Mining Technical Training Session

Chief Jimmy Bruneau School

June 2 & 3, 2010

Day 1

- Carter Clarkson (UBC)
- Rebecca Chouinard (WLWB)
- Brett Wheler (WLWB)

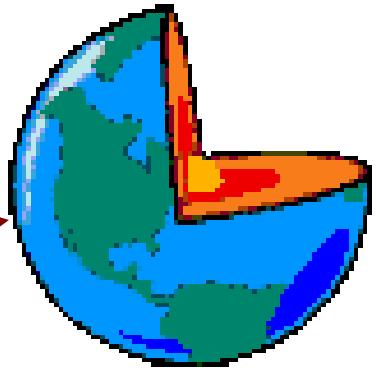
Geology Background

Rebecca, Brett

- Rocks
- Earth Layers
- Rock Formation

BACKGROUND

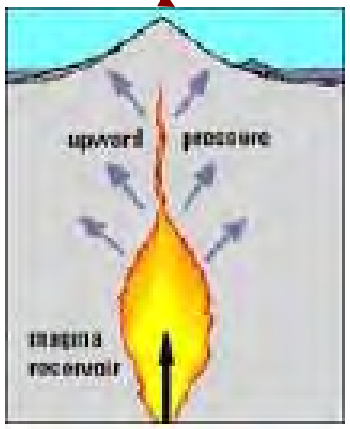
Rocks



The Earth

NWT Geology

Glaciers



Rock Formation

Rocks

BACKGROUND

The Earth

NWT Geology

Glaciers

Rock Formation

ROCKS

What is a Rock?

MINERALS →

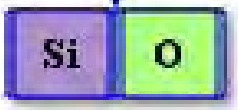
ELEMENTS →

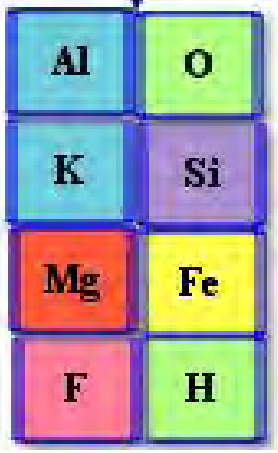
GRANITE

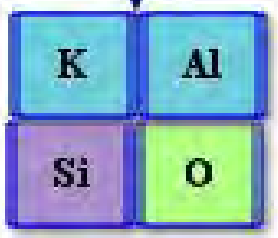
QUARTZ

MICA

FELDSPAR







What is an Element?

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra		Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub						

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

What is a Rock?

GRANITE

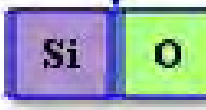
MINERALS →

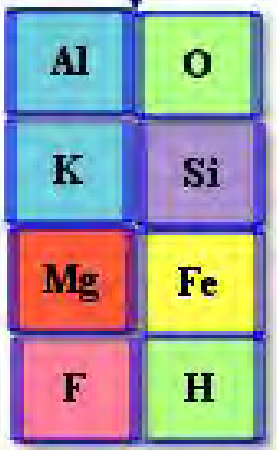
QUARTZ

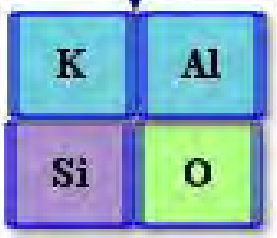
MICA

FELDSPAR

ELEMENTS →

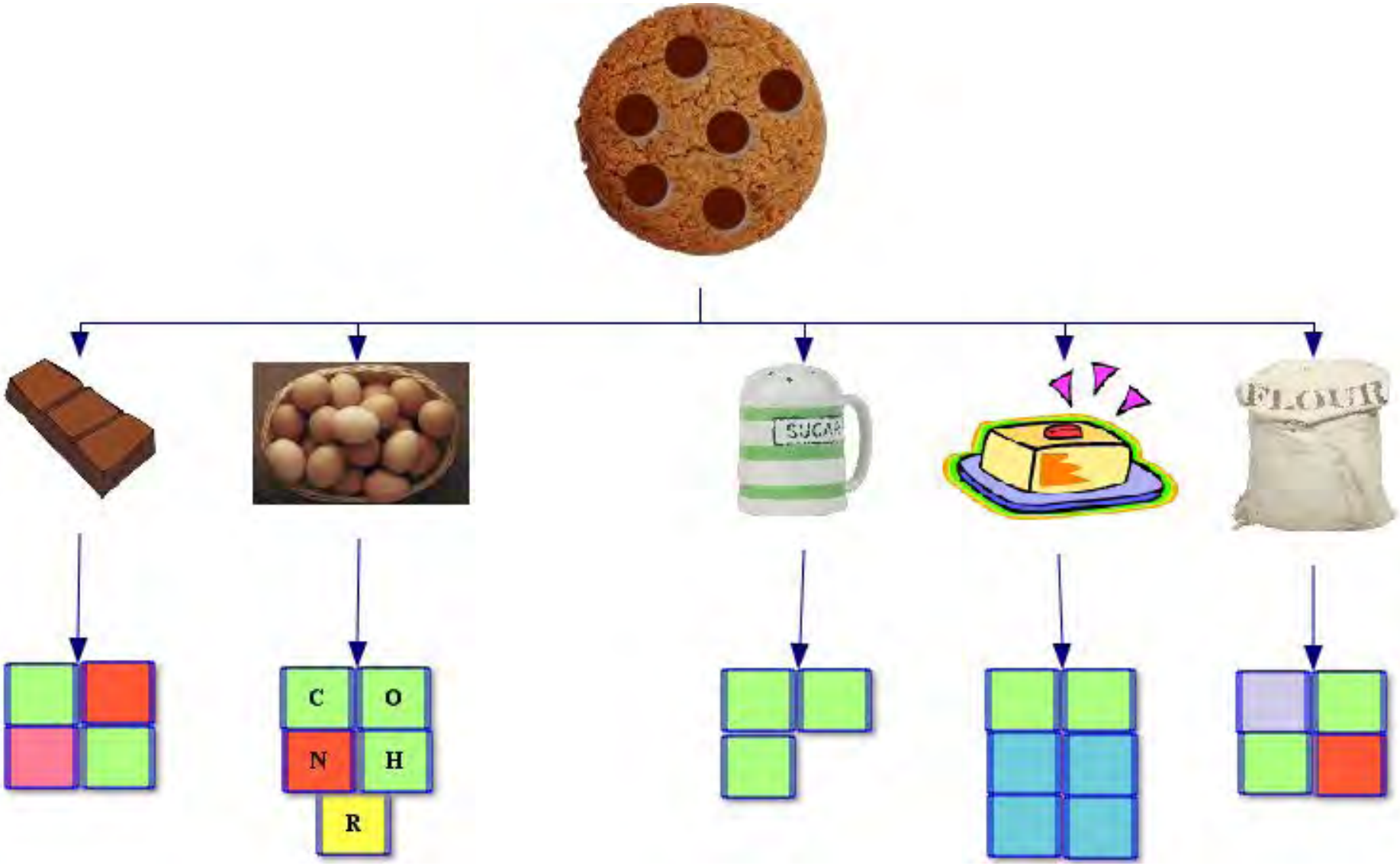






ELEMENTS

What is a Rock?



BACKGROUND

Rocks

The Earth

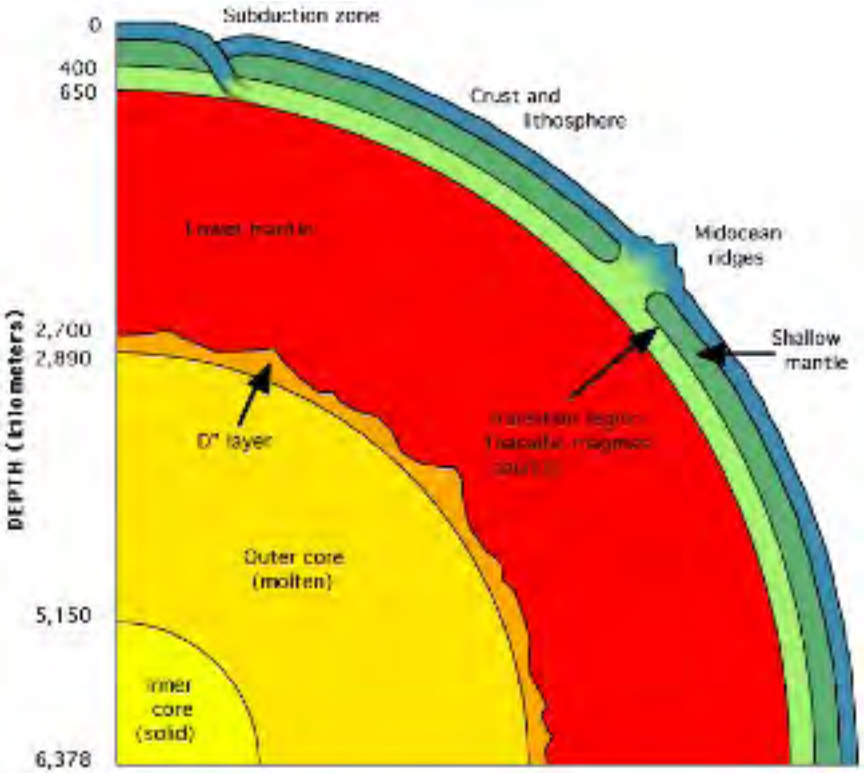
NWT Geology

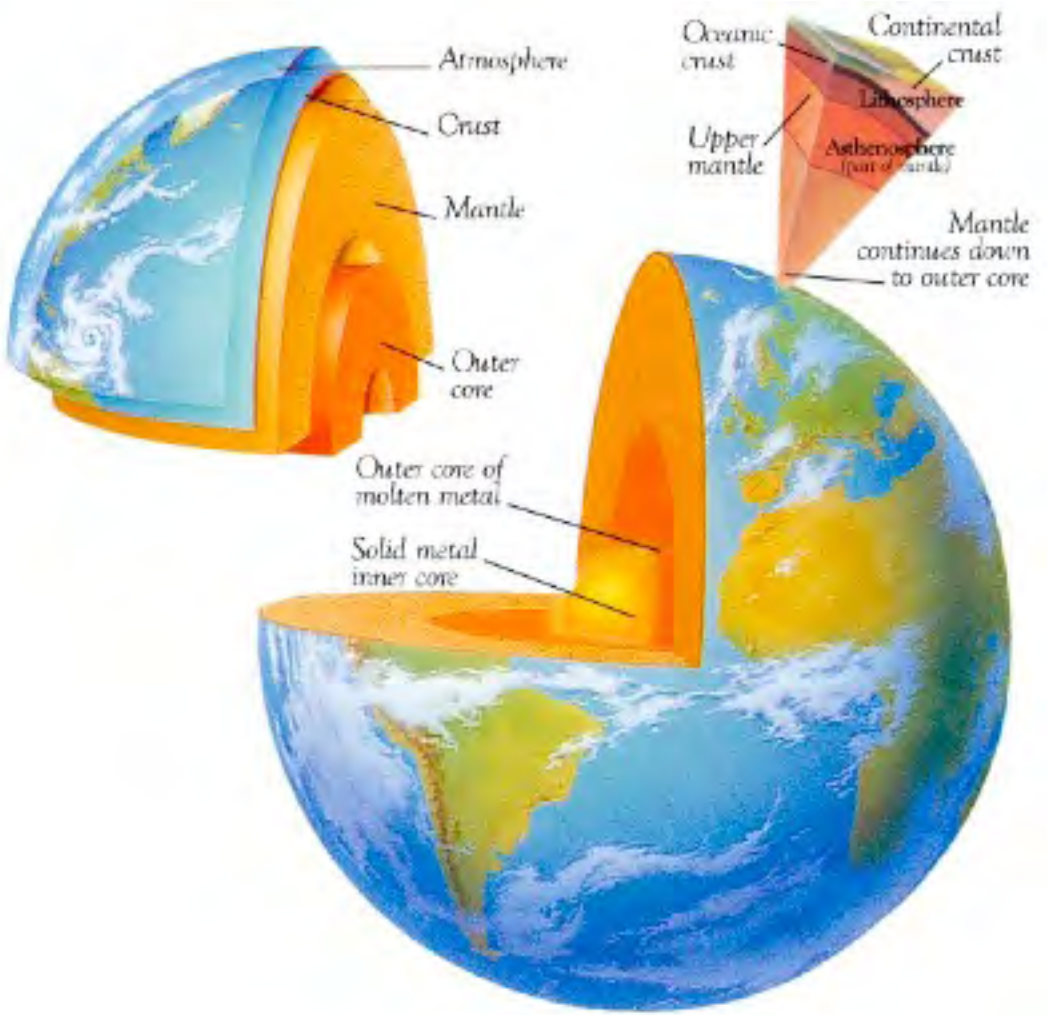
Glaciers

Rock Formation

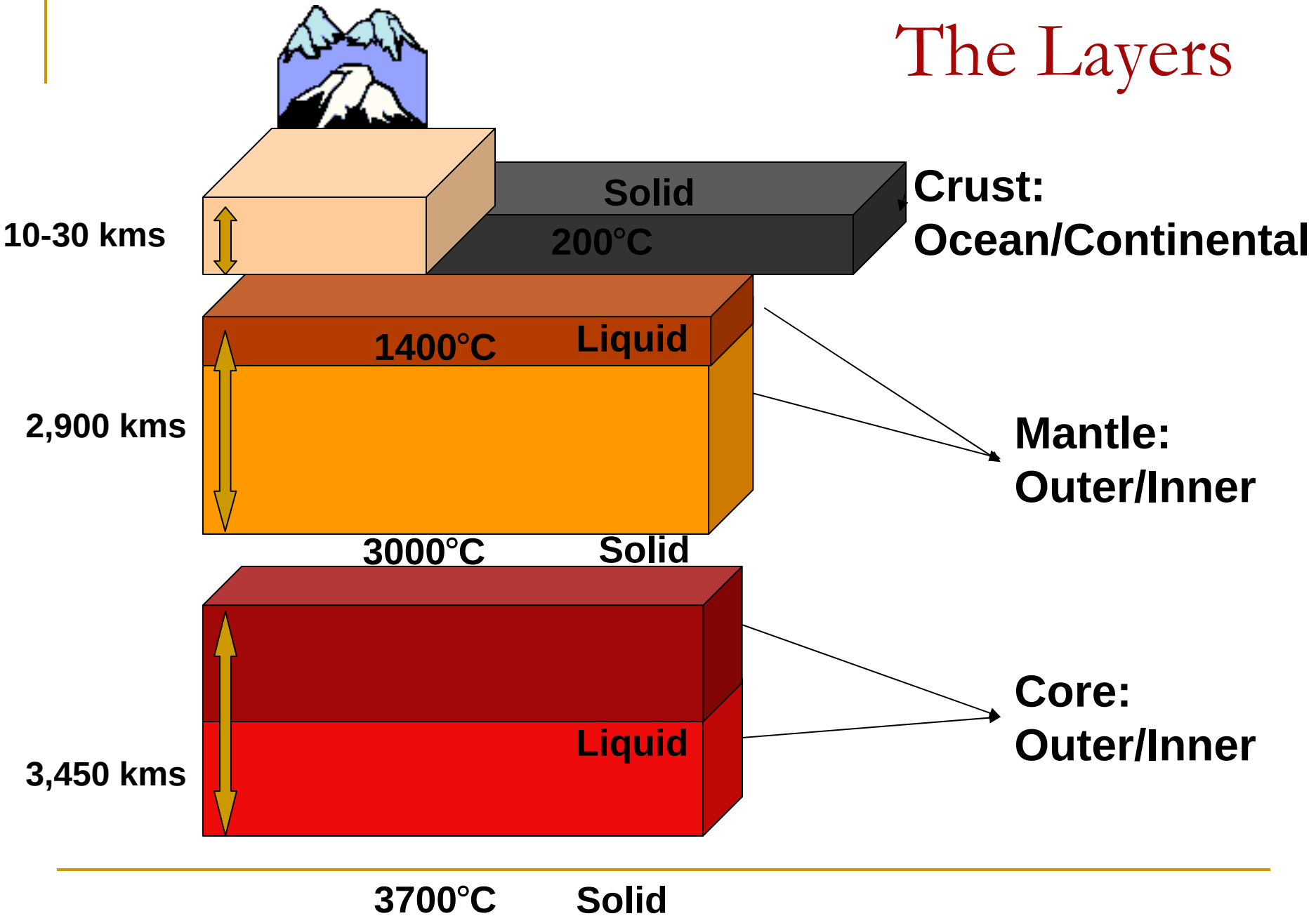
THE EARTH

The Earth Has Layers

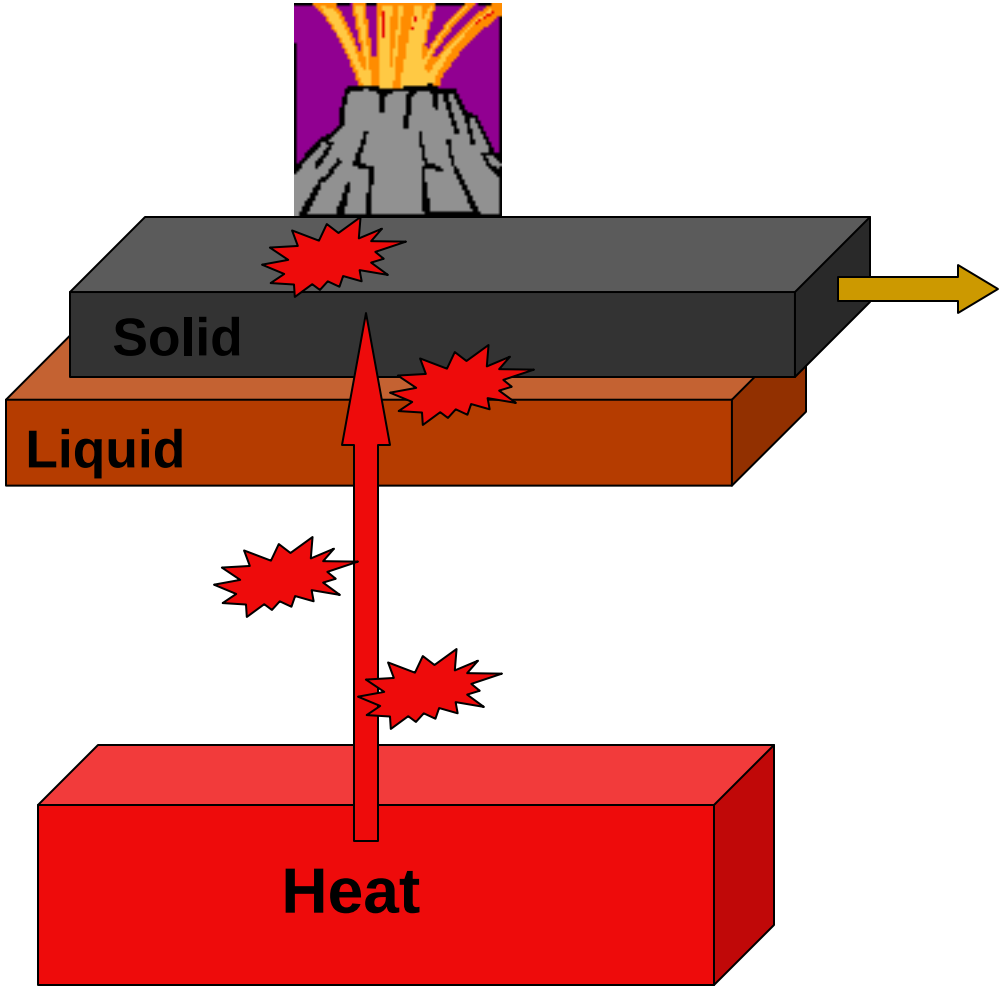




The Layers

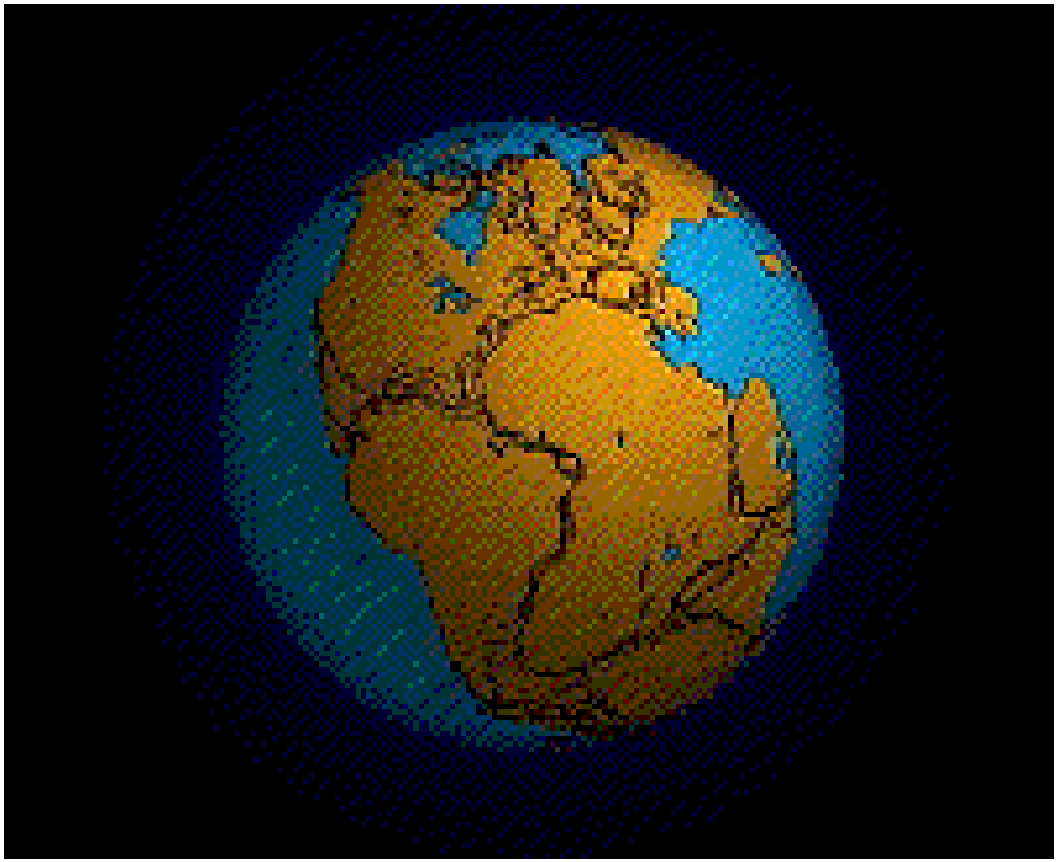

10-30 kms
Solid
200°C
Crust:
Ocean/Continental
1400°C
Liquid
2,900 kms
Mantle:
Outer/Inner
3000°C
Solid
Liquid
3,450 kms
Core:
Outer/Inner
3700°C
Solid

The Crust Moves



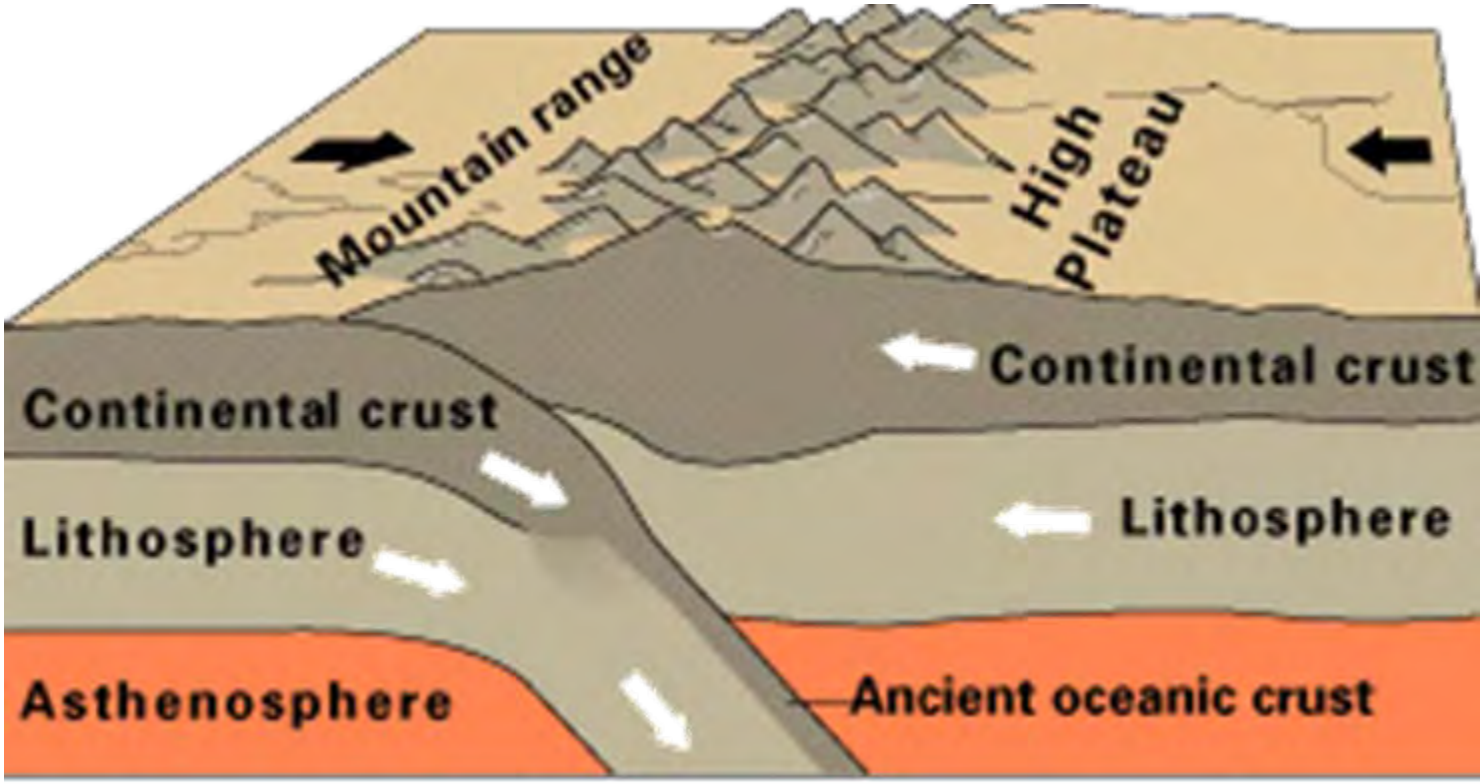
- **The thin crust floats on top of the liquid mantle layer (like ice on water)**
- **Heat from the core moves into the layers above and causes the crust to move**
- **Where there are cracks or weak areas in the crust, liquid rock will push into the cracks - sometimes all the way to Earth's surface (eg. a volcano)**

How the Earth Has Changed



- The Earth's crust is separated into pieces (like a puzzle)
- Over millions of years the pieces have moved around
- When the pieces collide, mountains are created, and earthquakes occur
- Clues are in the rocks

