IPNI
International
Plant Nutrition
Institute

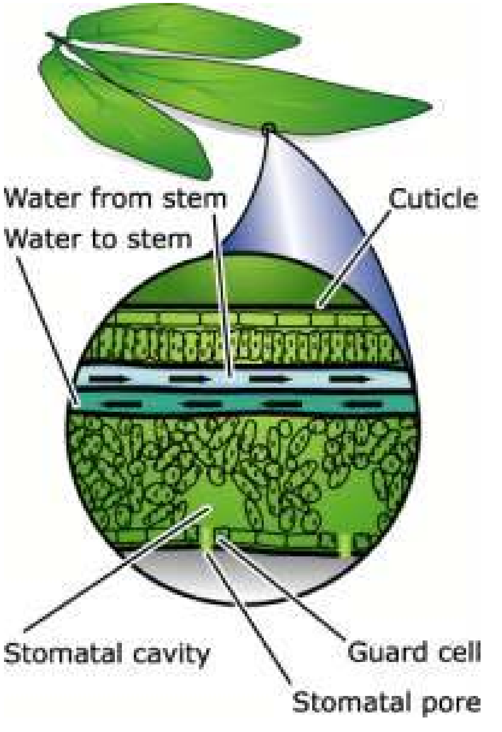
Potassium Fertilizer Production and Technology

Potassium Cycles through Complicated Ecosystems to Sustain Plant and Animal Life

Potassium Is Essential for Plants

- Taken up by the plant as K^+
- Does not form organic compounds in the plant
- Is vital to photosynthesis and protein synthesis
- Is associated with many metabolic functions

- Essential role for regulating leaf stomata and controlling water use



Potassium and Animal Nutrition

- Potassium is essential for many metabolic functions
- It maintains salt balance between cells and body fluids
- Adequate K is essential for nerve function and preventing muscle cramps
- It is routinely added to many animal feeds

Since K^+ is not stored in the human body, dietary replacement is required on a regular basis.

Government agencies state that:
…diets containing foods that are good sources of potassium and low in sodium may reduce the risk of high blood pressure and stroke.

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The History of Potash

Element symbol K comes from Latin ***K**alium*

Allow trees to bioaccumulate K and boil wood ash to recover nutrients…

Wood ash boiled in pots (**pot-ash**)

Not a sustainable practice

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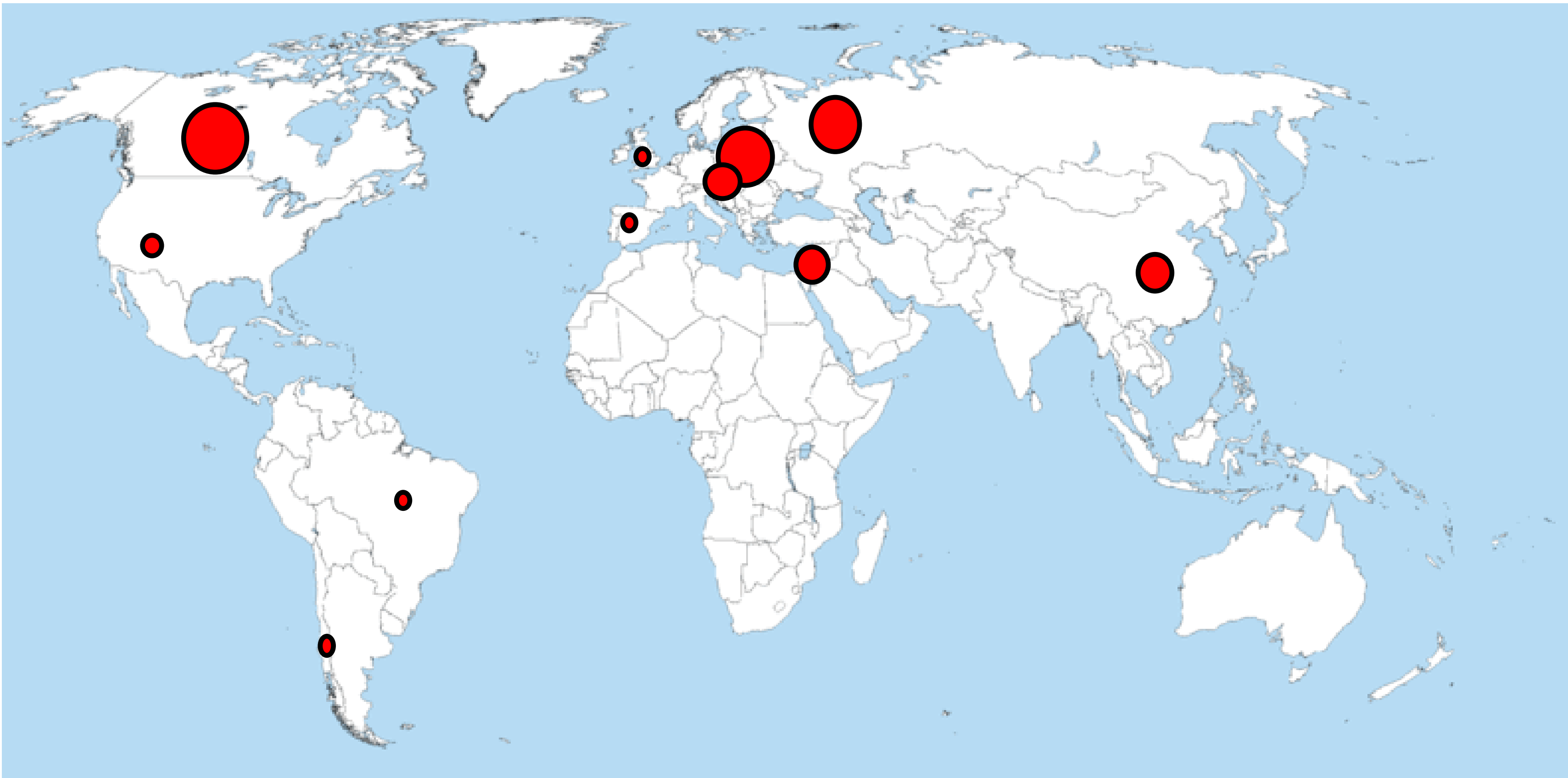
Potassium Fertilizer Is Mined and Produced in Many Parts of The World



Many other deposits are located throughout the world
(size of dot proportional to production in 2009)

Where Does Potash Come From?

