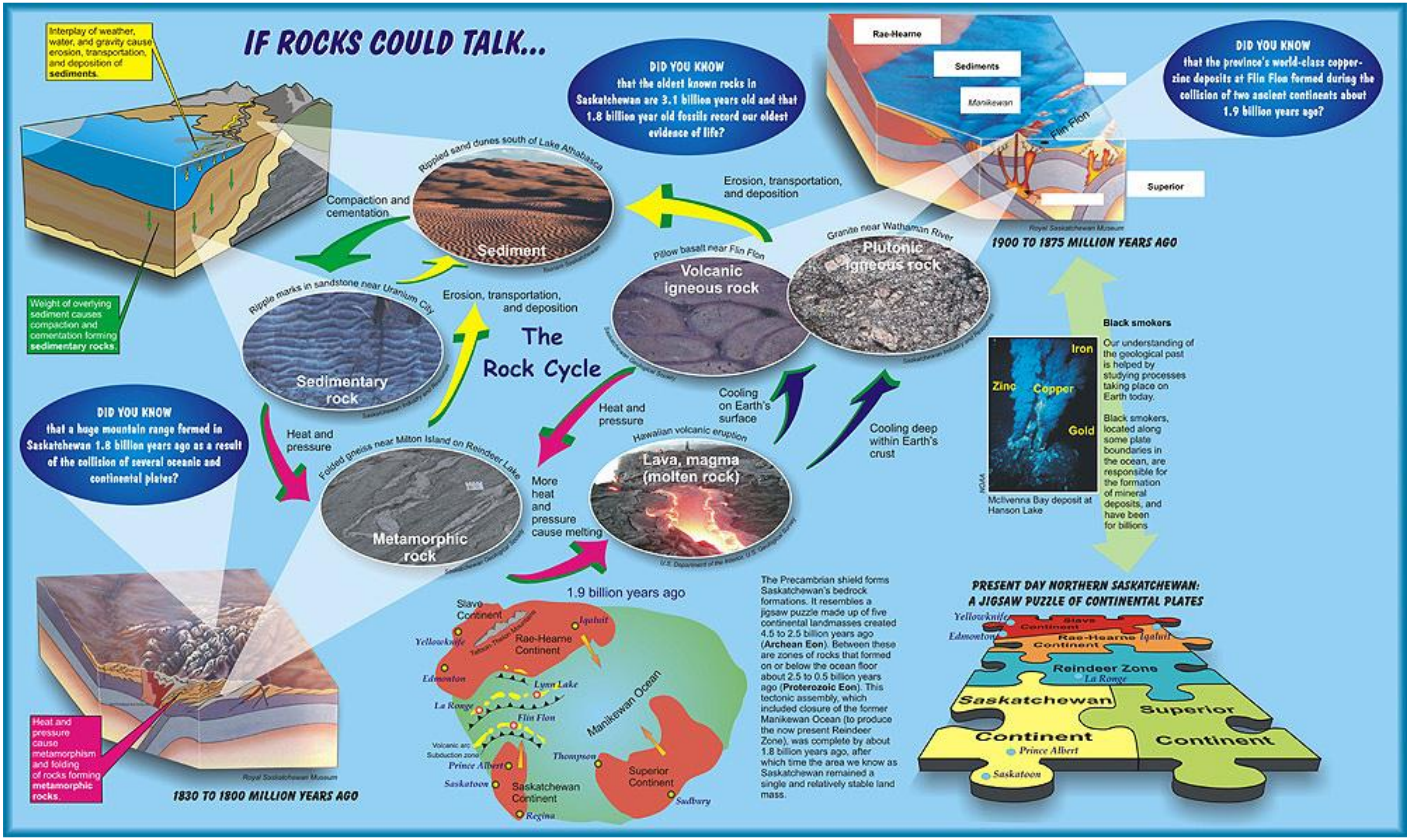
Mine: An opening or excavation in the earth for the purpose of extracting minerals.

Sedimentary Rock: Rock formed by the accumulation of sediment in water or from air.

THE ROCK CYCLE



NORTHERN SASKATCHEWAN ROCK CYCLE



Source: Northern Saskatchewan Geoscape Poster (http://www.nrcan.gc.ca/earth-sciences/products-services/mapping-product/geoscape/northern-saskatchewan/6075

SAMPLE ROCK CYCLE JOURNEY TABLE

ROLL #	STATION #	STATION NAME	WHAT HAPPENED (Stay as _____ or change into ____?)	Mineral Deposit Information
1	10	Magma	Stay as magma	**Diamond:** Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold Inc.) **Copper-Zinc:** When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)
2	10	Magma	Stay as magma	**Diamond:** Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold Inc.) **Copper-Zinc:** When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)
3	10	Magma	Go to Cooling and Hardening (Crystallization)	**Copper-Zinc**: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines**:** Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.) **Potash:** When warm potash rich brines are brought to the surface and left to cool in ponds during the winter months, the potash crystallizes out of solution. Mines: Belle Plaine (Mosaic); Patience Lake (Potash Corp)

4	9	Cooling and Hardening (Crystallization)	Cool and harden stay Crystalline	**Copper-Zinc**: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines**:** Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.) **Potash:** When warm potash rich brines are brought to the surface and left to cool in ponds during the winter months, the potash crystallizes out of solution. Mines: Belle Plaine (Mosaic); Patience Lake (Potash Corp)
5	9	Cooling and Hardening (Crystallization)	Change to Igneous Rock	**Diamonds:** Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. The igneous rocks diamonds are found in are called kimberlites. Example: Fort a la Corne (Shore Gold) **Copper-Zinc**: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock (mainly basalt). Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)
6	4	Igneous Rock	Change! Weathering and Erosion	**Placer Gold:** Gold has been eroded from nearby rocks and deposited in stream bed and lake shore sediments. Example: North Saskatchewan River, Ennis Lake **Sand and Gravel Deposits:** The ice of the last glaciations eroded the rock it advanced over depositing great quantities of sand, gravel and clay over most of Southern Saskatchewan (south of La Ronge). **Silica Sand Deposits:** The wave action during time of deposition of the sands has rounded the quartz (silica) grains and has helped to erode or clean any other bits of rock or minerals from these deposits. Mine: Hanson Lake Mine (Preferred Sands Ltd.)
7	11	Weathering and Erosion	Weathering and Erosion Stay here	**Placer Gold:** Gold has been eroded from nearby rocks and deposited in stream bed and lake shore sediments. Example: North Saskatchewan River, Ennis Lake **Sand and Gravel Deposits:** The ice of the last glaciations eroded the rock it advanced over depositing great quantities of sand, gravel and clay over most of Southern Saskatchewan (south of La Ronge). **Silica Sand Deposits:** The wave action during time of deposition of the sands has rounded the quartz (silica) grains and has helped to erode or clean any other bits of rock or minerals from these deposits. Mine: Hanson Lake Mine (Preferred Sands Ltd.)