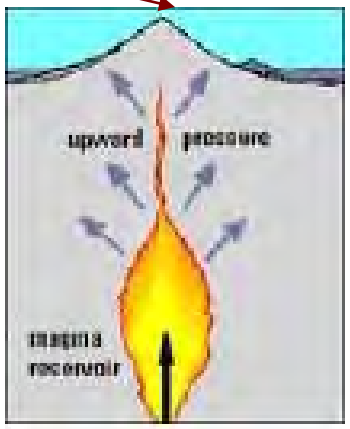
Geology - Folding



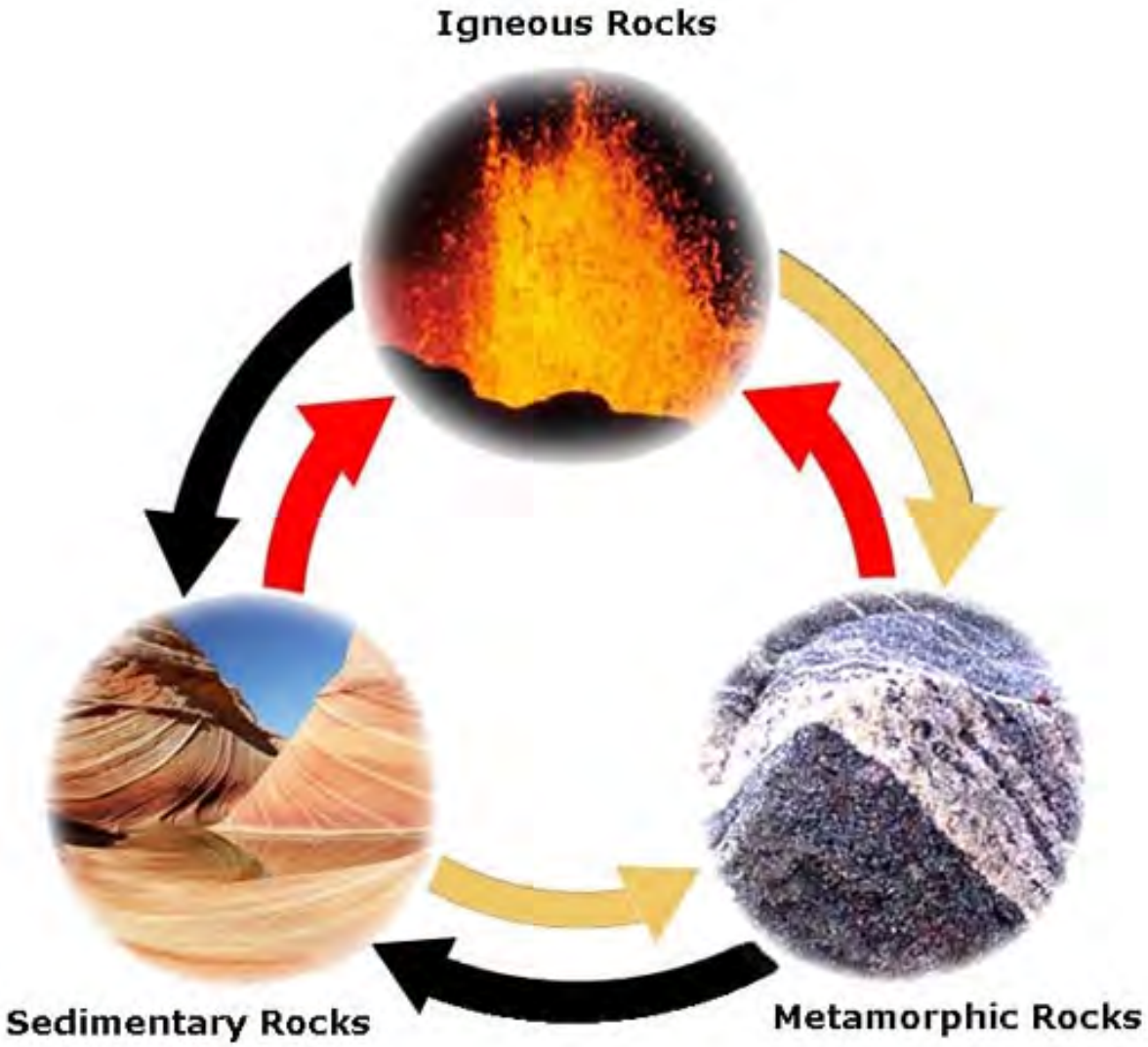
Source: Design and the universe website

BACKGROUND

- Rocks
- The Earth
- NWT Geology
- Glaciers



Rock Formation


Igneous Rocks
Sedimentary Rocks
Metamorphic Rocks

3 Rock Types Based on How They Form

SEDIMENTARY

Weathering

Weathering

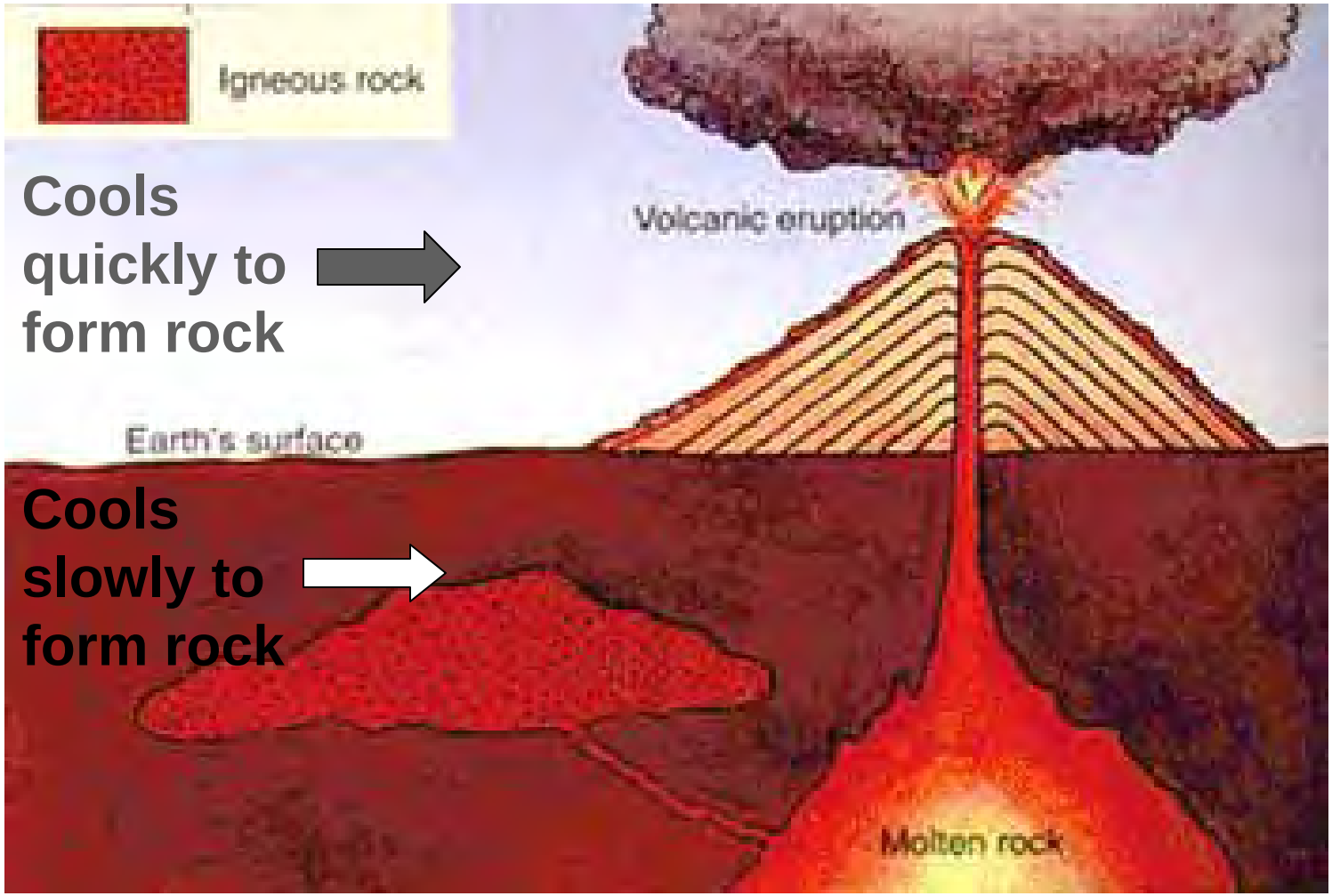
Melting

Heat & Pressure

IGNEOUS

METAMORPHIC

Igneous - Fire Rocks



Liquid layer cools and forms igneous rocks

http://geography.ridley.on.ca/Physical/Rocks/Rocks.html

Igneous Rock Examples

Pegmatite: Cooled In Crust

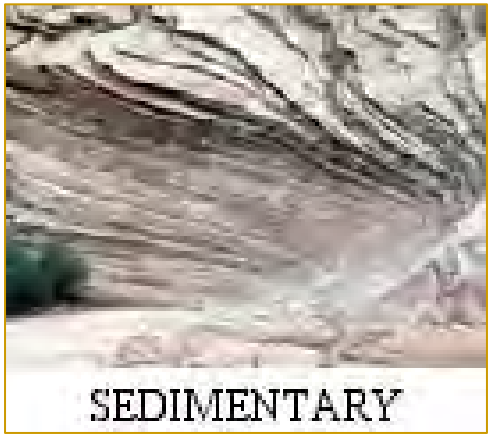
Diorite: Cooled In Crust

Basalt: Cooled Above Crust

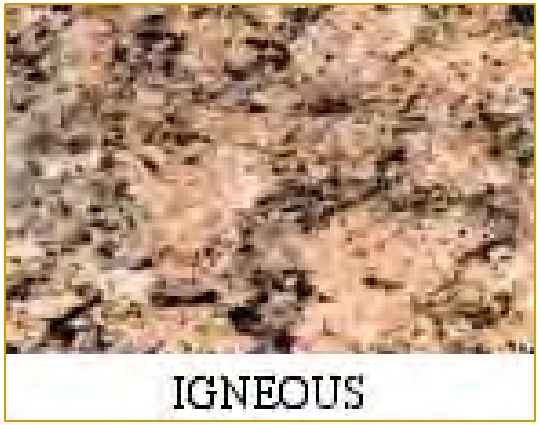
Pumice: Cooled Above Crust

3 Rock Types Based on How They Form

Weathering

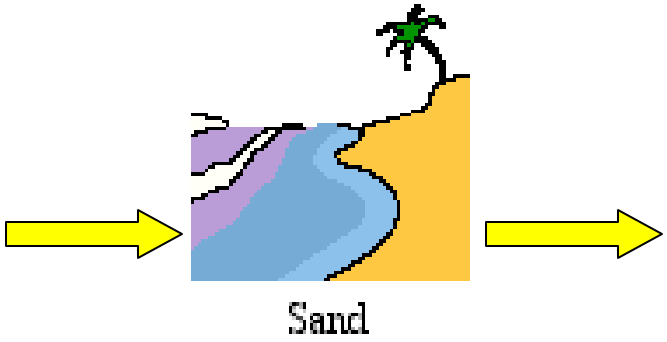


Weathering



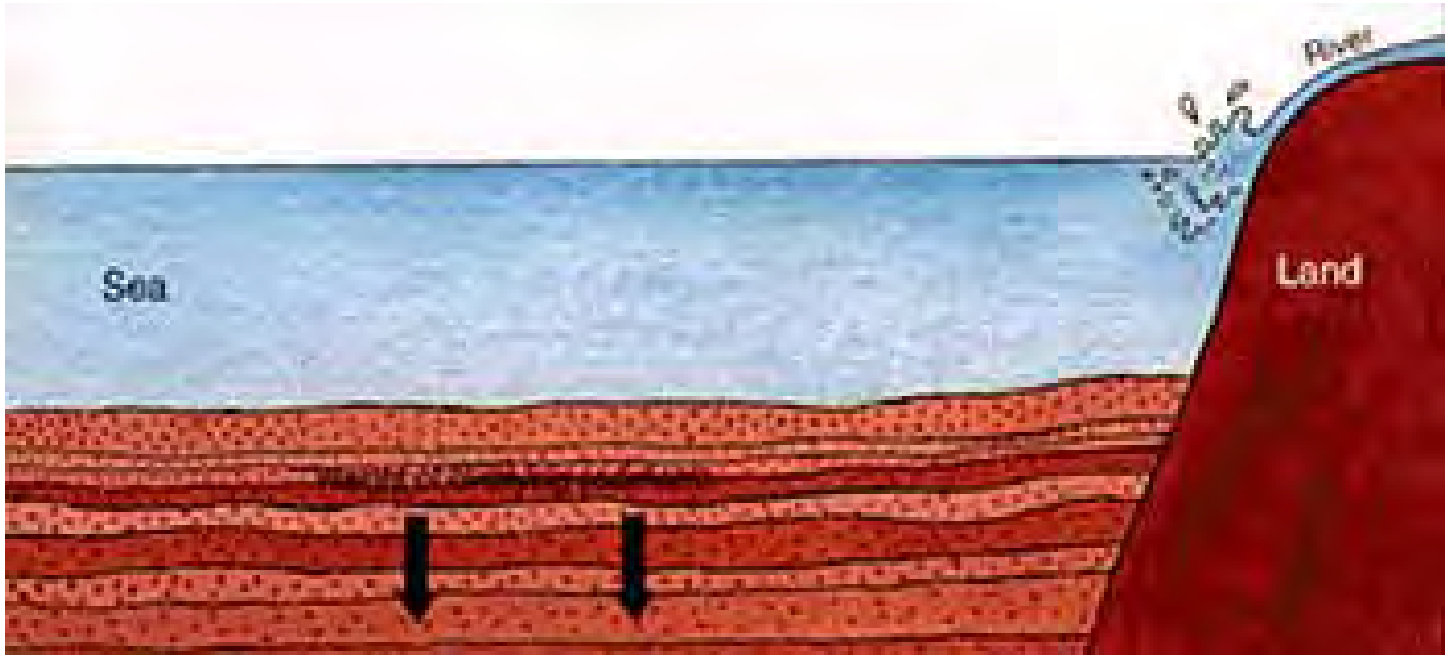
Sedimentary - Secondary Rocks

Granite



Sand

Existing rocks break down into grains.



Over time these grains form solid sedimentary rocks.

http://geography.ridley.on.ca/Physical/Rocks/Rocks.html

Sedimentary Rock Examples

Sandstone - Solidified Sand

Shale - Solidified Clay

Sandstone - Solidified Cobbles

Limestone - Solidified Shells

3 Rock Types Based on How They Form

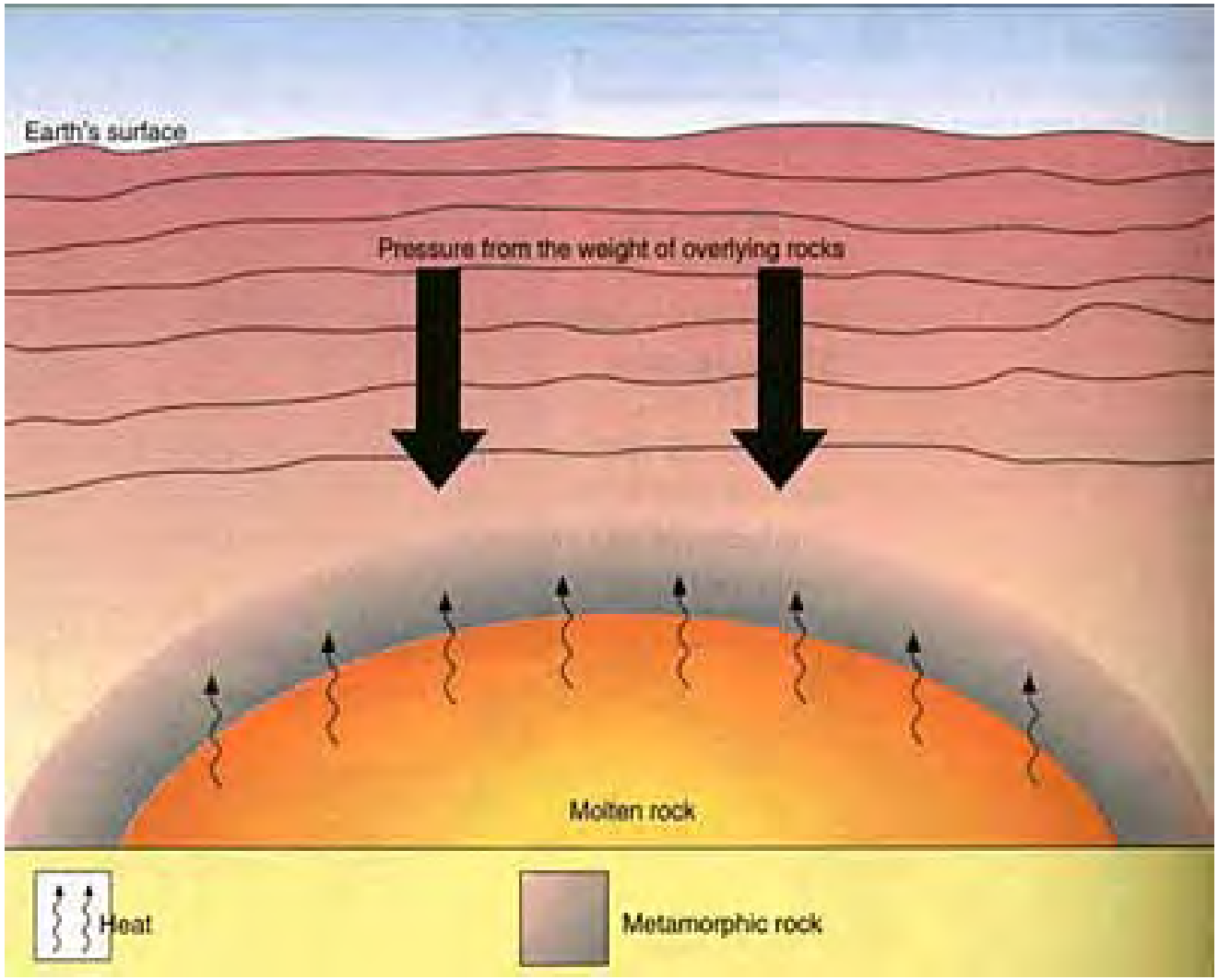
SEDIMENTARY

Heat & Pressure

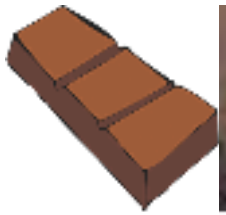
IGNEOUS

METAMORPHIC

Metamorphic - Changed Rocks



Existing rocks are exposed to pressure and/or heat to form Metamorphic rocks



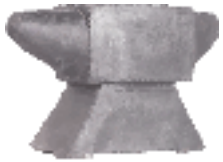
Ingredients

(minerals)

+

=

+



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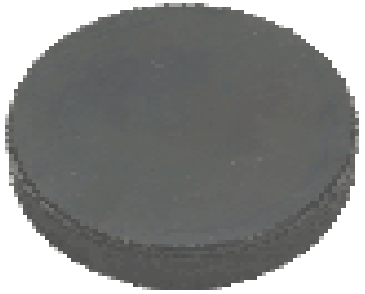
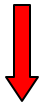


Chocolate Melts Out



→As a rock is heated, the ingredients can change, and the properties of the rock will change. The result is a new, Metamorphic, rock.

Metamorphic Rock Examples

Clay → Shale + Heat/Pressure → Slate → Schist

Slate

Schist

Granite + Heat/Pressure → Gneiss

Gneiss

Marble

Shells → Limestone + Heat/Pressure → Marble

3 Rock Types Based on How They Form

SEDIMENTARY

Weathering

Weathering

Melting

Heat & Pressure

IGNEOUS

METAMORPHIC

Geology Background

Brett

- Glaciers
- Ice

BACKGROUND

Rocks

The Earth

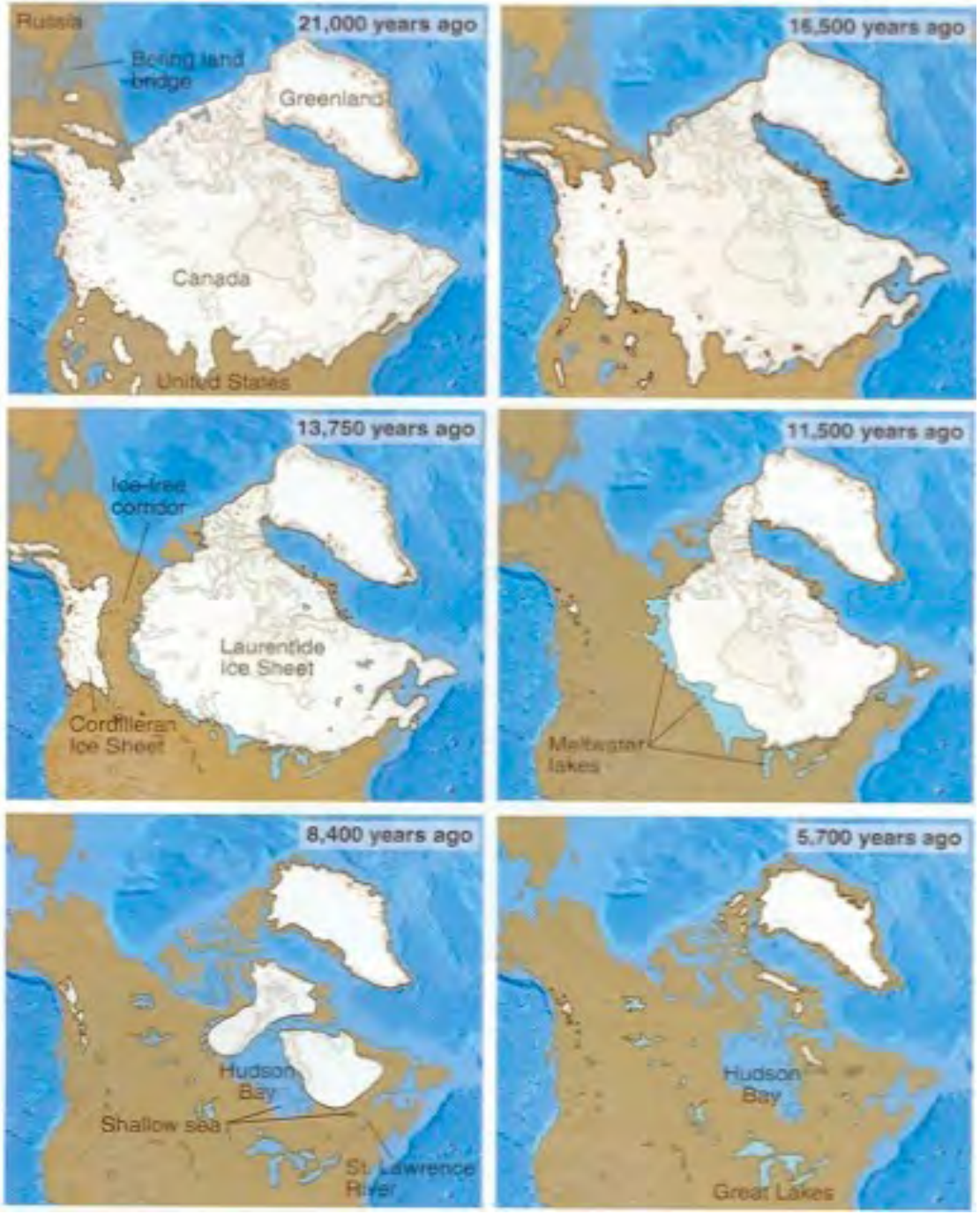
NWT Geology

Glaciers

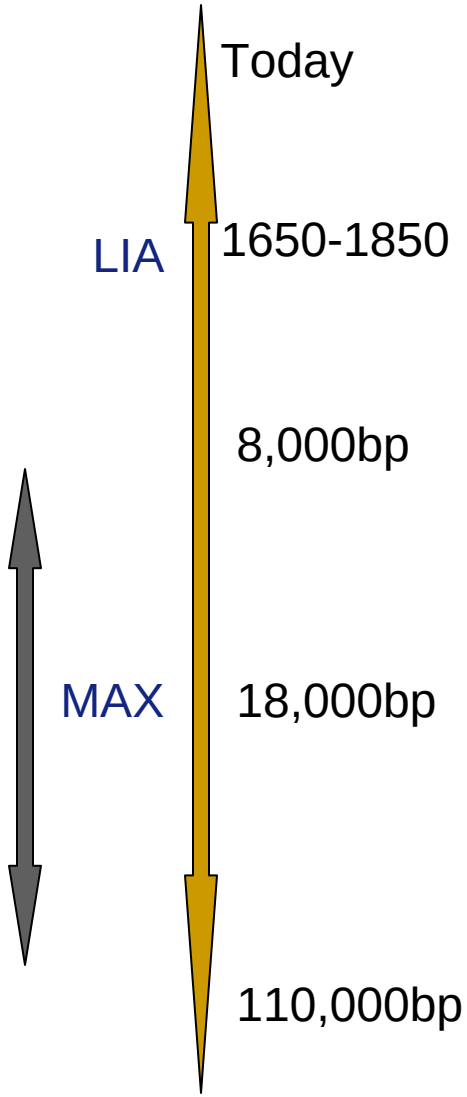
Rock Formation

Barnes Ice Cap, Nunavut

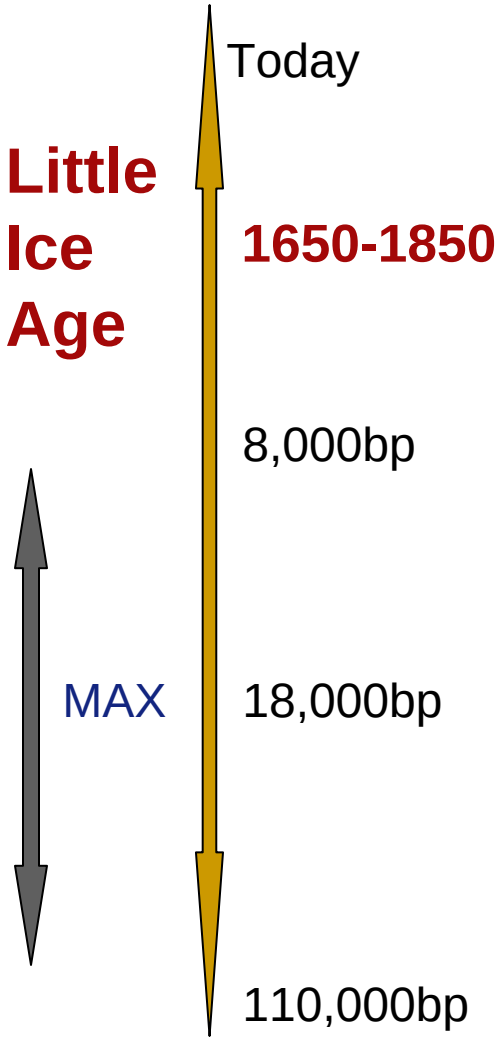
Glaciers: Many Shapes & Sizes



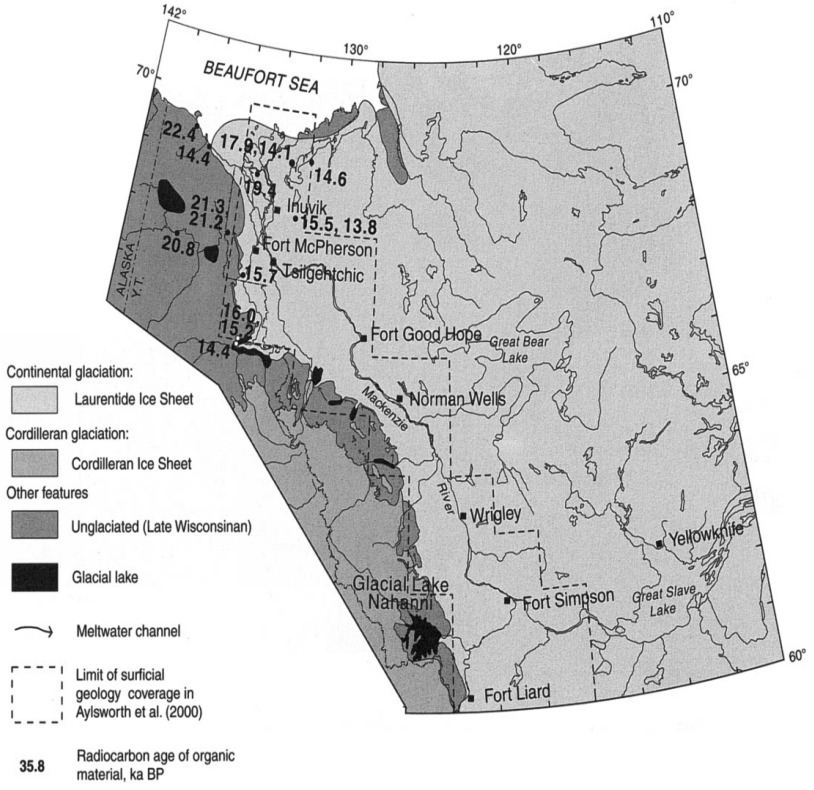
A History of Glaciation



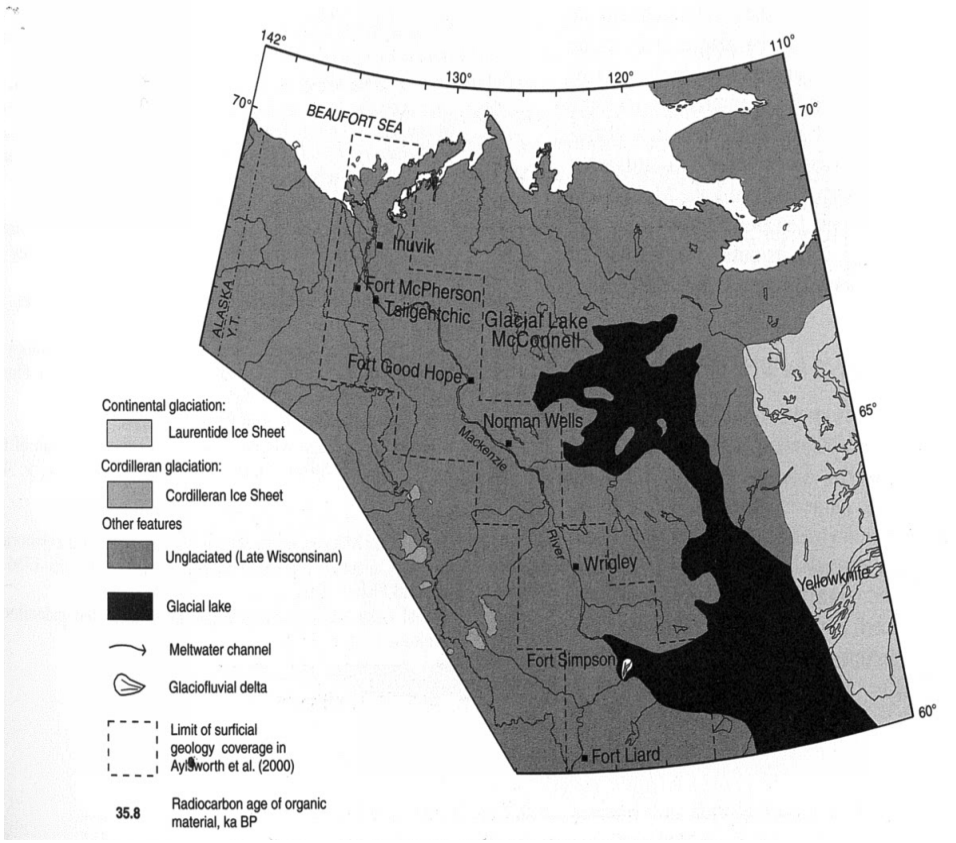
A History of Glaciation



Glaciation in the NWT

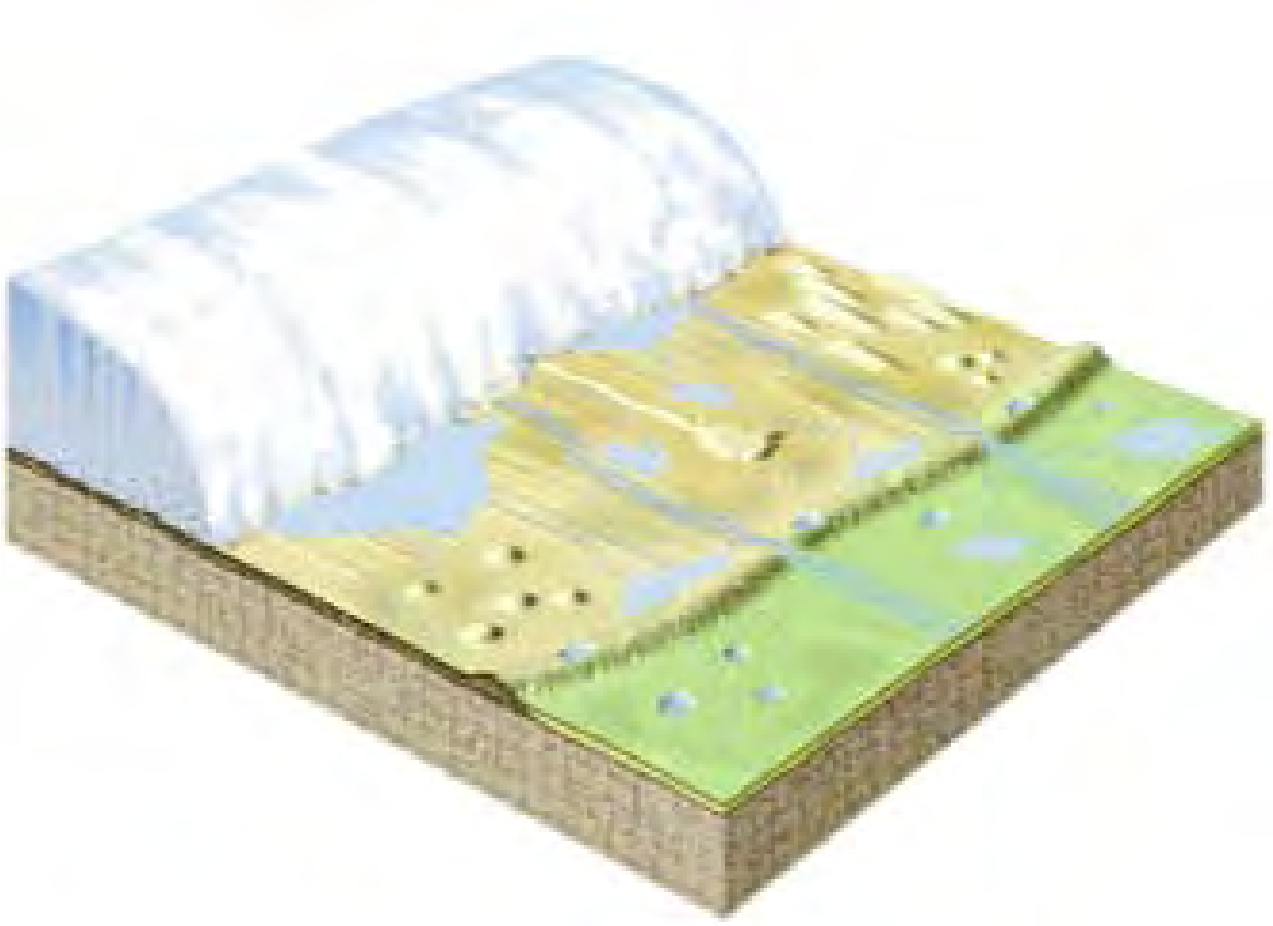


20 thousand years ago

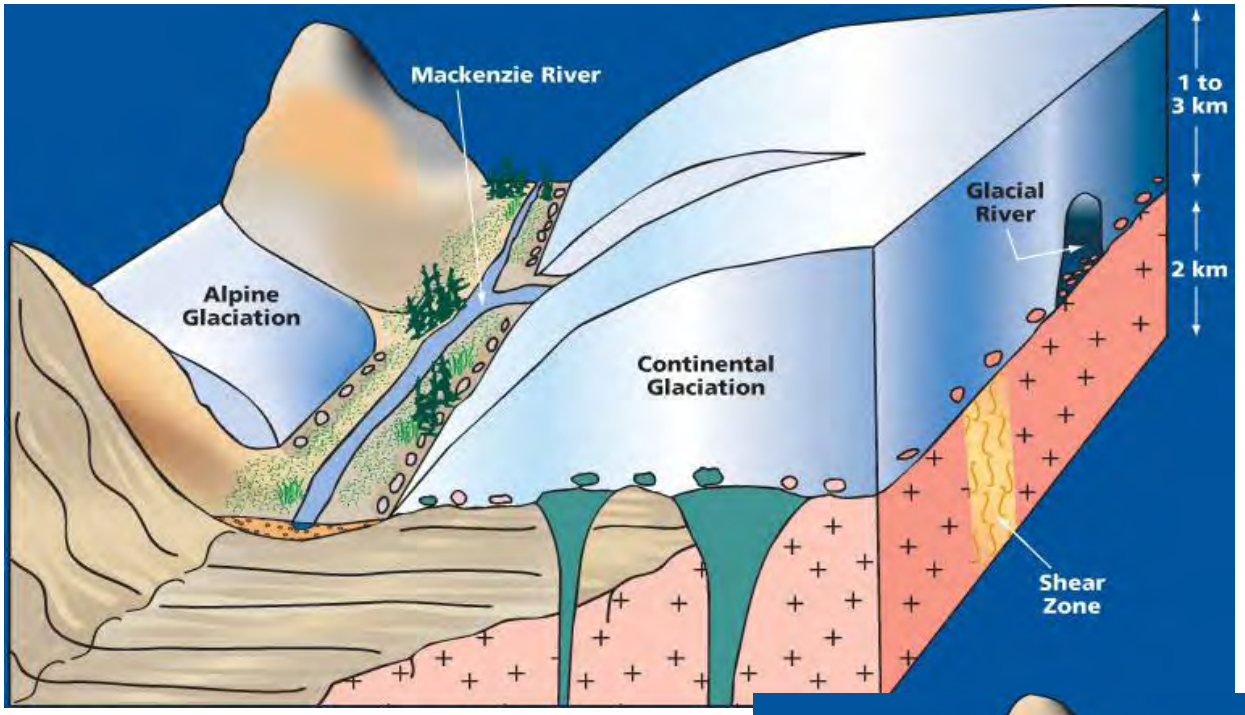


10 thousand years ago

Glacial Landforms

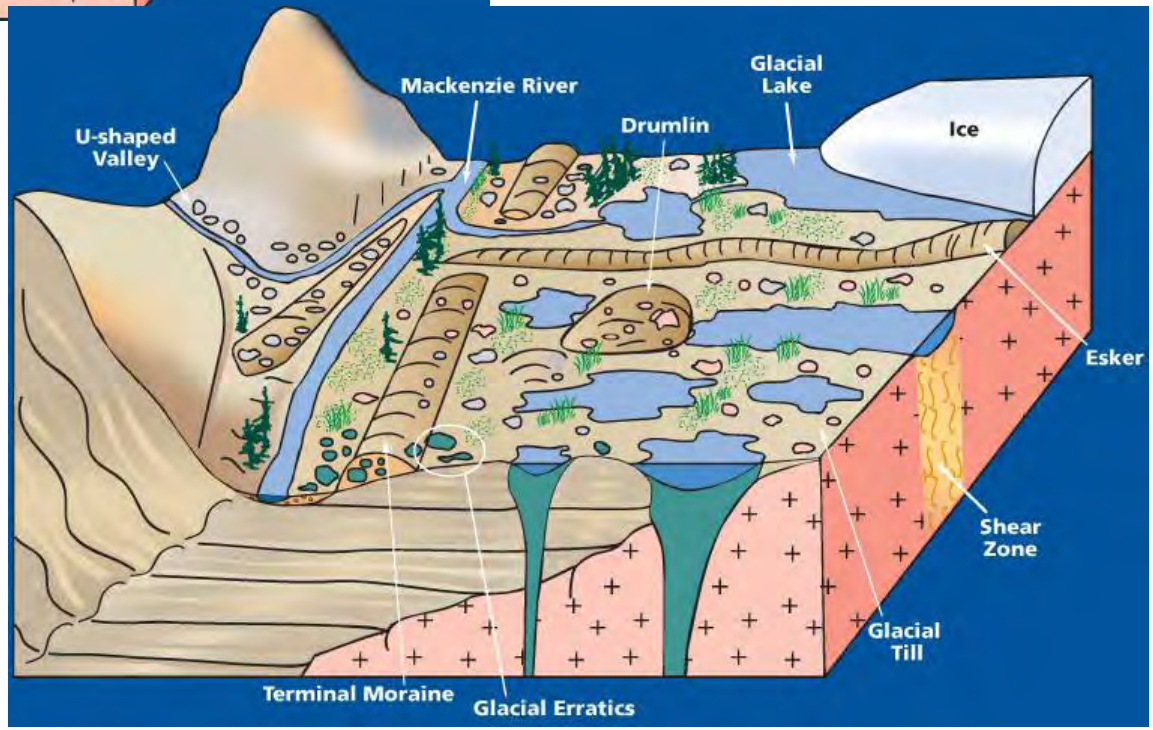


- Eskers
- Till
- Drumlins
- Moraines
- Striations
- Kettles & Kames
- Lakes
- Rivers