All commercial potash deposits come from marine sources:

1. Ancient seas that are now buried
2. Salt water brines

Some Common Potassium-Containing Minerals

Mineral	Composition	K_2O content (approx %)
Chlorides:		
Sylvinite	$KCl \cdot NaCl$	28
Sylvite	KCl	63
Carnalite	$KCl \cdot MgCl_2 \cdot 6H_2O$	17
Kainite	$4KCl \cdot 4MgSO_4 \cdot 11H_2O$	18
Sulfates:		
Polyhalite	$K_2SO_4 \cdot 2MgSO_4 \cdot 2CaSO_4 \cdot 2H_2O$	15
Langbeinite	$K_2SO_4 \cdot 2MgSO_4$	22
Schoenite	$K_2SO_4 \cdot MgSO_4 \cdot 4H_2O$	23
Nitrates:		
Niter	KNO_3	46

Potash Is Obtained By:

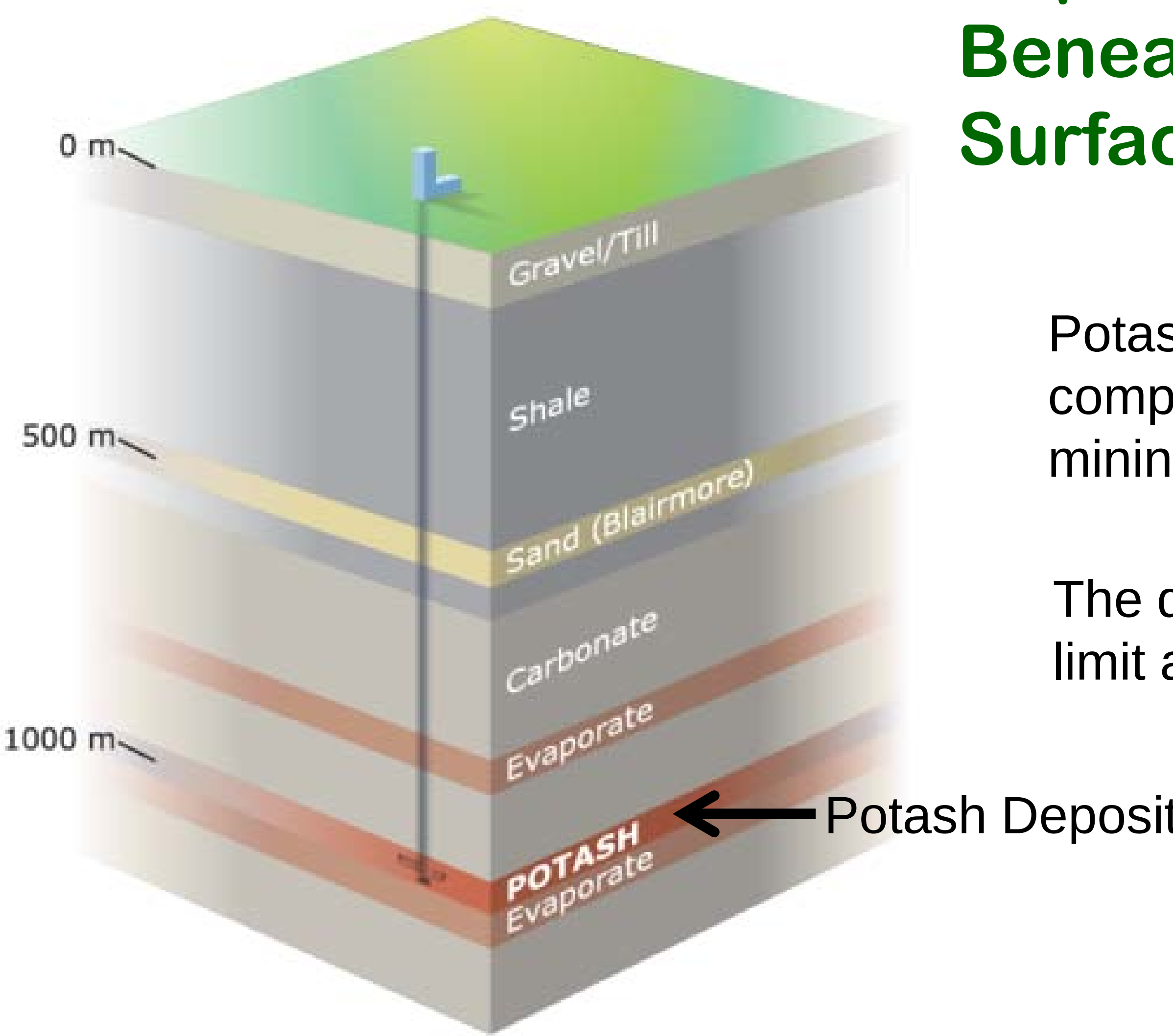
- Shaft mining
- Solution mining

Most potash deposits are too deep underground for surface mining

- Evaporation of brines

Water bodies such as the Dead Sea and the Great Salt Lake

The Largest Potash Deposits Are Deep Beneath the Earth's Surface



Example: Saskatchewan Deposits

Potash recovery requires complex and expensive mining techniques

The depth of the ore may limit access to the deposit

Conventional Shaft Mining

Vertical shafts drilled to the depth of potash deposit

Lifts are installed to provide access for equipment, workers, and to remove ore

Conventional Shaft Mining

Vertical shafts drilled into the earth

Ore veins are extracted with machine mining or blast methods, adapted to the specific geologic formation

Continuous mining machines are found in many varieties adapted to the specific geologic formation

Conventional Shaft Mining

Vertical shafts drilled into the earth
Deep horizontally-uniform ore veins
are mined with continuous mining machines

“Drum-type” continuous mining machine

Conventional Shaft Mining

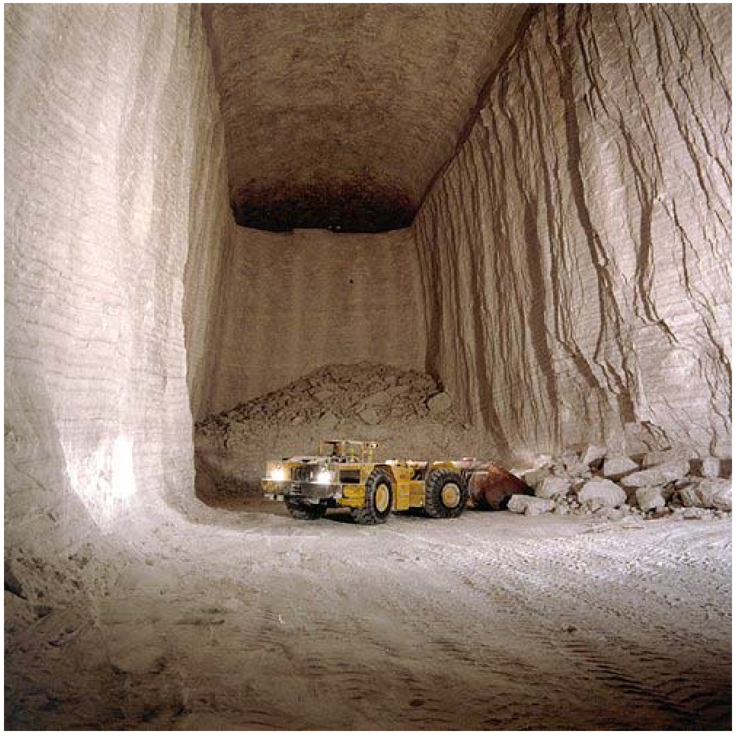
Vertical shafts drilled into the earth
Less uniform ore veins can be mined with rotary borers