8	11	Weathering and Erosion	Stay as Weathering and Erosion	**Placer Gold:** Gold has been eroded from nearby rocks and deposited in stream bed and lake shore sediments. Example: North Saskatchewan River, Ennis Lake **Sand and Gravel Deposits:** The ice of the last glaciations eroded the rock it advanced over depositing great quantities of sand, gravel and clay over most of Southern Saskatchewan (south of La Ronge). **Silica Sand Deposits:** The wave action during time of deposition of the sands has rounded the quartz (silica) grains and has helped to erode or clean any other bits of rock or minerals from these deposits. Mine: Hanson Lake Mine (Preferred Sands Ltd.)
9	11	Weathering and Erosion	Stay a Weathering and Erosion	**Placer Gold:** Gold has been eroded from nearby rocks and deposited in stream bed and lake shore sediments. Example: North Saskatchewan River, Ennis Lake **Sand and Gravel Deposits:** The ice of the last glaciations eroded the rock it advanced over depositing great quantities of sand, gravel and clay over most of Southern Saskatchewan (south of La Ronge). **Silica Sand Deposits:** The wave action during time of deposition of the sands has rounded the quartz (silica) grains and has helped to erode or clean any other bits of rock or minerals from these deposits. Mine: Hanson Lake Mine (Preferred Sands Ltd.)
10	11	Weathering and erosion	Change to Sediments	**Sand and Gravel Deposits:** The last glaciation deposited great quantities of sand, gravel and clays over most of Southern Saskatchewan (south of La Ronge). **Clay Deposits:** The mineral feldspar in feldspar rich sediment is altered to the clay mineral kaolinte during weathering. Mines: Gollier Creek Mine (Whitemud Resources Ltd.) Claybank- Past Producing **Placer Gold:** Gold has been eroded from nearby rocks and deposited in stream bed and lake shore sediments. Example: North Saskatchewan River, Ennis Lake
11	3	Sediments	Stay as Sediments	**Sand and Gravel Deposits:** The last glaciation deposited great quantities of sand, gravel and clays over most of Southern Saskatchewan (south of La Ronge). **Clay Deposits:** The mineral feldspar in feldspar rich sediment is altered to the clay mineral kaolinte during weathering. Mines: Gollier Creek Mine (Whitemud Resources Ltd.) Claybank- Past Producing **Placer Gold:** Gold has been eroded from nearby rocks and deposited in stream bed and lake shore sediments. Example: North Saskatchewan River, Ennis Lake

12	3	Sediments	Go to Compaction and Cementation	Uranium: As the Athabasca Basin filled, sand and gravel was compacted and cemented into sandstone and conglomerate. At the same time, hot oxidizing water containing dissolved uranium migrated through the sediment. On mixing with reducing water from fault zones extending into the underlying metamorphosed sedimentary rocks, uranium precipitated near the unconformity at the base of the sandstone. Mines: McArthur River, Eagle Point (Cameco) Cigar Lake (Cameco & Areva)
13	1	Compaction and Cementation	Go to Sedimentary Rock	**Potash:** The potash deposits are sedimentary rocks that formed when potash and other evaporite minerals crystallized as the sea waters evaporated. Mines: Esterhazy, Rocanville, Belle Plaine, Vanscoy, Cory, Colonsay, Allen, Lanigan, Patience Lake, **Coal Deposits**: About 65 million years ago, parts of southern Saskatchewan were covered by swamps. Thick accumulations of peat were buried by sand and transformed by heat and pressure into lignite, or brown coal. Mines: Poplar River, Boundary Dam, Bienfait (Sherritt Coal) **Uranium Deposits**: The uranium occurs in sandstones of the Athabasca Basin. The sand and gravel that filled the basin was eroded from a mountain range in northeastern Saskatchewan about 1750 million years ago. Mines: Rabbit Lake, Key Lake, Cigar Lake (Cameco) McLean Lake, Sue (Areva)
14	7	Sedimentary Rock	Go to Weathering and Erosion	**Placer Gold:** Gold has been eroded from nearby rocks and deposited in stream bed and lake shore sediments. Example: North Saskatchewan River, Ennis Lake **Sand and Gravel Deposits:** The ice of the last glaciations eroded the rock it advanced over depositing great quantities of sand, gravel and clay over most of Southern Saskatchewan (south of La Ronge). **Silica Sand Deposits:** The wave action during time of deposition of the sands has rounded the quartz (silica) grains and has helped to erode or clean any other bits of rock or minerals from these deposits. Mine: Hanson Lake Mine (Preferred Sands Ltd.)
15	11	Weathering and Erosion	Go to Sediments	Uranium: As the Athabasca Basin filled, sand and gravel was compacted and cemented into sandstone and conglomerate. At the same time, hot oxidizing water containing dissolved uranium migrated through the sediment. On mixing with reducing water from fault zones extending into the underlying metamorphosed sedimentary rocks, uranium precipitated near the unconformity at the base of the sandstone. Mines: McArthur River, Eagle Point (Cameco) Cigar Lake (Cameco & Areva) **Sand and Gravel Deposits:** The ice of the last glaciations eroded the rock it advanced over depositing great quantities of sand, gravel and clay over most of Southern Saskatchewan (south of La Ronge).