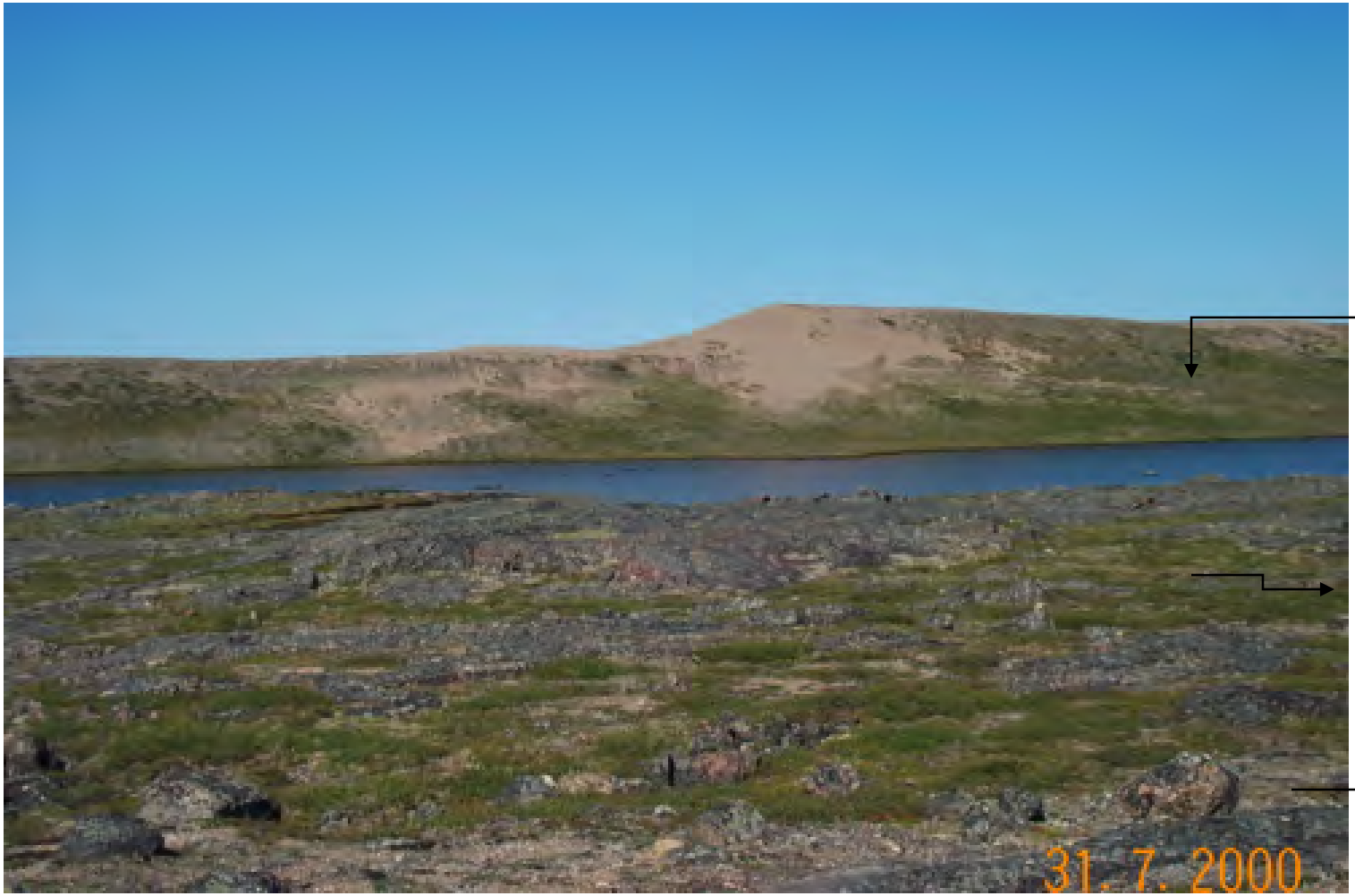


During glaciation

Once glaciers have retreated

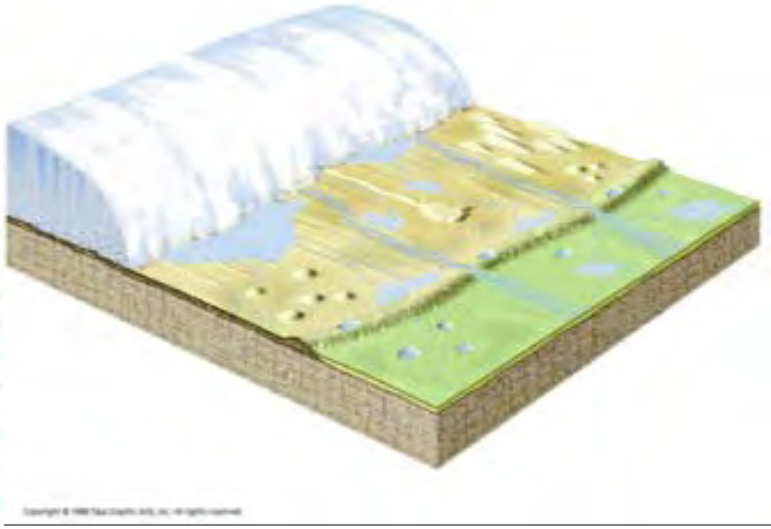


Glacial Landforms



Ice Direction

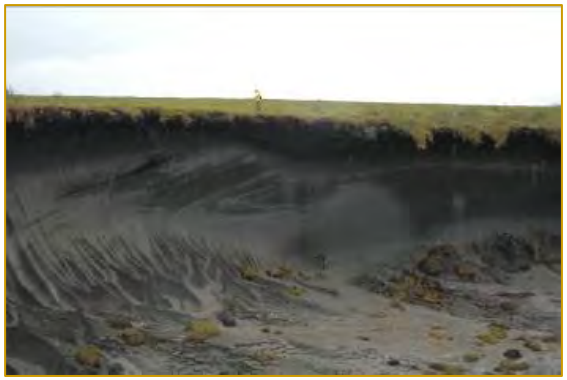
- Striations
- Landforms (eskers, rock shape)
- Samples: eskers, till, rivers



Landforms & land use

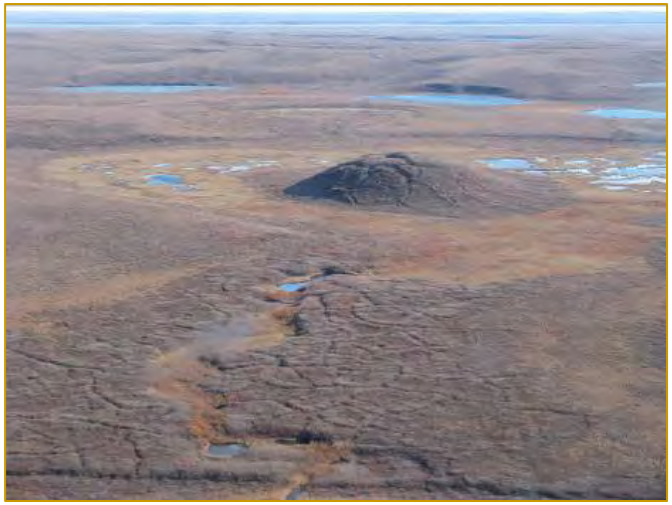
- An esker near Lac de Gras used as an airstrip
- Wildlife corridor & habitat

Permafrost landforms



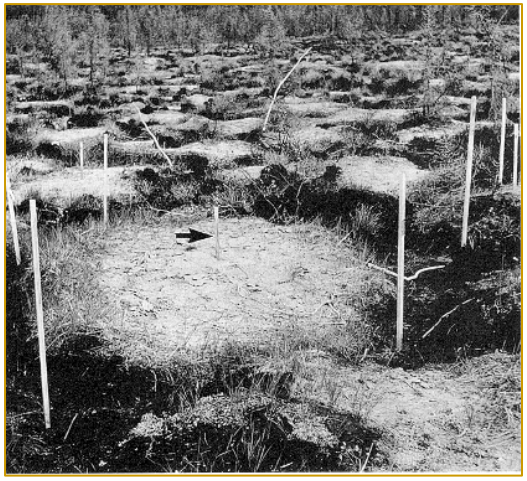
Thaw slumps

Massive ice



Pingos

Thermokarst lakes

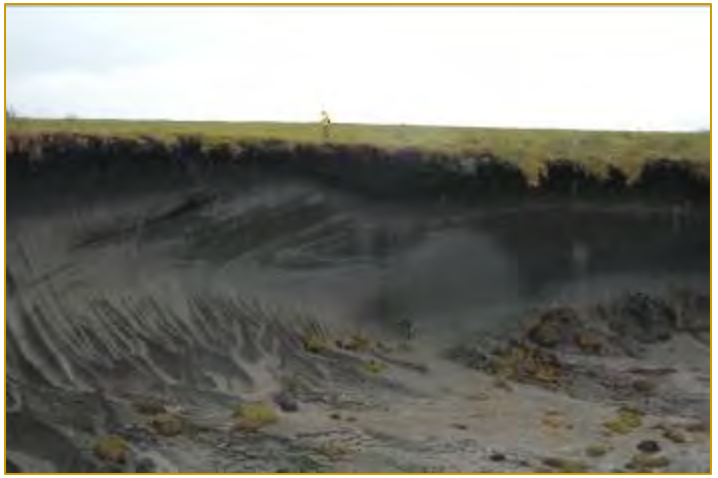


Hummocks

Patterned ground

What is permafrost?

Ground that stays below 0°C for two or more years

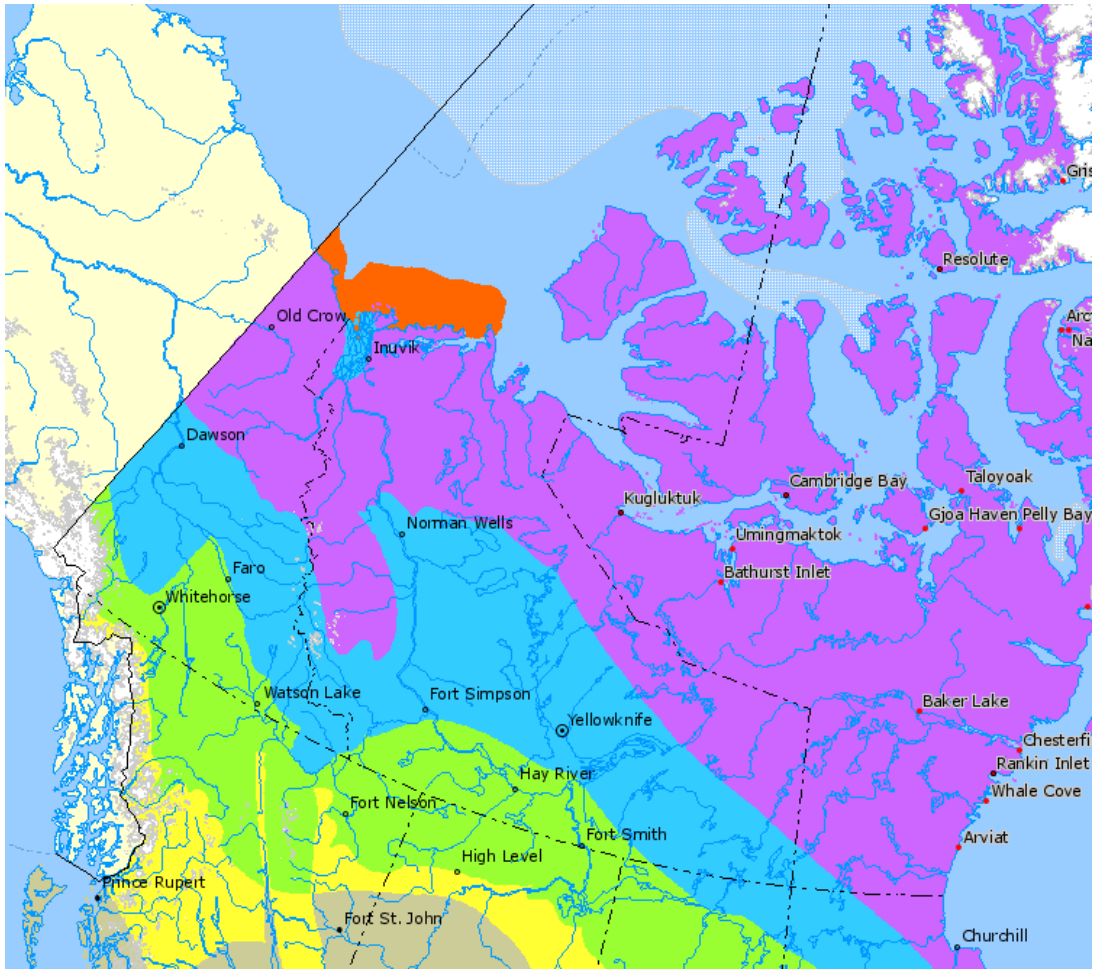


How are these landforms created?

Development of ground ice

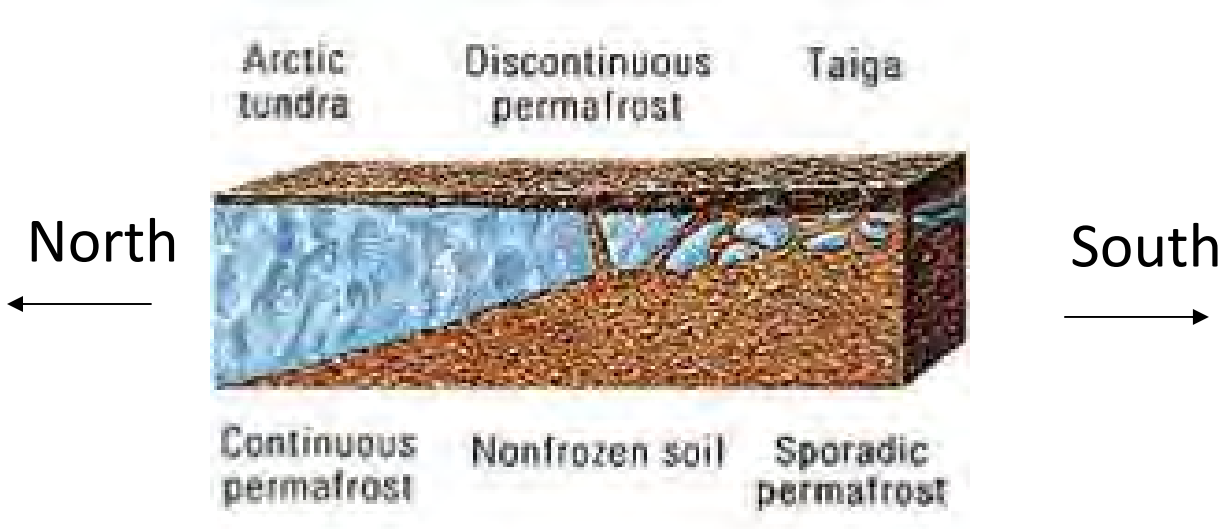
Freeze and thaw cycles

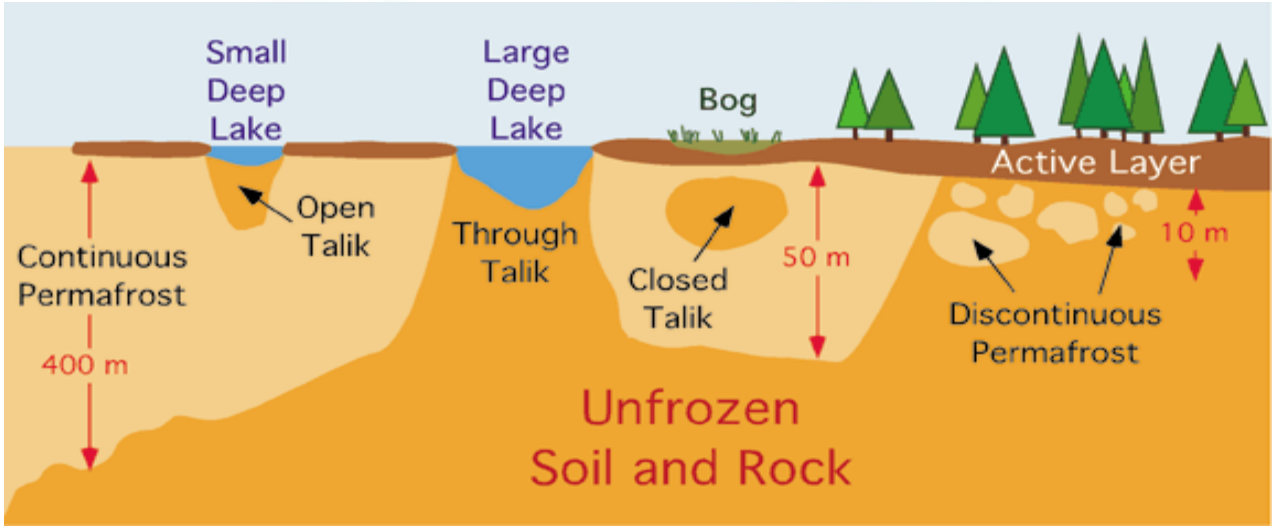
Where is Permafrost?



- Continuous (90-100%)
- Extensive Discontinuous (50 - 90%)
- Sporadic Discontinuous (10 - 50%)
- Isolated Patches (0 - 10%)
- Subsea Permafrost
- No permafrost

Continuous and Discontinuous Permafrost





BACKGROUND

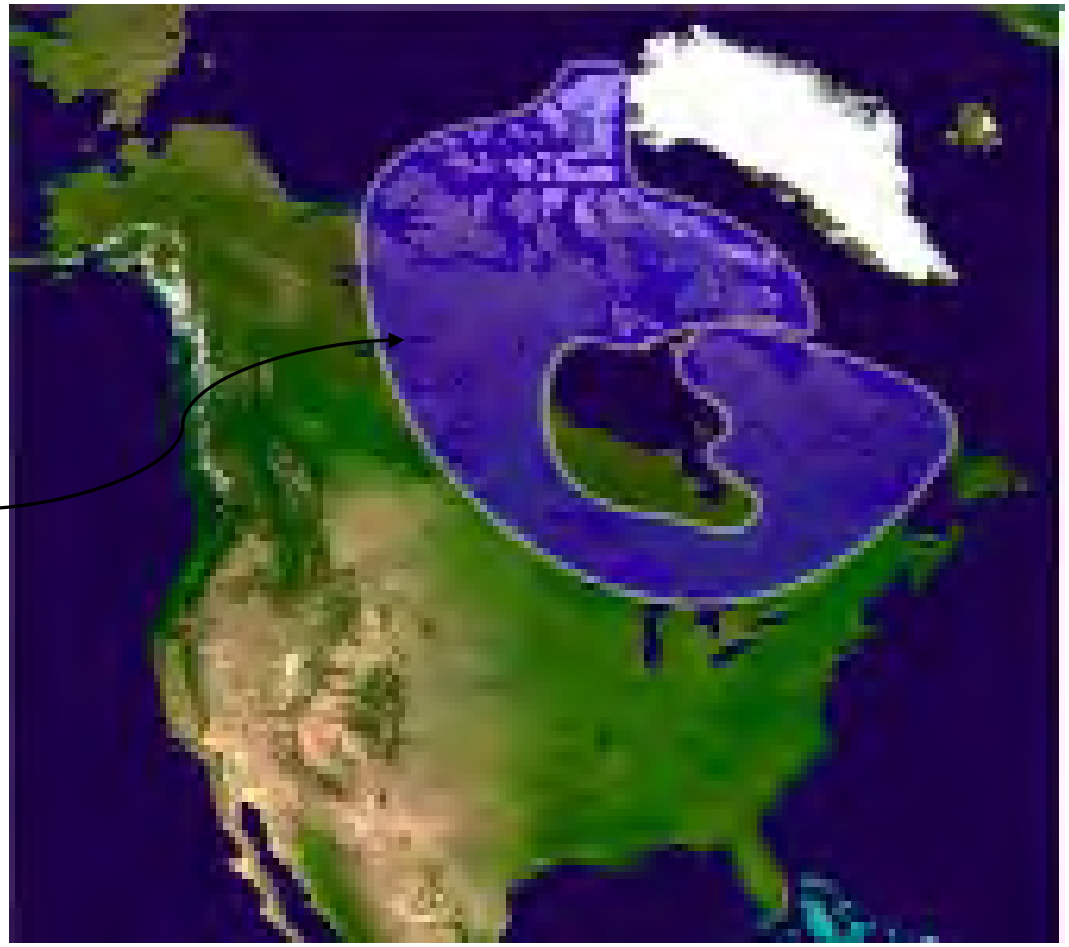
- Rocks
- The Earth
- Rock Formation
- Glaciers

NWT Geology

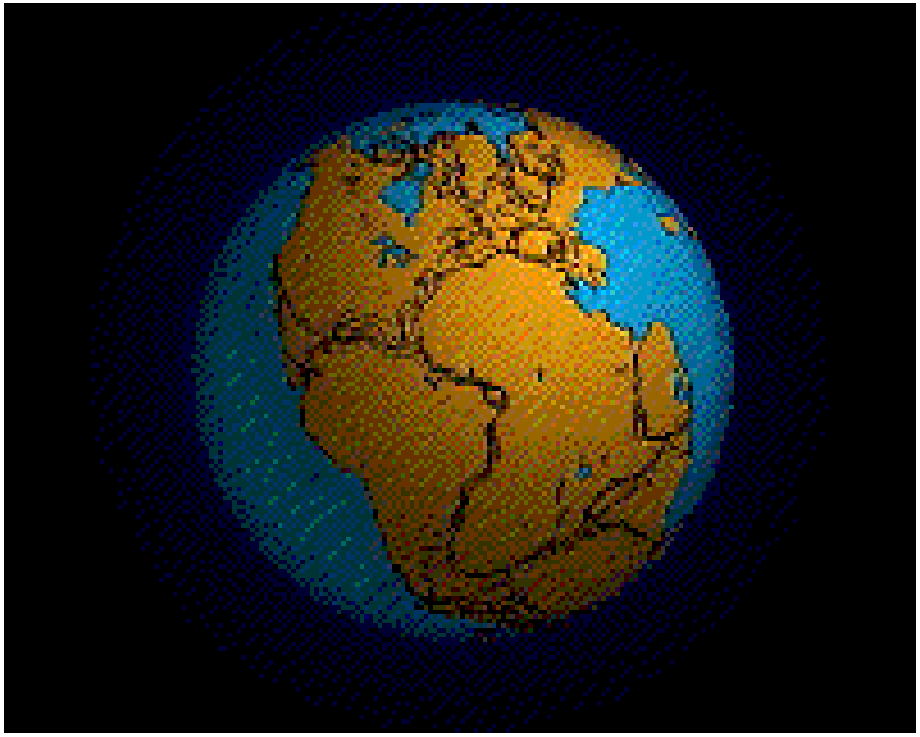
NWT GEOLOGY

The Canadian Shield

North America

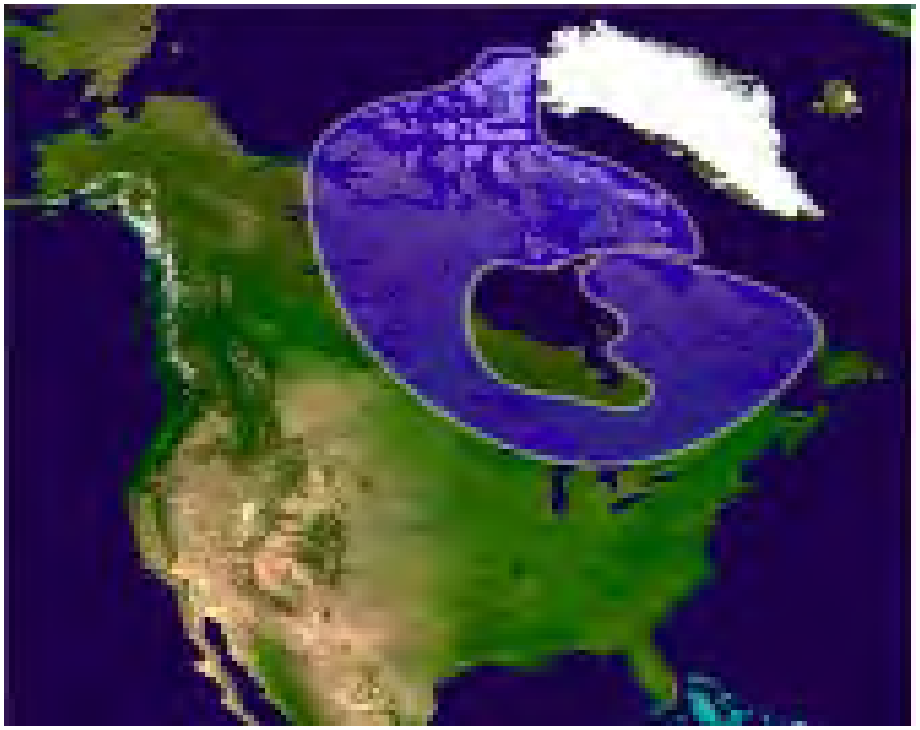


How the Earth Has Changed

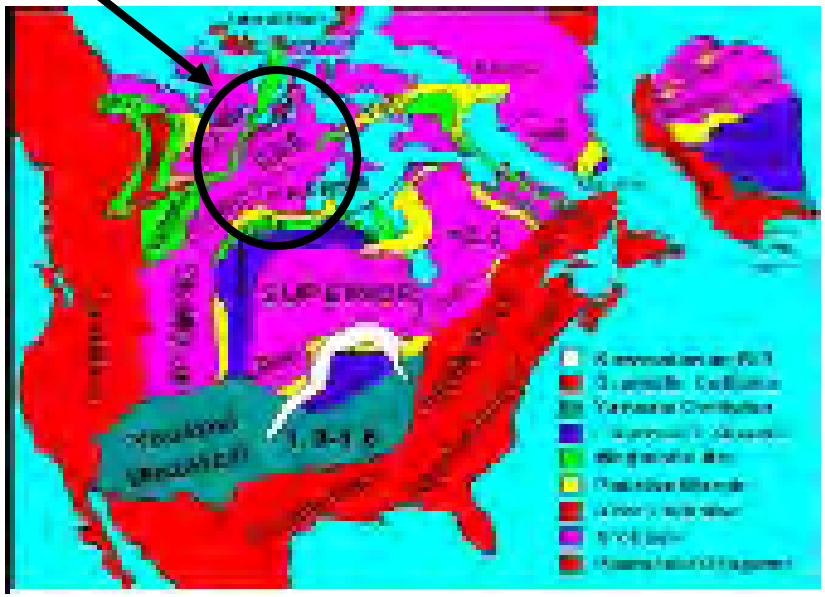


- The Earth's crust is separated into pieces (like a puzzle)
- Over millions of years the pieces have moved around
- When the pieces collide, mountains are created, and earthquakes occur
- Clues are in the rocks

Geologic Provinces



Yellowknife



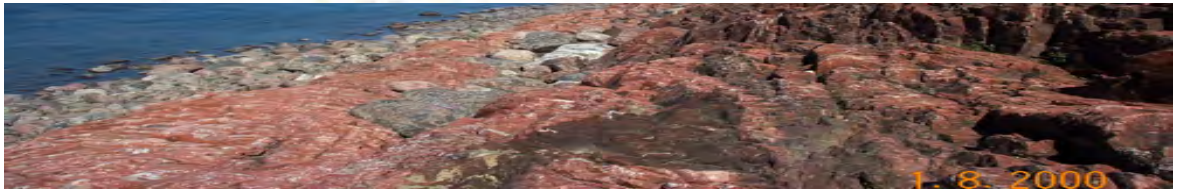
Main Rock Types in this Region

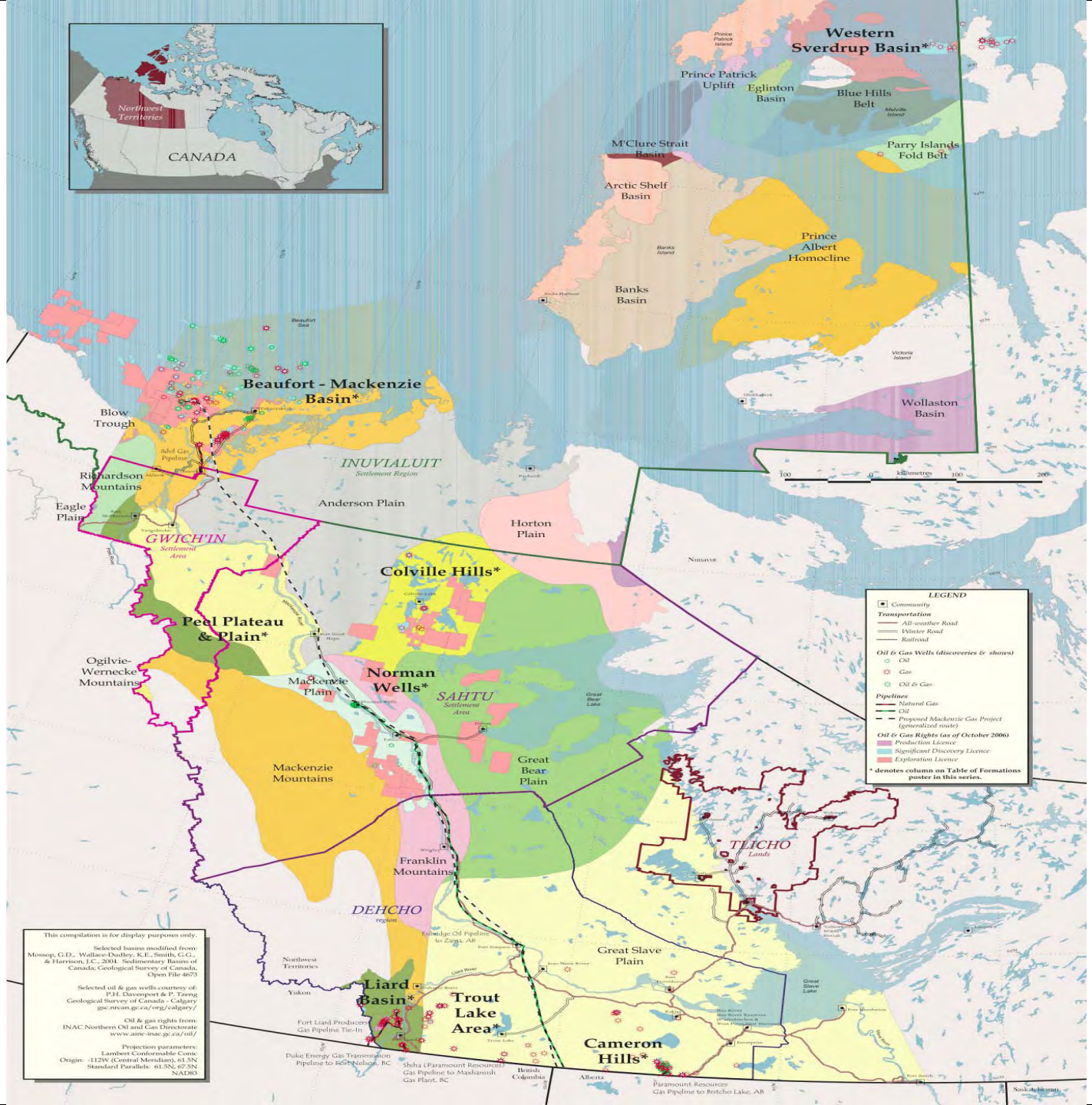
Greenstone
Metamorphic

Sea Rocks
Sedimentary

Gneiss
Metamorphic

Granite
Igneous




Northwest Territories
CANADA
Western Sverdrup Basin*
Prince Patrick Uplift
Eglinton Basin
Blue Hills Belt
M'Clure Strait Basin
Parry Islands Fold Belt
Arctic Shelf Basin
Prince Albert Homocline
Banks Basin
Wollaston Basin
Beaufort - Mackenzie Basin*
Blow Trough
Richardson Mountains
Eagle Plain
INUVIALUIT
Settlement Region
Anderson Plain
Horton Plain
GWICH'IN
Settlement Area
Colville Hills*
Peel Plateau & Plain*
Ogilvie-Wernecke Mountains
Mackenzie Plain
Norman Wells*
SAHTU
Settlement Area
Great Bear Plain
Mackenzie Mountains
Franklin Mountains
DEHCHO
region
TLICHO
Lands
Great Slave Plain
Liard Basin*
Trout Lake Area*
Cameron Hills*
Kilometres
LEGEND
Community
Transportation
All-weather Road
Winter Road
Railroad
Oil & Gas Wells (discoveries & shows)
Oil
Gas
Oil & Gas
Pipelines
Natural Gas
Oil
Proposed Mackenzie Gas Project (generalized route)
Oil & Gas Rights (as of October 2006)
Production Licence
Significant Discovery Licence
Exploration Licence
* denotes column on Table of Formations poster in this series.
This compilation is for display purposes only.
Selected basins modified from: Mossop, G.D., Wallace-Dudley, K.E., Smith, G.G., & Harrison, J.C., 2004: Sedimentary Basins of Canada; Geological Survey of Canada, Open File 4673
Selected oil & gas wells courtesy of: P.H. Davenport & P. Tzeng Geological Survey of Canada - Calgary gsc.nrcan.gc.ca/org/calgary/
Oil & gas rights from: INAC Northern Oil and Gas Directorate www.ainc-inac.gc.ca/oil/
Projection parameters: Lambert Conformable Conic Origin: -112W (Central Meridian), 61.5N Standard Parallels: 61.5N, 67.5N NAD83
Fort Liard Producers Gas Pipeline Tie-In
Duke Energy Gas Transmission Pipeline to Fort Nelson, BC
Shiha (Paramount Resources) Gas Pipeline to Mashamish Gas Plant, BC
Paramount Resources Gas Pipeline to Bistcho Lake, AB
Enbridge Oil Pipeline to Zama, AB
Alberta
British Columbia
Saskatchewan
Yukon
Northwest Territories
Nunavut