“Drum-type” mining machines

Conventional Shaft Mining

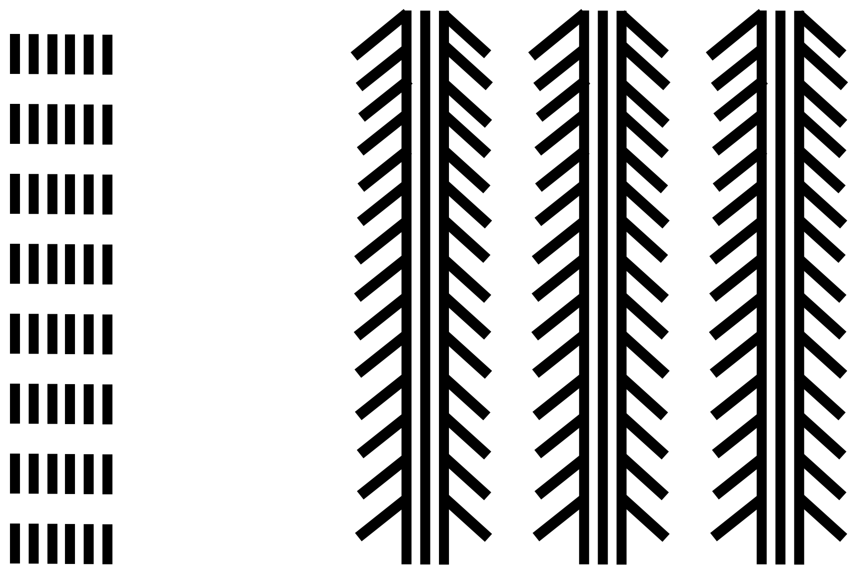
Vertical shafts drilled into the earth
Some ore veins are mined using blast methods

Adding explosive
prior to blast



Large underground chamber

Mining Techniques:



Long panels Herringbone panels

Conventional Shaft Mining

Vertical shafts drilled into the earth
Ore veins are mined
Broken ore is transported to skip with a conveyor belt or shuttle car

Potash ore may be transported many kilometers–
from the mine face to the skip location

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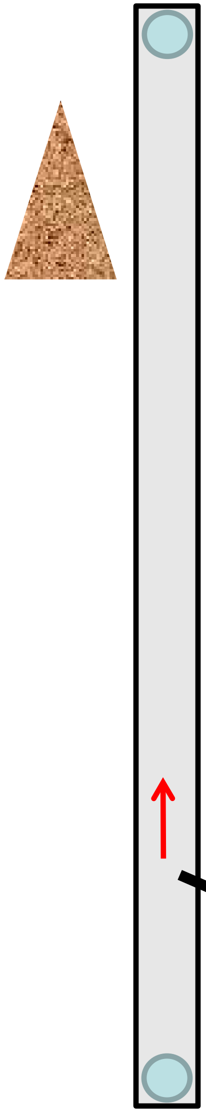
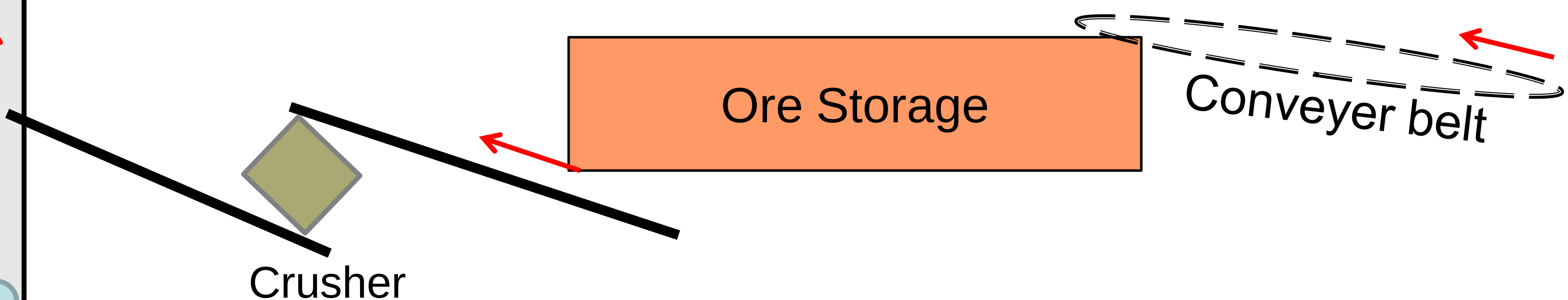
Conventional Shaft Mining

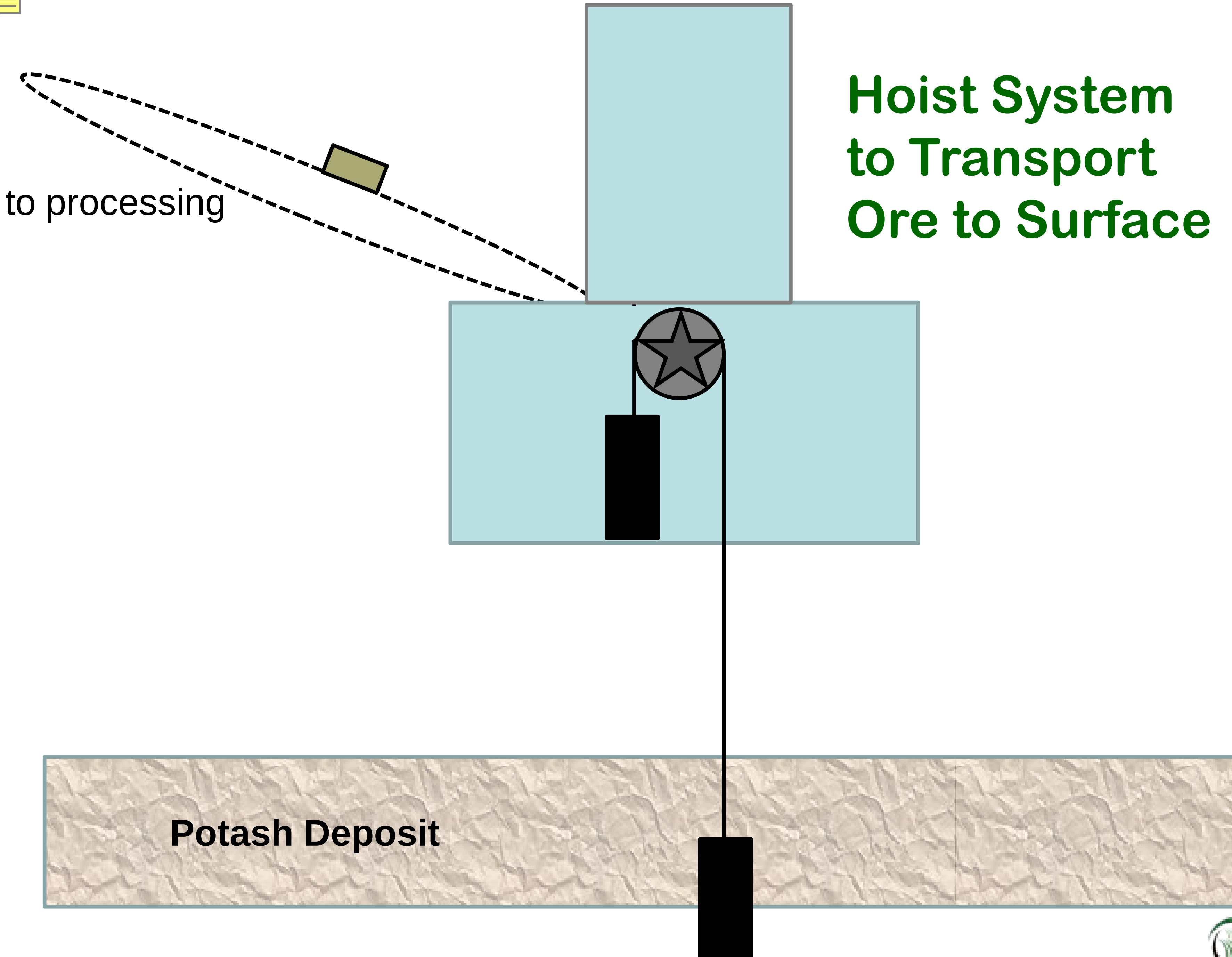


Vertical shafts drilled into the earth
Ore veins are mined with rotary borers or blast methods
Broken ore is transported to skip with a conveyor belt or shuttle car
Hoists bring ore to the surface for further processing

