Grade 7: Mixtures and Solutions; Earth's Crust and Resources

Lesson: Potash Solution Mining Model

Overview

In a hands-on, inquiry, and model making activity, students further their understanding of how solution mining of potash deposits occurs.

Duration: I class, monitor for 4- 5 days

Materials:

- Plasticine
- Rock or coarse salt (kosher salt, pickling salt)
- Straws ~ 2 per group
- Rubber tubing (aquarium tubing) ~ 40 cm per group
- Clear plastic cups 3 per group
- Large plastic syringe 1 per group
- Blue dye for water
- **Student Observation Sheet**
- **Potash Solution Model PowerPoint**
- **Potash Solution Mining in Saskatchewan diagram**

Note to Teacher

This lesson could also be done as a teacher demonstration along with the Potash Solution Model PowerPoint.

Instructional Methods:

Model making

Solution pond PotashCorp Patience Lake

Learning Outcomes and Indicators

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.

a. Identify questions to investigate arising from practical problems and issues related to the study of Earth's geological resources (e.g., "What types of rocks are best for cement-making or road construction?" and "What are some environmental concerns related to open-pit mining?").

e. Relate processes used to extract primary mineral resources in Saskatchewan (e.g., open-pit mining, underground mining, and solution mining) to the location, type, and depth of the resource

MS7.2 Investigate methods of separating the components of mechanical mixtures and solutions, and analyze the impact of industrial and agricultural applications of those methods. [SI, TPS]

a. Describe methods used to separate the components of mechanical mixtures and solutions, including mechanical sorting, filtration, evaporation, distillation, magnetism, and chromatography.

d. Design and conduct an experiment to determine the effectiveness and/or efficiency of one or more methods of separating mechanical mixtures and solutions.

h. Describe the scientific principles underlying a past or present industrial technology designed to separate mixtures (e.g., petroleum refining, sewage treatment plant, recycling station, combine, and cream separator).

j. Use a technological problem-solving process to design, construct, and evaluate a prototype of a process or device for separating a mechanical mixture or solution (e.g., purifying drinking water, separating household waste).

Source: **Saskatchewan Evergreen Curriculum**

Big Picture Question

1. **How is potash mined if it is too deep in the ground to mine in the conventional underground method?**

Background Information

Saskatchewan, potash is extracted from deep underground deposits (generally greater than1000 m deep) using either conventional (mining machines) or solution mining (brine is used to remove the mineral in solution) techniques. To mine at depths greater than 1000m (1 km) it is more economical as well as safer to solution mine.

The largest potash solution mine in the world is located at Belle Plaine, Saskatchewan. It took the Mosaic Company years of research to develop the solution mining system currently used.

In this technique, warm water is pumped down wells into the potash formation. The potash is dissolved deep underground and the resulting solution is pumped to the plant on surface where the potash is removed. Large amounts of water are removed from the solution using evaporators. The evaporated water is recovered and reused. As the water is evaporated the salt crystallizes first before the potash. Some of this salt goes to the nearby Canadian Salt Company plant. Once the salt has crystallized the remaining potash rich solution goes though the process of crystallizing the potash mineral sylvite (KCl).

Another method of recovering the potash is through cooling ponds. The warm salt (NaCl and KCl) rich solution flows into outdoor ponds. As the solution cools potash crystallizes and sinks to the pond floor. A dredge is used to collect the crystals and pump them in a slurry to the plant where it will be separated out.

The same process can be used above ground to extract the potash from the sylvinite ore. After potash is mined, it is processed in a surface mill, where it is separated into product (KCl) and waste (tailings comprised of salt and clays).

Safety concerns

- Do not rub eyes after handling salt solution

Vocabulary

brine	dissolve
halite	ore
potash	sylvite
sylvinite	

THE ACTIVITY

Potash Solution Mining

(Modeling, Inquiry) (Initial set up 40 min.)

This activity could also be done as a teacher demonstration.

Teacher Preparation:

Review the PowerPoint *Potash Solution Model*

Prepare cups with plastecine and salt. 1 cup per group.

Motivational Set: (15 min.)

In some places in Saskatchewan, the potash resource is too deep to mine by the conventional underground method. As potash is very valuable, the mining companies are looking for a way to mine it.

