

Mining... GREAT for Saskatchewan!

Potash Solution Mining





Potash Ore – What is it?



- Sylvanite
- Red mineral – iron oxide
- Grey mineral – clay
- Rest is made up of the minerals
halite (NaCl) table salt
and
sylvite (KCl) potash

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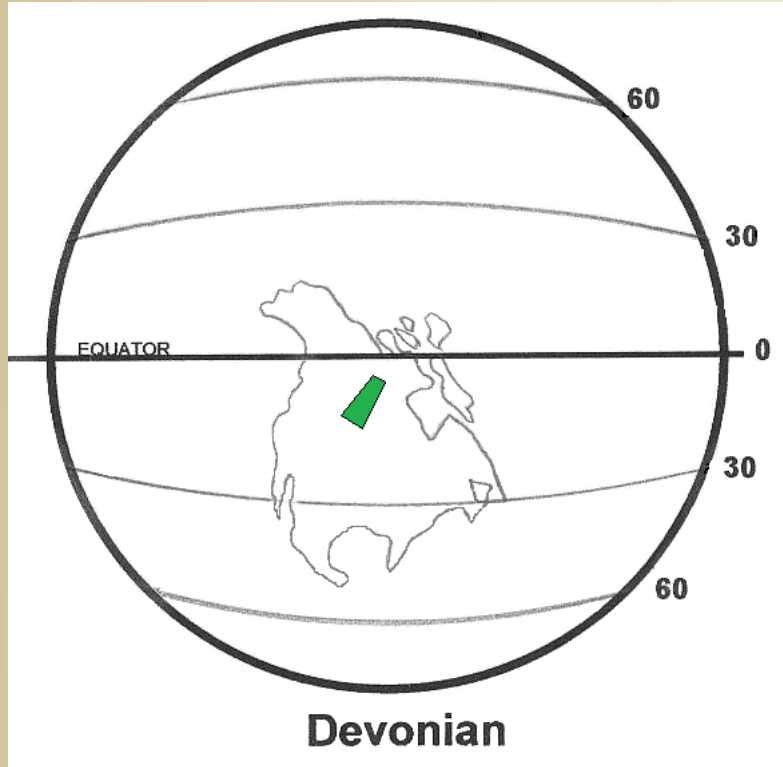


Every rock tells a story

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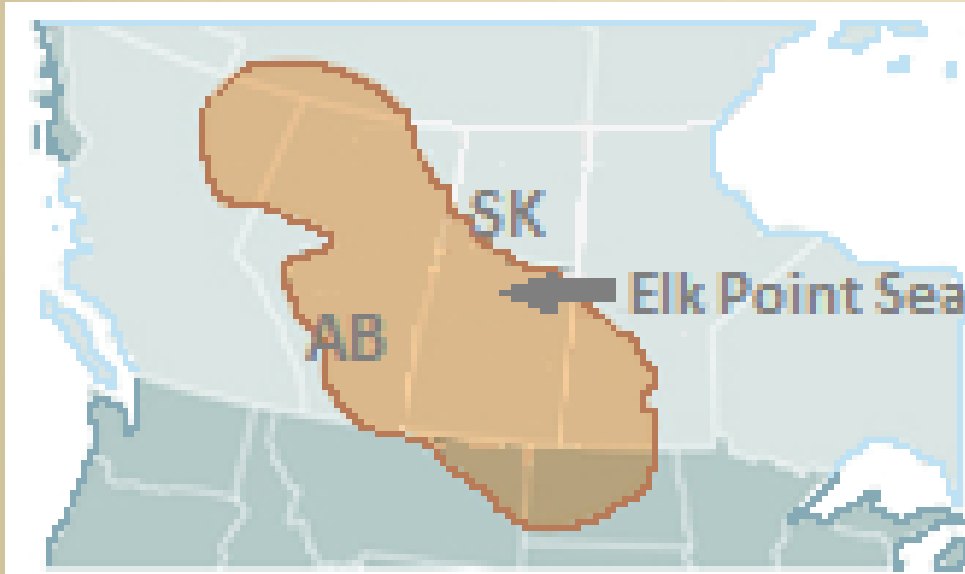


WHY IS THERE POTASH IN SASKATCHEWAN?



- 380 million years ago Saskatchewan was tropical.