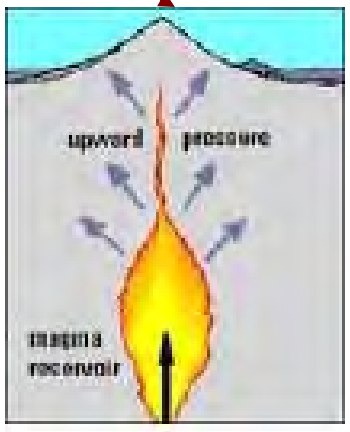
BACKGROUND

Rocks

The Earth

NWT Geology

Glaciers



Rock Formation

Can You…

- Define a rock
- Describe the layers of the Earth
- List 3 different types of rocks based on the way they form
- Describe the history of glaciers in the NWT
- Describe the basic geology of the NWT

Geologic Journey DVD

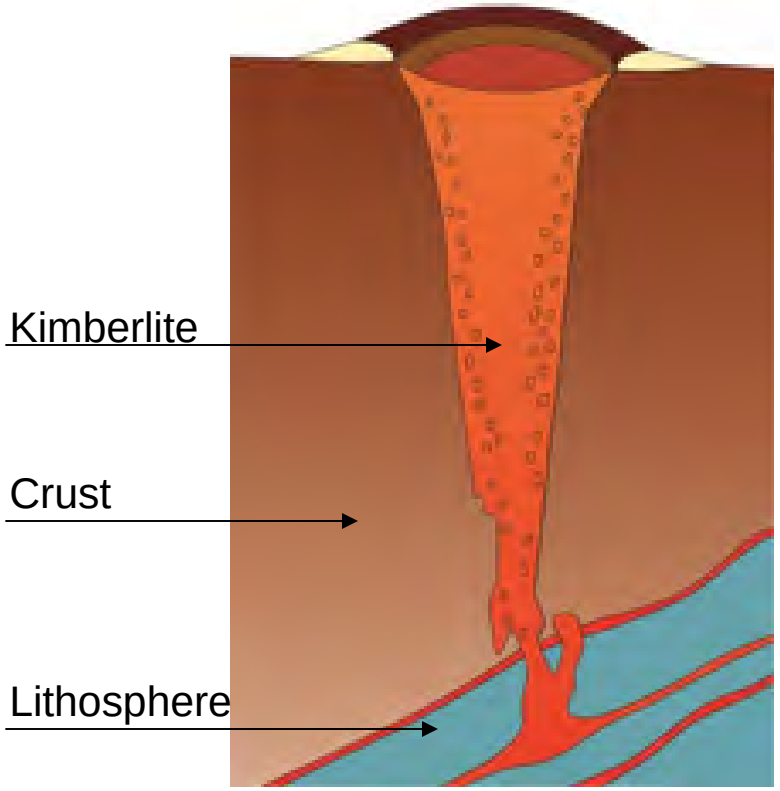
Geology of Snap Lake

Carter

- Rock Formation
- Glacial History

Kimberlite Deposits

- Kimberlite deposits are almost always found in the form of kimberlite pipes
- A kimberlite pipe is cause by an explosive intrusion of magma in the earths crust



Typical Kimberlite Deposit

Snap Lake Kimberlite Deposit

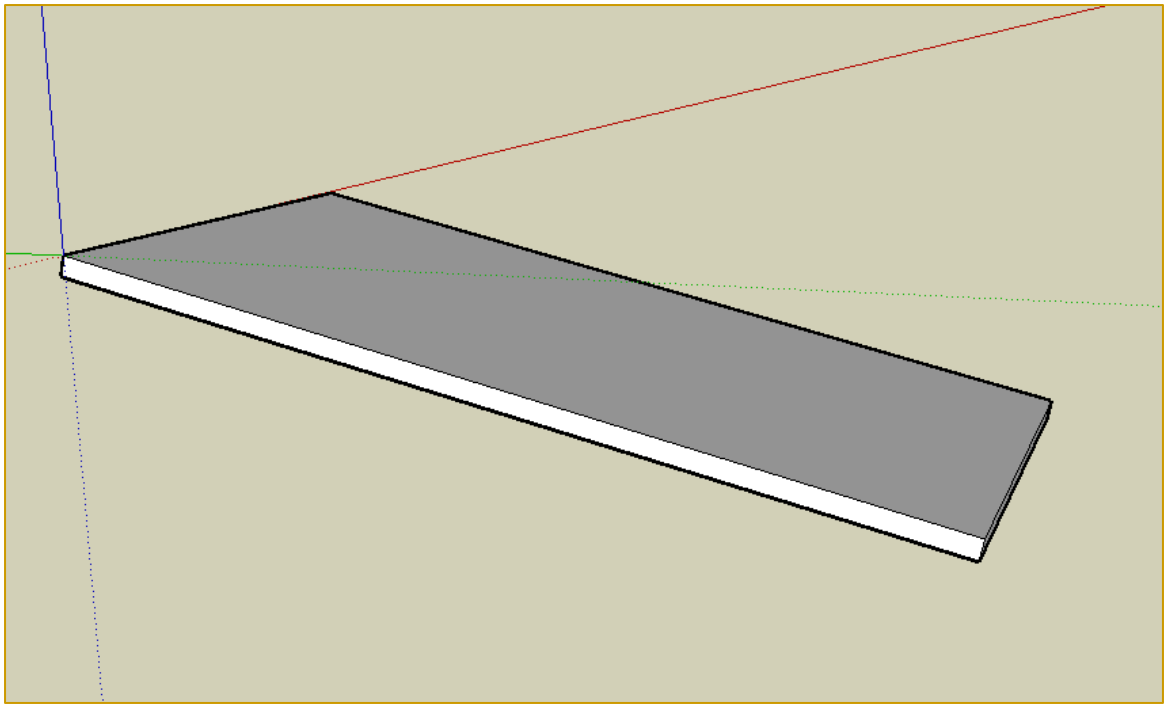
- The Snap Lake deposit is unique, it is one of very few kimberlite deposits of its kind in the world and the only one to ever be mined

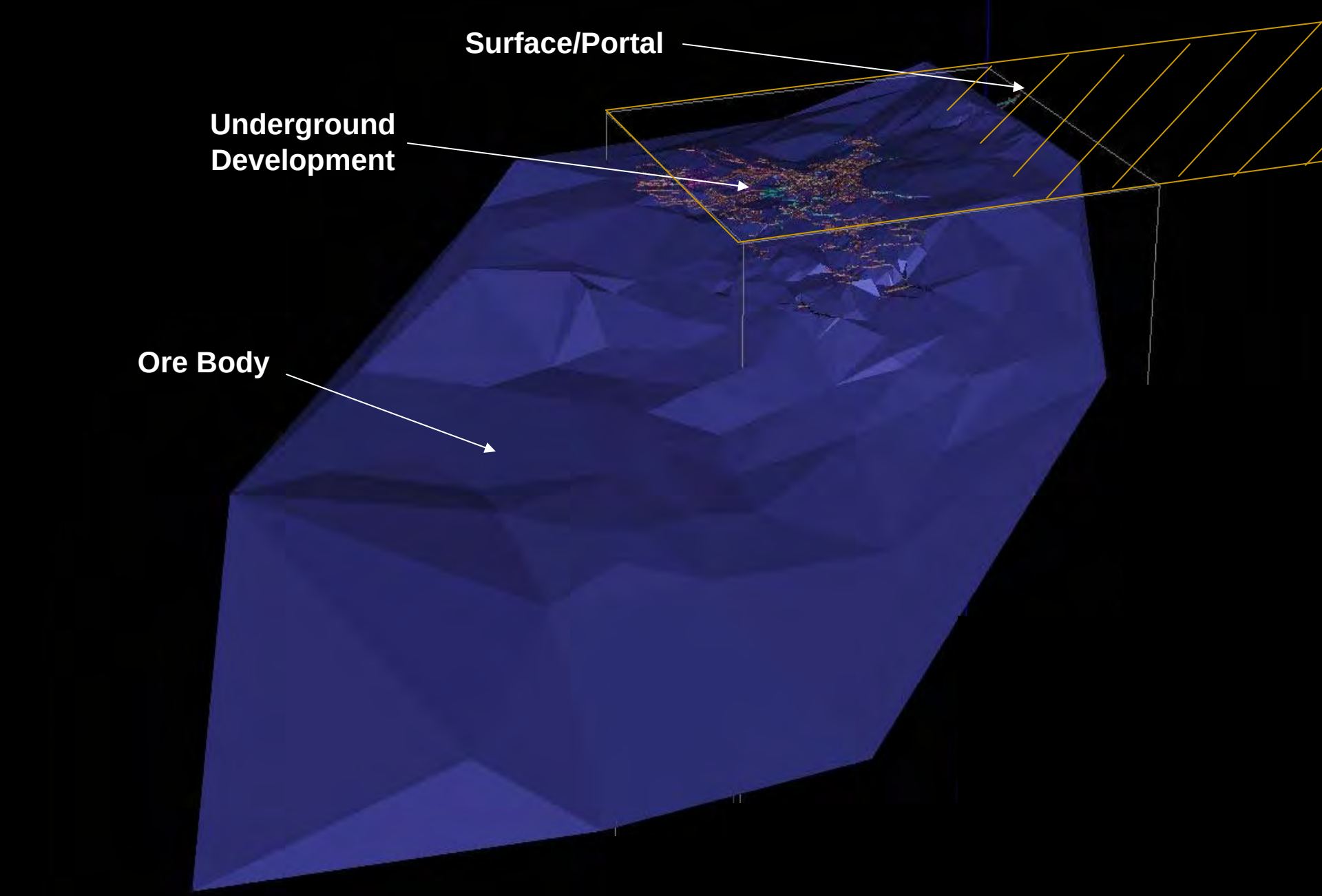
- Here is what makes the Snap Lake kimberlite ore body so special:

Snap Lake Geology

Snap Lake Dyke

- Dyke: tabular sheet-like igneous intrusion

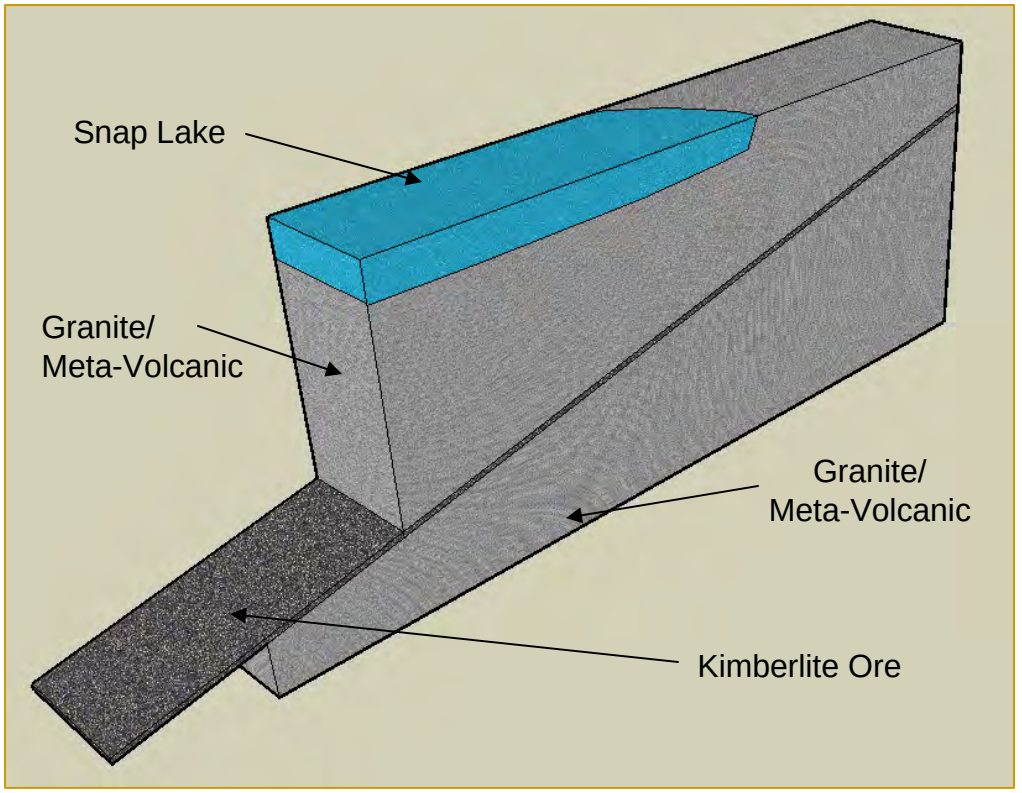




Gemcom Simulation of Snap Lake Ore Body

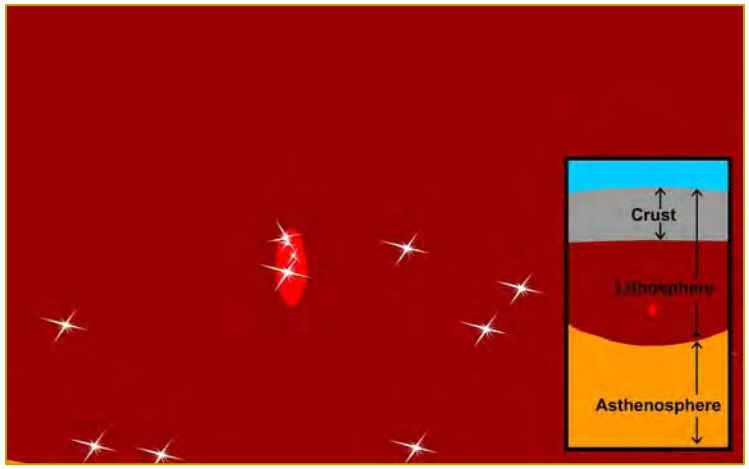
Surrounding Rock

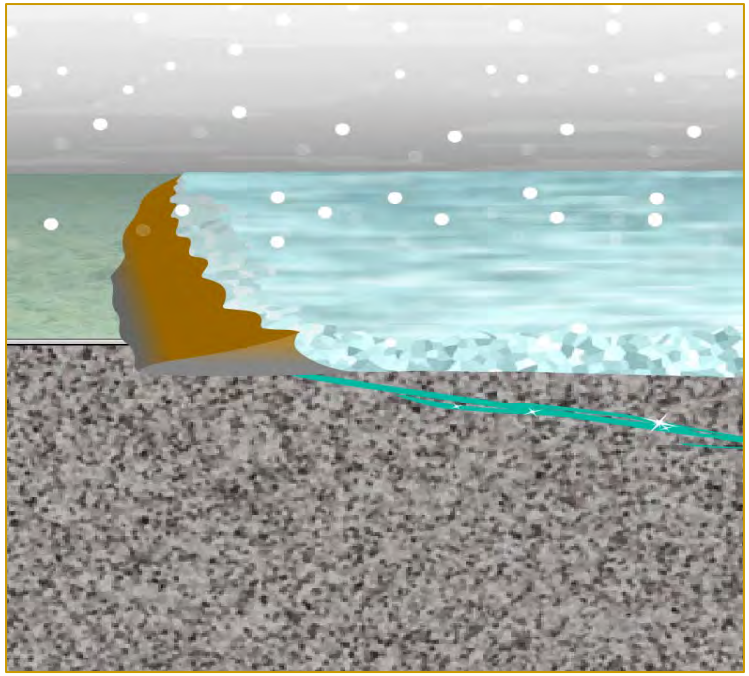
- The Snap Lake kimberlite dyke is surround by ‘country rock’
- This rock consists of either granite and meta-volcanic rock



Geology Summary

- The Snap Lake dyke was formed by liquid hot kimberlite traveling from the asthenosphere towards the surface through cracks in the earths crust
- Diamonds in the lithosphere were picked up by the magma and carried upwards
- The top of the ore body was then exposed by glaciers





Video

Discussion and Questions

Lunch

Outdoor Activity

All

- Classify Rocks
- Look for evidence of glacial activity
- Discuss

Mining Background

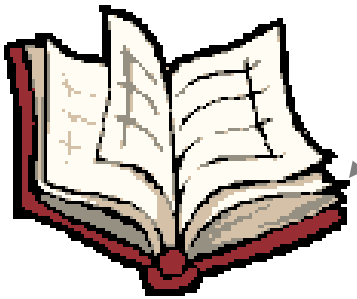
Rebecca, Brett

- Ore Bodies
- Exploration

NWT MINING

Ore Bodies

Exploration



Regulation

Mine Cycle

Ore Bodies

NWT MINING

Exploration

Regulation

Mine Cycle

ORE BODIES

What is Ore?

<u>Yellowknife Quarry</u>
= sand and gravel rocks for construction of roads

Rocks & Rocks with Minerals of Value

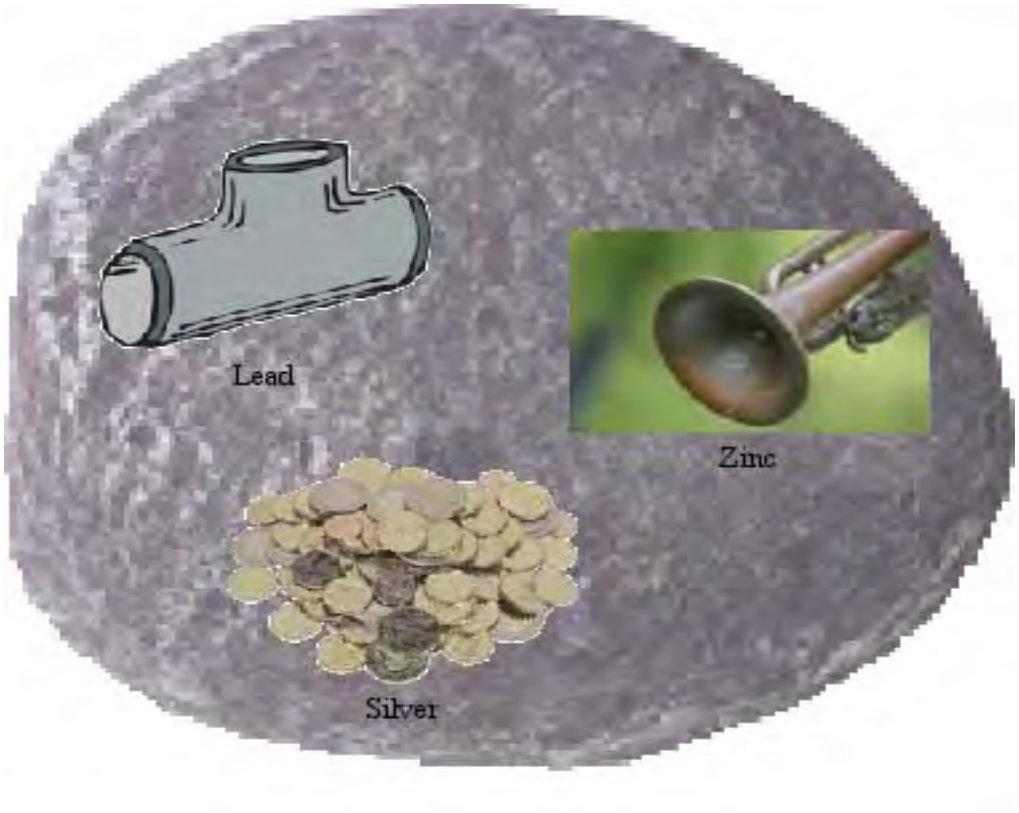
ORE is Whole Rocks

<u>Minas Gerais, Brazil</u> = slate rocks for roof tops

Photo Credit: Maiko Sell

ORE is Rock with Valuable Minerals

Galena Mineral = Lead + Sulfur (PbS) & often traces of Silver (Ag)

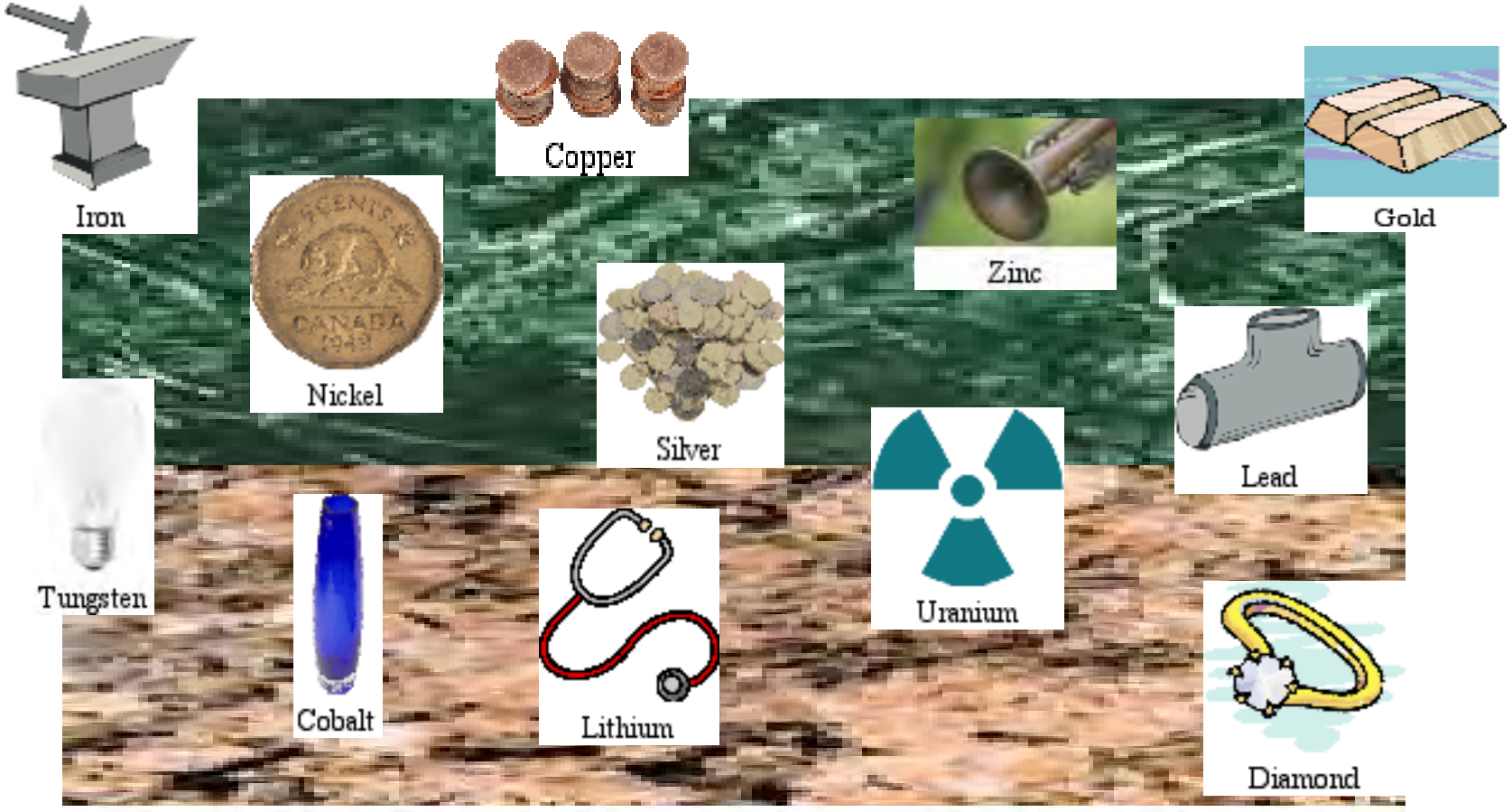


Sphalerite Mineral = Zinc + Sulfur (ZnS)

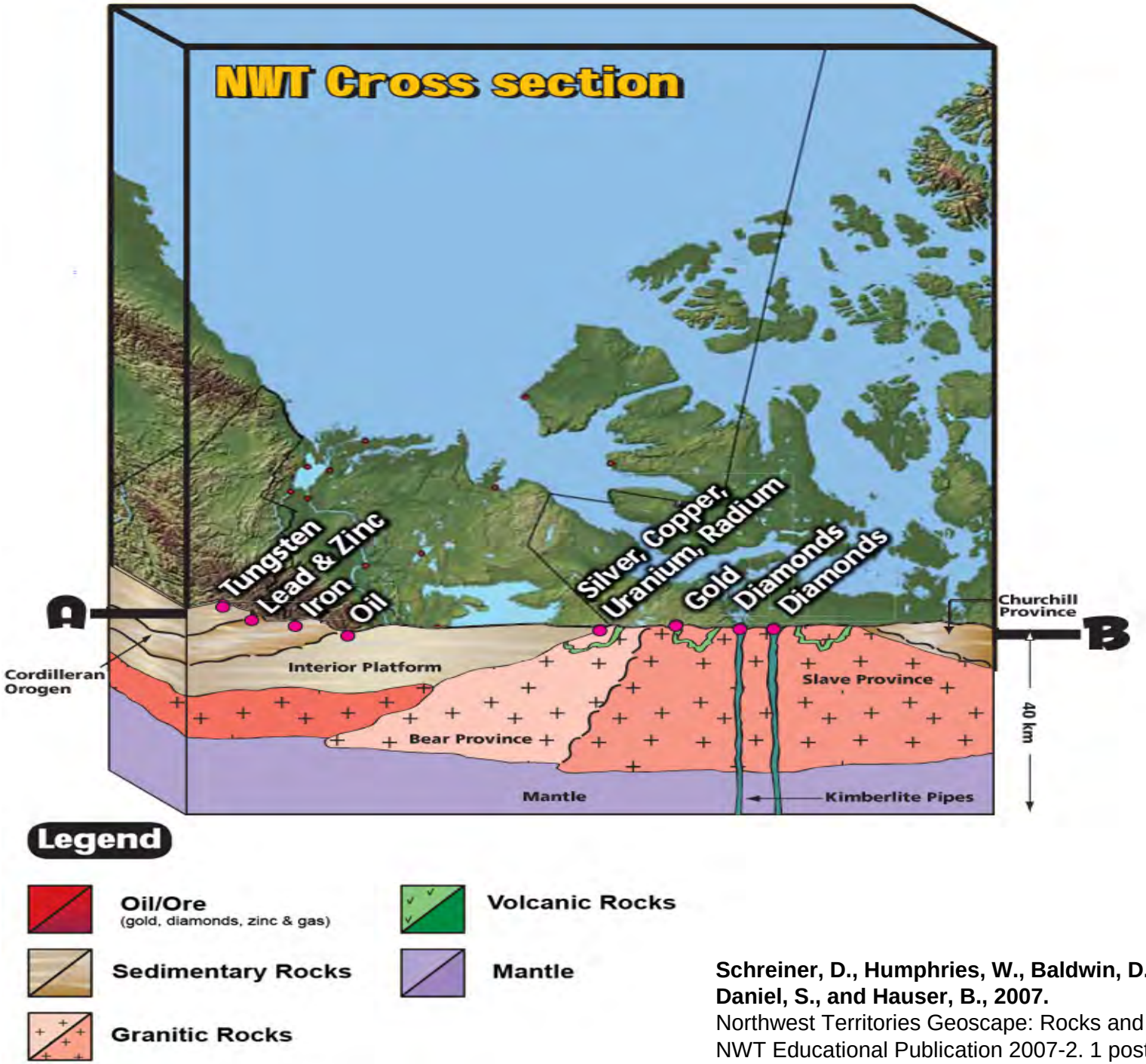
Galena and Sphalerite minerals form under similar conditions

They are often found together

Rocks and Minerals of the Slave Province



NWT ORE



Schreiner, D., Humphries, W., Baldwin, D., Bruce, K., Daniel, S., and Hauser, B., 2007.
Northwest Territories Geoscape: Rocks and Resources; NWT Educational Publication 2007-2. 1 poster.

NWT MINING

Ore Bodies

Exploration

Regulation

Mine Cycle

Exploration

Levels of Exploration

1. **Desktop Study**
2. **Fly Camps**
3. **Preliminary Study**
4. **Advanced Exploration**
5. **Feasibility Study**

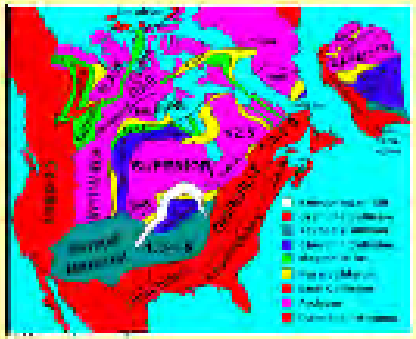
Desktop Study

- Local Geology

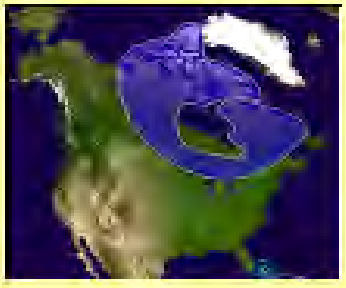
  Rocks & Minerals

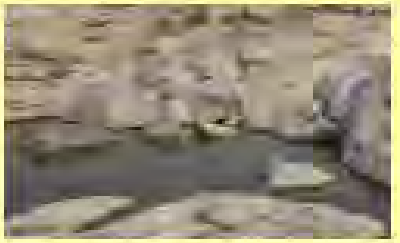
- Local Glaciology

Local Geology



Local Mines



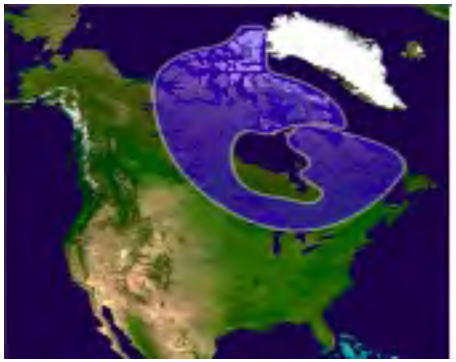


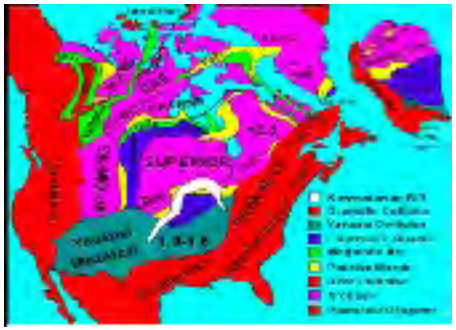
DESKTOP STUDY

Read & Learn

Ice Flow Direction

History of Glaciers





Clues

The Rocks & Minerals

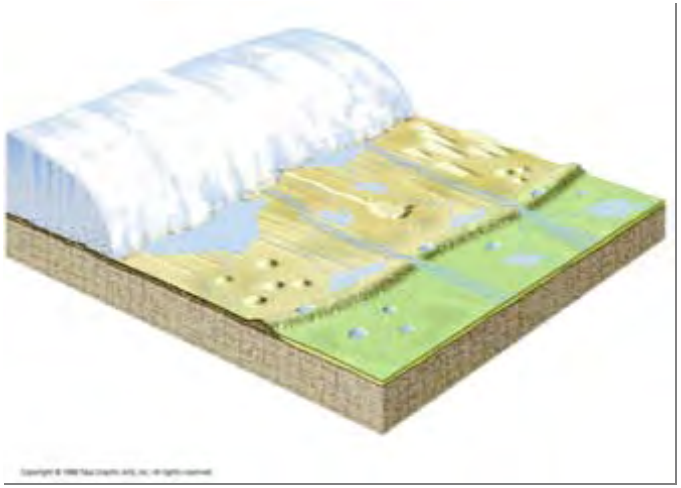
We know the rock types that are in this region

We know the minerals that are typically found in these rock types

Clues

Glacial History

Striation marks and glacial landforms are mapped



Levels of Exploration

1. **Desktop Study**
2. **Fly Camps**

Glacial History

Ice movement: Drift Prospecting

Find the indicators, trace them back to the source

Kimberlite Pipe

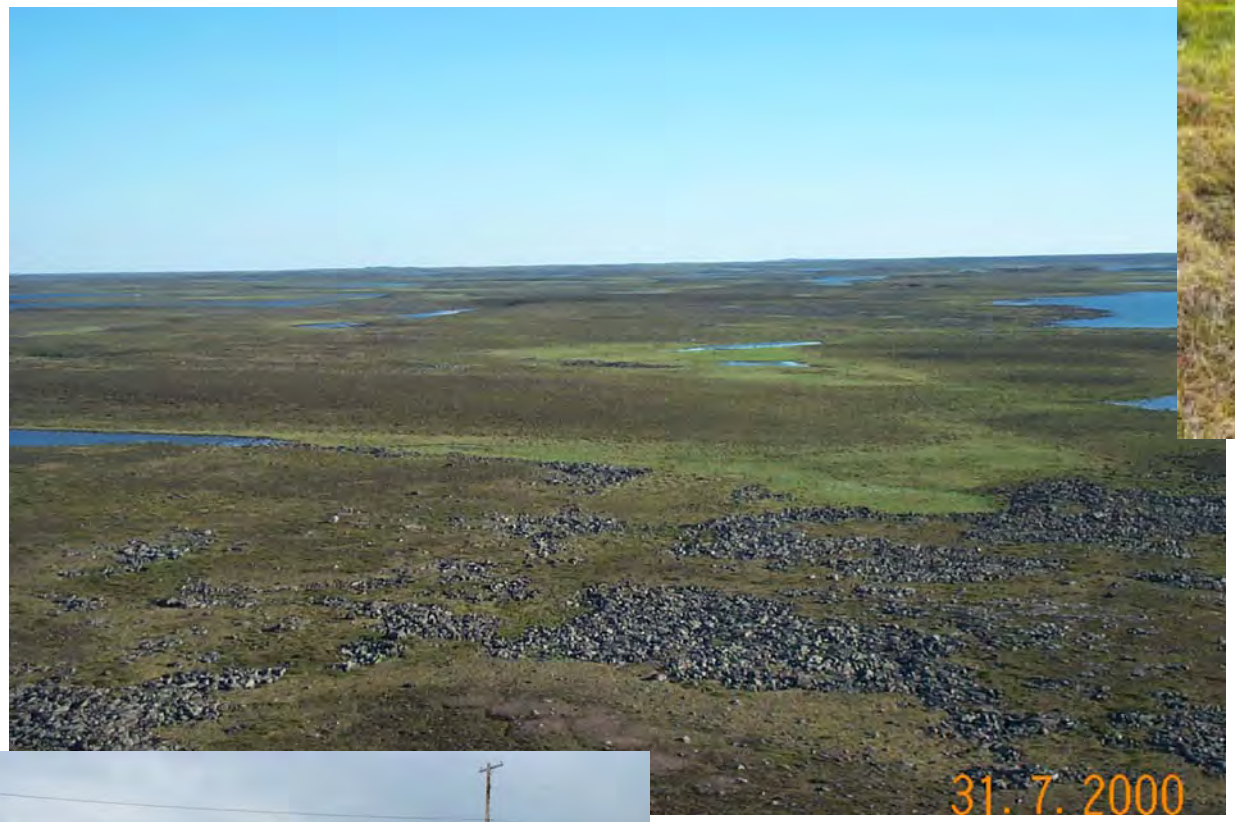
Landscapes

Sampling

Camps

Levels of Exploration

1. **Desktop Study**
2. **Fly Camps**
3. **Preliminary Study**



Frost boils: deep rocks pushed to surface because of freeze-thaw cycles

Till is deposited directly from glaciers. This material has not traveled far.