1. Review what the students know about potash ore. ***Students can research what minerals are in Potash. Potash ore is made up of salts NaCl and KCl. Tell the students that NaCl is table salt.***

The Activity

1. Hand out the cups with plasticine and salt layers. Explain that each cup represents the potash deposits in Saskatchewan. These layers are too deep to dig out or go underground to mine. Because the potash is so valuable, the mining companies are looking for a method to mine it.
2. Explain that the students will have to figure out how to get the potash out of the ground using the ”tools” that are available. They are not allowed to dig through the layers.
4. Show the students the “tools”: straws, tubing, syringes, plastic cups, water
5. Have students draw a picture of their plan and write a brief description of what they are going to do and the expected outcome.
   If the students are having difficulties brainstorming you may have to lead them to the conclusion that salt dissolves in water.
6. Once the students have had their plan approved have them build their models.
7. Hand out Observation Sheets.

8. Have students record their initial observations.
9. Leave the models overnight or until the next class. ***It may take a while for the salt to dissolve, unless the students choose to use warm water.***
10. Next class have students test their models. Can they get the salt out of the ground?
11. Show students the diagram of how the potash is extracted in solution from the ground, by mining companies.
12. Explain that this is one way that Mosaic Belle Plaine separates the potash from the salt. Warm water (52^{o}C) is injected down a well into the potash ore where it dissolves the salts NaCl and KCl. The solution is then pumped back up to the surface and to the mill where it is processed to recover the dissolved KCl. In the winter the KCl and NaCl rich brine solution from underground is pumped out into holding ponds where the cold temperature of the air cools the warm brine and causes the KCl to precipitate out. In the summer the precipitation is done inside the mill.
13. Have the students take out two syringes of salty water daily and place it into the 3rd cup, for 4 days.
14. Have students describe what is happening in the "reservoir" cup.

Assessment Method and Evidence

Students will investigate a method of separating the components of mechanical mixtures and solutions, and analyze the impact of industrial and agricultural applications of those methods. [SI, TPS]

✓ **Model/Observation Sheet**

- The students will be able to describe and show, using their models, how the potash mining companies use solubility, dissolution and evaporation to separate the components of the mechanical mixture sylvinite (potash ore) to mine the valuable mineral potash.

- The students will be able to describe the scientific principles underlying the present industrial technology designed to separate mixture of soluble and insoluble minerals in the potash ore and how it is used to extract the valuable ore mineral sylvite (KCl).

- The students will use a technological problem-solving process to design, construct, and evaluate a prototype of a process or device for separating a mechanical mixture or solution when they mine (extract) the salt layer without disturbing the overlying "rocks".

- Students will identify questions related to how to mine potash from depth if the mining company can not develop a conventional mine. (E.g. What are the minerals in potash, how can we get the potash to the surface if we can't dig or sink a shaft? What happens if we add water? How deep can a drill go?)

- Students will relate solution mining with extraction of soluble minerals at great depth (greater than 1,000m).

Resources

Mining and milling processes used at the PotashCorp mines.
http://www.potashcorp.com/media/POT_Mini_Mine_Tour_brochure.pdf

Saskatchewan Potash Interpretive Centre:
http://www.potashinterpretivecentre.com/index2.htm