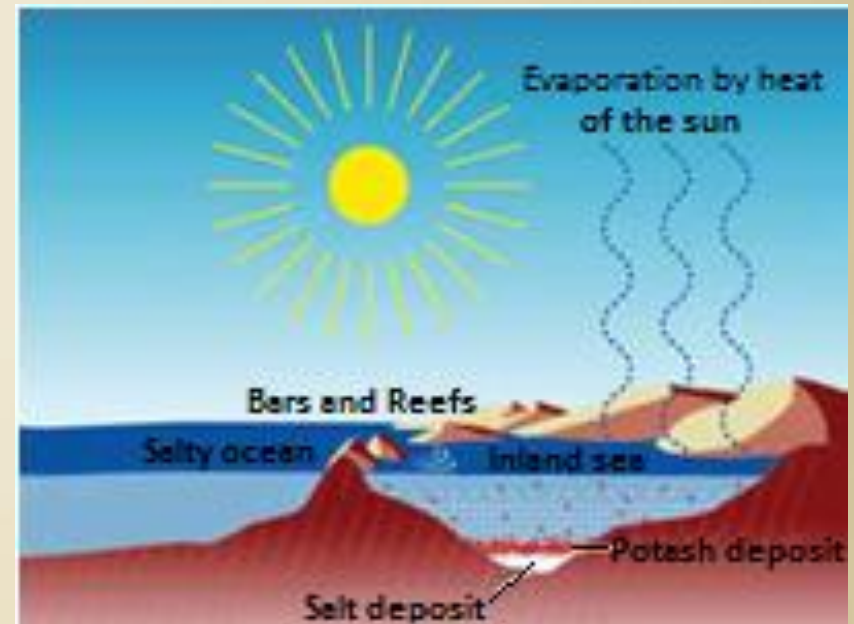
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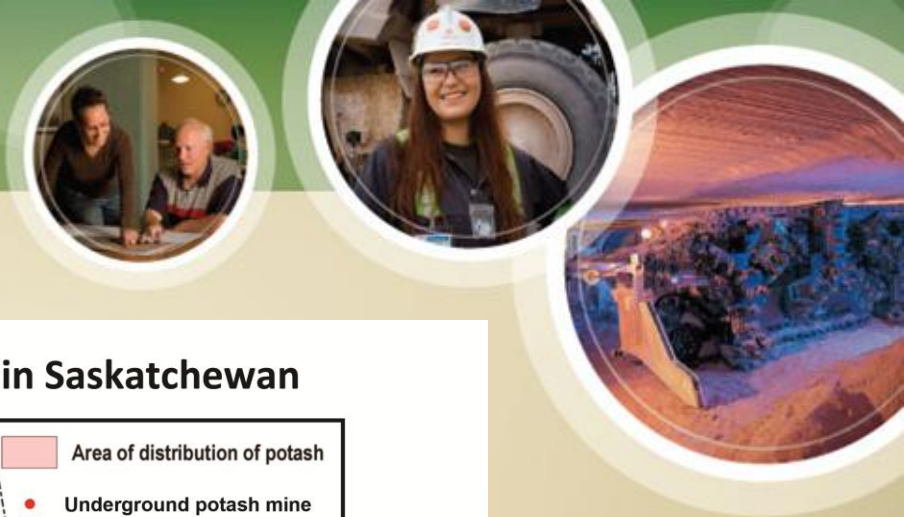
- Salt water sea covered Saskatchewan and Alberta stretching from the Arctic to the Gulf of Mexico.
- Coral reefs to the west and north of the Elk Point Sea grew and blocked the flow of water from the open ocean to the north.
- The sea became restricted.

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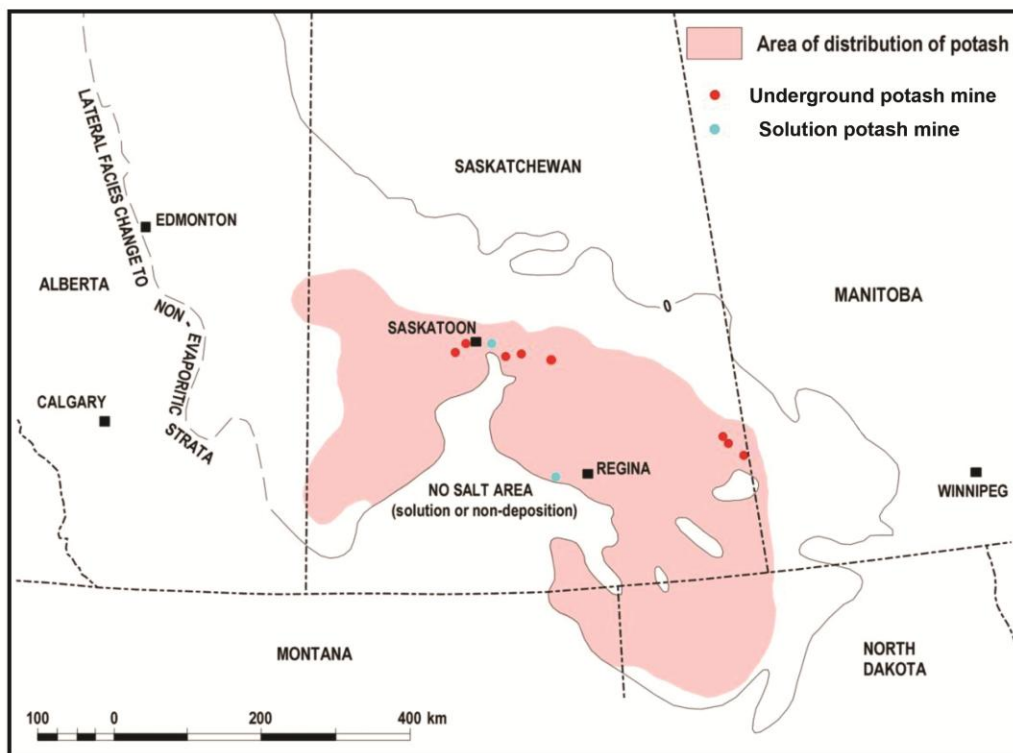
- The water evaporated in the warm climate.
- Concentrations of mineral salts increased and crystal layers formed on the sea floor for over 2 million years.
- Occur 1,000 metres deep in the north around Saskatoon, 1,600 metres deep at Belle Plaine and up to 3,000 metres deep in North-eastern Montana and North Dakota.