Station #1 Mineral Deposits formed by Compaction and/or Cementation

Uranium: As the Athabasca Basin filled, sand and gravel was compacted and cemented into sandstone and conglomerate. At the same time, hot oxidizing water containing dissolved uranium migrated through the sediment. On mixing with reducing water from fault zones extending into the underlying metamorphosed sedimentary rocks, uranium precipitated near the unconformity at the base of the sandstone. Mines: McArthur River, Eagle Point (Cameco) Cigar Lake (Cameco & Areva)	Uranium: As the Athabasca Basin filled, sand and gravel was compacted and cemented into sandstone and conglomerate. At the same time, hot oxidizing water containing dissolved uranium migrated through the sediment. On mixing with reducing water from fault zones extending into the underlying metamorphosed sedimentary rocks, uranium precipitated near the unconformity at the base of the sandstone. Mines: McArthur River, Eagle Point (Cameco) Cigar Lake (Cameco & Areva)
Uranium: As the Athabasca Basin filled, sand and gravel was compacted and cemented into sandstone and conglomerate. At the same time, hot oxidizing water containing dissolved uranium migrated through the sediment. On mixing with reducing water from fault zones extending into the underlying metamorphosed sedimentary rocks, uranium precipitated near the unconformity at the base of the sandstone. Mines: McArthur River, Eagle Point (Cameco) Cigar Lake (Cameco & Areva)	Uranium: As the Athabasca Basin filled, sand and gravel was compacted and cemented into sandstone and conglomerate. At the same time, hot oxidizing water containing dissolved uranium migrated through the sediment. On mixing with reducing water from fault zones extending into the underlying metamorphosed sedimentary rocks, uranium precipitated near the unconformity at the base of the sandstone. Mines: McArthur River, Eagle Point (Cameco) Cigar Lake (Cameco & Areva)
Uranium: As the Athabasca Basin filled, sand and gravel was compacted and cemented into sandstone and conglomerate. At the same time, hot oxidizing water containing dissolved uranium migrated through the sediment. On mixing with reducing water from fault zones extending into the underlying metamorphosed sedimentary rocks, uranium precipitated near the unconformity at the base of the sandstone. Mines: McArthur River, Eagle Point (Cameco) Cigar Lake (Cameco & Areva)	Uranium: As the Athabasca Basin filled, sand and gravel was compacted and cemented into sandstone and conglomerate. At the same time, hot oxidizing water containing dissolved uranium migrated through the sediment. On mixing with reducing water from fault zones extending into the underlying metamorphosed sedimentary rocks, uranium precipitated near the unconformity at the base of the sandstone. Mines: McArthur River, Eagle Point (Cameco) Cigar Lake (Cameco & Areva)
Uranium: As the Athabasca Basin filled, sand and gravel was compacted and cemented into sandstone and conglomerate. At the same time, hot oxidizing water containing dissolved uranium migrated through the sediment. On mixing with reducing water from fault zones extending into the underlying metamorphosed sedimentary rocks, uranium precipitated near the unconformity at the base of the sandstone. Mines: McArthur River, Eagle Point (Cameco) Cigar Lake (Cameco & Areva)	Uranium: As the Athabasca Basin filled, sand and gravel was compacted and cemented into sandstone and conglomerate. At the same time, hot oxidizing water containing dissolved uranium migrated through the sediment. On mixing with reducing water from fault zones extending into the underlying metamorphosed sedimentary rocks, uranium precipitated near the unconformity at the base of the sandstone. Mines: McArthur River, Eagle Point (Cameco) Cigar Lake (Cameco & Areva)

Station #2 Mineral Deposits associated with High Temperature and/or Pressure

Gold: Earthquakes create fractures in rocks. Pressure drops in the fractures. As the earthquake shock waves pass through gold and silica rich hot water, in the fractures, the drop in pressure causes the dissolved material to come out of solution (think of how CO2 gas comes out of solution when you open a can of pop) to form veins of quartz and gold. Mines: Seabee (Claude Resources Inc.) Roy Lloyd (Golden Band Resources Inc.)	**Gold**: Earthquakes create fractures in rocks. Pressure drops in the fractures. As the earthquake shock waves pass through gold and silica rich hot water, in the fractures, the drop in pressure causes the dissolved material to come out of solution (think of how CO2 gas comes out of solution when you open a can of pop) to form veins of quartz and gold. Mines: Seabee (Claude Resources Inc.) Roy Lloyd (Golden Band Resources Inc.)
Gold: Earthquakes create fractures in rocks. Pressure drops in the fractures. As the earthquake shock waves pass through gold and silica rich hot water, in the fractures, the drop in pressure causes the dissolved material to come out of solution (think of how CO2 gas comes out of solution when you open a can of pop) to form veins of quartz and gold. Mines: Seabee (Claude Resources Inc.) Roy Lloyd (Golden Band Resources Inc.)	**Gold**: Earthquakes create fractures in rocks. Pressure drops in the fractures. As the earthquake shock waves pass through gold and silica rich hot water, in the fractures, the drop in pressure causes the dissolved material to come out of solution (think of how CO2 gas comes out of solution when you open a can of pop) to form veins of quartz and gold. Mines: Seabee (Claude Resources Inc.) Roy Lloyd (Golden Band Resources Inc.)
Gold: Earthquakes create fractures in rocks. Pressure drops in the fractures. As the earthquake shock waves pass through gold and silica rich hot water, in the fractures, the drop in pressure causes the dissolved material to come out of solution (think of how CO2 gas comes out of solution when you open a can of pop) to form veins of quartz and gold. Mines: Seabee (Claude Resources Inc.) Roy Lloyd (Golden Band Resources Inc.)	**Gold**: Earthquakes create fractures in rocks. Pressure drops in the fractures. As the earthquake shock waves pass through gold and silica rich hot water, in the fractures, the drop in pressure causes the dissolved material to come out of solution (think of how CO2 gas comes out of solution when you open a can of pop) to form veins of quartz and gold. Mines: Seabee (Claude Resources Inc.) Roy Lloyd (Golden Band Resources Inc.)
Gold: Earthquakes create fractures in rocks. Pressure drops in the fractures. As the earthquake shock waves pass through gold and silica rich hot water, in the fractures, the drop in pressure causes the dissolved material to come out of solution (think of how CO2 gas comes out of solution when you open a can of pop) to form veins of quartz and gold. Mines: Seabee (Claude Resources Inc.) Roy Lloyd (Golden Band Resources Inc.)	**Gold**: Earthquakes create fractures in rocks. Pressure drops in the fractures. As the earthquake shock waves pass through gold and silica rich hot water, in the fractures, the drop in pressure causes the dissolved material to come out of solution (think of how CO2 gas comes out of solution when you open a can of pop) to form veins of quartz and gold. Mines: Seabee (Claude Resources Inc.) Roy Lloyd (Golden Band Resources Inc.)