Example of underground storage and ore hoisting

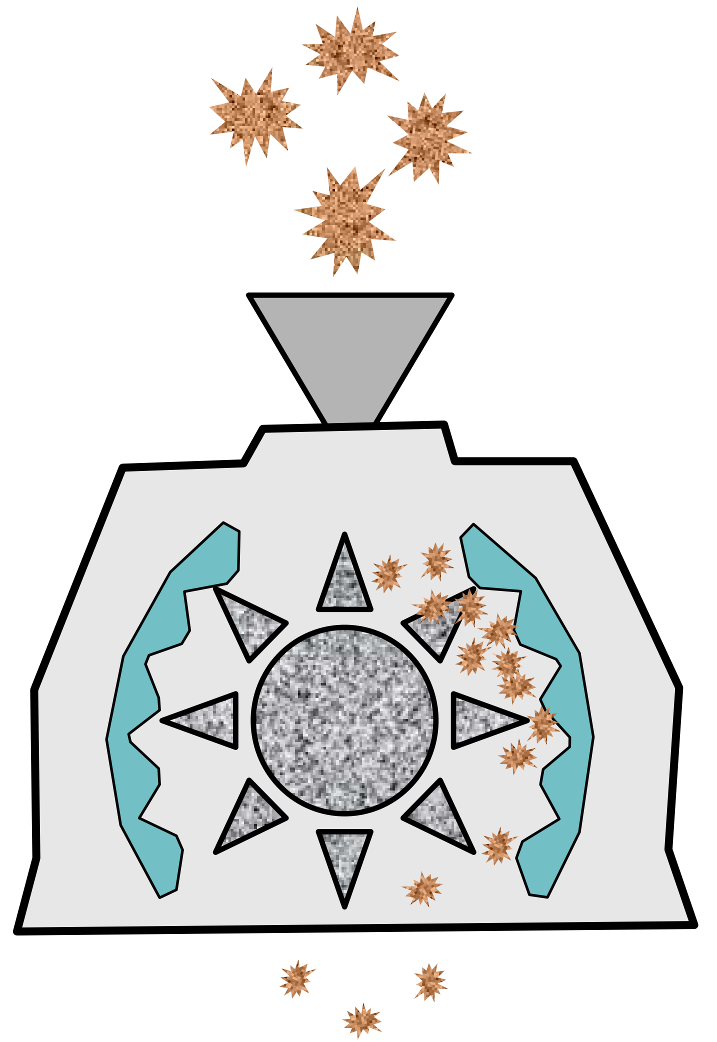


Hoist System to Transport Ore to Surface



Crushing and Grinding

Reduce the particle size to <2 mm prior to separating the potash minerals from the clay and other salts



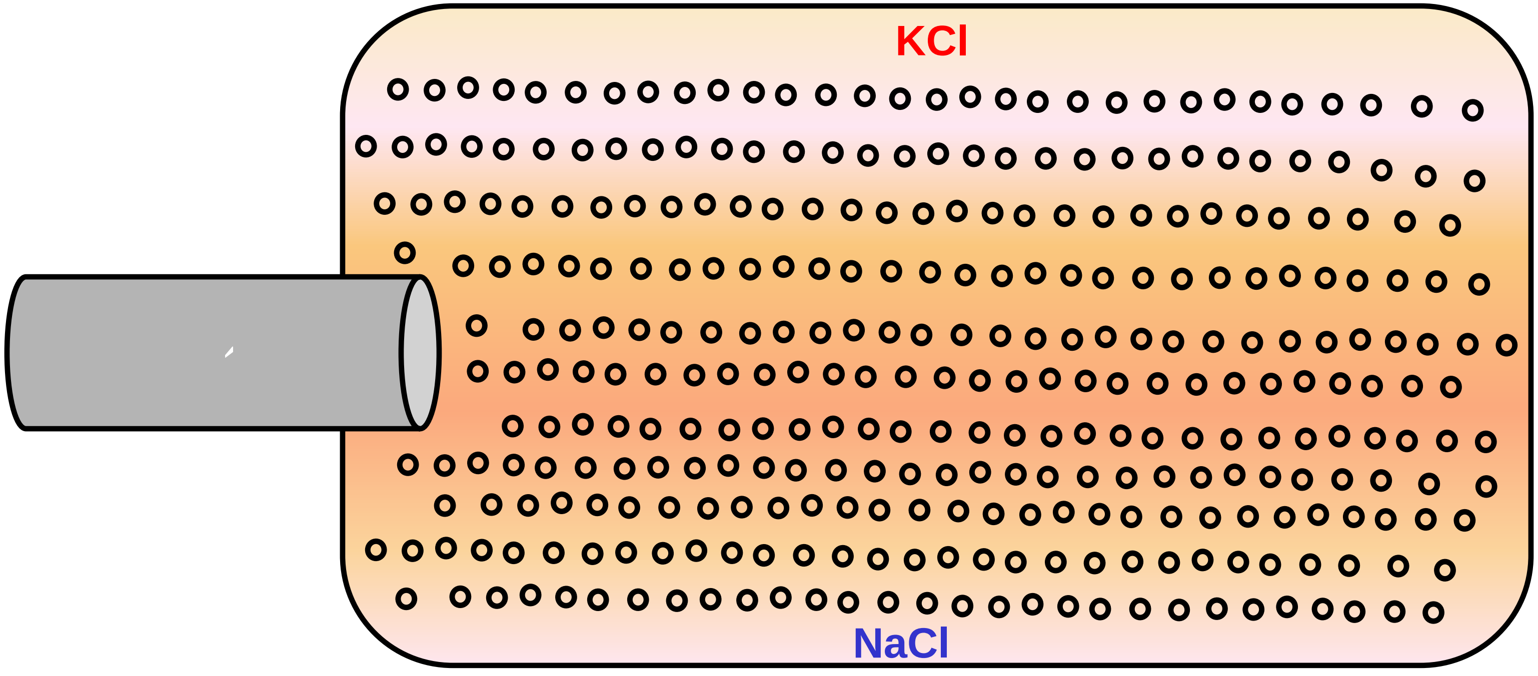
Scrubbing and Desliming (Wet Separation)

Potash ore is rinsed and agitated with a saturated salt solution to remove clay and impurities

Flotation Separation

Amine reagents coat KCl but not NaCl

Air bubbles cling to amine and float KCl to surface while NaCl and clay sink to bottom



Flotation

Potassium-containing minerals rise to the surface of the flotation cells and then skimmed off