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Current day distribution of potash in Saskatchewan

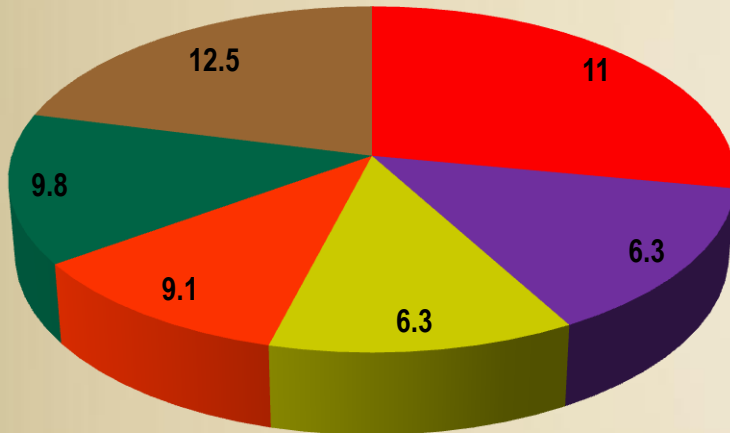


(from Potash in Saskatchewan by Fuzesy, 1982)

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Why do we mine it?



■ China	■ India
■ Other Asia	■ Latin America
■ North America	■ Other

GLOBAL FERTILIZER USE

- Fertilizer needed for crop growth (wheat, corn, rice, oilseed, fruits and vegetables)
- Key Markets – China, North America, Latin America, India, Asia

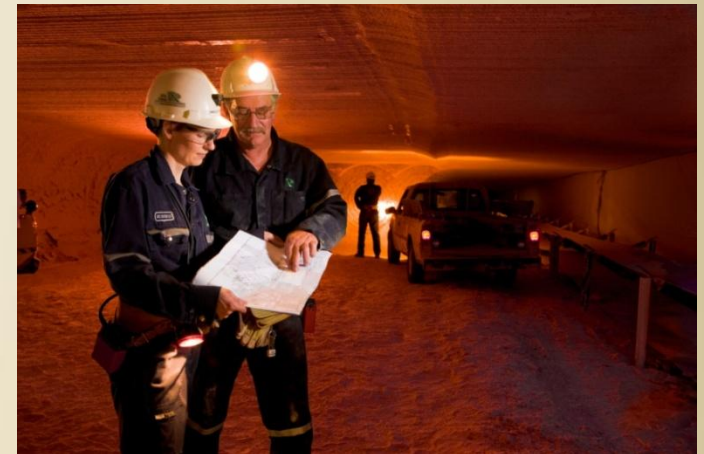
Source: Fertecon, PotashCorp

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SASKATCHEWAN PRODUCTION

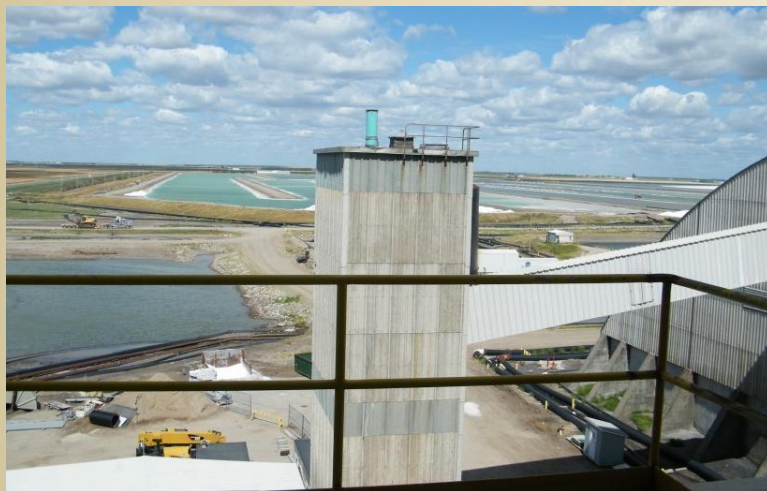
- 10 producing mines
 - (8 underground and 2 solution)
- 3 producing companies:
 - PotashCorp (5)
 - Mosaic (4)
 - Agrium (1)
- 2 mines in development
 - K+S (solution)
 - BHP Billiton (underground)



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Saskatchewan's Solution Mines