Station #3 Mineral Deposits in Sediments

Sand and Gravel Deposits: The last glaciation deposited great quantities of sand, gravel and clays over most of Southern Saskatchewan (south of La Ronge). **Clay Deposits:** The mineral feldspar in feldspar rich sediment is altered to the clay mineral kaolinte during weathering. Mines: Gollier Creek Mine (Whitemud Resources Ltd.) Claybank- Past Producing	**Sand and Gravel Deposits:** The last glaciation deposited great quantities of sand, gravel and clays over most of Southern Saskatchewan (south of La Ronge). **Clay Deposits:** The mineral feldspar in feldspar rich sediment is altered to the clay mineral kaolinte during weathering. Mines: Gollier Creek Mine (Whitemud Resources Ltd.) Claybank- Past Producing
Sand and Gravel Deposits: The last glaciation deposited great quantities of sand, gravel and clays over most of Southern Saskatchewan (south of La Ronge). **Clay Deposits:** The mineral feldspar in feldspar rich sediment is altered to the clay mineral kaolinte during weathering. Mines: Gollier Creek Mine (Whitemud Resources Ltd.) Claybank- Past Producing	**Sand and Gravel Deposits:** The last glaciation deposited great quantities of sand, gravel and clays over most of Southern Saskatchewan (south of La Ronge). **Clay Deposits:** The mineral feldspar in feldspar rich sediment is altered to the clay mineral kaolinte during weathering. Mines: Gollier Creek Mine (Whitemud Resources Ltd.) Claybank- Past Producing
Sand and Gravel Deposits: The last glaciation deposited great quantities of sand, gravel and clays over most of Southern Saskatchewan (south of La Ronge). **Clay Deposits:** The mineral feldspar in feldspar rich sediment is altered to the clay mineral kaolinte during weathering. Mines: Gollier Creek Mine (Whitemud Resources Ltd.) Claybank- Past Producing	**Sand and Gravel Deposits:** The last glaciation deposited great quantities of sand, gravel and clays over most of Southern Saskatchewan (south of La Ronge). **Clay Deposits:** The mineral feldspar in feldspar rich sediment is altered to the clay mineral kaolinte during weathering. Mines: Gollier Creek Mine (Whitemud Resources Ltd.) Claybank- Past Producing
Sand and Gravel Deposits: The last glaciation deposited great quantities of sand, gravel and clays over most of Southern Saskatchewan (south of La Ronge). **Clay Deposits:** The mineral feldspar in feldspar rich sediment is altered to the clay mineral kaolinte during weathering. Mines: Gollier Creek Mine (Whitemud Resources Ltd.) Claybank- Past Producing	**Sand and Gravel Deposits:** The last glaciation deposited great quantities of sand, gravel and clays over most of Southern Saskatchewan (south of La Ronge). **Clay Deposits:** The mineral feldspar in feldspar rich sediment is altered to the clay mineral kaolinte during weathering. Mines: Gollier Creek Mine (Whitemud Resources Ltd.) Claybank- Past Producing

Station #4 Mineral Deposits in Igneous Rocks

Diamonds: Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. The igneous rocks diamonds are found in are called kimberlites. Example: Fort a la Corne (Shore Gold) **Copper-Zinc**: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock (mainly basalt). Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)	**Diamonds:** Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. The igneous rocks diamonds are found in are called kimberlites. Example: Fort a la Corne (Shore Gold) **Copper-Zinc**: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock (mainly basalt). Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)
Diamonds: Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. The igneous rocks diamonds are found in are called kimberlites. Example: Fort a la Corne (Shore Gold) **Copper-Zinc**: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock (mainly basalt). Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)	**Diamonds:** Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. The igneous rocks diamonds are found in are called kimberlites. Example: Fort a la Corne (Shore Gold) **Copper-Zinc**: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock (mainly basalt). Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)
Diamonds: Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. The igneous rocks diamonds are found in are called kimberlites. Example: Fort a la Corne (Shore Gold) **Copper-Zinc**: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock (mainly basalt). Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)	**Diamonds:** Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. The igneous rocks diamonds are found in are called kimberlites. Example: Fort a la Corne (Shore Gold) **Copper-Zinc**: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock (mainly basalt). Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)
Diamonds: Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. The igneous rocks diamonds are found in are called kimberlites. Example: Fort a la Corne (Shore Gold) **Copper-Zinc**: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock (mainly basalt). Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)	**Diamonds:** Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. The igneous rocks diamonds are found in are called kimberlites. Example: Fort a la Corne (Shore Gold) **Copper-Zinc**: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock (mainly basalt). Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)

Station #5 Minerals that have travelled To the Surface to form deposits.

Diamonds: Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold) **Sulphate Lakes: G**round water brings sodium and magnesium to the surface and is deposited into internally drained lakes. As evaporation occurs in the summer months the sodium and magnesium become concentrated and precipitate as sodium or magnesium sulphate crystals. Mines: Chaplin Lake (Saskatchewan Minerals Inc.); Big Quill Lake (Big Quill Lake Resources)	**Diamonds:** Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold) **Sulphate Lakes: G**round water brings sodium and magnesium to the surface and is deposited into internally drained lakes. As evaporation occurs in the summer months the sodium and magnesium become concentrated and precipitate as sodium or magnesium sulphate crystals. Mines: Chaplin Lake (Saskatchewan Minerals Inc.); Big Quill Lake (Big Quill Lake Resources)
Diamonds: Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold) **Sulphate Lakes: G**round water brings sodium and magnesium to the surface and is deposited into internally drained lakes. As evaporation occurs in the summer months the sodium and magnesium become concentrated and precipitate as sodium or magnesium sulphate crystals. Mines: Chaplin Lake (Saskatchewan Minerals Inc.); Big Quill Lake (Big Quill Lake Resources)	**Diamonds:** Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold) **Sulphate Lakes: G**round water brings sodium and magnesium to the surface and is deposited into internally drained lakes. As evaporation occurs in the summer months the sodium and magnesium become concentrated and precipitate as sodium or magnesium sulphate crystals. Mines: Chaplin Lake (Saskatchewan Minerals Inc.); Big Quill Lake (Big Quill Lake Resources)
Diamonds: Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold) **Sulphate Lakes: G**round water brings sodium and magnesium to the surface and is deposited into internally drained lakes. As evaporation occurs in the summer months the sodium and magnesium become concentrated and precipitate as sodium or magnesium sulphate crystals. Mines: Chaplin Lake (Saskatchewan Minerals Inc.); Big Quill Lake (Big Quill Lake Resources)	**Diamonds:** Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold) **Sulphate Lakes: G**round water brings sodium and magnesium to the surface and is deposited into internally drained lakes. As evaporation occurs in the summer months the sodium and magnesium become concentrated and precipitate as sodium or magnesium sulphate crystals. Mines: Chaplin Lake (Saskatchewan Minerals Inc.); Big Quill Lake (Big Quill Lake Resources)
Diamonds: Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold) **Sulphate Lakes: G**round water brings sodium and magnesium to the surface and is deposited into internally drained lakes. As evaporation occurs in the summer months the sodium and magnesium become concentrated and precipitate as sodium or magnesium sulphate crystals. Mines: Chaplin Lake (Saskatchewan Minerals Inc.); Big Quill Lake (Big Quill Lake Resources)	**Diamonds:** Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths to build volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold) **Sulphate Lakes: G**round water brings sodium and magnesium to the surface and is deposited into internally drained lakes. As evaporation occurs in the summer months the sodium and magnesium become concentrated and precipitate as sodium or magnesium sulphate crystals. Mines: Chaplin Lake (Saskatchewan Minerals Inc.); Big Quill Lake (Big Quill Lake Resources)