Photo credit: Maiko Sell

Camps are more permanent, have more people, and operate year round

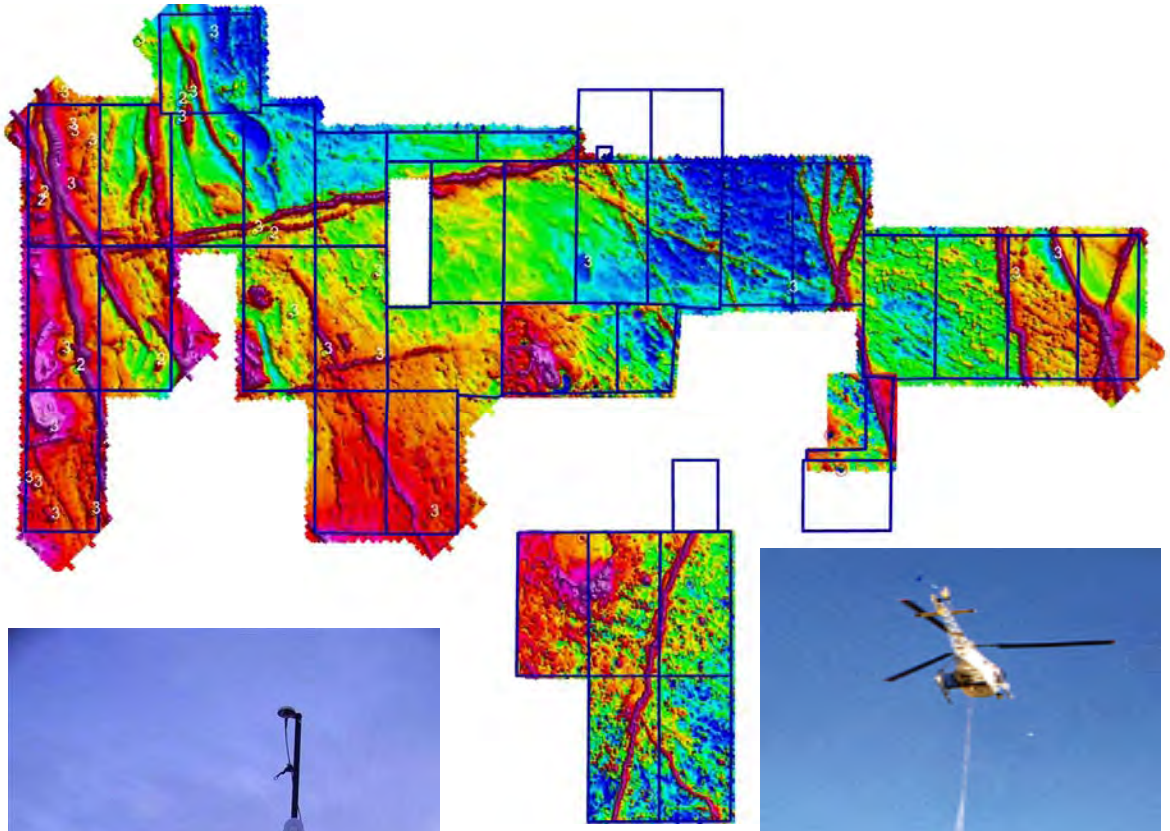


Photo credit: Maiko Sell

Geophysics Surveys

Drill Program

Levels of Exploration

1. **Desktop Study**
2. **Fly Camps**
3. **Preliminary Study**
4. **Advanced Exploration**

Advanced Program

- Larger Camps
- Defined Drill Targets
- Large Drill Samples (1 tonne bags)
- The GRADE of the ore is determined

Diamond GRADE = carats / tonne of rock

1 carat = 200 mg

Examples

0.2 carats per tonne

Large deposit

Fort-a-la-corne, SK

www.saskmining.ca

0.3 carats per tonne

High quality

Victor, ON

attawapiskat.com

North $$ = > 1 carat/tonne

Levels of Exploration

1. **Desktop Study**
2. **Fly Camps**
3. **Preliminary Study**
4. **Advanced Exploration**
5. **Feasibility Study**

Exploration

- Difficult
- Expensive
- Takes Time

We do this…..to get this…..

Diamond Exploration Animation

Mining Snap Lake

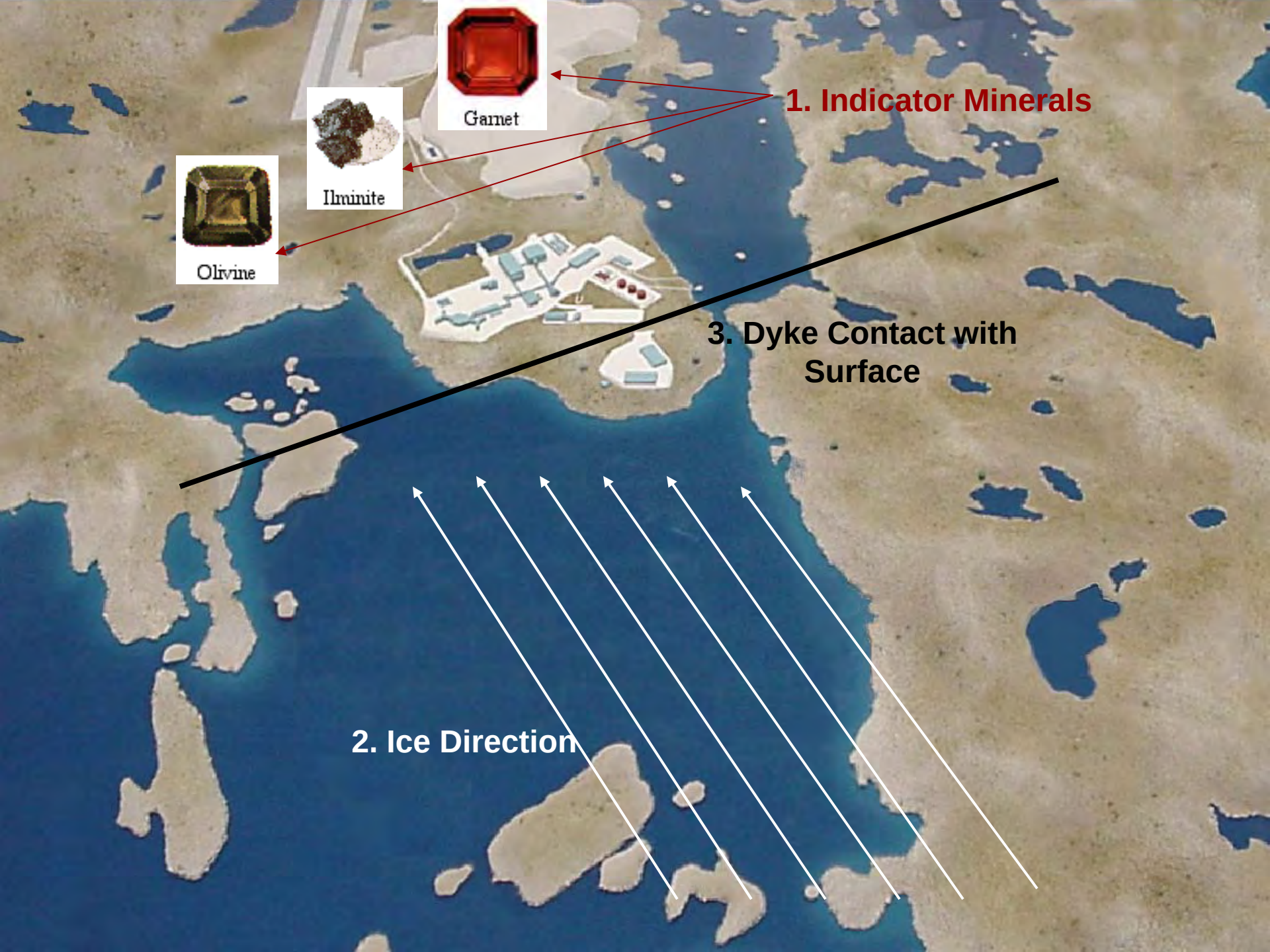
Carter

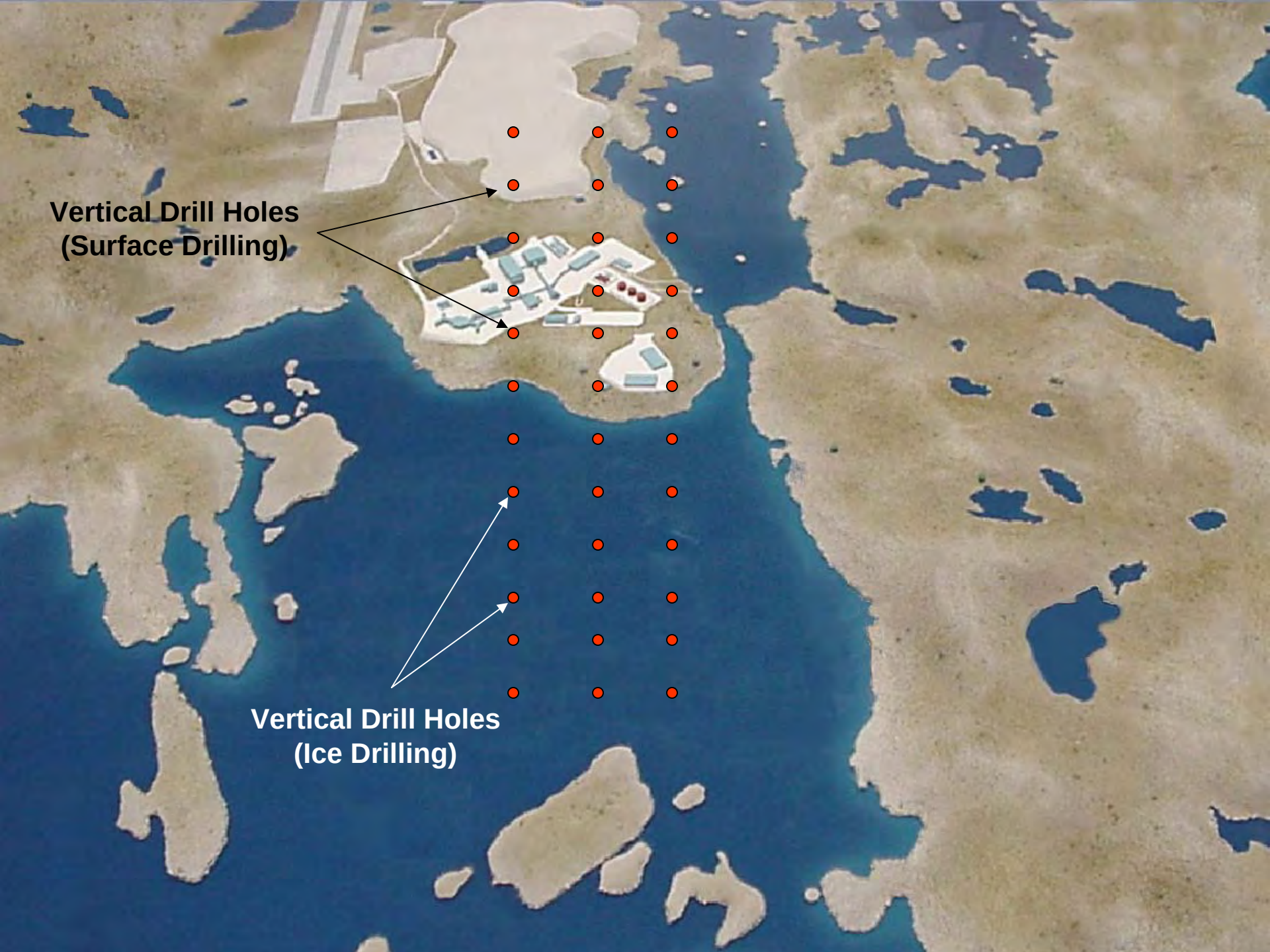
- Exploration
- Ore Body

Exploration

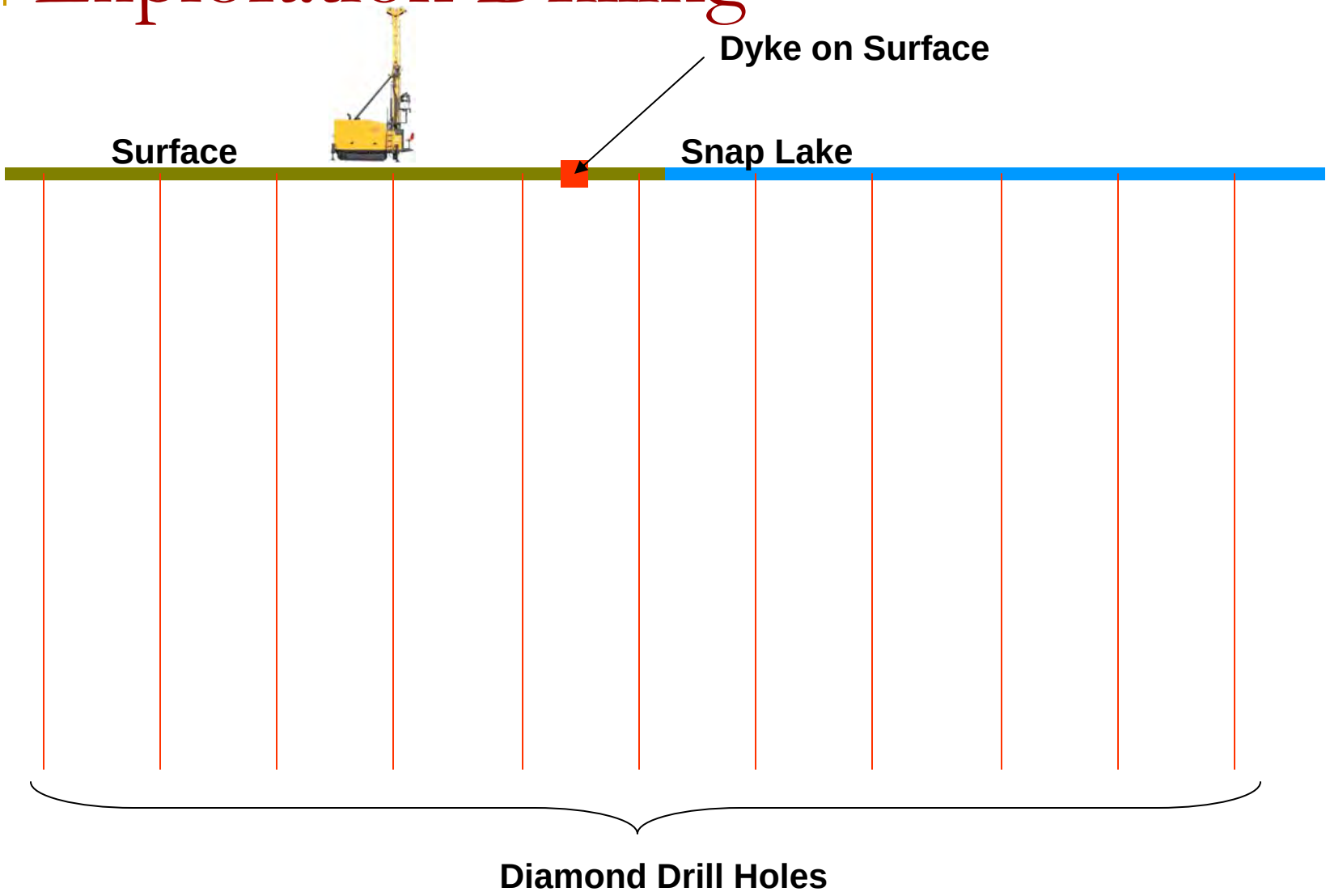
- Exploration began in 1955 by Winspear Resource.
- Winspear discovered the kimberlite diamond deposit in 1997.
- De Beers acquired Winspear in 2000 and determined the size, thickness and depth of the kimberlite deposit.
- Construction started in 2005 and cost 1.1 billion
- Production began in 2008.


North Pile
(Processed Kimberlite)
Air Strip
Mine Site
Snap Lake


Garnet
Ilminite
Olivine
1. Indicator Minerals
3. Dyke Contact with Surface
2. Ice Direction

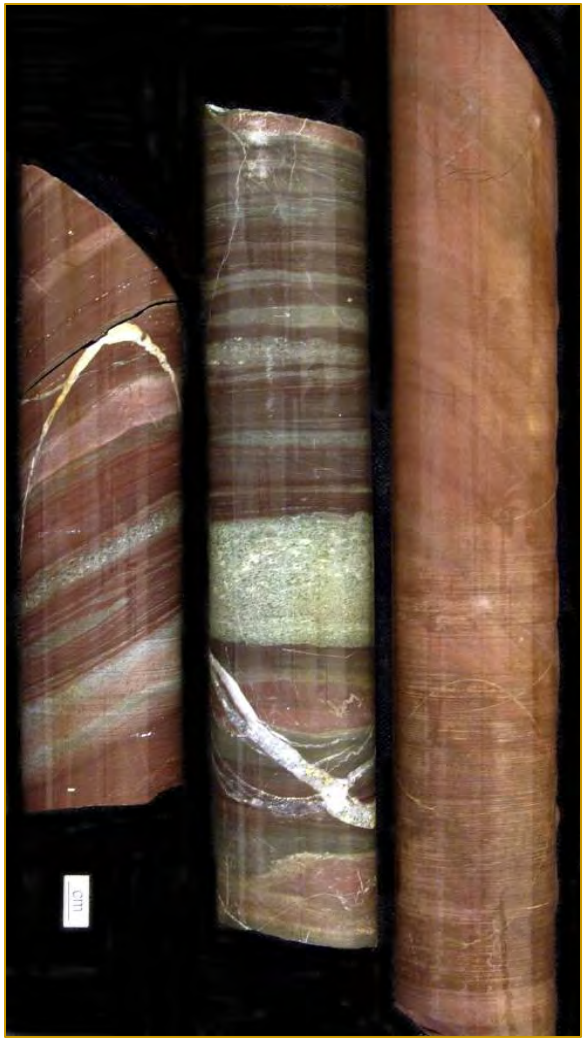

Vertical Drill Holes
(Surface Drilling)
Vertical Drill Holes
(Ice Drilling)

Exploration Drilling

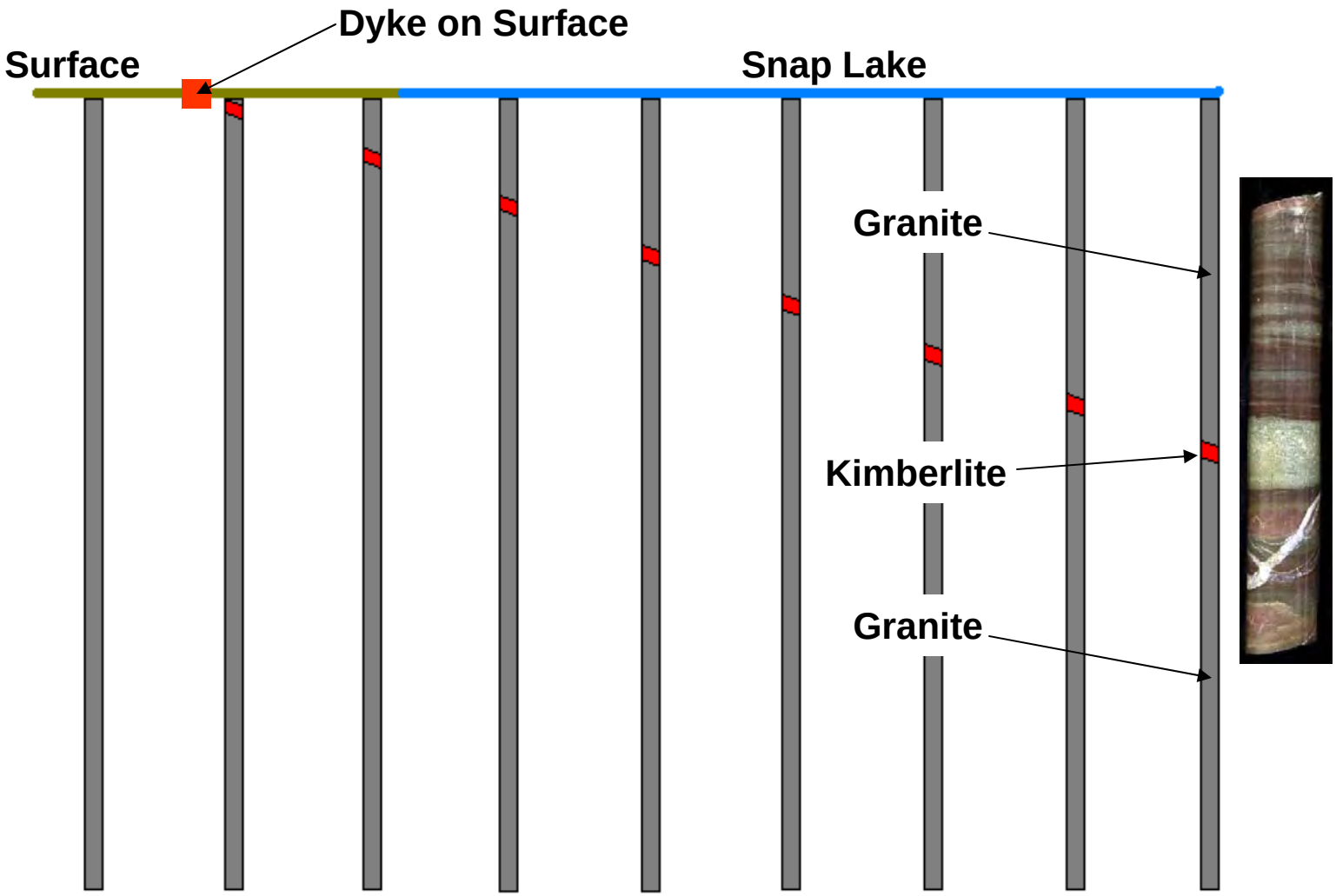


Diamond Drill

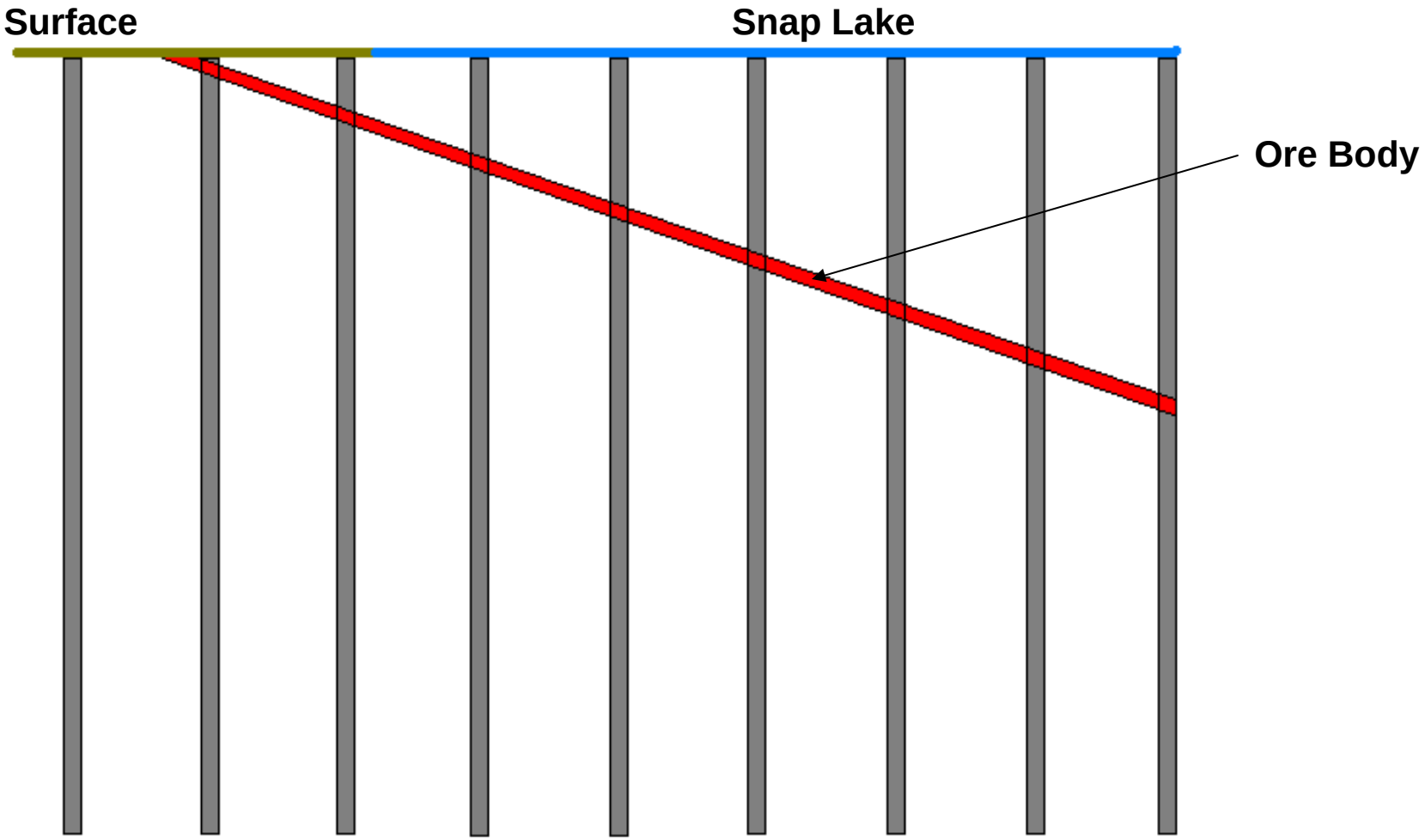
Drill Core Samples



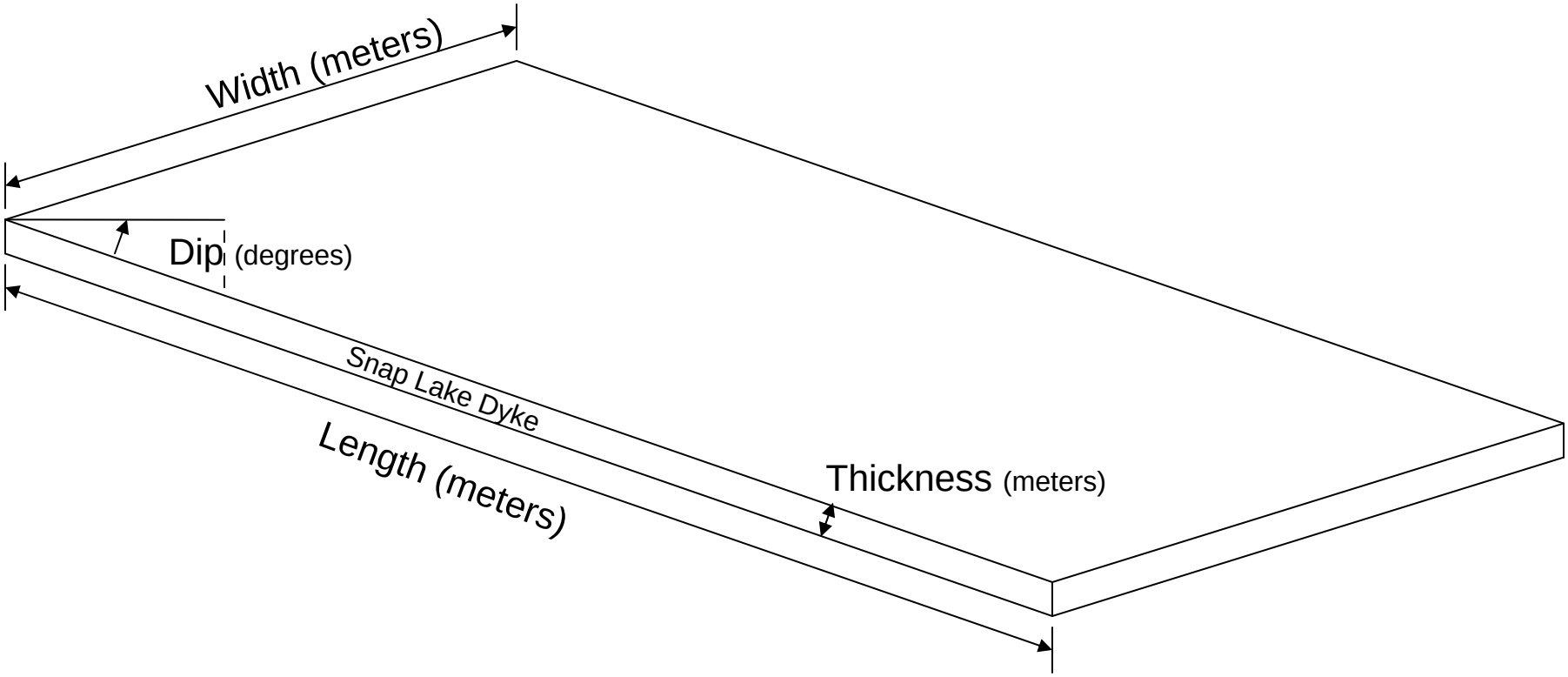
Exploration Drilling



Exploration Drilling



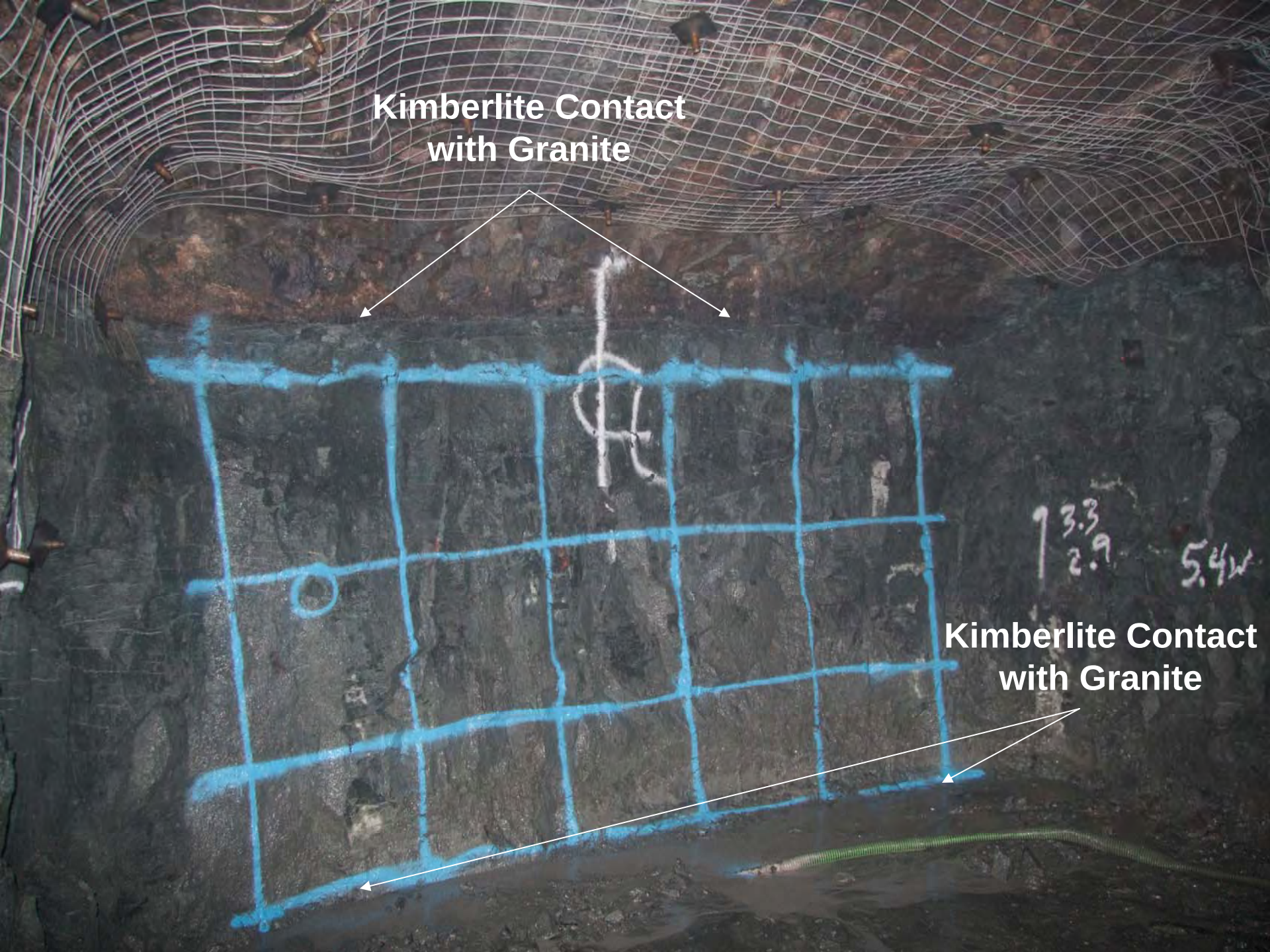
Ore Body Dimensions



Snap Lake Ore Body

- Diamond bearing kimberlite
- 2.5 meters thick on average
- Dipping (slanting) at 13 degrees
- Unknown width and length