Mosaic Belle Plaine

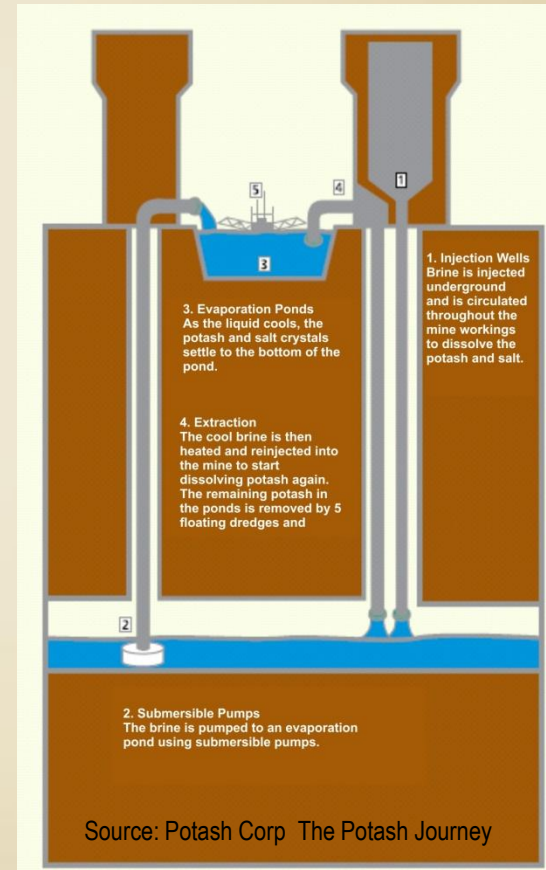
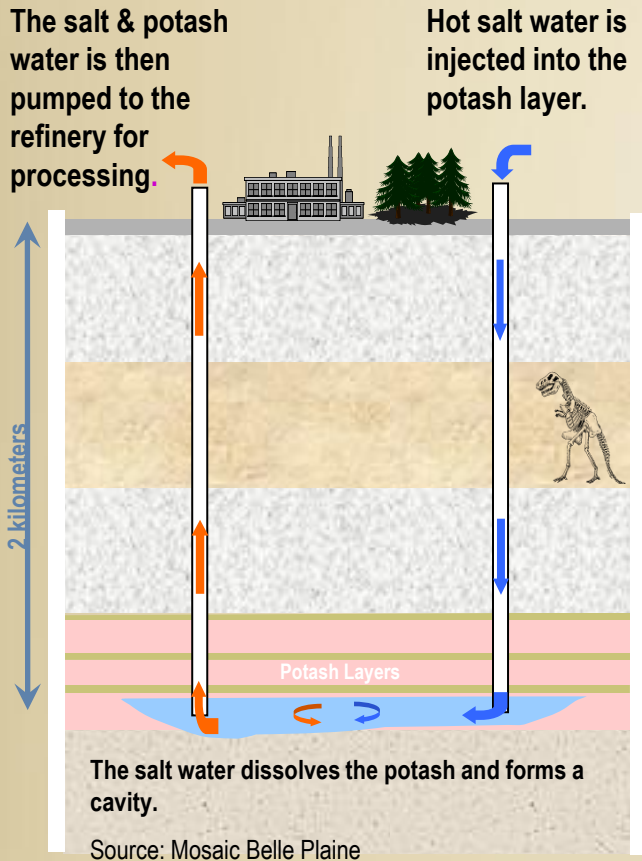
PotashCorp Patience Lake



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This is the method used by solution mines such as Potash Corporation Patience Lake and Mosaic Belle Plaine



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Lesson Plans and Curriculum Correlation



Grade 4 Rocks Minerals and Erosion

2 lessons – Dissolution and Recovery

- **Objectives covered:**

- **RM4.1 Investigate physical properties of rocks and minerals, including those found in their local environment.**

RM4.1b. b) Document the locations and characteristics of rocks that exist in their local environment.

RM4.1c. c) Observe and describe physical properties (e.g., colour, texture, lustre, hardness, cleavage, transparency, and crystal structure) of rocks and minerals.

RM4.1d. Use appropriate tools (e.g., hand lens, safety glasses, brush, rock pick, knife, and gloves) safely while making observations and collecting information on the physical properties of rocks and minerals.

RM4.1f. Record observations of rocks and minerals using jot notes, labelled diagrams, and charts.



Grade 7 Mixtures and Solutions

3 lessons – Dissolution, Recovery, and How Do We Know?