Station #6 Mineral Deposits that occur in Metamorphic Rocks or have formed through Metamorphism.

Uranium: Some uranium deposits are hosted along faults in the metamorphic rocks (gneiss) underlying the Athabasca sandstone. They formed when the warm uranium bearing fluids travelled up the faults and came in contact with a reducing environment. Example: Rabbit Lake. **Graphite**: Carbon in organic-rich sedimentary rock is recrystallized during high pressure and temperature metamorphism to form graphite. Example: Deep Bay deposit (Noble Bay Mining Development Inc.)	**Uranium:** Some uranium deposits are hosted along faults in the metamorphic rocks (gneiss) underlying the Athabasca sandstone. They formed when the warm uranium bearing fluids travelled up the faults and came in contact with a reducing environment. Example: Rabbit Lake. **Graphite**: Carbon in organic-rich sedimentary rock is recrystallized during high pressure and temperature metamorphism to form graphite. Example: Deep Bay deposit (Noble Bay Mining Development Inc.)
Uranium: Some uranium deposits are hosted along faults in the metamorphic rocks (gneiss) underlying the Athabasca sandstone. They formed when the warm uranium bearing fluids travelled up the faults and came in contact with a reducing environment. Example: Rabbit Lake. **Graphite**: Carbon in organic-rich sedimentary rock is recrystallized during high pressure and temperature metamorphism to form graphite. Example: Deep Bay deposit (Noble Bay Mining Development Inc.)	**Uranium:** Some uranium deposits are hosted along faults in the metamorphic rocks (gneiss) underlying the Athabasca sandstone. They formed when the warm uranium bearing fluids travelled up the faults and came in contact with a reducing environment. Example: Rabbit Lake. **Graphite**: Carbon in organic-rich sedimentary rock is recrystallized during high pressure and temperature metamorphism to form graphite. Example: Deep Bay deposit (Noble Bay Mining Development Inc.)
Uranium: Some uranium deposits are hosted along faults in the metamorphic rocks (gneiss) underlying the Athabasca sandstone. They formed when the warm uranium bearing fluids travelled up the faults and came in contact with a reducing environment. Example: Rabbit Lake. **Graphite**: Carbon in organic-rich sedimentary rock is recrystallized during high pressure and temperature metamorphism to form graphite. Example: Deep Bay deposit (Noble Bay Mining Development Inc.)	**Uranium:** Some uranium deposits are hosted along faults in the metamorphic rocks (gneiss) underlying the Athabasca sandstone. They formed when the warm uranium bearing fluids travelled up the faults and came in contact with a reducing environment. Example: Rabbit Lake. **Graphite**: Carbon in organic-rich sedimentary rock is recrystallized during high pressure and temperature metamorphism to form graphite. Example: Deep Bay deposit (Noble Bay Mining Development Inc.)
Uranium: Some uranium deposits are hosted along faults in the metamorphic rocks (gneiss) underlying the Athabasca sandstone. They formed when the warm uranium bearing fluids travelled up the faults and came in contact with a reducing environment. Example: Rabbit Lake. **Graphite**: Carbon in organic-rich sedimentary rock is recrystallized during high pressure and temperature metamorphism to form graphite. Example: Deep Bay deposit (Noble Bay Mining Development Inc.)	**Uranium:** Some uranium deposits are hosted along faults in the metamorphic rocks (gneiss) underlying the Athabasca sandstone. They formed when the warm uranium bearing fluids travelled up the faults and came in contact with a reducing environment. Example: Rabbit Lake. **Graphite**: Carbon in organic-rich sedimentary rock is recrystallized during high pressure and temperature metamorphism to form graphite. Example: Deep Bay deposit (Noble Bay Mining Development Inc.)

Station #7 Mineral Deposits in Sedimentary Rocks

Potash: The potash deposits are sedimentary rocks that formed when potash and other evaporite minerals crystallized as the sea waters evaporated.

Mines: Esterhazy, Rocanville, Belle Plaine, Vanscoy, Cory, Colonsay, Allen, Lanigan, Patience Lake,

Coal Deposits: About 65 million years ago, parts of southern Saskatchewan were covered by swamps. Thick accumulations of peat were buried by sand and transformed by heat and pressure into lignite, or brown coal.

Mines: Poplar River, Boundary Dam, Bienfait (Sherritt Coal)

Uranium Deposits: The uranium occurs in sandstones of the Athabasca Basin. The sand and gravel that filled the basin was eroded from a mountain range in northeastern Saskatchewan about 1750 million years ago.

Mines: Rabbit Lake, Key Lake, Cigar Lake (Cameco)
McLean Lake, Sue (Areva)

Potash: The potash deposits are sedimentary rocks that formed when potash and other evaporite minerals crystallized as the sea waters evaporated.

Mines: Esterhazy, Rocanville, Belle Plaine, Vanscoy, Cory, Colonsay, Allen, Lanigan, Patience Lake,

Coal Deposits: About 65 million years ago, parts of southern Saskatchewan were covered by swamps. Thick accumulations of peat were buried by sand and transformed by heat and pressure into lignite, or brown coal.