Ore Body Animation


Kimberlite Contact
with Granite
Kimberlite Contact
with Granite


Kimberlite Contact
with Granite

Discussion and Questions

End Day 1

Day 2

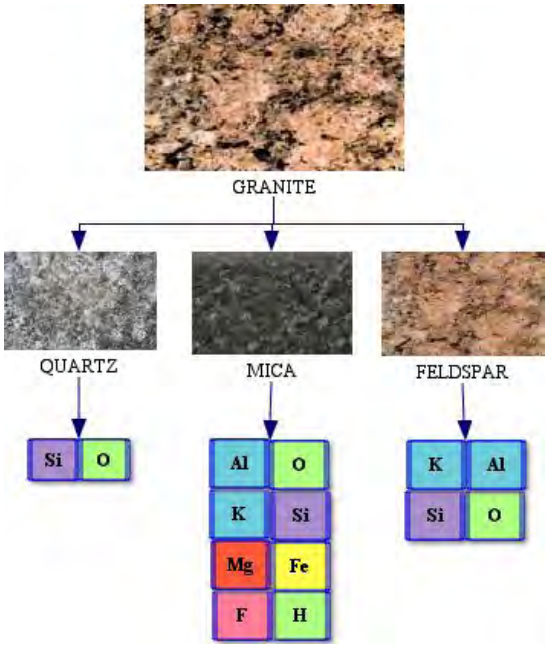
Review

Carter

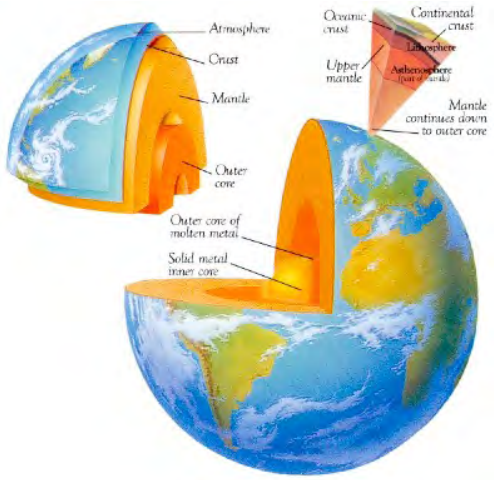
- Summary of Day 1
- Context and Big Picture

Geology - Review

- What Makes Rocks:
  - Rocks – Minerals – Elements



- Earth's Layers:
  - Core
  - Asthenosphere
  - Lithosphere
  - Crust



Geology - Review

- Types of Rocks:
  - Sedimentary
  - Metamorphic
  - Igneous

SEDIMENTARY

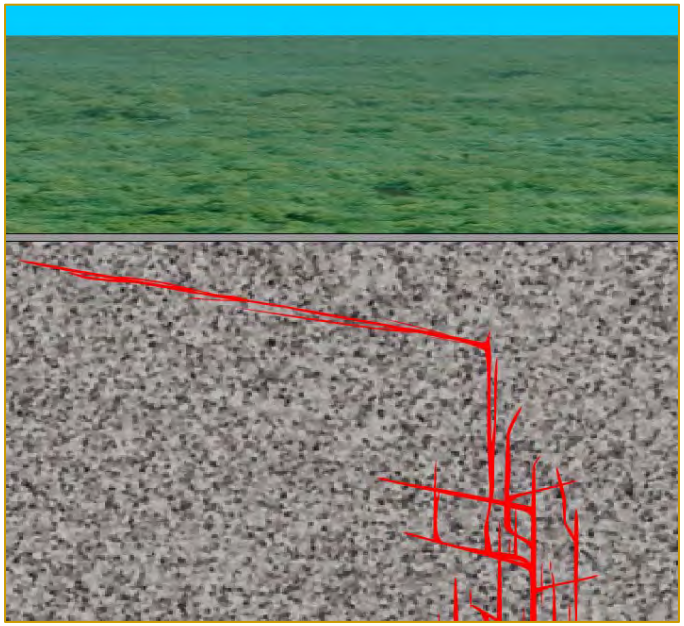
METAMORPHIC

IGNEOUS

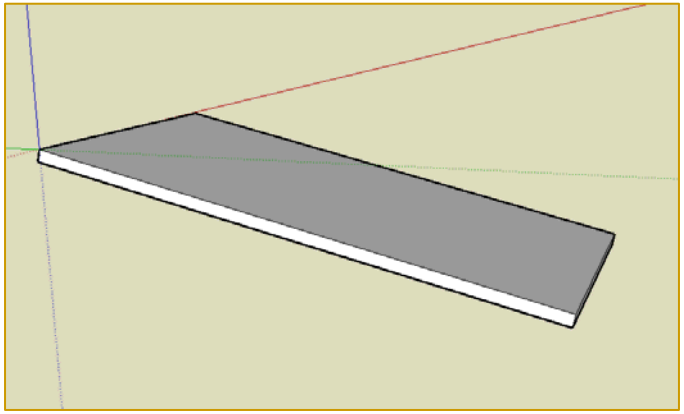
- Glaciers:
  - Have carved the landscape that we see today

Geology - Review

- The Snap Lake ore body was formed by molten Kimberlite moving to surface through cracks in earth's crust

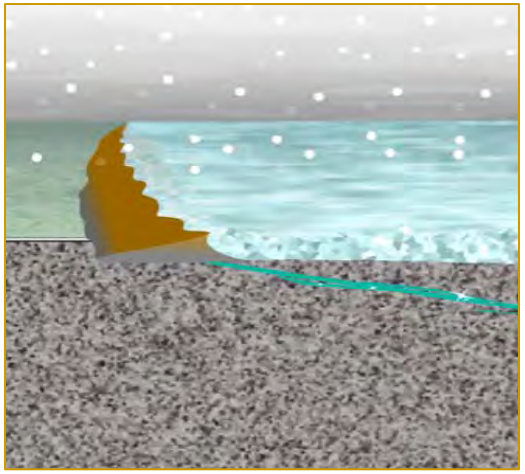


- Dyke – tabular sheet-like igneous intrusion

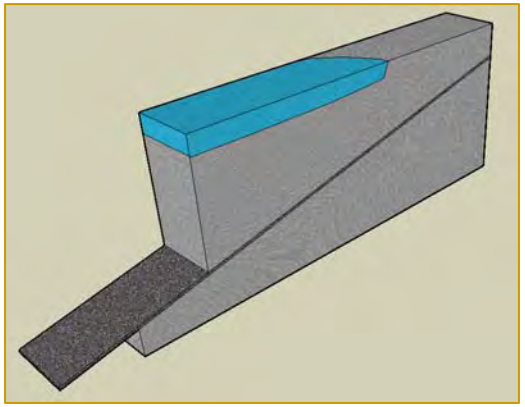


Geology - Review

- The Snap Lake dyke was exposed by glaciers



- The dyke is surrounded by two types of rock:
  - Meta-volcanic
  - Granite



Mining Background…

- Mine Cycle
- Regulation

Ore Bodies

Exploration

NWT MINING

Regulation

Mine Cycle

Mine Cycle

Intro to Technical Mining Terms:

Mining Terms Video

- Jackleg drillers
- Blasters
- Scale the stopes
- Muckers and slushers
- Mucking out
- Blast-holes or holes
- Cages
- Rock bolters

THE MINE CYCLE

Gold ring

Ore Body

How do we go from this..

..to this?

Mining

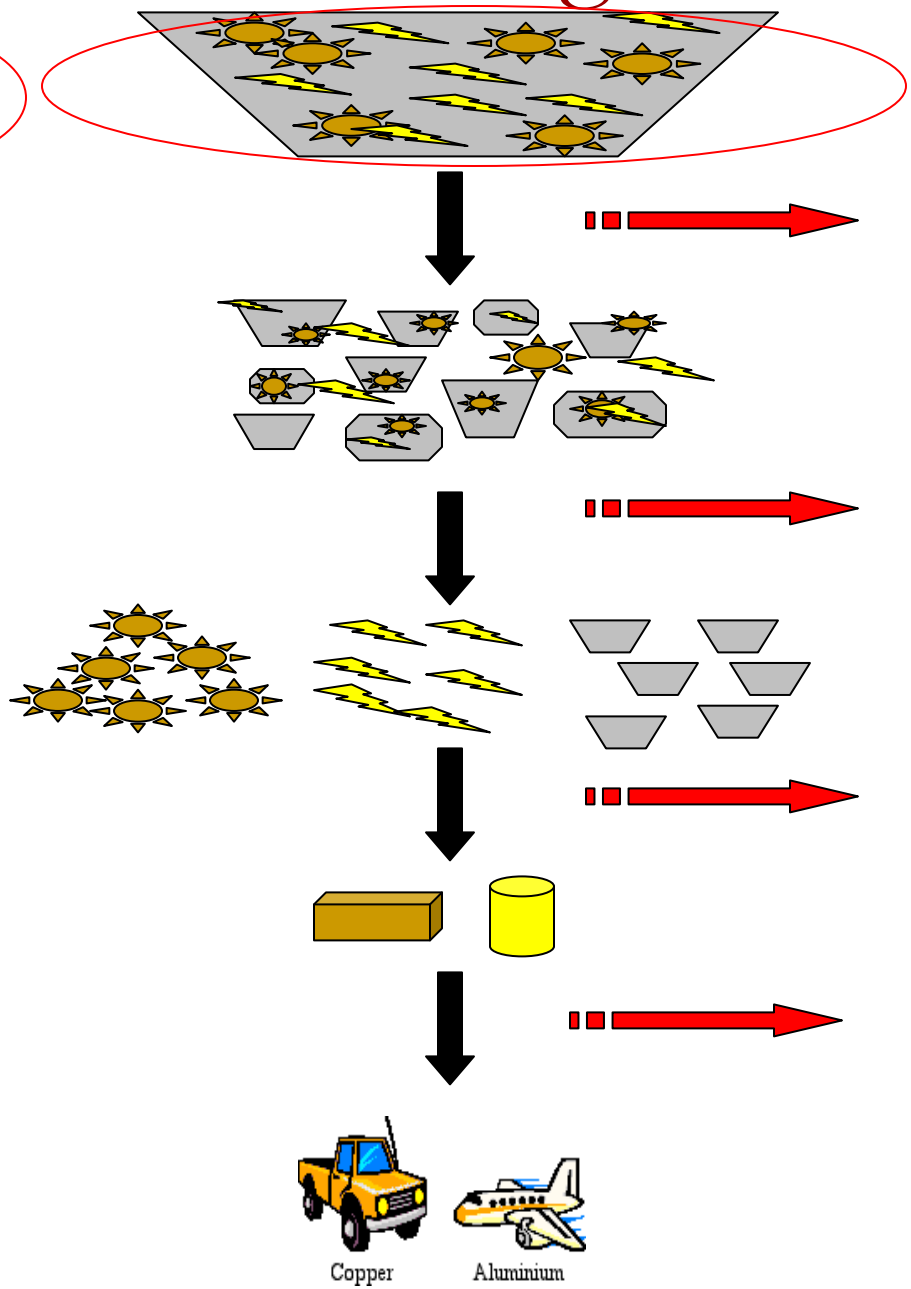
Ore Removal

Crush

Separate

Refine

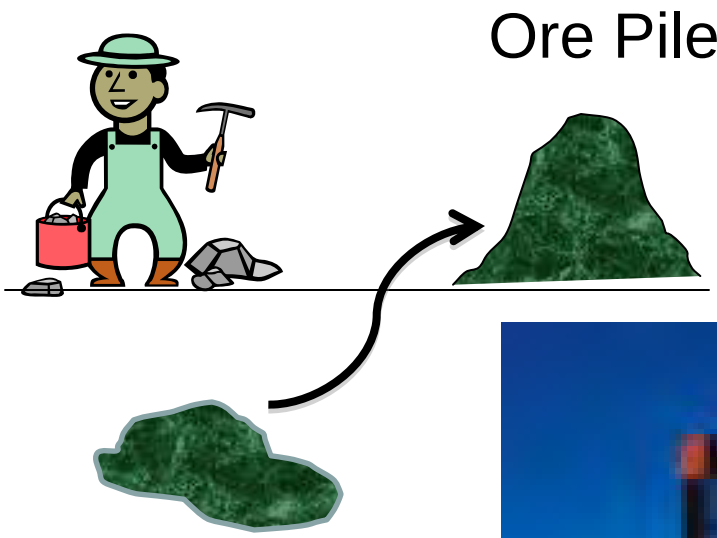
Transform

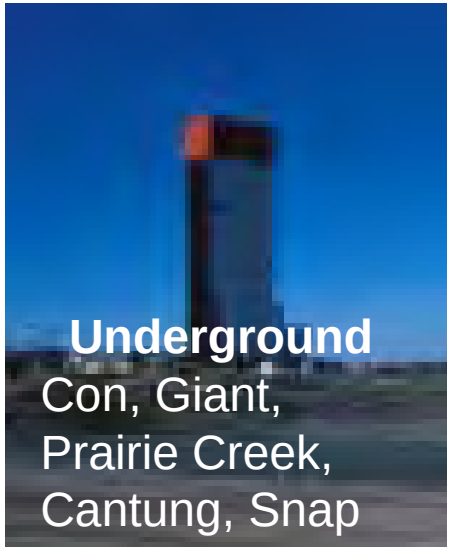


WASTE

- Dust
- Noise
- Ammonia
- Tailings
- Waste Rock
- Metals
- Fuel
- Chemicals
- Buildings
- Equipment
- Garbage
- Waste Water

Step 1 – Ore Removal





Mine Methods Depends On..

- Cost
- Location of ore
- Technology
- Environment
- Safety
- Community & Stakeholder Support

Step 1 – Ore Removal

Drill Blastholes

Step 1 – Ore Removal

Common Terms

- Ammonium
- Dust
- Sediment/small rock fragments
- Waste Rock
- Fuel/exhaust
- Stockpiles
- Runoff water

Step 1 – Ore Removal

Common Terms

Muck	Ore
Mucking	Loading ore into a car
Slushing	Moving ore around
Load Haul Dump (LHD)	Machine that loads and moves ore
Scoops	Same as LHD

Mining

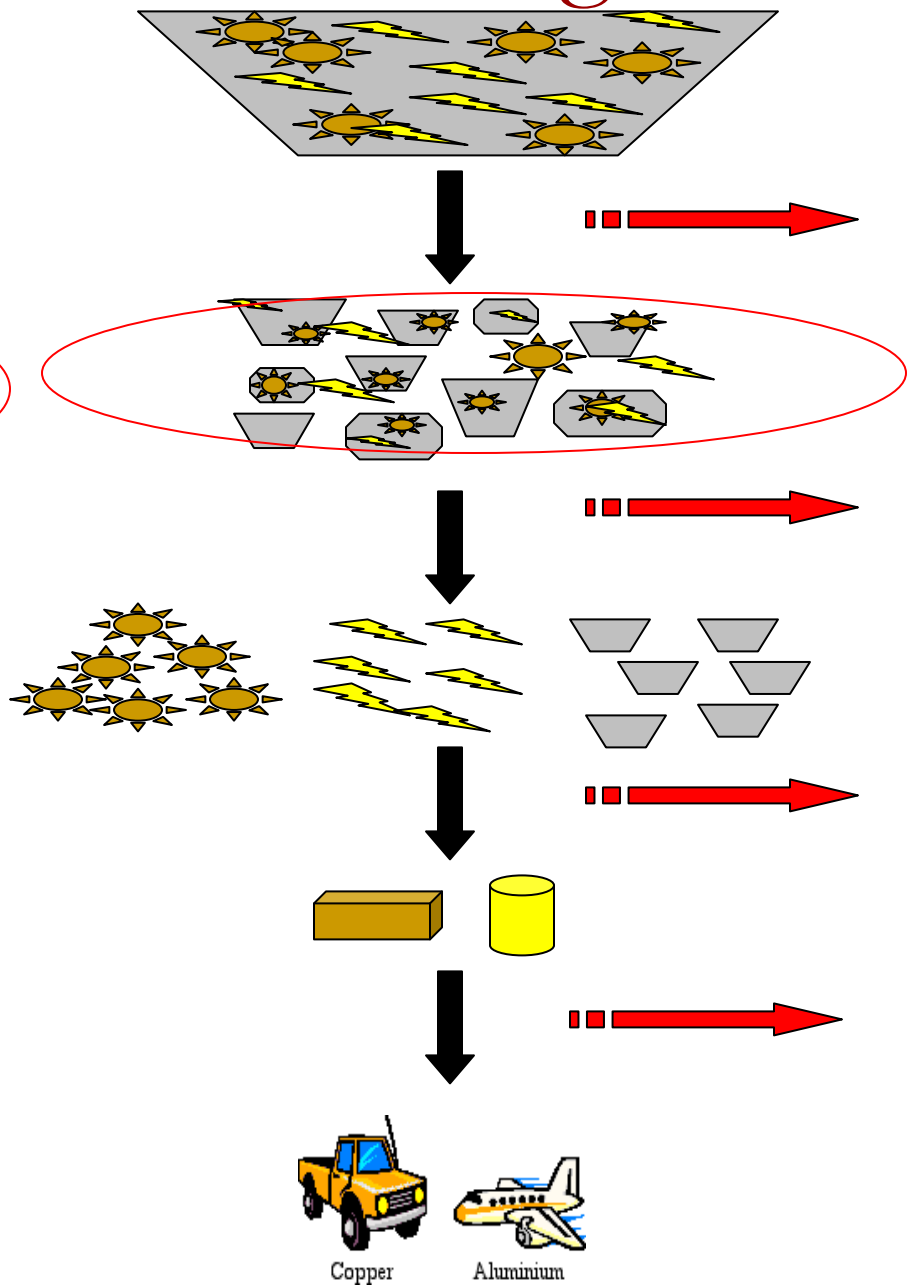
Ore Removal

Crush

Separate

Refine

Transform



WASTE

Dust

Noise

Ammonia

Tailings

Waste Rock

Metals

Fuel

Chemicals

Buildings

Equipment

Garbage

Waste Water

Step 2 - Crushing

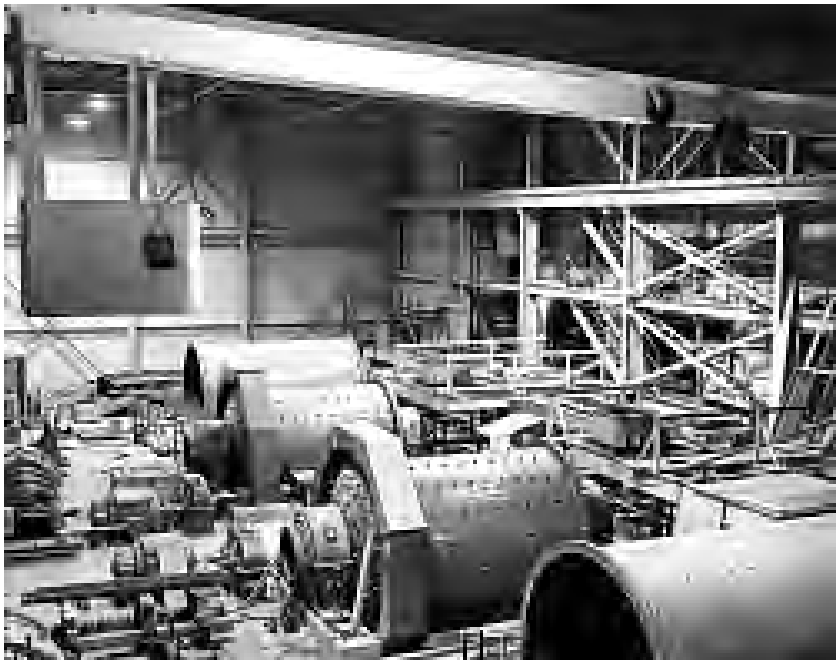
QuickTime™ and a
GIF decompressor
are needed to see this picture.

What waste is created?

- Dust
- Fuel/exhaust
- Chemicals
- Tailings
- Contaminated water
- Buildings/Equipment

Crushing Devices

Crushers at Pine Point



Mining

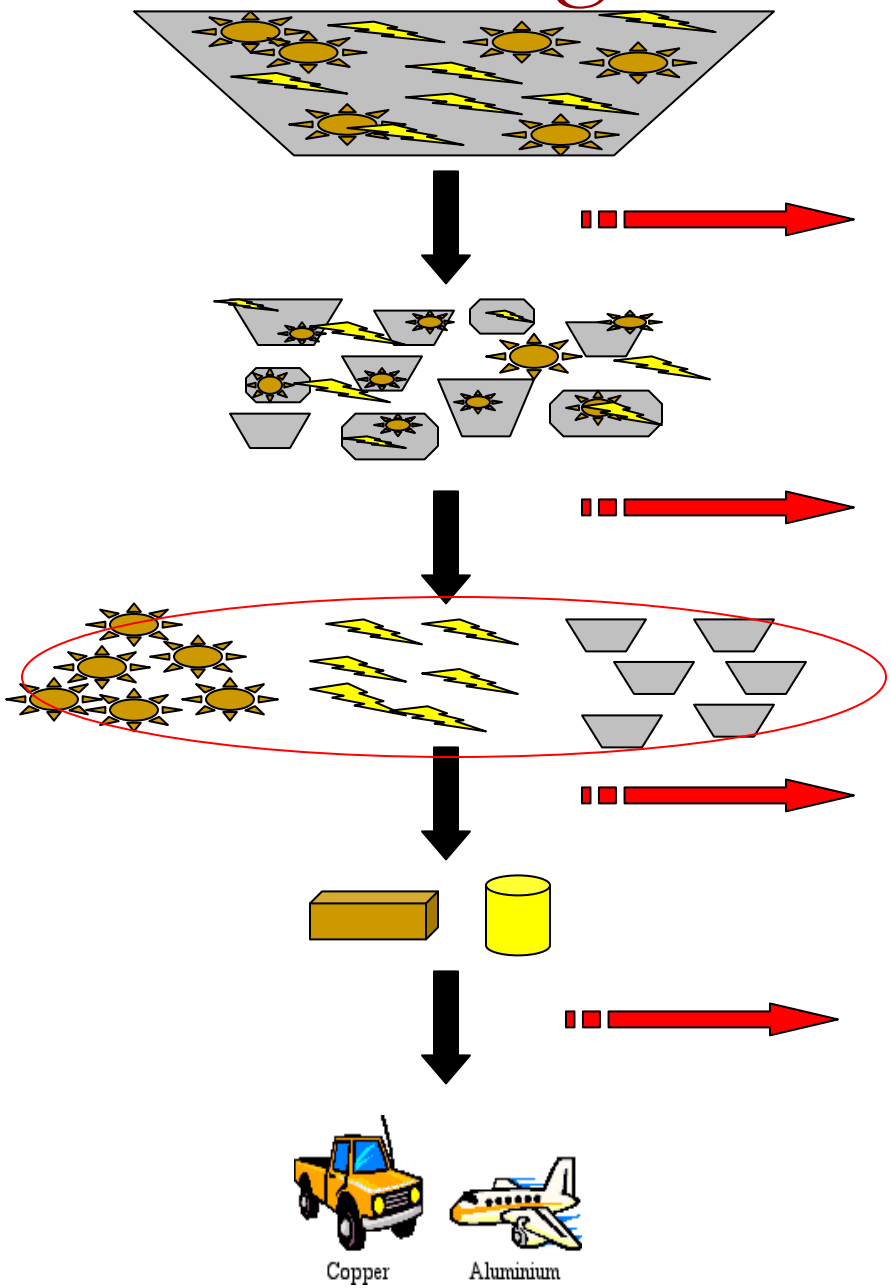
Ore Removal

Crush

Separate

Refine

Transform



WASTE

Dust

Noise

Ammonia

Tailings

Waste Rock

Metals

Fuel

Chemicals

Buildings

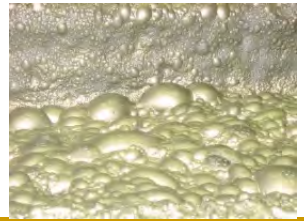
Equipment

Garbage

Waste Water

Step 3 - Separating

Get valuable minerals out of rock



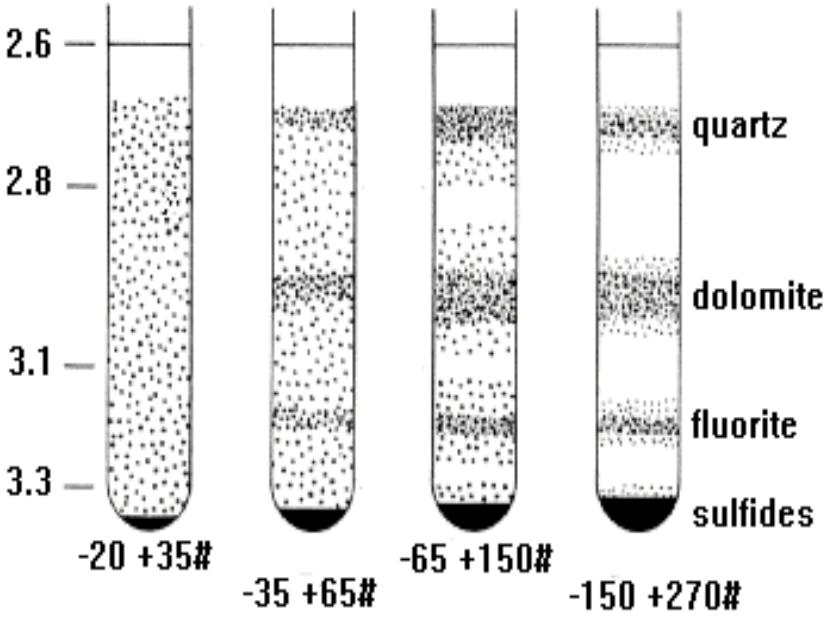
SEPERATION

- We use the properties of the materials to separate the grains
  - Sizing
  - Gravity
  - Magnetic
  - Floatation
  - Electrostatic

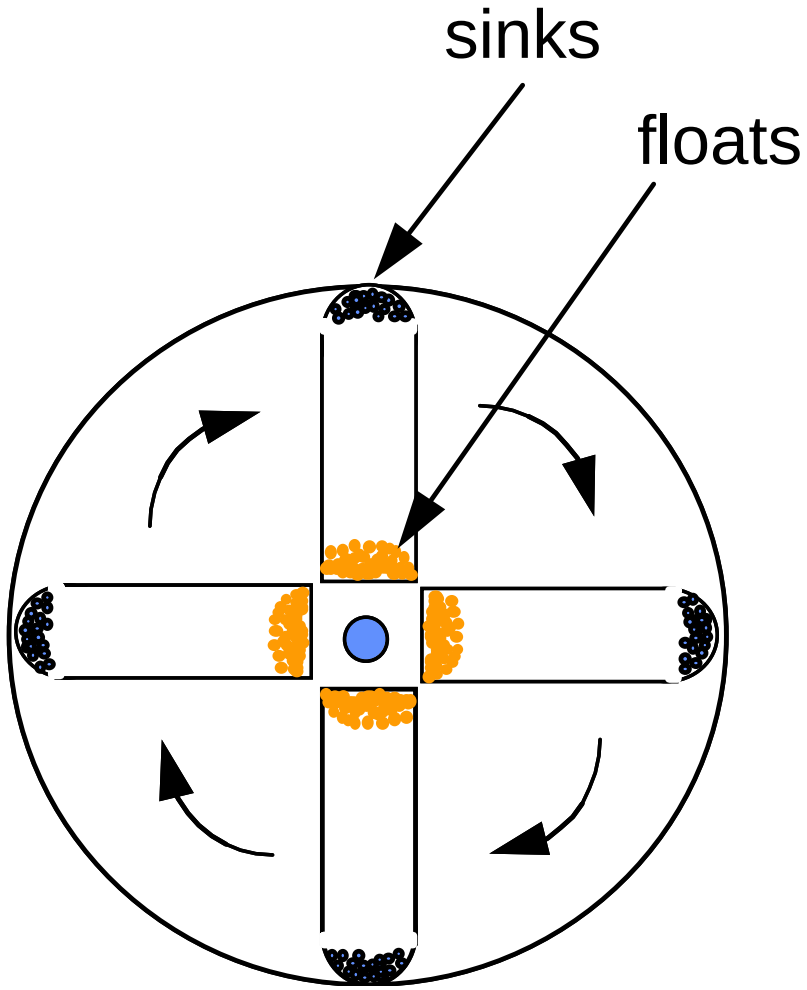
Size Separation

Mining Shaker Table

Gravity Separation



1. Heavy Liquid

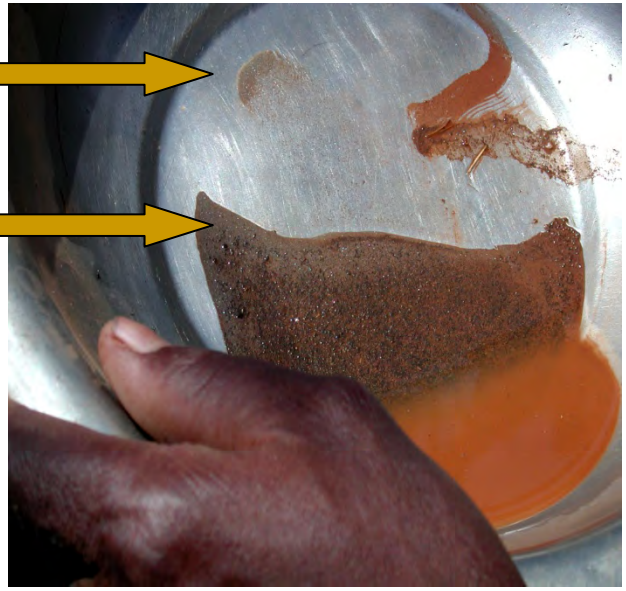


2. Centrifuge

Gravity Separation

Heavy Gold

Light



3. Panning

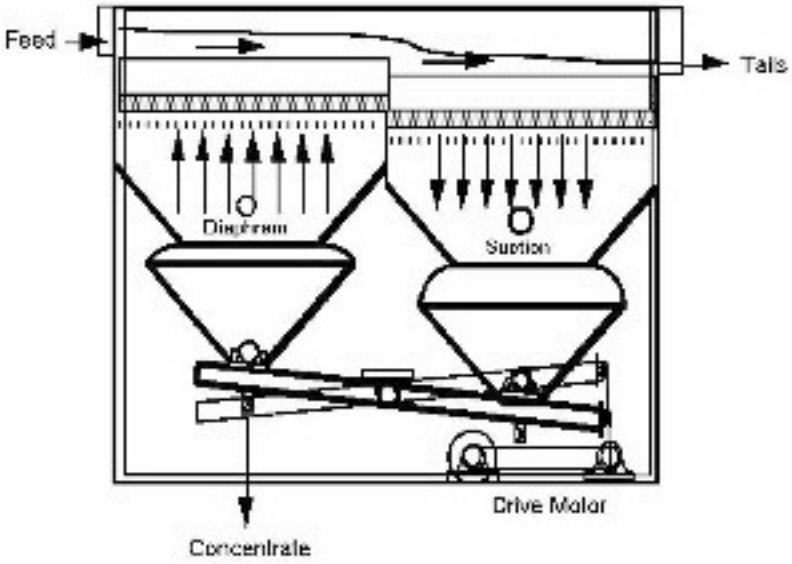
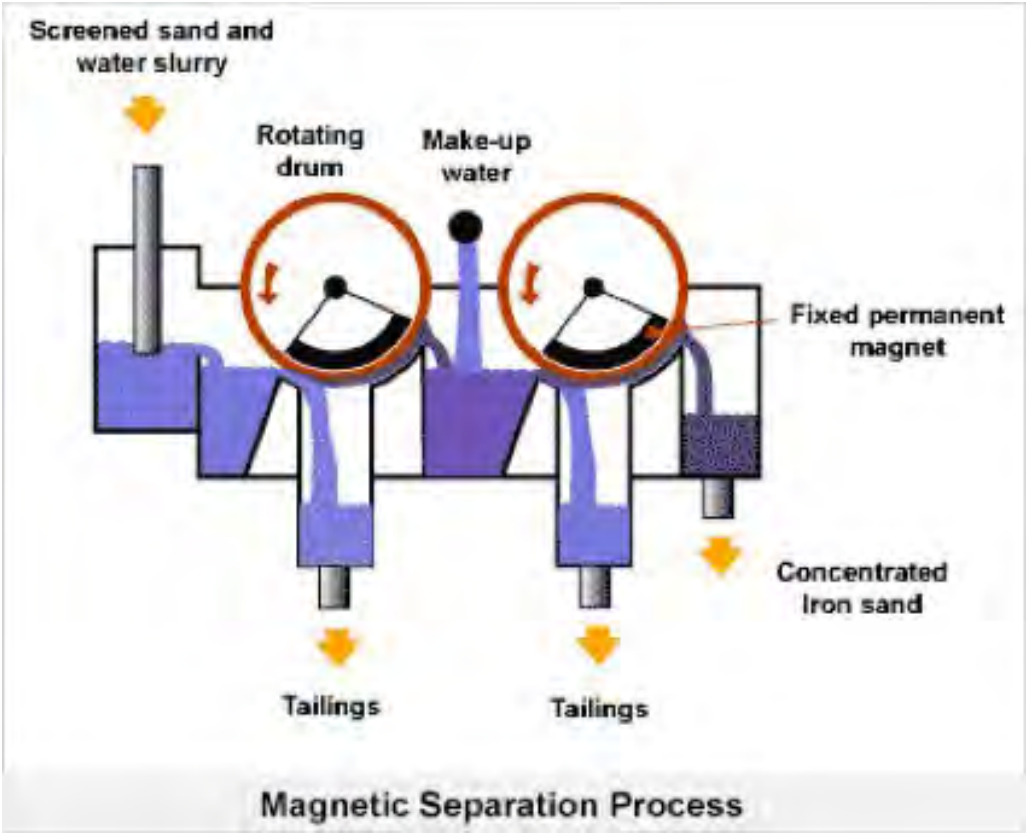