• Objectives covered:

- MS7.1 Distinguish between pure substances and mixtures (mechanical mixtures and solutions) using the particle model of matter.
MS7.1a, MS7.1b, MS7.1f
- 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.
MS7.2a , MS7.2h, MS2i
- MS7.3 Investigate the properties and applications of solutions, including solubility and concentration.
M&.3a, MS7.3b,MS7.3.c, MS7.3e, MS7.3i, MS7.3j



Grade 7 Earth's Crust and Resources

2 lessons – Dissolution and Recovery

- Objectives covered:

- 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.
EC7.2b, EC7.2c, EC7.2e, EC7.2i

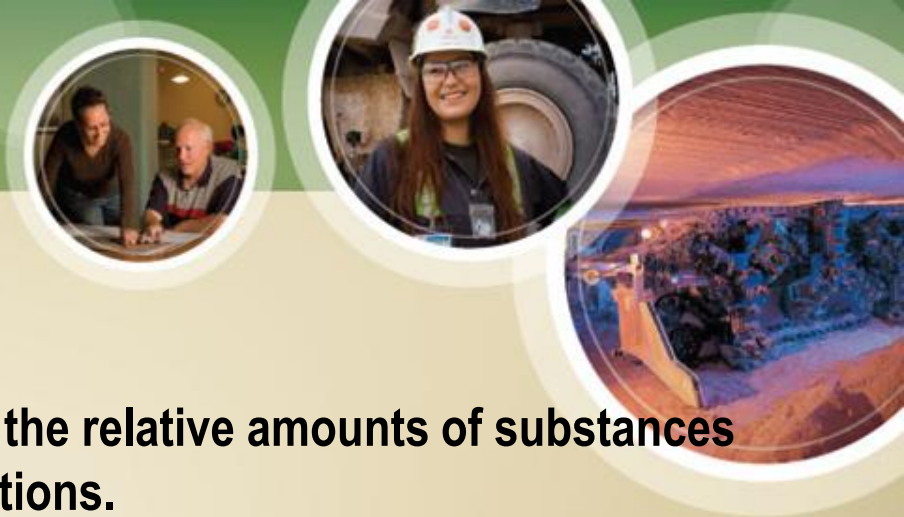


Physical Science 20

Objectives covered ??:

Foundations of Chemistry

- **PS20-FC1 Predict products of the five basic types of chemical reactions and evaluate the impact of these reactions on society and the environment.**
 - d. Predict products of synthesis and decomposition reactions given the reactants.
(S, K) ???
- **PS20-FC2 Construct an understanding of the mole as a unit for measuring the amount of substance.**
 - f. Calculate the molar mass of molecular and ionic compounds. (S)
 - i. Research the applications of solutions in industry, mining, and agriculture.
(STSE, S, K)



Physical Science 20

- **PS20-FC3 Use stoichiometry to determine the relative amounts of substances consumed and produced in chemical reactions.**
 - a. Determine the relative numbers of moles in a variety of chemical reactions using balanced chemical equations. (K, S)
 - e. Communicate results of experiments using narrative and formal lab reports. (S)
 - g. Compare theoretical yield and actual yield for a variety of chemical reactions by calculating the percent yield. (S, K)
 - h. Explain how actual yield differs from theoretical yield using the concept of sources of error. (STSE, S)
 - i. Predict how to maximize the yield of a particular chemical process. (STSE, S)
 - j. Discuss the economic impact of the yield of chemical reactions with respect to the maximizing of product and profit, and minimizing the production of waste. (STSE, A)



Chemistry 30 Solubility and Solutions

1 lesson – PBL

Foundational Objectives

Understand the principles of qualitative analysis of solutions.

- Use solubility charts to determine the solubility of various substances.
- Describe how to separate ions in solution by selective precipitation.

Use numbers and numerical data to strengthen understanding of the concept of solubility.

- Read and interpret solubility charts and tables.

Promote both intuitive, imaginative thought and the ability to evaluate ideas, processes, and experiences in meaningful contexts.

- Generate and evaluate alternative solutions to problems.
- Analyze data to create hypotheses, predictions and estimates.
- Consider all evidence before drawing conclusions and developing generalizations.



Chemistry 30: Solubility and Solutions & Physical Science 20: Foundations of Chemistry

- Working to determine best fit of this activity in the new Secondary curricula
- Suggest using either the PBL activity developed for Chem 30, or adapt the grade 7 Mixtures and Solutions lesson plan
- Looking for feedback



Lesson 1. Dissolution of Potash



Have the students weigh their samples and filter paper.

- will be able to calculate the amount of insoluble material, KCl and NaCl in the rock. (may be able to determine the grade of the ore.)
- amount will vary depending upon where the ore comes from.
 - Saskatoon area lot of insoluble clay and iron oxide.
 - Esterhazy area there is very little clay and iron oxide.



Grade 4: Rocks Minerals and Erosion & Grade 7: Earth's Crust and Resources

More of a focus on the minerals

- Students observe and describe their samples.
- Colour, hardness, cleavage, habit, lustre, transparency
- Rock (sylvanite) or mineral (sylvite)



Observation of Potash ore (the rock) dry and wet

- Using magnifying lenses, hardness testing tools (fingernail, penny, steel nail) students determine, colour, hardness, crystal shape, lustre, transparency of the 4 minerals present
- Students record their observations in a table.
- Students draw a picture of their potash ore (rock)
- Students may taste their rock, but do not share rocks. This may help them determine that some of the minerals are salt.



So how do we get the potash (sylvite) out of the rock?