Mines: Poplar River, Boundary Dam, Bienfait (Sherritt Coal)

Uranium Deposits: The uranium occurs in sandstones of the Athabasca Basin. The sand and gravel that filled the basin was eroded from a mountain range in northeastern Saskatchewan about 1750 million years ago.

Mines: Rabbit Lake, Key Lake, Cigar Lake (Cameco)
McLean Lake, Sue (Areva)

Potash: The potash deposits are sedimentary rocks that formed when potash and other evaporite minerals crystallized as the sea waters evaporated.

Mines: Esterhazy, Rocanville, Belle Plaine, Vanscoy, Cory, Colonsay, Allen, Lanigan, Patience Lake,

Coal Deposits: About 65 million years ago, parts of southern Saskatchewan were covered by swamps. Thick accumulations of peat were buried by sand and transformed by heat and pressure into lignite, or brown coal.

Mines: Poplar River, Boundary Dam, Bienfait (Sherritt Coal)

Uranium Deposits: The uranium occurs in sandstones of the Athabasca Basin. The sand and gravel that filled the basin was eroded from a mountain range in northeastern Saskatchewan about 1750 million years ago.

Mines: Rabbit Lake, Key Lake, Cigar Lake (Cameco)
McLean Lake, Sue (Areva)

Potash: The potash deposits are sedimentary rocks that formed when potash and other evaporite minerals crystallized as the sea waters evaporated.

Mines: Esterhazy, Rocanville, Belle Plaine, Vanscoy, Cory, Colonsay, Allen, Lanigan, Patience Lake,

Coal Deposits: About 65 million years ago, parts of southern Saskatchewan were covered by swamps. Thick accumulations of peat were buried by sand and transformed by heat and pressure into lignite, or brown coal.

Mines: Poplar River, Boundary Dam, Bienfait (Sherritt Coal)

Uranium Deposits: The uranium occurs in sandstones of the Athabasca Basin. The sand and gravel that filled the basin was eroded from a mountain range in northeastern Saskatchewan about 1750 million years ago.

Mines: Rabbit Lake, Key Lake, Cigar Lake (Cameco)
McLean Lake, Sue (Areva)

Potash: The potash deposits are sedimentary rocks that formed when potash and other evaporite minerals crystallized as the sea waters evaporated.

Mines: Esterhazy, Rocanville, Belle Plaine, Vanscoy, Cory, Colonsay, Allen, Lanigan, Patience Lake,

Coal Deposits: About 65 million years ago, parts of southern Saskatchewan were covered by swamps. Thick accumulations of peat were buried by sand and transformed by heat and pressure into lignite, or brown coal.

Mines: Poplar River, Boundary Dam, Bienfait (Sherritt Coal)

Uranium Deposits: The uranium occurs in sandstones of the Athabasca Basin. The sand and gravel that filled the basin was eroded from a mountain range in northeastern Saskatchewan about 1750 million years ago.

Mines: Rabbit Lake, Key Lake, Cigar Lake (Cameco)
McLean Lake, Sue (Areva)

Potash: The potash deposits are sedimentary rocks that formed when potash and other evaporite minerals crystallized as the sea waters evaporated.

Mines: Esterhazy, Rocanville, Belle Plaine, Vanscoy, Cory, Colonsay, Allen, Lanigan, Patience Lake,

Coal Deposits: About 65 million years ago, parts of southern Saskatchewan were covered by swamps. Thick accumulations of peat were buried by sand and transformed by heat and pressure into lignite, or brown coal.

Mines: Poplar River, Boundary Dam, Bienfait (Sherritt Coal)

Uranium Deposits: The uranium occurs in sandstones of the Athabasca Basin. The sand and gravel that filled the basin was eroded from a mountain range in northeastern Saskatchewan about 1750 million years ago.

Mines: Rabbit Lake, Key Lake, Cigar Lake (Cameco)
McLean Lake, Sue (Areva)

Potash: The potash deposits are sedimentary rocks that formed when potash and other evaporite minerals crystallized as the sea waters evaporated.

Mines: Esterhazy, Rocanville, Belle Plaine, Vanscoy, Cory, Colonsay, Allen, Lanigan, Patience Lake,

Coal Deposits: About 65 million years ago, parts of southern Saskatchewan were covered by swamps. Thick accumulations of peat were buried by sand and transformed by heat and pressure into lignite, or brown coal.

Mines: Poplar River, Boundary Dam, Bienfait (Sherritt Coal)

Uranium Deposits: The uranium occurs in sandstones of the Athabasca Basin. The sand and gravel that filled the basin was eroded from a mountain range in northeastern Saskatchewan about 1750 million years ago.

Mines: Rabbit Lake, Key Lake, Cigar Lake (Cameco)
McLean Lake, Sue (Areva)

Potash: The potash deposits are sedimentary rocks that formed when potash and other evaporite minerals crystallized as the sea waters evaporated.

Mines: Esterhazy, Rocanville, Belle Plaine, Vanscoy, Cory, Colonsay, Allen, Lanigan, Patience Lake,

Coal Deposits: About 65 million years ago, parts of southern Saskatchewan were covered by swamps. Thick accumulations of peat were buried by sand and transformed by heat and pressure into lignite, or brown coal.

Mines: Poplar River, Boundary Dam, Bienfait (Sherritt Coal)

Uranium Deposits: The uranium occurs in sandstones of the Athabasca Basin. The sand and gravel that filled the basin was eroded from a mountain range in northeastern Saskatchewan about 1750 million years ago.