Figure 1. Section of a modern placer jig

4. Jig

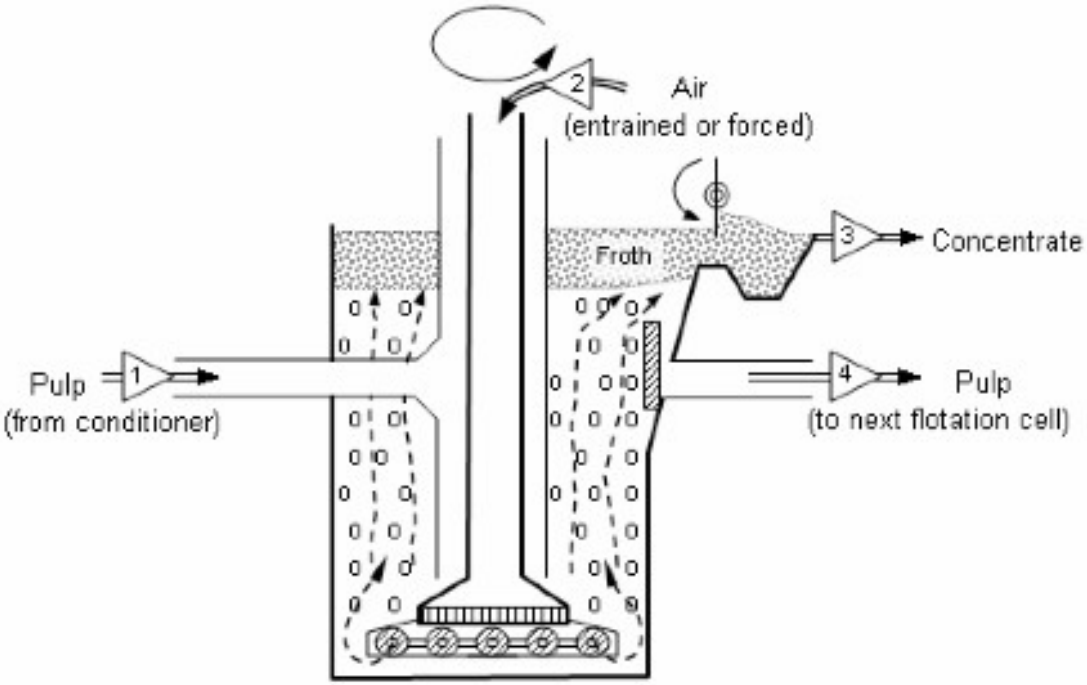
Magnetic Separation

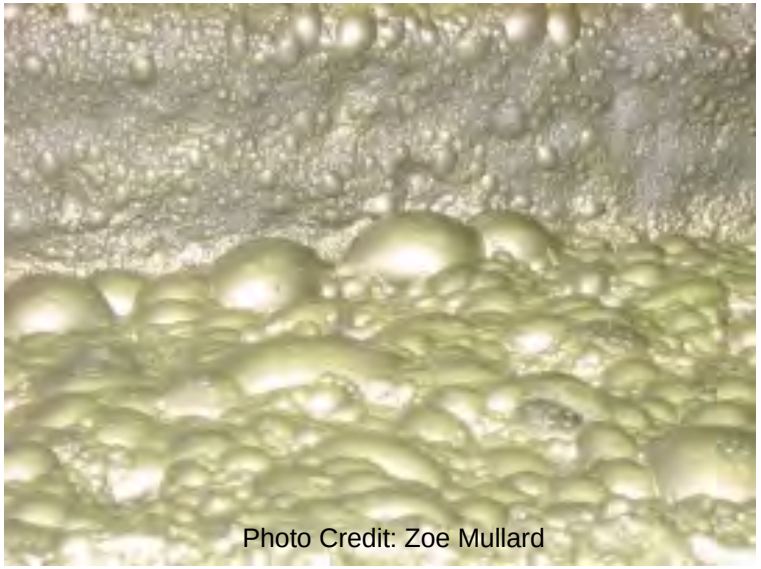


Magnetic Separation Process

Floatation Separation

Floatation Circuit

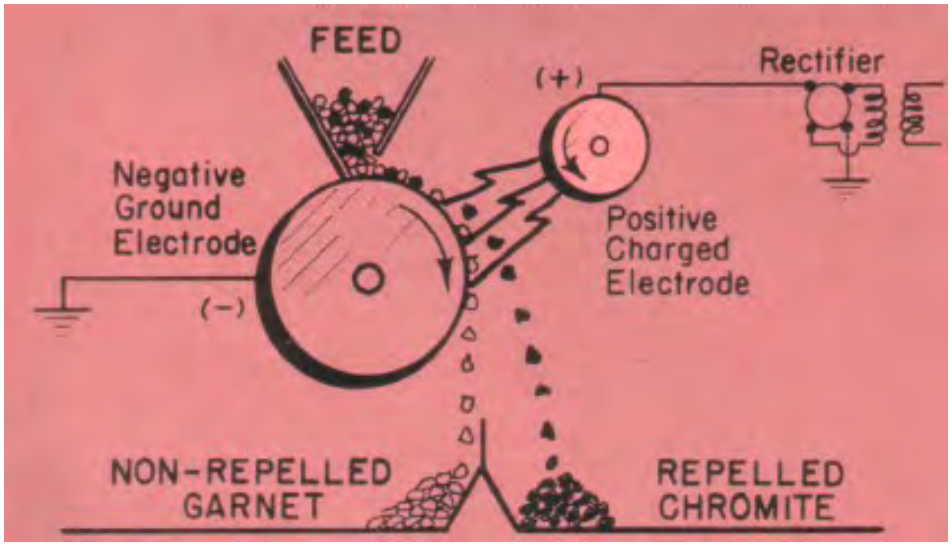




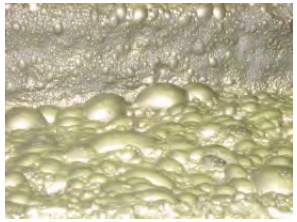
Copper Froth, BC

Electrostatic Separation

- Some grains maintain an electrostatic charge (induced electrically) and are pinned to a charged drum. Grains that are not charged, fall of the drum. Thus, minerals like ilmenite and chromite can be separated.



Mineral Processing:



- Sizing
- Gravity
- Magnetic
- Floatation
- Electrostatic
- Roasting

- Tailings
- Waste Rock
- Fuel
- Equipment
- Buildings
- Chemicals
- Contaminated Water
- Metals

Mining

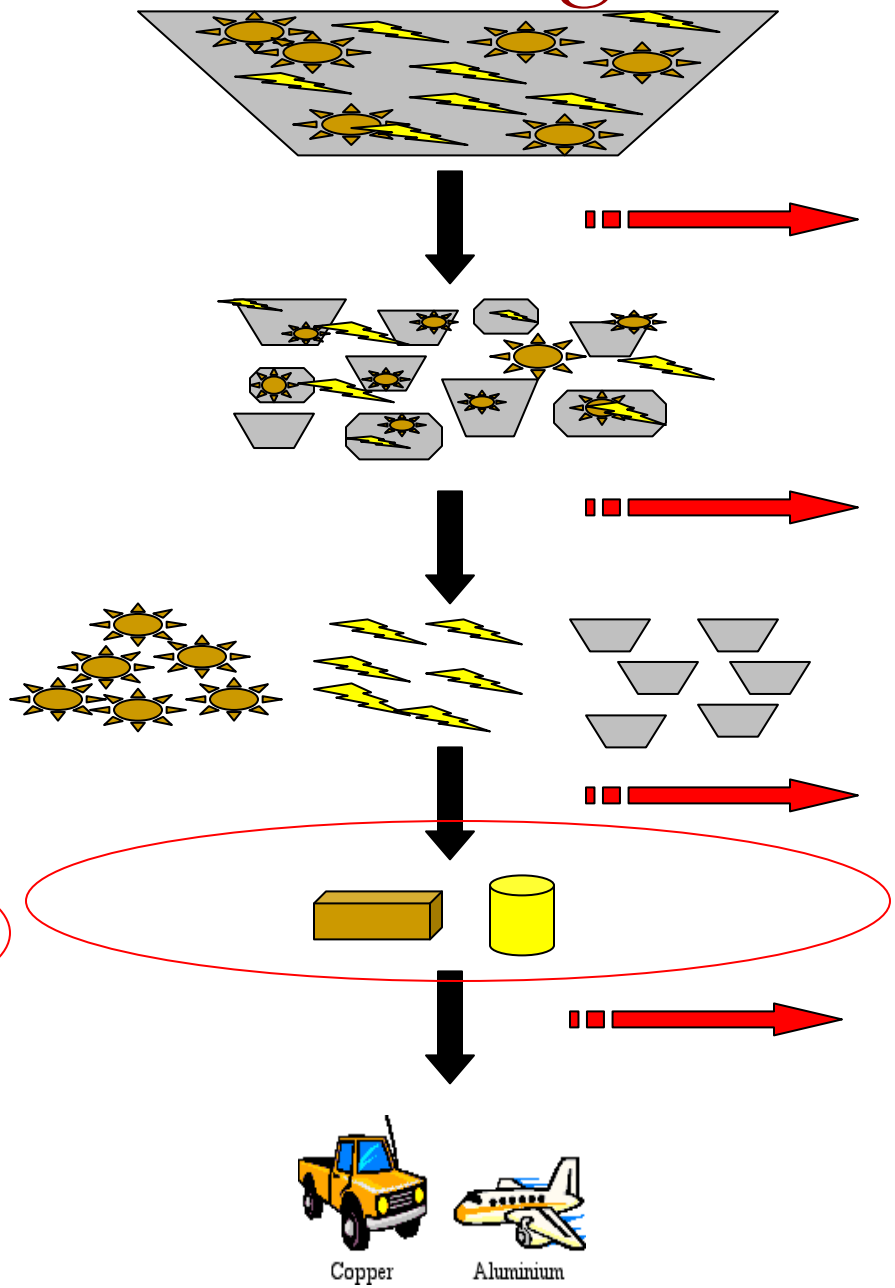
Ore Removal

Crush

Separate

Refine

Transform



WASTE

Dust

Noise

Ammonia

Tailings

Waste Rock

Metals

Fuel

Chemicals

Buildings

Equipment

Garbage

Waste Water

Steps 4 – Refining

-Add heat

-Add chemicals

-Increase pressure

How do miners purify metals?

Step 4 - Refining

Sometimes refining is not needed..

- Coal - it is ready to sell once separated
- Diamonds at De Beers, BHP and Diavik – diamonds only need to be separated before being cut (separation is by crushing, gravity, and x-rays)

Step 4 – Refining

- Remove impurities
- Some refining may happen on site, but usually, mines ship their “concentrate” (concentrated ore) to specialized refining/smelting operators

Mining

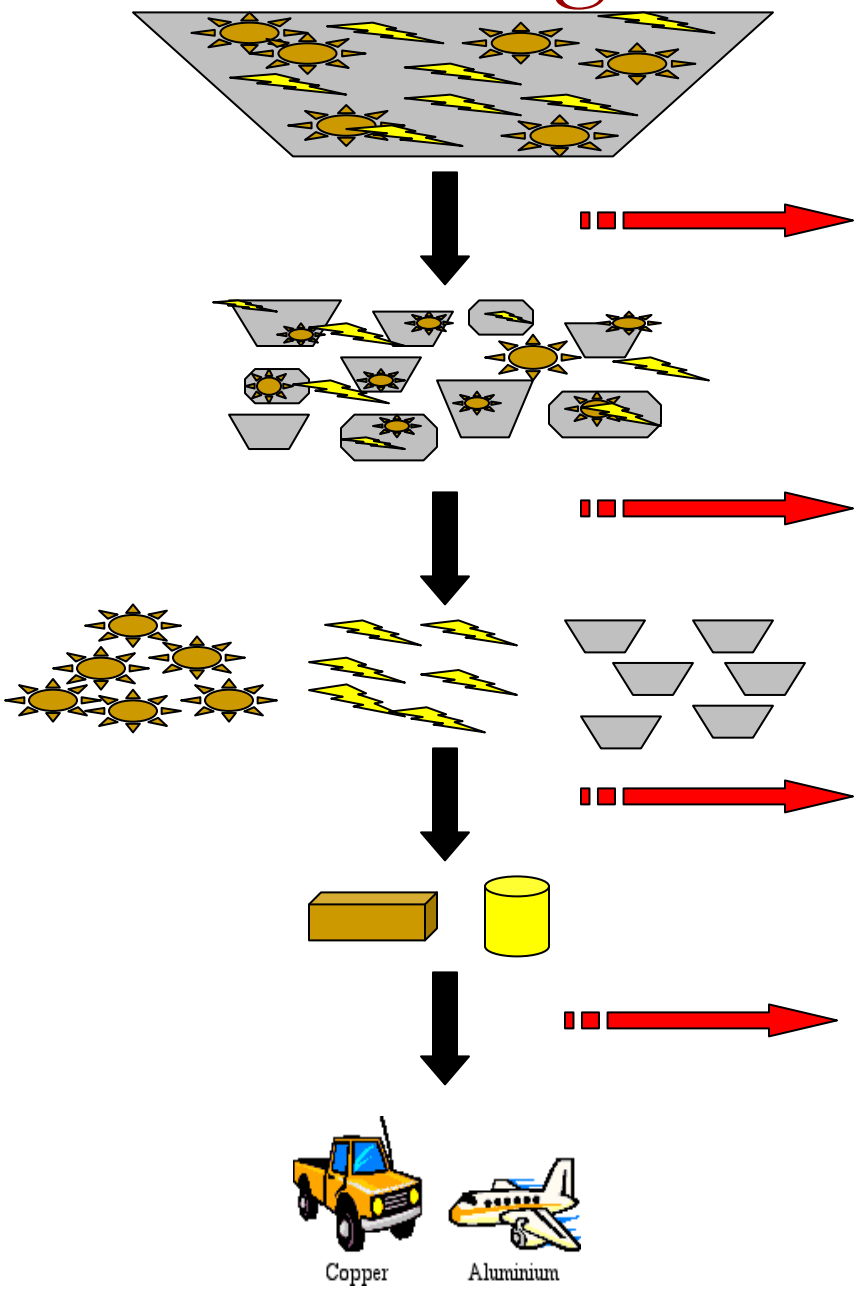
Ore Removal

Crush

Separate

Refine

Transform



WASTE

Dust

Noise

Ammonia

Tailings

Waste Rock

Metals

Fuel

Chemicals

Buildings

Equipment

Garbage

Waste Water

WASTE

Contaminated Water

Effluent

Blasting

Garbage

Electrical Wires

Equipment/Buildings

- Naturally Occurring
- Brought On-Site
- Mining Effects

- Dust & Noise
- Ammonia & Fuel
- Tailings & Waste Rock
- Metals & Chemicals
- Buildings & Equipment
- Garbage
- Waste Water

Waste: Mine Components

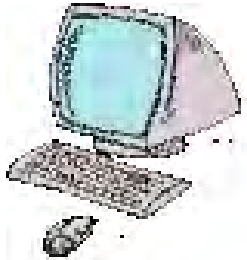
- Underground
- Open Pit
- Waste Rock & Overburden
- Tailings
- Buildings & Equipment
- Infrastructure
- Landfills/Waste Disposal Sites
- Water Management Systems

Ekati, Google Earth

Mining Products

Diamond

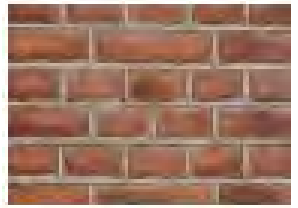
Emerald



Zinc

Cobalt

Gravel



Limestone

Coal

Steel

Copper

Aluminium

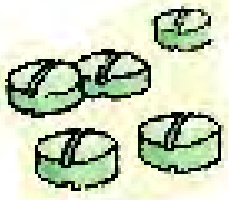
Barite

Quartz

Calcite

Apatite

Carbonate



Kaolinite

Regulation

Ore Bodies

Exploration

NWT MINING

Mine Cycle

REGULATION

Triggers

- Camps, fuel, explosives, heavy equipment, stream crossings or diversions and trails → LUP
- Water usage and waste deposition→ WL

Fortune Minerals, Road

Peregrine Diamonds, Fuel

Camps & Permitting

- Fuel storage
- Waste management

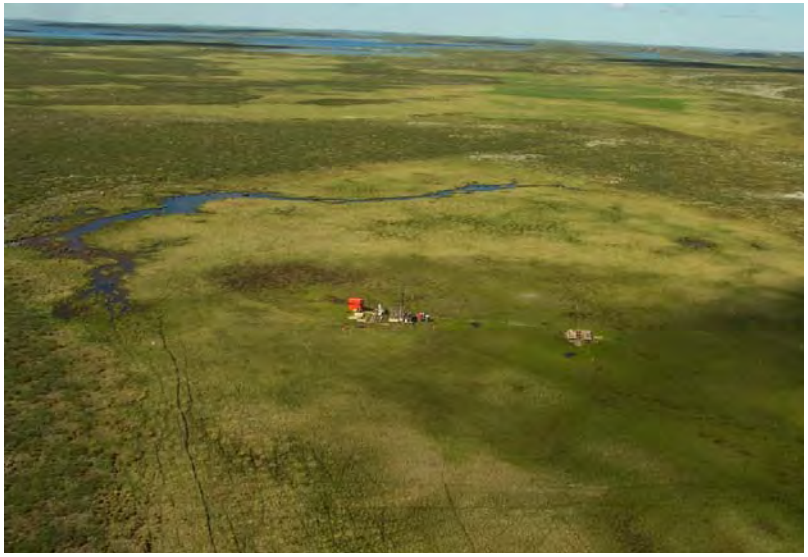
Advanced Exploration Camps

Additional permitting concerns:

- Water use
- Site selection
- Roads & Trails

Drilling & Permitting

- Site selection
- Fuel storage
- Waste management



Land Use Permit

TYPE B

- Camps – 200-400 person days
- Fuel – 4000-80,000 L (single container 2000-4000 L)
- Trails – >1.5 m wide, <4 ha area (4 km long)
- Heavy Equipment – 5-10 t
- Drilling – 0.5-2.5 t
- Explosives – <150 kg/month

LUP Conditions (Example)

Management Plans & Best Practices

- Incinerate or remove combustible waste petroleum products
- Recirculating drill if close to high water mark
- Notify inspector of drill locations prior to drilling
- Non-toxic drill waste to a sump
- Toxic drill waste off-site
- All drill waste removed from ice surface
- Spill contingency plan

Water License

REQUIRED IF:

- Water Use – greater than 100 m^3 per day
- Waste Disposal – directly into water
- Stream Crossings – greater than 5 m wide
- Stream diversions – greater than 2 m wide
- Others… depending on activity (mining, power, municipal, industrial, other)

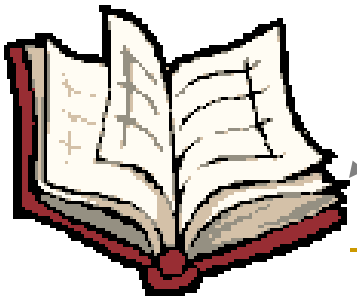
Water License Conditions (Example)

- Effluent quality criteria
- Water sampling requirements (e.g. AEMP)
- Management Plans (eg. Closure & Reclamation Plan)
- Best practices and adaptive management

NWT MINING

Ore Bodies

Exploration



Regulation

Mine Cycle

CAN YOU…

- Give examples of typical ORE found in the NWT?
- Describe the various levels and techniques associated with mineral exploration?
- Describe the basic mine cycle and mining techniques?
- List some products from mining?
- Describe the basic regulatory framework for mining in the NWT?

Break

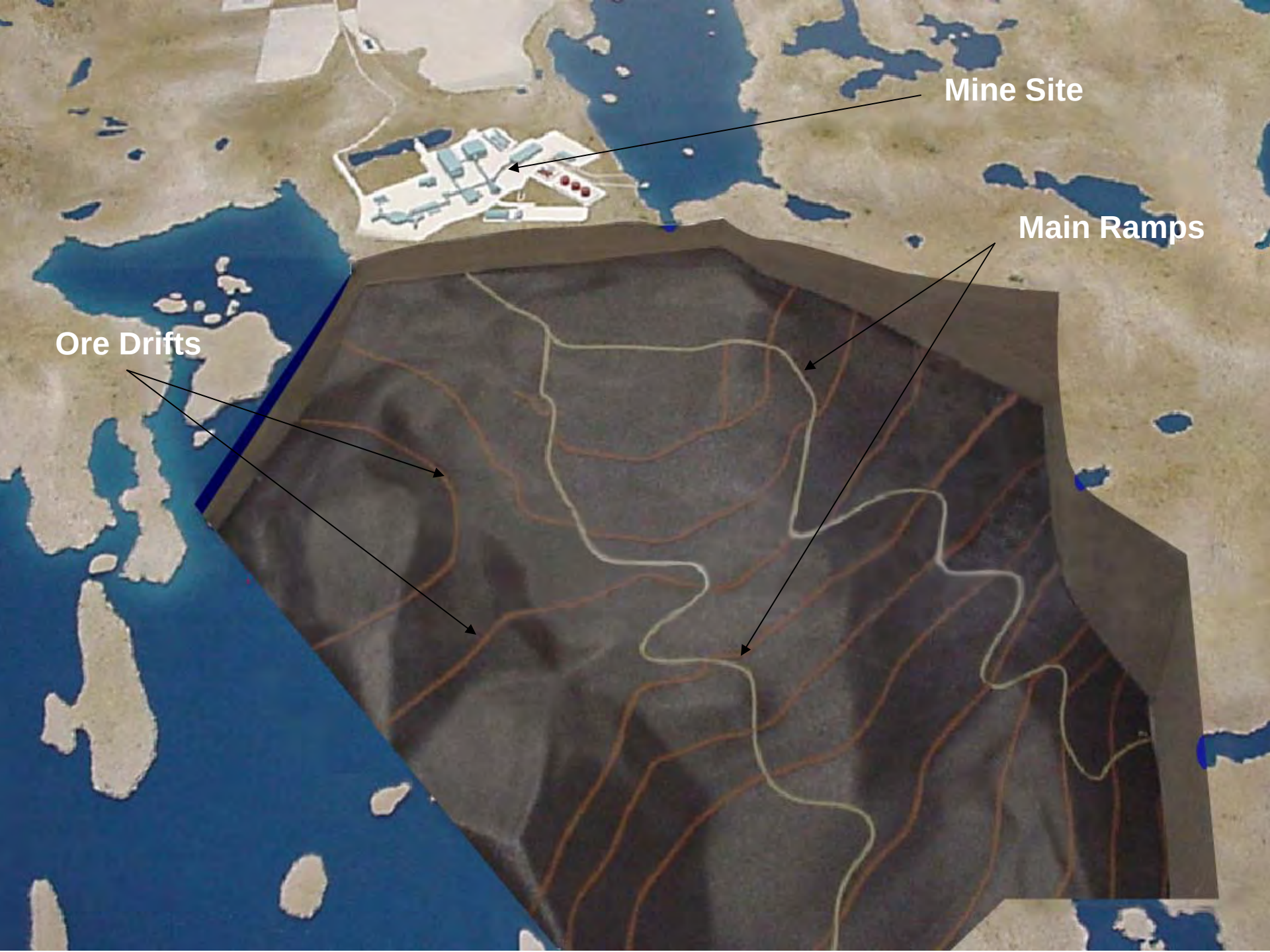
Mining Snap Lake

Carter

- Mining Cycle
- Regulation

Snap Lake Mine Area

1. Airstrip
2. Laydown area
3. Water Management Pond
4. Process Plant
5. Central Services Complex
6. Utilities Building
7. Conveyor Portal
8. Portal to Underground
9. Exploration Test Pit
10. Vent Raise - Underground Heating Plant
11. Fresh Water Pump House
12. Bulk Fuel Storage
13. Construction Camp
14. Landfill Site and Ammonia Nitrate Storage
15. Emulsion Plant
16. Waste Management Area
17. North Pile
18. Maintenance Shops


Mine Site
Main Ramps
Ore Drifts

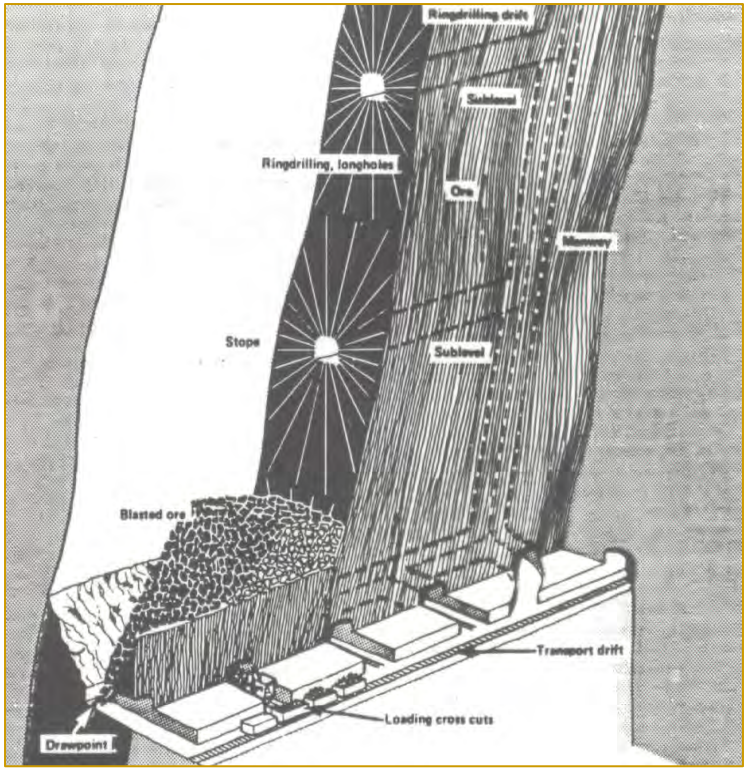
Snap Lake Mining Overview

- De Beers Snap Lake mine is solely an underground operation
- Day to day activities from mining to processing are shown in the next animation

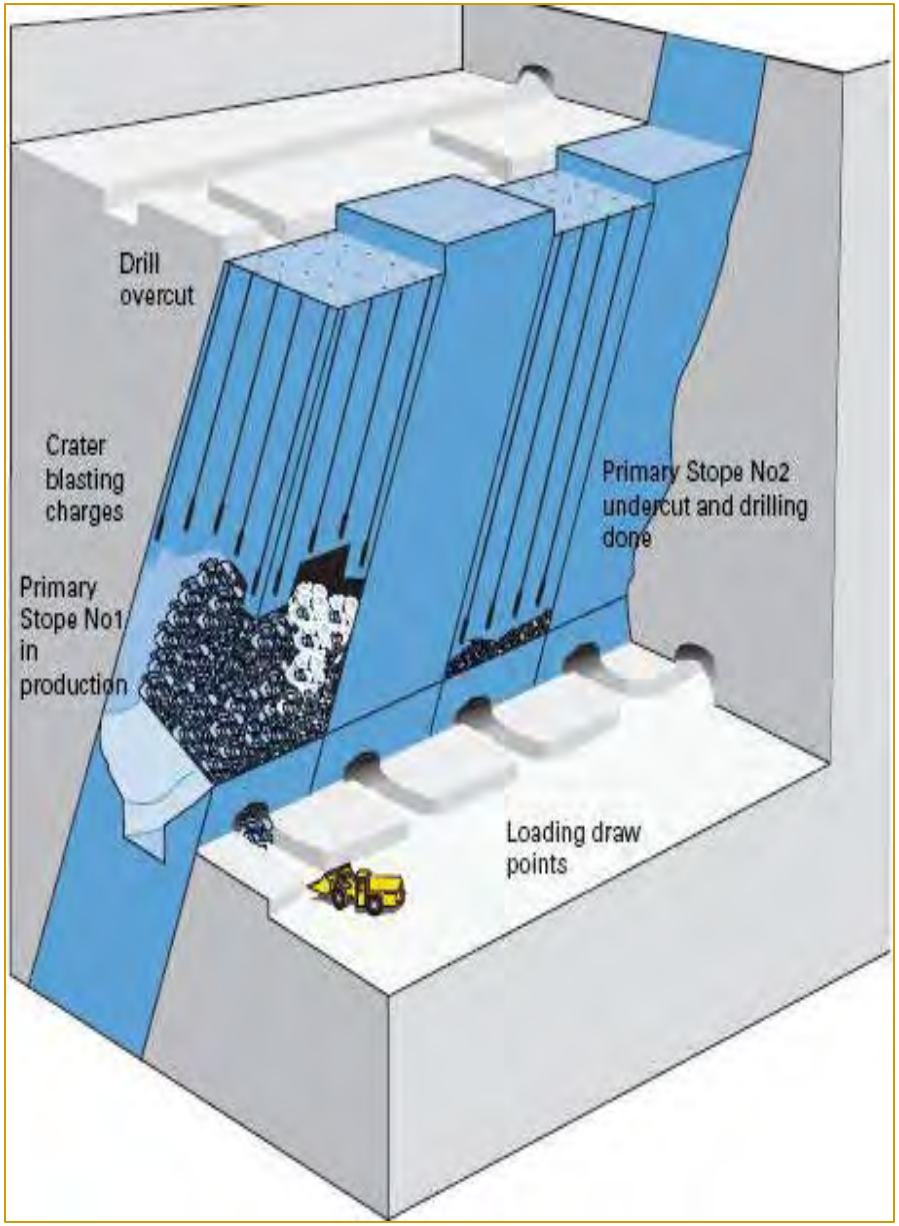
- Mining Snap Lake

Mining Method

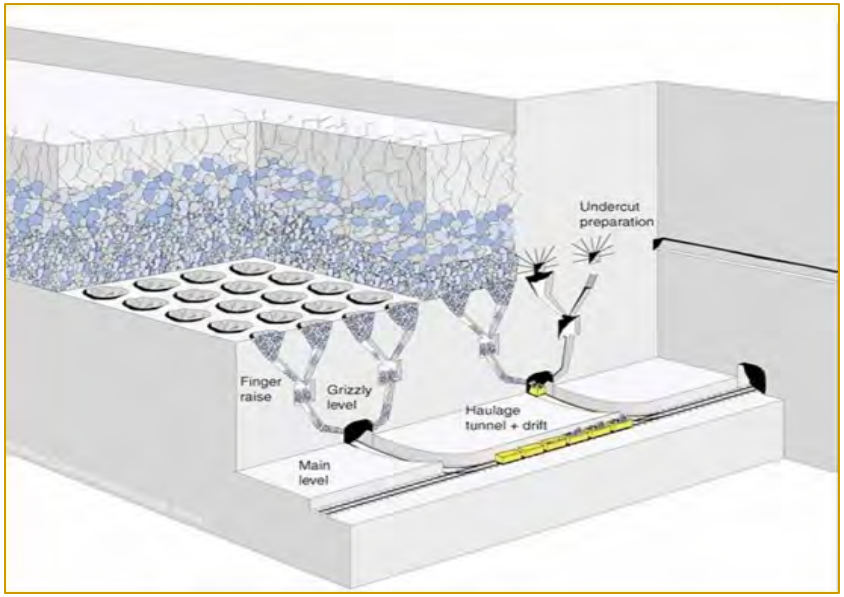
- There are many mining methods available depending on the size, shape, depth and grade of the ore body (among many other factors)
- Mining Engineers must take into account all factors when considering which method will be most effective