Step 1: What do we know about the make up of the rock?

- It has clay, iron oxide, and two salts halite (NaCl) table salt and potash salt (KCl) also called sylvite
- Salt dissolves in water



Step 2: We dissolve the rock



Not everything
dissolves!
Now what?

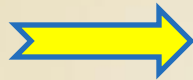


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Step 3: Deslime – get rid of the clay and iron oxides

Filter out the insolubles



Left with clear KCl & NaCl rich solution



Iron oxides (red)
Clays (grey)



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What do the Grade 7 students do after filtering?

- Leave the filters to dry, when dry weigh the filter and residue, determine the amount of the dissolved salts and the amount of the insoluble materials.
- Calculate the % dissolved solids and % insolubles

Weight of residue and filter paper: _____
 - Weight of filter paper: _____

Weight of residue = _____ (the minerals (insolubles) that did not dissolve in the water)

Weight of sylvinite ore: _____
 - Weight of residue: _____

= _____ Weight of dissolve salts

% dissolved salts = (weight of dissolved salts / total weight of sylvinite sample X 100) = _____

% of insolubles = (weight of dry residue / total weight of sylvinite sample X 100) = _____

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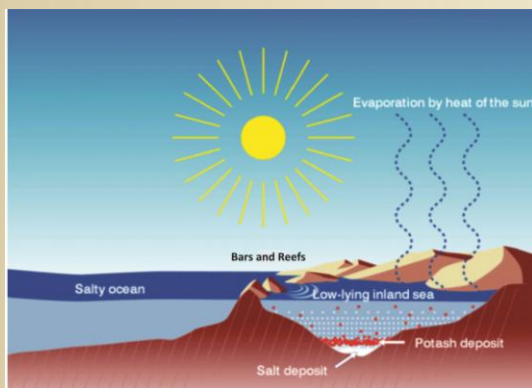
Lesson 2: Recovering the Potash



Now we have a challenge - How do we separate the NaCl (halite or table salt) from the KCl (what we really want)?



The potash deposits originally crystallized from a saturated solution.



Ponds, Mosaic Belle Plaine



Potash Corp Patience Lake ponds

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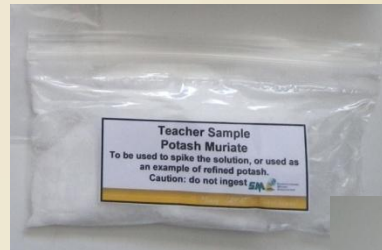


Step 4: Precipitation

- When the solution is saturated in potassium and the amount of water is decreased by evaporation the potassium salt will start to crystallize and precipitate out, so will the sodium salt.
- We know that when cold (around freezing) crystals of KCl will precipitate (grow) and settle out of the solution before NaCl will.



Our solutions are not saturated, so we need to reduce the amount of water by boiling, or supersaturate the solution by adding potassium muriate (relatively pure KCL)



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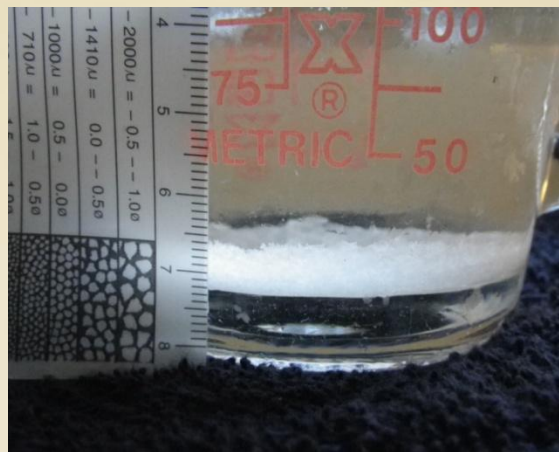
Precipitating the potash (KCl)