Mines: Rabbit Lake, Key Lake, Cigar Lake (Cameco)
McLean Lake, Sue (Areva)

Station #9 Mineral Deposits formed by either Cooling and/or Hardening (Crystallization)

Copper-Zinc: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines**:** Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.) **Potash:** When warm potash rich brines are brought to the surface and left to cool in ponds during the winter months, the potash crystallizes out of solution. Mines: Belle Plaine (Mosaic); Patience Lake (Potash Corp)	**Copper-Zinc**: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines**:** Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.) **Potash:** When warm potash rich brines are brought to the surface and left to cool in ponds during the winter months, the potash crystallizes out of solution. Mines: Belle Plaine (Mosaic); Patience Lake (Potash Corp)
Copper-Zinc: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines**:** Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.) **Potash:** When warm potash rich brines are brought to the surface and left to cool in ponds during the winter months, the potash crystallizes out of solution. Mines: Belle Plaine (Mosaic); Patience Lake (Potash Corp)	**Copper-Zinc**: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines**:** Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.) **Potash:** When warm potash rich brines are brought to the surface and left to cool in ponds during the winter months, the potash crystallizes out of solution. Mines: Belle Plaine (Mosaic); Patience Lake (Potash Corp)
Copper-Zinc: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines**:** Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.) **Potash:** When warm potash rich brines are brought to the surface and left to cool in ponds during the winter months, the potash crystallizes out of solution. Mines: Belle Plaine (Mosaic); Patience Lake (Potash Corp)	**Copper-Zinc**: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines**:** Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.) **Potash:** When warm potash rich brines are brought to the surface and left to cool in ponds during the winter months, the potash crystallizes out of solution. Mines: Belle Plaine (Mosaic); Patience Lake (Potash Corp)
Copper-Zinc: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines**:** Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.) **Potash:** When warm potash rich brines are brought to the surface and left to cool in ponds during the winter months, the potash crystallizes out of solution. Mines: Belle Plaine (Mosaic); Patience Lake (Potash Corp)	**Copper-Zinc**: When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines**:** Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.) **Potash:** When warm potash rich brines are brought to the surface and left to cool in ponds during the winter months, the potash crystallizes out of solution. Mines: Belle Plaine (Mosaic); Patience Lake (Potash Corp)

Station #10 Formation of Economic Minerals and Mineral Deposits in Magma

Diamond: Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths building volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold Inc.) **Copper-Zinc:** When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)	**Diamond:** Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths building volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold Inc.) **Copper-Zinc:** When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)
Diamond: Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths building volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold Inc.) **Copper-Zinc:** When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)	**Diamond:** Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths building volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold Inc.) **Copper-Zinc:** When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)
Diamond: Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths building volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold Inc.) **Copper-Zinc:** When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)	**Diamond:** Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths building volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold Inc.) **Copper-Zinc:** When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)
Diamond: Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths building volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold Inc.) **Copper-Zinc:** When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)	**Diamond:** Diamonds form at extremely high pressure and temperature very deep within the earth. Magma rising from these depths building volcanoes may carry diamonds up towards the surface. Example: Fort a la Corne (Shore Gold Inc.) **Copper-Zinc:** When magma rich in copper and zinc reacts with hot seawater containing dissolved sulphur, copper and zinc sulphide minerals will crystallize as the magma cools, forming sulphide-rich layers or zones within the volcanic rock. Mines: Triple 7 mine at Flin Flon, MB; past-producing mines at Creighton, SK (HudBay Minerals Inc.)

Station #11 Formation Mineral Deposits through Weathering and Erosion

Sand and Gravel Deposits: The ice of the last glaciations eroded the rock it advanced over depositing great quantities of sand, gravel and clay over most of Southern Saskatchewan (south of La Ronge). **Silica Sand Deposits:** The wave action during time of deposition of the sands has rounded the quartz (silica) grains and has helped to erode or clean any other bits of rock or minerals from these deposits. Mine: Hanson Lake Mine (Preferred Sands Ltd.)	**Sand and Gravel Deposits:** The ice of the last glaciations eroded the rock it advanced over depositing great quantities of sand, gravel and clay over most of Southern Saskatchewan (south of La Ronge). **Silica Sand Deposits:** The wave action during time of deposition of the sands has rounded the quartz (silica) grains and has helped to erode or clean any other bits of rock or minerals from these deposits. Mine: Hanson Lake Mine (Preferred Sands Ltd.)
Sand and Gravel Deposits: The ice of the last glaciations eroded the rock it advanced over depositing great quantities of sand, gravel and clay over most of Southern Saskatchewan (south of La Ronge). **Silica Sand Deposits:** The wave action during time of deposition of the sands has rounded the quartz (silica) grains and has helped to erode or clean any other bits of rock or minerals from these deposits. Mine: Hanson Lake Mine (Preferred Sands Ltd.)	**Sand and Gravel Deposits:** The ice of the last glaciations eroded the rock it advanced over depositing great quantities of sand, gravel and clay over most of Southern Saskatchewan (south of La Ronge). **Silica Sand Deposits:** The wave action during time of deposition of the sands has rounded the quartz (silica) grains and has helped to erode or clean any other bits of rock or minerals from these deposits. Mine: Hanson Lake Mine (Preferred Sands Ltd.)
Sand and Gravel Deposits: The ice of the last glaciations eroded the rock it advanced over depositing great quantities of sand, gravel and clay over most of Southern Saskatchewan (south of La Ronge). **Silica Sand Deposits:** The wave action during time of deposition of the sands has rounded the quartz (silica) grains and has helped to erode or clean any other bits of rock or minerals from these deposits. Mine: Hanson Lake Mine (Preferred Sands Ltd.)	**Sand and Gravel Deposits:** The ice of the last glaciations eroded the rock it advanced over depositing great quantities of sand, gravel and clay over most of Southern Saskatchewan (south of La Ronge). **Silica Sand Deposits:** The wave action during time of deposition of the sands has rounded the quartz (silica) grains and has helped to erode or clean any other bits of rock or minerals from these deposits. Mine: Hanson Lake Mine (Preferred Sands Ltd.)
Sand and Gravel Deposits: The ice of the last glaciations eroded the rock it advanced over depositing great quantities of sand, gravel and clay over most of Southern Saskatchewan (south of La Ronge). **Silica Sand Deposits:** The wave action during time of deposition of the sands has rounded the quartz (silica) grains and has helped to erode or clean any other bits of rock or minerals from these deposits. Mine: Hanson Lake Mine (Preferred Sands Ltd.)	**Sand and Gravel Deposits:** The ice of the last glaciations eroded the rock it advanced over depositing great quantities of sand, gravel and clay over most of Southern Saskatchewan (south of La Ronge). **Silica Sand Deposits:** The wave action during time of deposition of the sands has rounded the quartz (silica) grains and has helped to erode or clean any other bits of rock or minerals from these deposits. Mine: Hanson Lake Mine (Preferred Sands Ltd.)