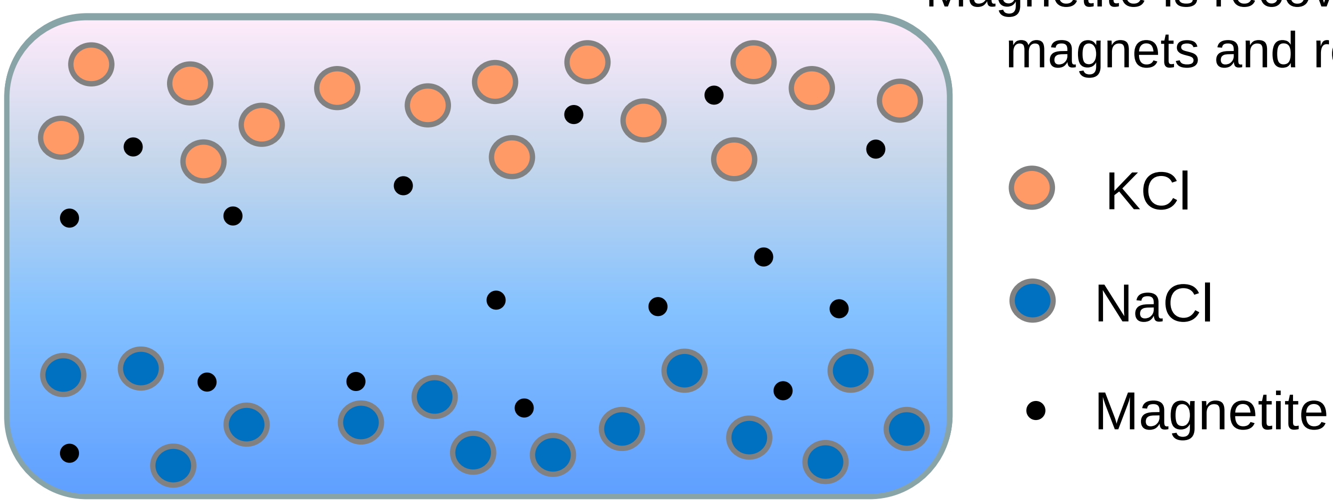
Heavy-Media Separation of KCl from NaCl

Mineral	Density (g/cm^3)
KCl	1.99
NaCl	2.16
$K{\cdot}MgSO_4$	2.83
$CaSO_4$	2.96
Magnetite	5.18

In a solution with a density between 1.99 and 2.16 g/cm^3, KCl will **float** and NaCl will **sink** – allowing mineral separation

Ground magnetite mineral is added to the brine to reach 2.08 g/cm^3 density.

Magnetite is recovered with magnets and reused



Final Steps: Dewatering and Sizing

A final rinse with saturated brine water and then the finished product is dewatered, centrifuged, dried, and compacted to desired particle sizes

Compacting

Compacting produces granular material by compressing fine particles of hot KCl in a roller press

The sheet of pressed flakes is crushed and screened to uniform sizes

Crystallization

The process to make pure and totally soluble KCl

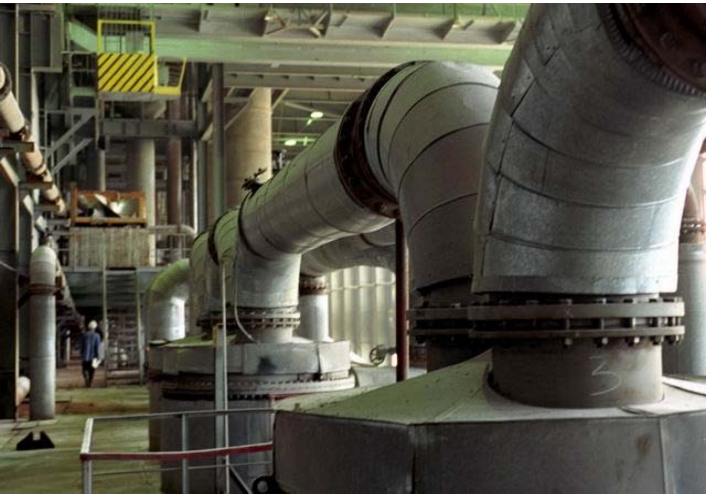
Hot-process: KCl is dissolved in boiling water to dissolve NaCl and KCl.

As the hot brine cools, salts differentially crystallize and are removed from solution.

Cold process: KCl solubility is lower in cold temperatures than Na and Mg salts, allowing crystallization and separation

Granular grade

Soluble grade



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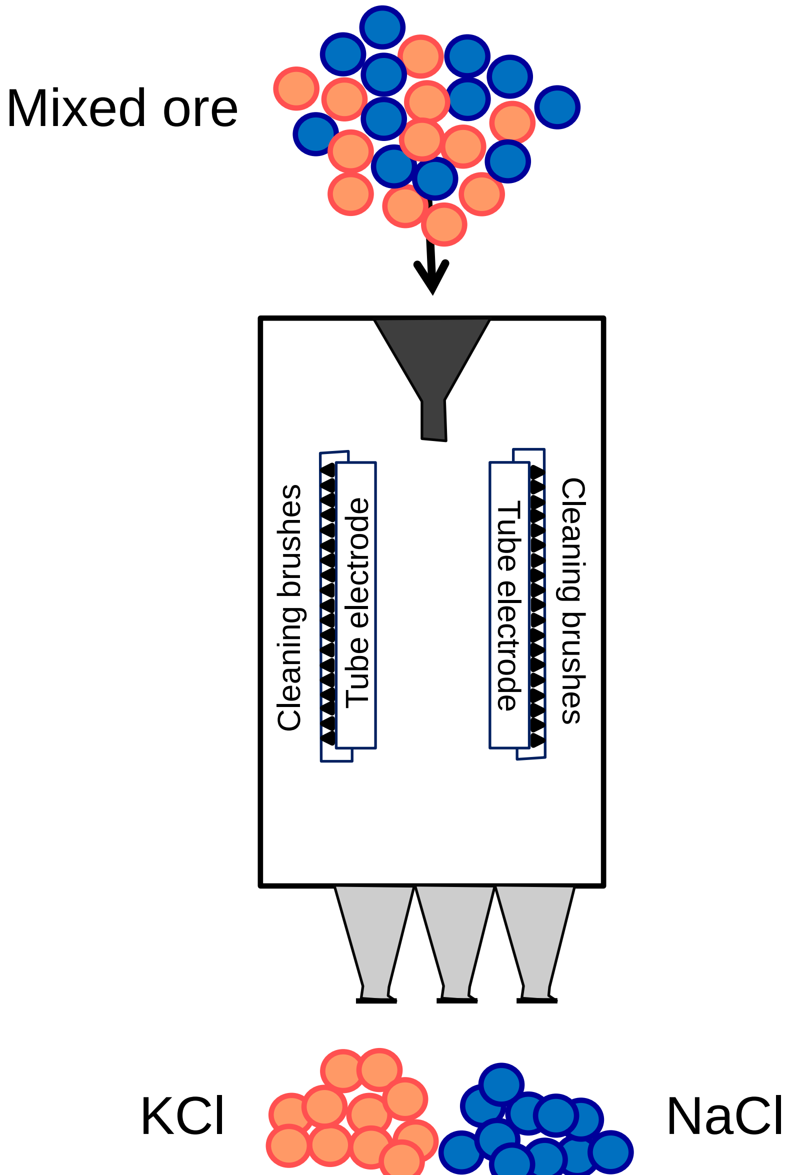
Electrostatic Separation (Dry Separation)