After 34
minutes



50 minutes



90 minutes



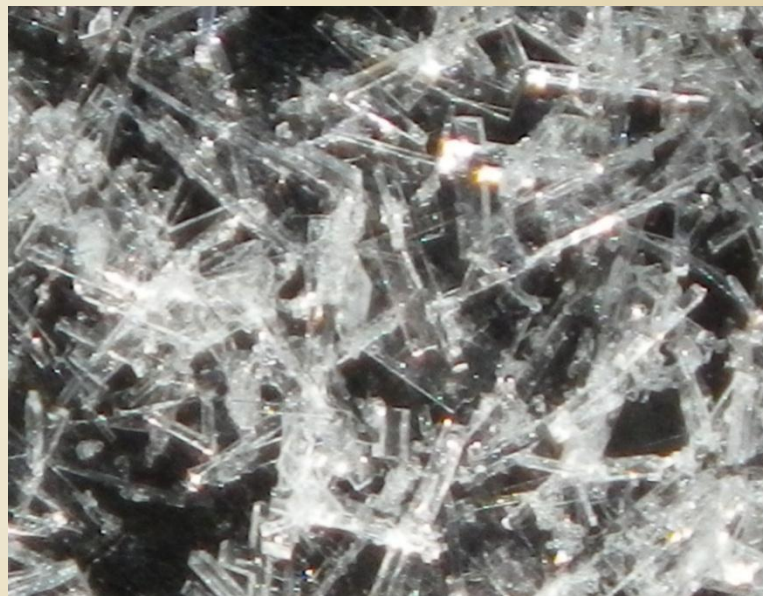
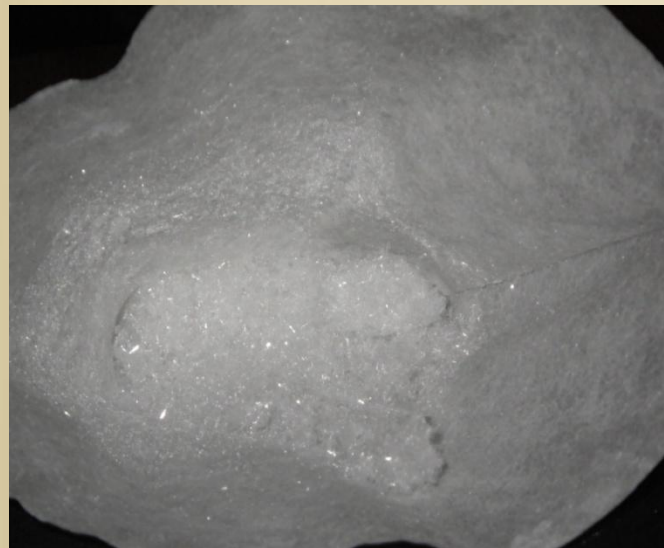
Overnight in the fridge



Saskatchewan!



Crystalline potash KCl (after
filtering and drying)



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After precipitation of KCl

- Filter to remove KCl from solution, dry, weigh, observe and describe noting how different it looks from the rock at the beginning.
- Allow remaining solution to evaporate, as it evaporates NaCl will crystallize. Weigh, observe and describe



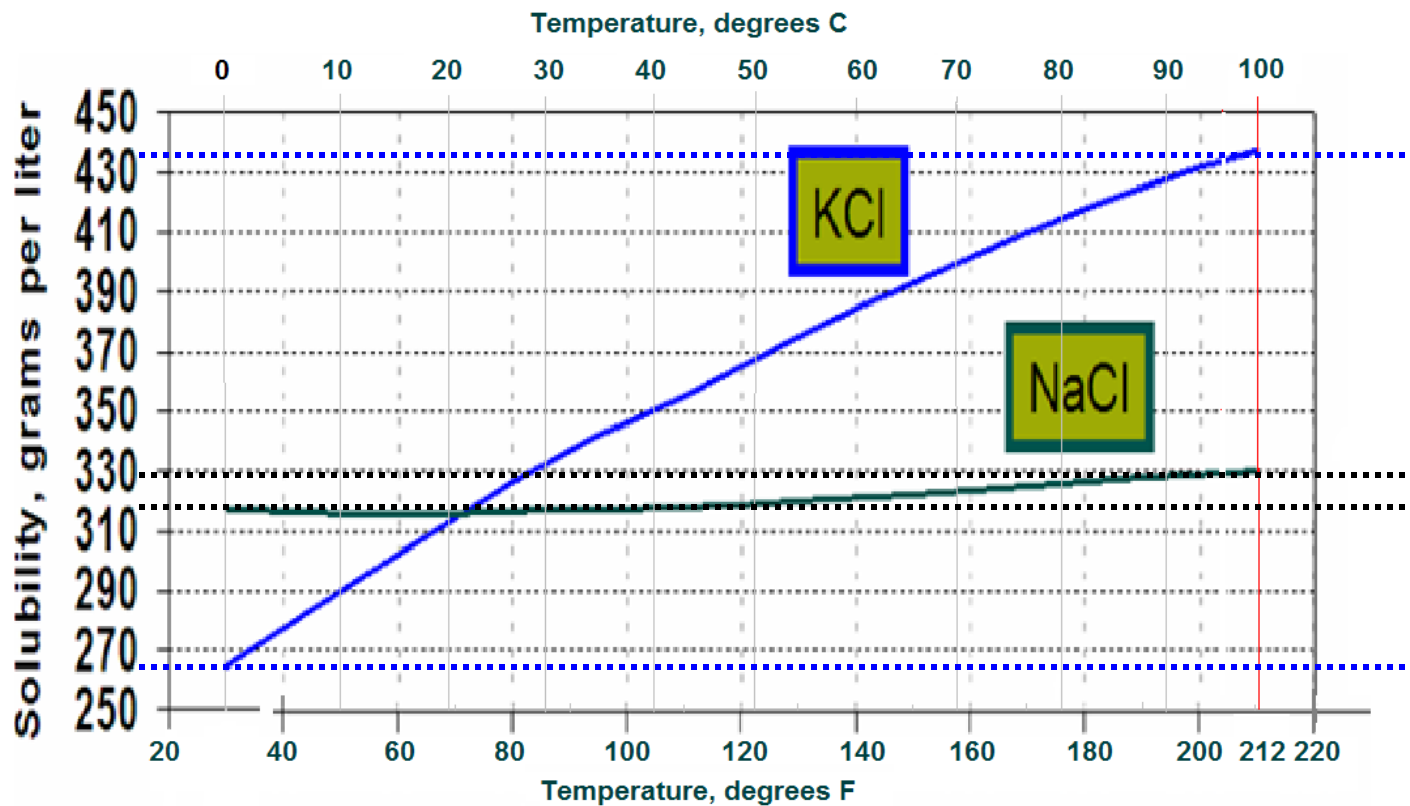
ewan!