Student Instructions

The rock cycle is a dynamic force that drives geologic activity and affects entire continents, the formation and destruction of Earth's surface features (mountains, oceans), global weather and life on Earth. In this activity you will model what can happen to a bit of rock or sediment as it moves through the rock cycle.

Background:

In this activity various rock types and processes such as melting, cooling, and weathering, are located at 11 different stations. Each station has a "die" – a box that is labeled on each of its six sides. The sides of the dice are marked to reflect the relative likelihood of materials actually moving through these phases. For example, rock material may remain in a molten state inside the earth for long periods of time. To show this, the die at station # 10, "Magma," has four sides that say "magma (stay as you are)" and just two sides that say "cooling and hardening." If you roll the "magma (stay as you are)" side of the die, you will stay at station #10 and roll again when it is your turn. If you roll one of the sides that say "cooling and hardening" you would move to station #9, the "Cooling and Hardening (crystallization)" station.

At each station you will also find a Saskatchewan Mineral Deposits sign as well as smaller "cards" and tape or glue. These cards explain the various Saskatchewan minerals deposits, what rock type they occur in or the process that helped form them.

1. Begin by choosing one station to start at. There are 11 stations so there should be two or three students at each station at the beginning of the game. It does not matter where you start; you probably will have a chance to visit most of the other stations during the game.

2. Using the **Rock Cycle Journey Table** record the # of the station you begin at as well as the name of the station.

3. If there is a Saskatchewan Mineral Deposits card, take one and tape/glue it in the appropriate column (Mineral Deposits Information).

4. Now roll the die and record what the die instructed you to do in the "what happened" column of the table.

5. In reality there is no set formula for how long rocky material spends at each phase of the rock cycle. It may speed through in just 200,000 years or so, or it may stay at the same point in the cycle for millions of years. For the purposes of this game, **count each roll of the die as 200,000 years.** Even if you end up staying at the same place for multiple turns, every time you roll the die you add another 200,000 years to the age of your rock.

6. Record each of these pieces of information in your **Rock Cycle Journey Table** each time you have a turn. It is important to keep careful records, as you will need the information to complete a "data summary" and answer some questions.

ROCK CYCLE JOURNEY TABLE

ROLL #	STATION #	STATION NAME	WHAT HAPPENED (Stay as _____ or change into ____?)	Mineral Deposit Information
1				
2				
3				

ROLL #	STATION #	STATION NAME	WHAT HAPPENED (stay as _______ or change into _________?	MINERAL DEPOSIT INFORMATION
4				
5				
6				
7				

ROLL #	STATION #	STATION NAME	WHAT HAPPENED (stay as _______ or change into _________?	MINERAL DEPOSIT INFORMATION
8				
9				
10				
11				

ROLL #	STATION #	STATION NAME	WHAT HAPPENED (stay as _______ or change into _________?	MINERAL DEPOSIT INFORMATION
12				
13				
14				
15				

DATA SUMMARY

TOTAL NUMBER OF VISITS TO EACH STATION Each time you are told to "go" or "stay" at a station it counts as a visit.		
Station #	**Station Name**	**Total Number of Visits**
1.	Compaction and Cementation	
2.	High Temperature and Pressure	
3.	Sediments	
4.	Igneous Rock	
5.	To the Surface	
6.	Metamorphic Rock	
7.	Sedimentary Rock	
8.	Melting	
9.	Cooling and Hardening (crystallization)	
10.	Magma	
11.	Weathering and Erosion	

Along your path you came across mineral deposits being formed. List the Saskatchewan mineral deposits, the host rocks (sedimentary, igneous, metamorphic) and/or the processes that formed them.

Mineral Deposit	Host Rock	Process

Review and Reflect

Answer the following questions in the space below.

1. a. Did you get "stuck" for more than 3 turns at any particular station? Which one and for how long?

   b. Explain why you think you were "stuck" there for such a length of time.

2. Which station did you spend the least amount of time at and explain why you think that would be.

3. What phase did you end up at? (Igneous, metamorphic or sedimentary rock, sediment or magma)

4. Choose one of the ore deposits that you visited.
   Ore deposit: ______________________ Host rock: _____________________

   Locate the deposit on the Saskatchewan Mineral Deposit Map. Where in Saskatchewan are you located?

5. How long did it take you as a grain of sand to move through the rock cycle? Each roll of the dice is a turn and each turn is equal to 200,000 years of geologic time. Find the age by multiplying your total number of turns by 200,000. Write the answer below.

6. Compare your journey through the rock cycle with at least two other students. Is there only one path through the rock cycle? Explain.

7. Show your journey on the Rock Cycle diagram.

Rock Cycle Journey Summary Activity

Use this sheet as a journey log to help plan your story. Record your steps as you travelled to new stations during your rock cycle journey. Describe your experience at each station and say what kind of rock or material you were (igneous, sediments, magma, etc.). Include whether or not a mineral deposit formed along your travels and explain what happened to it along the way. It is okay if you did not actually go to new stations 15 times; just fill out what you did. If you travelled to more than 15 stations create your own sentences or recycle some of the ones here.

1. I began my adventure as a grain of sand at this station: *(fill in what happened at station #1).* 2. The next station I went to after that was # ___________________________ where I became ____.

3. After that station, I became ____at station: # ______________________________________. 4. Next, I went to this station #____ and turned into ___________________________________. After that, I found myself at station: ___________________________________ where I became ______________________. Next, I went to ____ and turned into _________________________________**.** 8. The next station I went to after that was __________________________________ where I became _______________________.

9. After my experiences there, I became ____________________________________. At this station # ____. 10. Next, I went to ____ and turned into ____. 11. Following that, I went to _____________________________________ where I became ____. 12.Wondering what was going to happen next , I travelled to station # ________________________________ where I was _____________________________. 13. With that completed I continued

on to station # ________________________________and that's where I was

__________________________ 14. Caught up in this cycle I landed at station#

_______________. That's where I _______________ 15. Finally, after that last

station I ended up as ____________________________________ at this

station_#____.

I am currently (choose one of: a) on the Earth's surface, b) still deep in the crust, c) still deep in the mantle (if magma) .

While on this incredible cyclical journey I became the host for a (name the type of one of the mineral deposits visited) which formed (explain how it formed, see processes) and is currently being

Choose one or more of

a) mined (if it is a mine) in (indicate where the deposit is located) Saskatchewan.

b) explored (if it is a deposit) in indicate where the deposit is located) Saskatchewan.