Electrostatic generator provides static charge to some minerals:

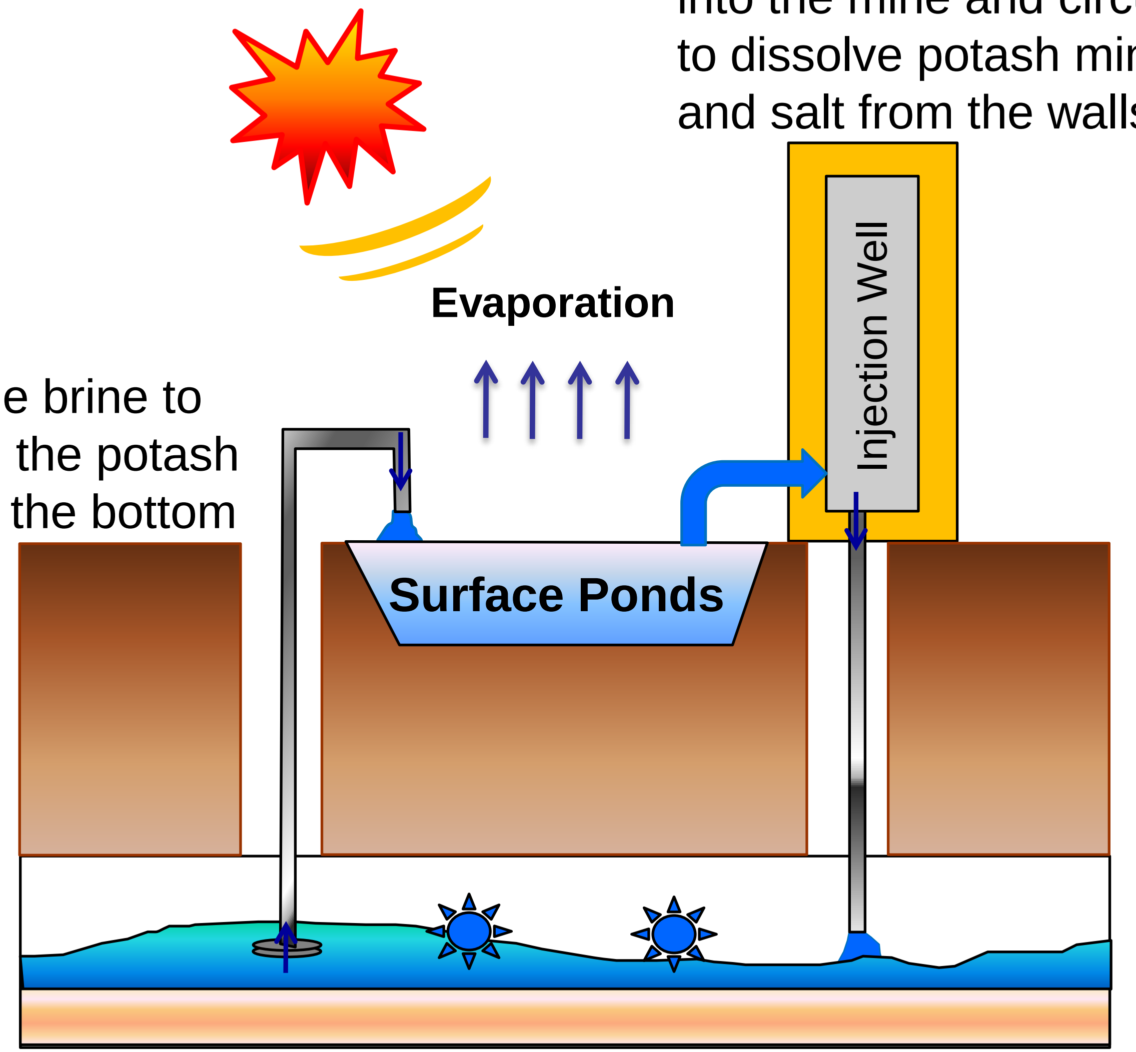
Non-conductive KCl is separated from charged NaCl

Solution Mining

Used when potash deposits are very deep, have irregular deposits, or have become flooded

Heated salt water is injected into the mine and circulated to dissolve potash minerals and salt from the walls

Submersible pumps lift the brine to evaporation ponds where the potash crystallizes and settles to the bottom



Solution Mining Example

- Brine brought to surface from depth of 1000 m
- Evaporated in 180 ha of vinyl-lined solar ponds

Potash Production Also Occurs from Natural Salt Brines

Tailing Disposal

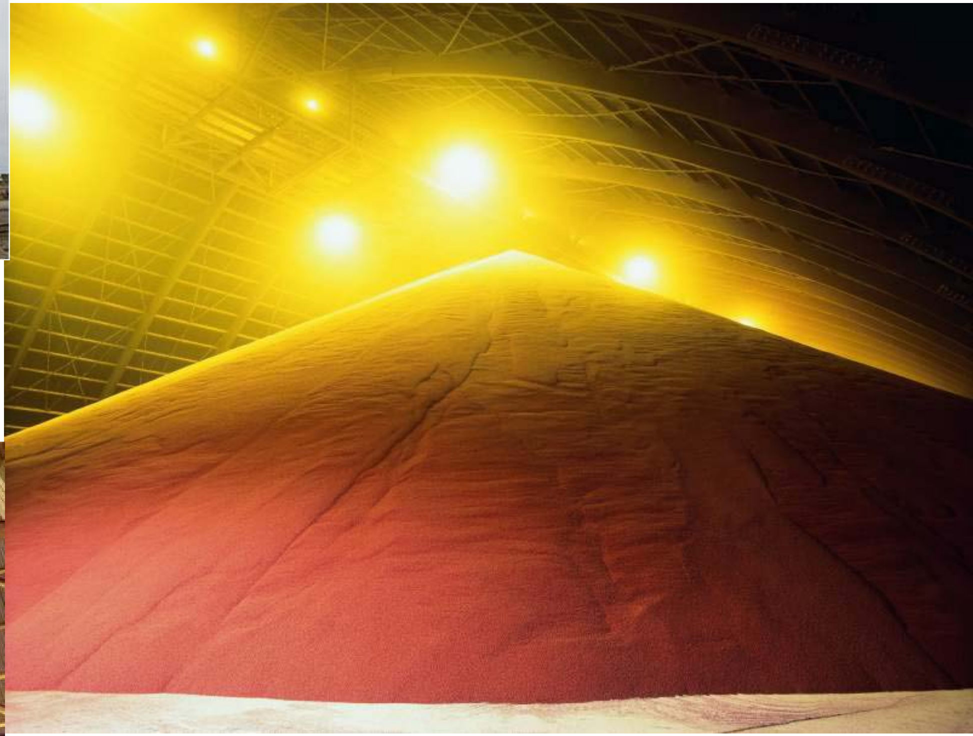
Common potash ores, such as sylvinite, contains up to 50% NaCl, up to 15% clay