Lesson 3: So How Do We Know it is KCl?



Solubility Curves of KCl (sylvite) and NaCl (halite)

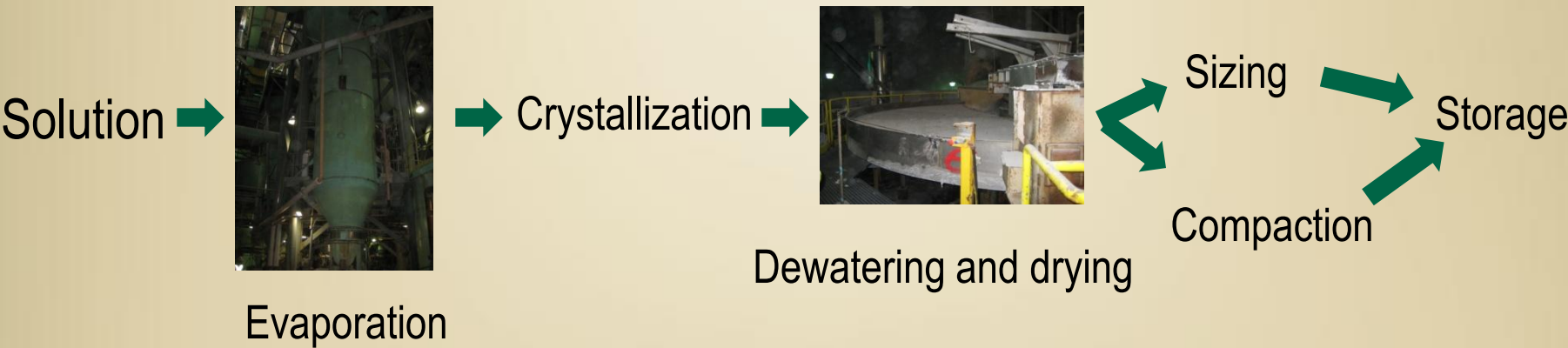


Amount of KCl precipitated (170g/l) with drop in temperature (100 to 0°C)

Amount of NaCl precipitated (10g/l) with drop in temperature (100 to 0°C)

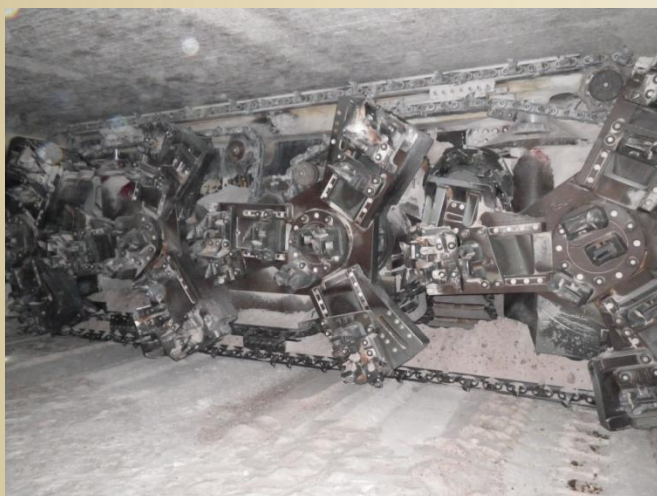


Solution Mining Processing





Underground Mining



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Processing

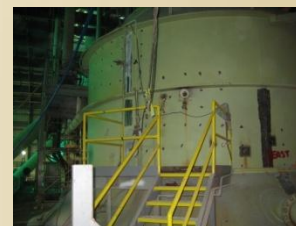
Crushing



Desliming



Flotation



Debrining
(centrifuge)



Drying



Sizing



Storage (coarse product)



Compaction

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Conventional Potash Mining and the Mill

Videos for the classroom

- PotashCorp <http://minetour.potashcorp.com/>
- Potash 101 Mosaic Company
<http://www.youtube.com/watch?v=ULLLmm6cCJ8>
- Rick Mercer goes underground at the Allen Mine
http://www.youtube.com/watch?v=ZKQmsr5m_uY

All available on our Pinterest Page

<http://www.pinterest.com/educationsma>

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Check out our WebPages:

Main SMA page: www.saskmining.ca

Education Outreach page: www.saskminined.com

Please e-mail me at education@saskmining.ca if you have any questions or feedback about the lesson plans.

We would love to see pictures of your students doing the activities if you can share your photos.