Saskatchewan Mining Association Website:
http://www.saskmining.ca

Potash Corporation of Saskatchewan Website:
http://www.potashcorp.com/

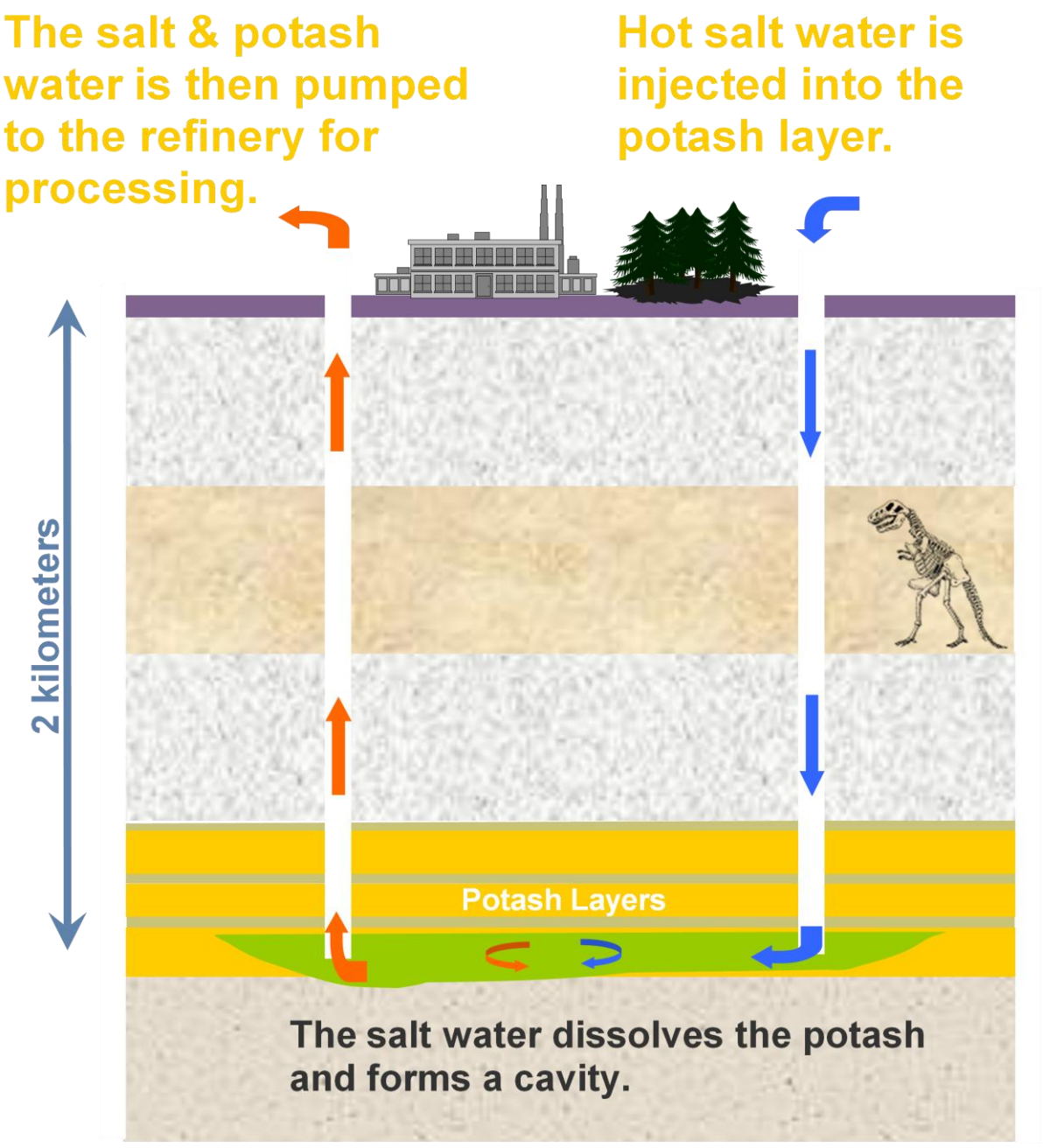
International Fertilizer Association Website:
http://www.fertilizer.org/ifa/default.asp

Agrium Website: http://www.agrium.com

The Mosaic Company Website:
http://www.mosaicco.com

OBSERVATIONS		
Time + Date	Observations	Drawing

Potash Solution Mining in Saskatchewan



Source: Mosaic BellePlaine

Vocabulary

Brine: Water saturated with or containing large amounts of a salt, especially sodium chloride. The water of a sea or an ocean is a brine.

Dissolve: To break into parts to become incorporated into a liquid so as to form a solution.

Halite: Sodium chloride (NaCl) as a mineral, typically occurring as colourless cubic crystals; what we know as salt.

Ore: is rock that contains important minerals including metals**.** The ore is extracted through mining and processed to extract the valuable element(s). Ore contains minerals that can be mined at a profit.

Potash: is Saskatchewan's provincial mineral. Potash is the common name for the potassium rich ore mined in Saskatchewan. It is made up of the minerals sylvite, halite, sometimes carnallite, clay and iron oxides.

Sylvinite: is the most important ore for the production of potash in North America. It is a mechanical mixture of sylvite (KCl, or potassium chloride) and halite (NaCl, or sodium chloride).

Sylvite: is potassium chloride (KCl) in natural mineral form. It forms very similar to normal rock salt, halite (NaCl). Sylvite is colorless to white with shades of yellow and red due to inclusion of other minerals. It has a Mohs hardness of 2.5. Sylvite has a bitter, salty taste. Its principal use is as a potassium fertilizer.