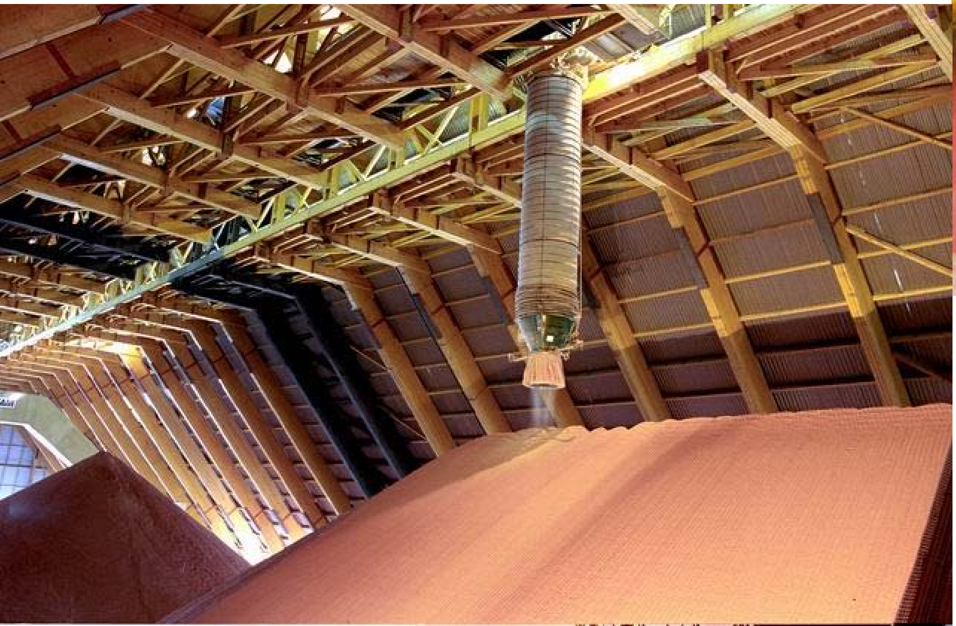
After potash is removed, separated salt and clay are backfilled into the mine or stockpiled into a tailing management area

Tailings solidify into rock-like mass (mostly NaCl)

Managed to minimize off-site movement

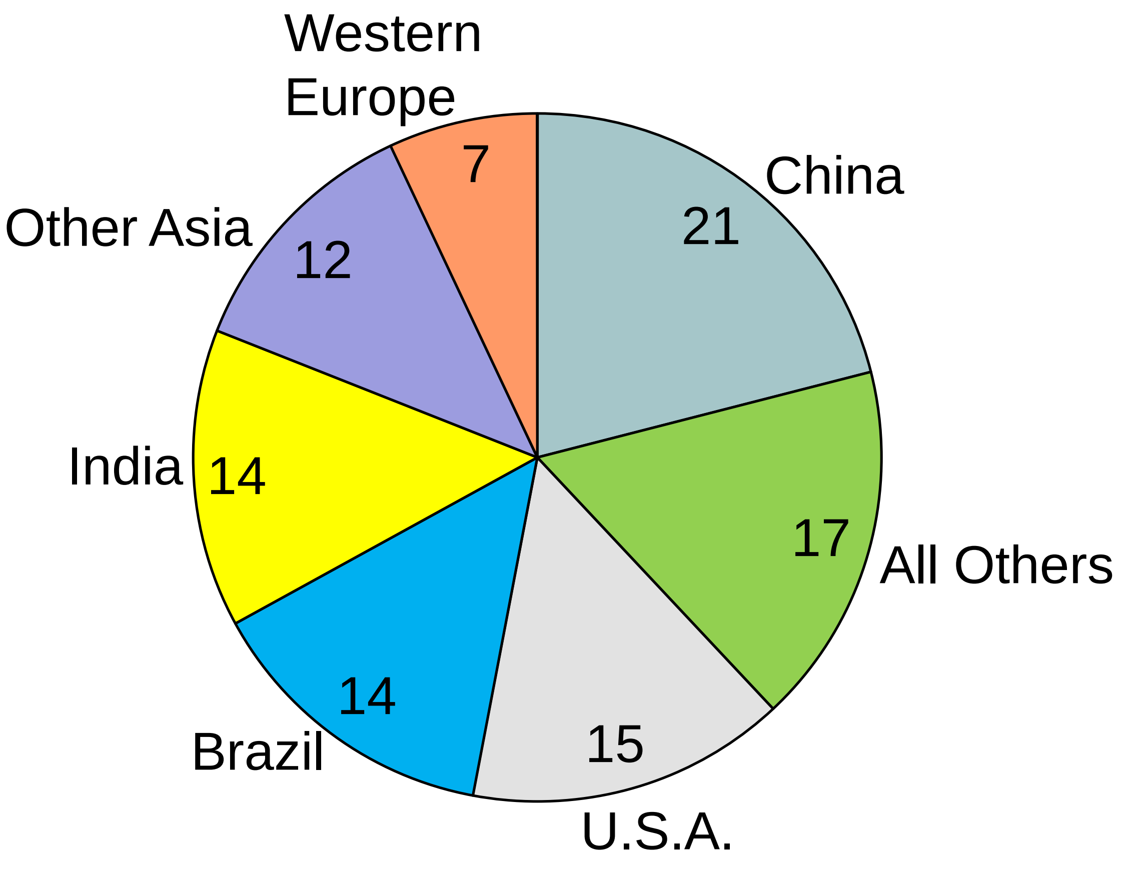
Storage





Shipping Potash Fertilizers

2009 Global Potash Use, %



International Global Potash Trade

Example of some major international potash distribution channels

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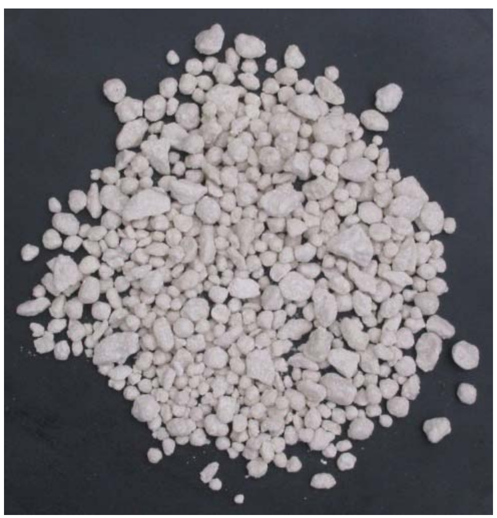
Potassium Chloride (Muriate of Potash; MOP)

- KCl
- Grade: 60 to 63% K_2O; 46%Cl
- Primarily mined as sylvinite ore containing KCl and NaCl
- Milling and a floatation agent used to separate salts
- Many colors and sizes available
- Traces of iron oxide give some particles a reddish tint

Potassium Sulfate (Sulfate of Potash; SOP)



- K_2SO_4
- Grade: 48 to 53% K_2O

  17 to 18% S

- Rarely found in pure form in nature
- Generally produced by manipulating potash ores to remove other materials

- Valued when both K and S are needed for plant nutrition

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Potassium Magnesium Sulfate (Langbeinite)

- $K_2SO_4{\cdot}2MgSO_4$
- Grade: 20 to 22% K_2O
  21 to 22% S
  10 to 11% Mg
- Distinct geologic material found in only a few places in the world
- Generally produced by manipulating potash ores to remove other materials
- Valued when both K, S, and Mg are needed for plant nutrition

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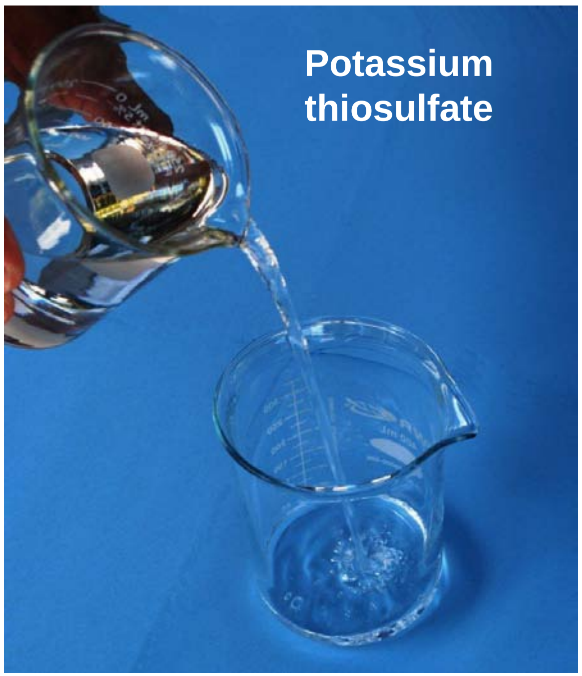
Potassium Nitrate (Nitrate of Potash; NOP)

- KNO_3
- Grade: 44% K_2O
  13% N
- Made by reacting KCl with nitrate salts or nitric acid
- Valued when both K and N are needed for plant nutrition

Other Potassium Fertilizers



- Small quantities of specialty potash fertilizers are made for unique crop or soil conditions, such as:

- Potassium phosphate (KH_2PO_4)
- Potassium carbonate (K_2CO_3)
- Potassium hydroxide (KOH)
- Potassium thiosulfate ($K_2S_2O_3$)

All are manufactured from basic potash materials

Environmental Concerns with Potash

- Potash fertilizer has no significant impacts on water or air quality
- Adequate potash is required for plants to use other essential nutrients. Healthy crop growth and efficient nutrient recovery results from balanced nutrition
- Potash applications should be guided by soil and plant tissue testing where possible
- Mine tailings require management to avoid off-site movement of salt and water

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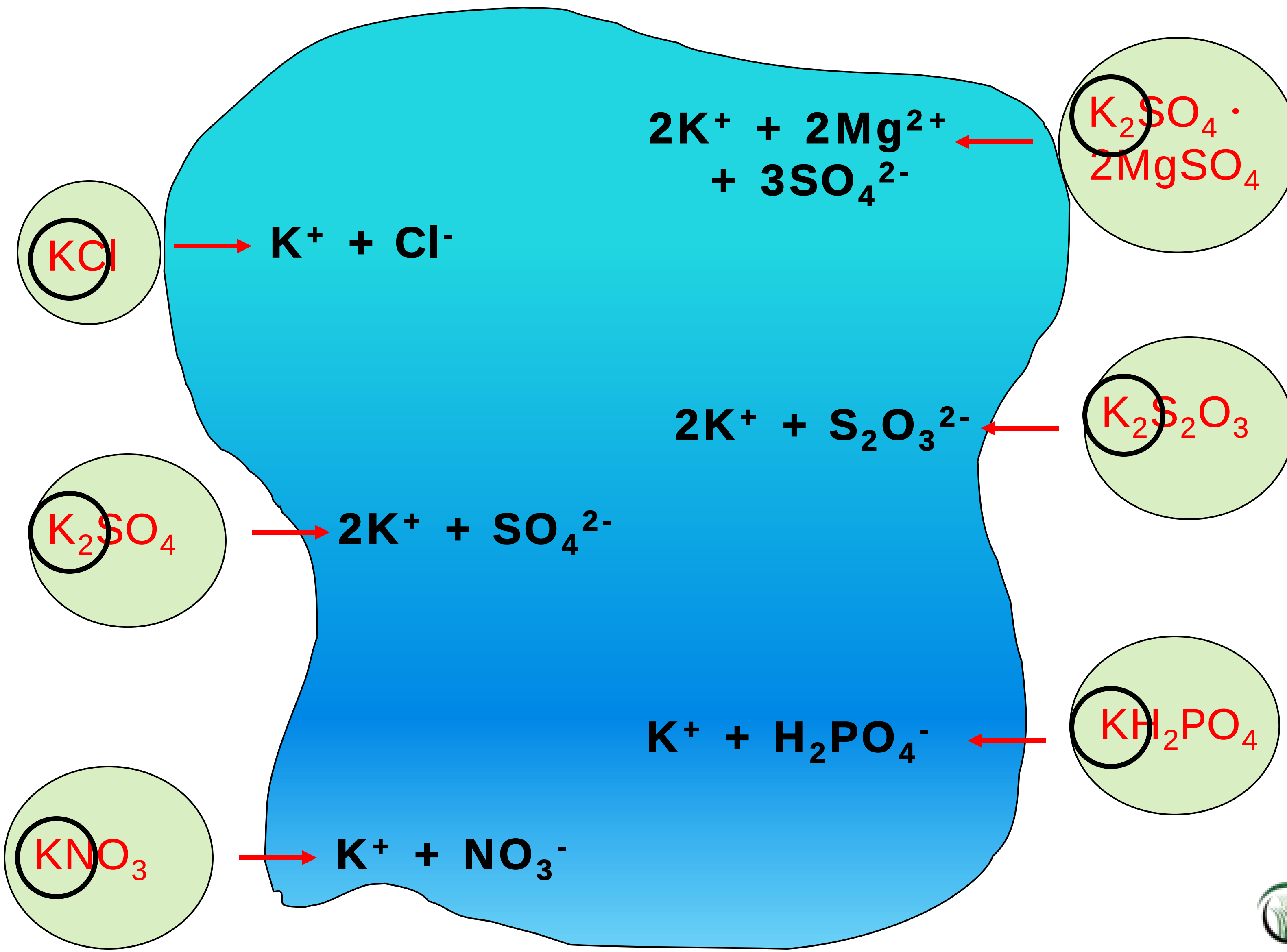
Potash Fertilizers All Supply the Same Nutrient in the Soil



High Yielding Crops Remove Large Amounts of K

Potassium is essential for many metabolic functions that directly impact crop yield and quality

Crop	Yield/A	Nutrient removal, lb K_2O/A	Yield, mt/ha	Nutrient removal, kg K_2O/ha
Cotton	3 bales	55	1.6	62
Rice	70 cwt	25	7.8	28
Alfalfa	8 tons	390	18	437
Maize	180 bu	45	11	50
Wheat	60 bu	20	4	22
Potato	500 cwt	275	56	310

Potash Applications to Soil

Potash is often spread across a field or applied in concentrated bands beneath the soil surface

Many application techniques are used

Potash fertilizer has limited mobility in most soils

It is retained by soil colloids on cation exchange sites

Potash Application through Irrigation Systems

Most K fertilizers are very water soluble and many are suitable for use in irrigation systems

Foliar Application

Many studies have demonstrated benefits from foliar application to plants to alleviate stress

Foliar K applications are supplemental to the major supply of nutrients through the roots

Applications of K can alleviate mid-season deficiencies or supplement the soil supply during periods of peak demand by the plant

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Additional information on
plant nutrient production
and management are
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www.ipni.net

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