Sub-Level Stoping



Vertical Crater Retreat



Block Caving

Open Pit

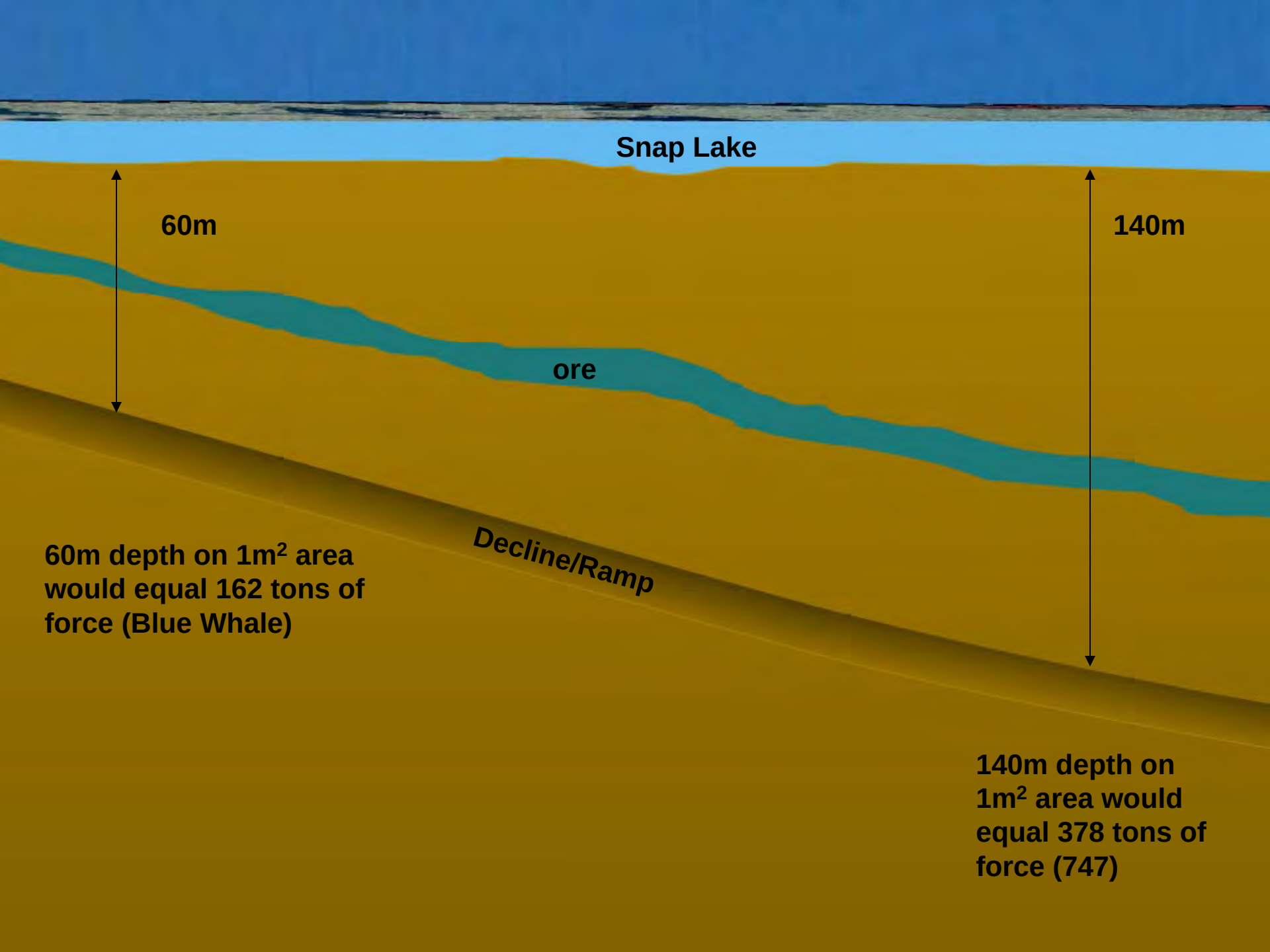
Mine Cycle/Equipment

Video

Ground Support/Large Scale

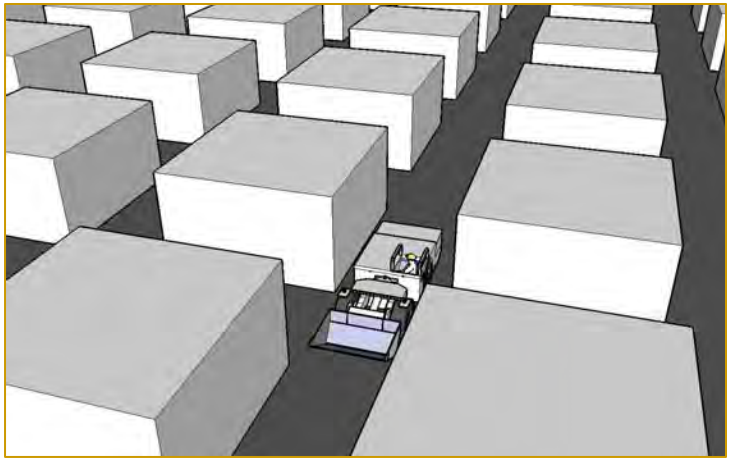
- Rock has a high density and therefore a large mass
- Density is the mass per unit volume
- For example: Granite has a density of 2.7 ton/m^3

  This means 1 cubic meter of rock (the size of a washing machine) weighs 2.7 tons (weight of a hummer)

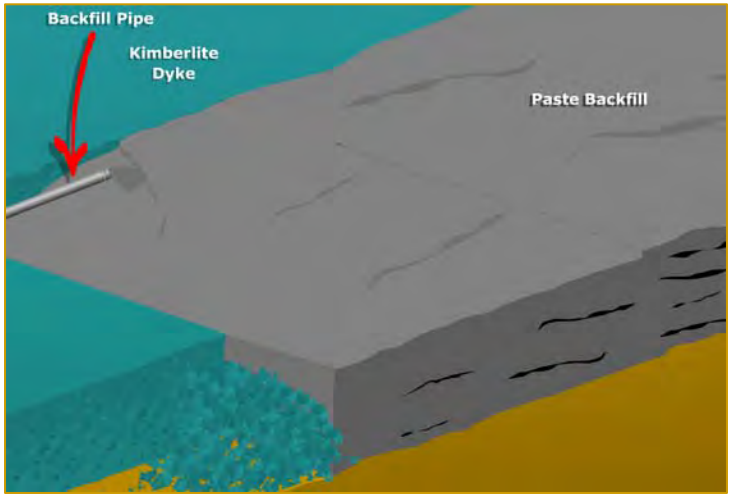

Snap Lake
60m
140m
ore
Decline/Ramp
60m depth on 1m² area would equal 162 tons of force (Blue Whale)
140m depth on 1m² area would equal 378 tons of force (747)

Ground Support/Large Scale

- The deeper you go into the earth, the more mass you have over your head
- This means all of the ore cannot be removed, some ore must be left to support the roof overhead or the void must be backfilled



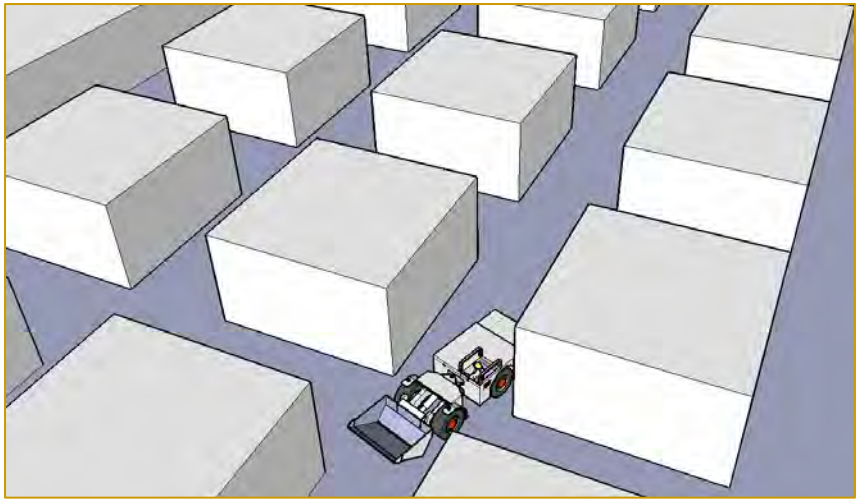
Room & Pillar



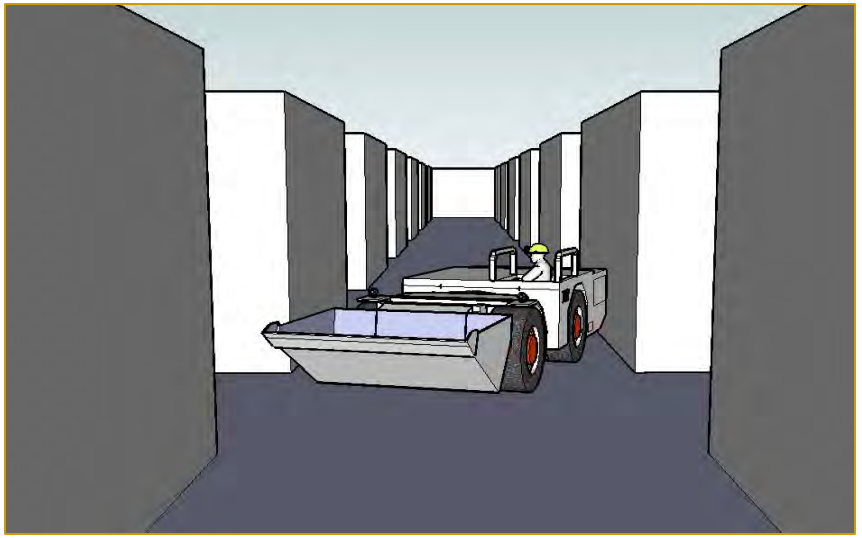
Paste Backfill

Modified Room & Pillar

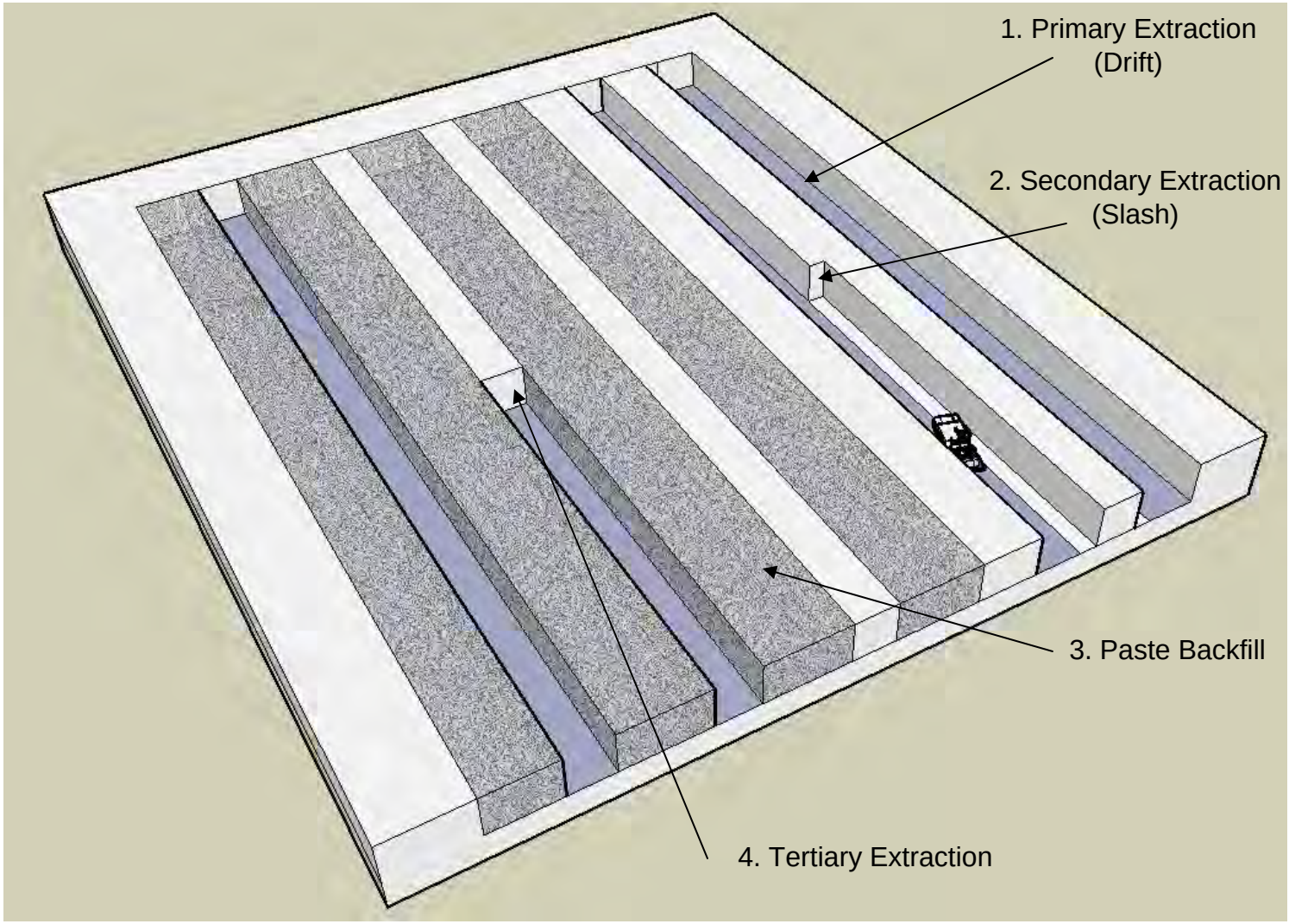
- Consists of cutting out blocks and leaving pillars as support

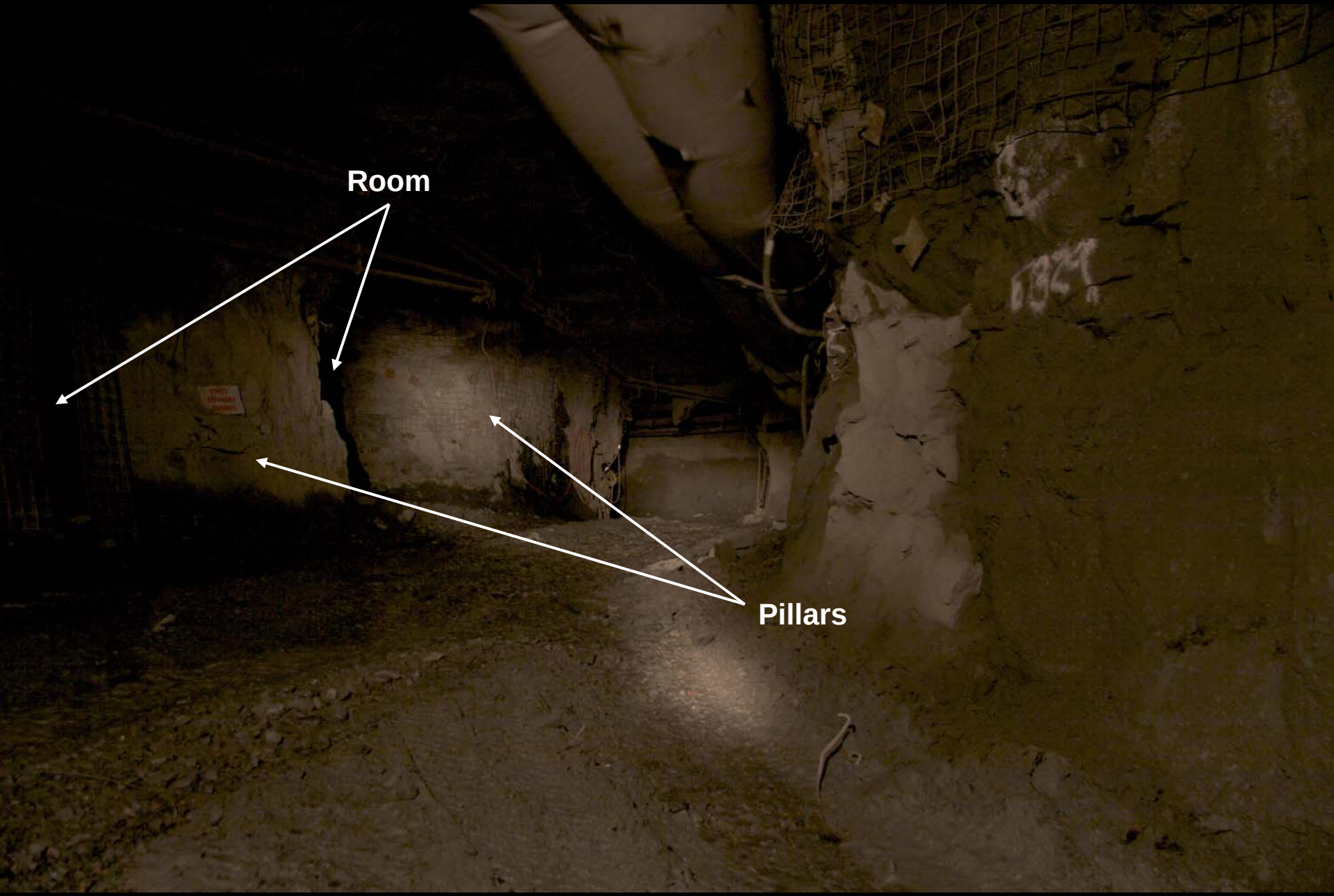


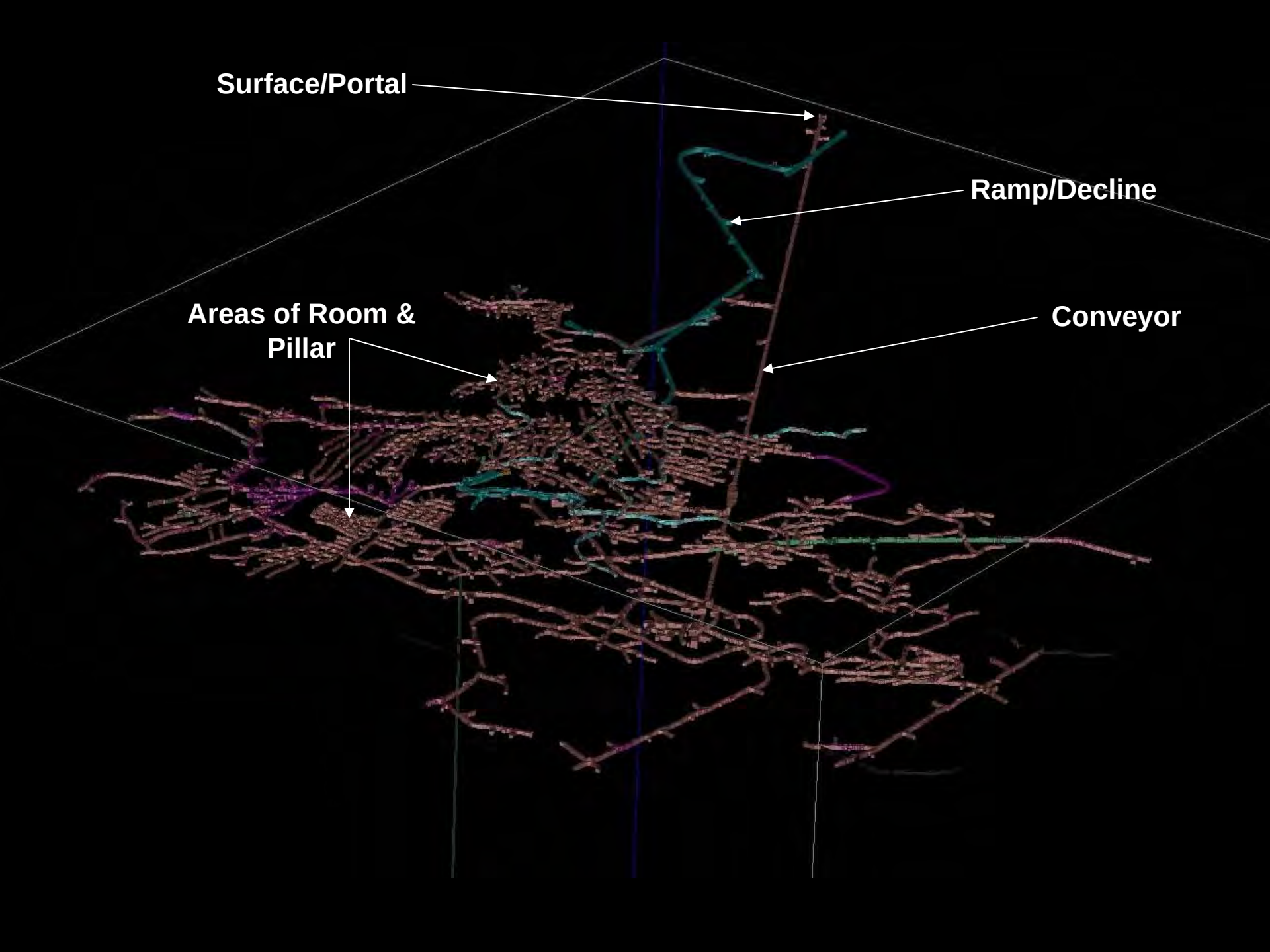
- Once a block has been mined out the pillars can be mined out through secondary extraction starting at far end of ‘room’



Diamond Drift Slash and Fill

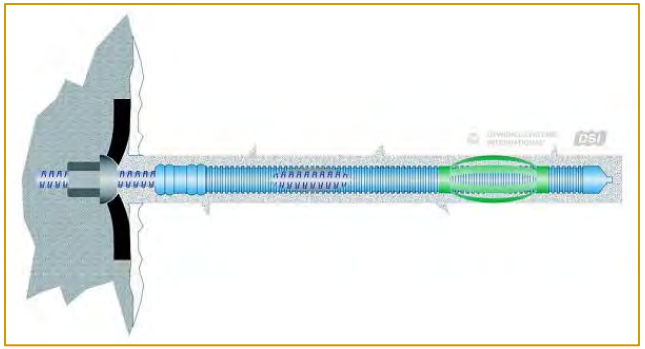



Room
Pillars

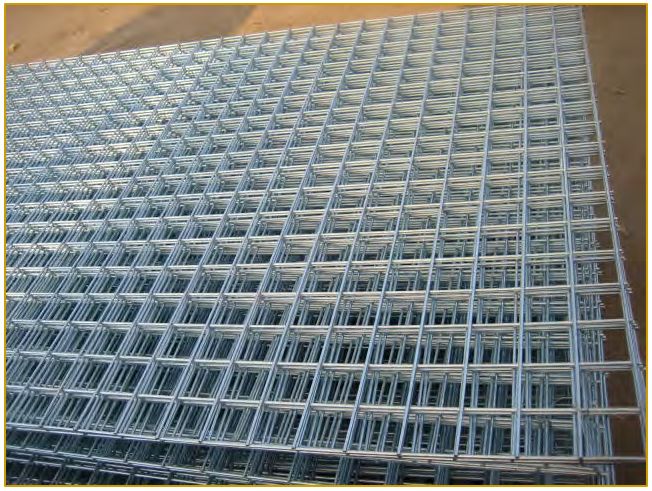

Surface/Portal
Ramp/Decline
Areas of Room &
Pillar
Conveyor

Rock Support/Small Scale

- Boulders and small rocks must be kept from falling from the ceiling to minimize risk for workers and machinery
- This includes the use of rock bolts and welded wire mesh



Rock Bolt



Welded Wire Mesh


Rock Bolts
Wire Mesh

Processing

- Crush and scrub kimberlite
- Dense Media Separation

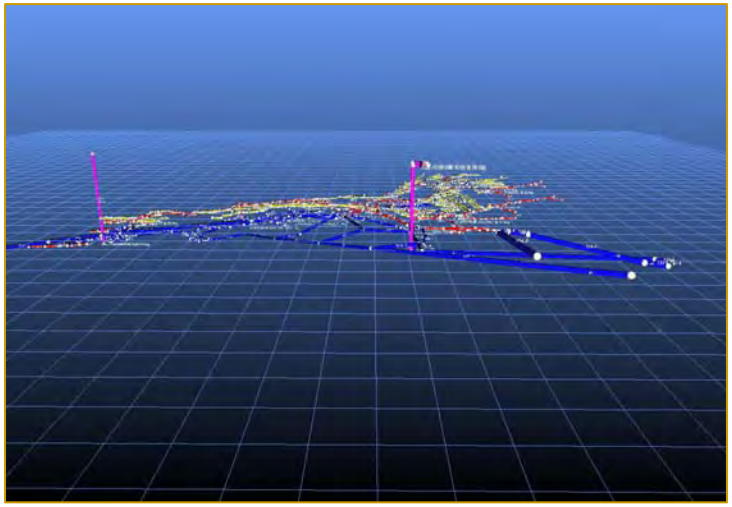
  Use mixture of ferrosilicon (iron and silicon, SG 6.8) and water (SG 1) to create slurry with specified SG

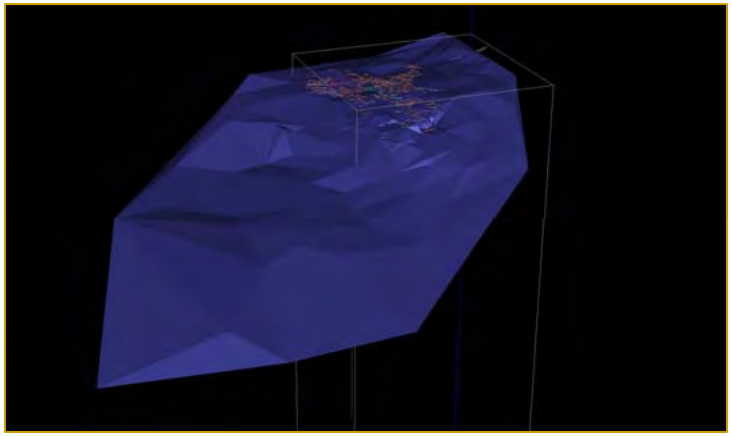
  - Diamond – SG 3.5
  - Kimberlite – SG 2.5

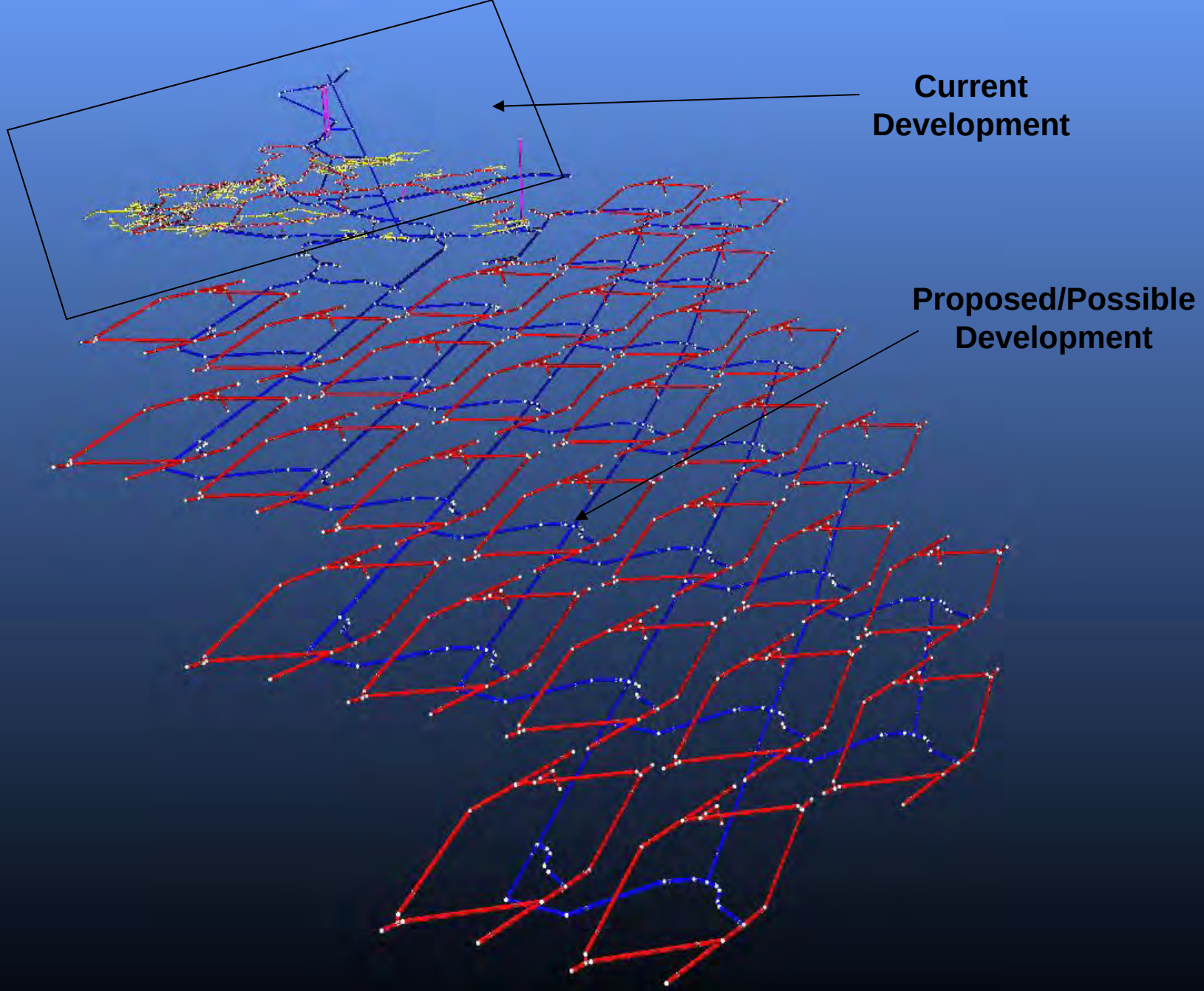
  This allows for diamonds to sink and the kimberlite to float

Mine Life

- Engineers and geologists have not yet determined the true size of the ore body
- Estimates from the current volume mapped project a mine life of 22 years (2008)
- 20 more years of production






Current
Development
Proposed/Possible
Development

Regulation

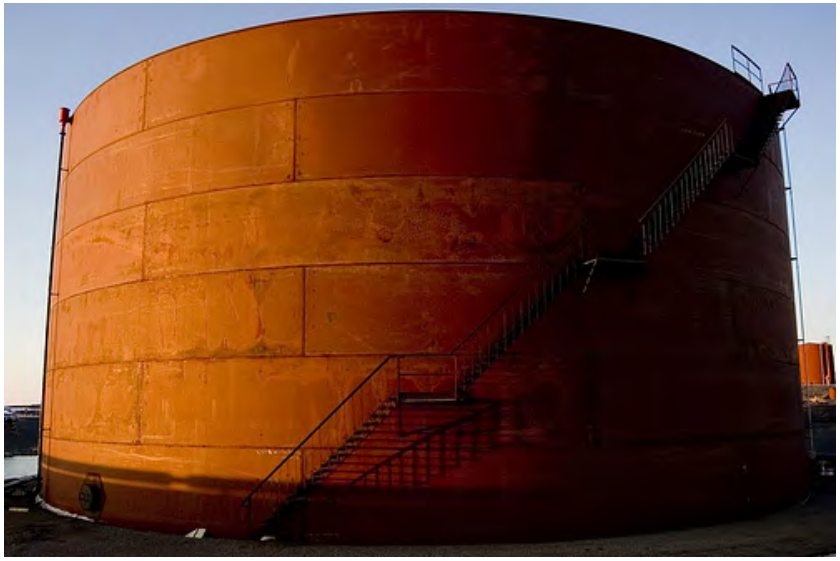
- Mackenzie Valley Land and Water Board

  "The mandate of the boards is to regulate the use of land and waters and the deposit of waste so as to provide for the conservation, development and utilization of land and water resources in a manner that will provide the optimum benefit to the residents of the settlement area and of the Mackenzie Valley and to all Canadians."

Regulation

Snap Lake Mine → **Type “A” Land Use Permit**

Snap Lake Mine → **Type “A” Water License**



One of Snap Lakes three, 12 million liter fuel tanks

Discussion and Questions

Lunch

Mineral Processing Activity

All

- Discuss

The University Experience

Carter

Background

- Born and raised in Banff, Alberta.
- Attend the University of British Columbia
- Studying Mining Engineering

University

- Transition
- People
- Activities
- Course Load

Engineering Classes

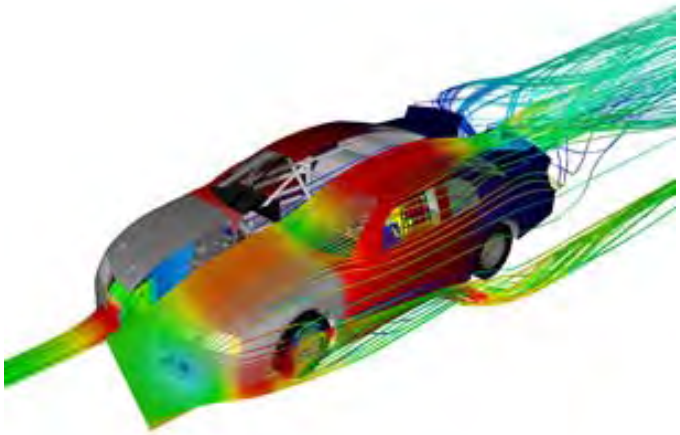
- Challenging
- Gain greater understanding

First Year

- Basic knowledge building for all engineers, no specialization:
  - Physics x3
  - Calculus x3
  - Chemistry x2
  - English (required)
  - Anthropology (elective)
  - Computer Programming
  - Engineering Ethics

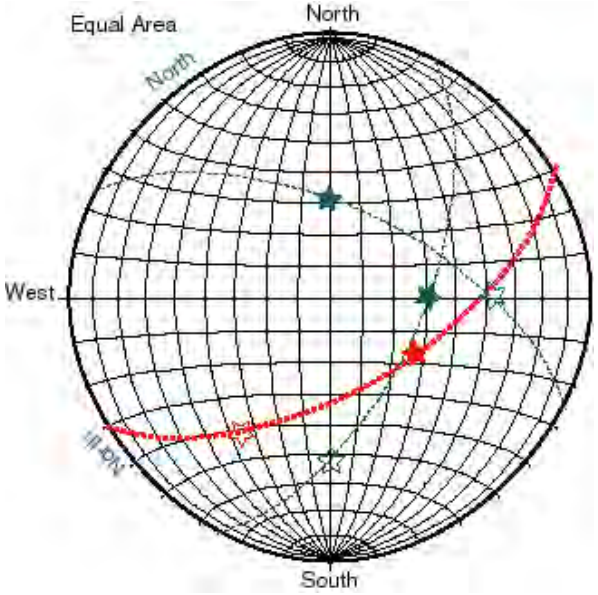
Second Year

- Specialize into Mining Engineering
  - Mechanics
  - Fluid Dynamics
  - Soil Mechanics
  - More Calculus x2
  - Introduction to Mineral Processing
  - Introduction to Open Pit Mining
  - Geology
  - Mineralogy and Petrology
  - Macro Economics
  - Technical Writing



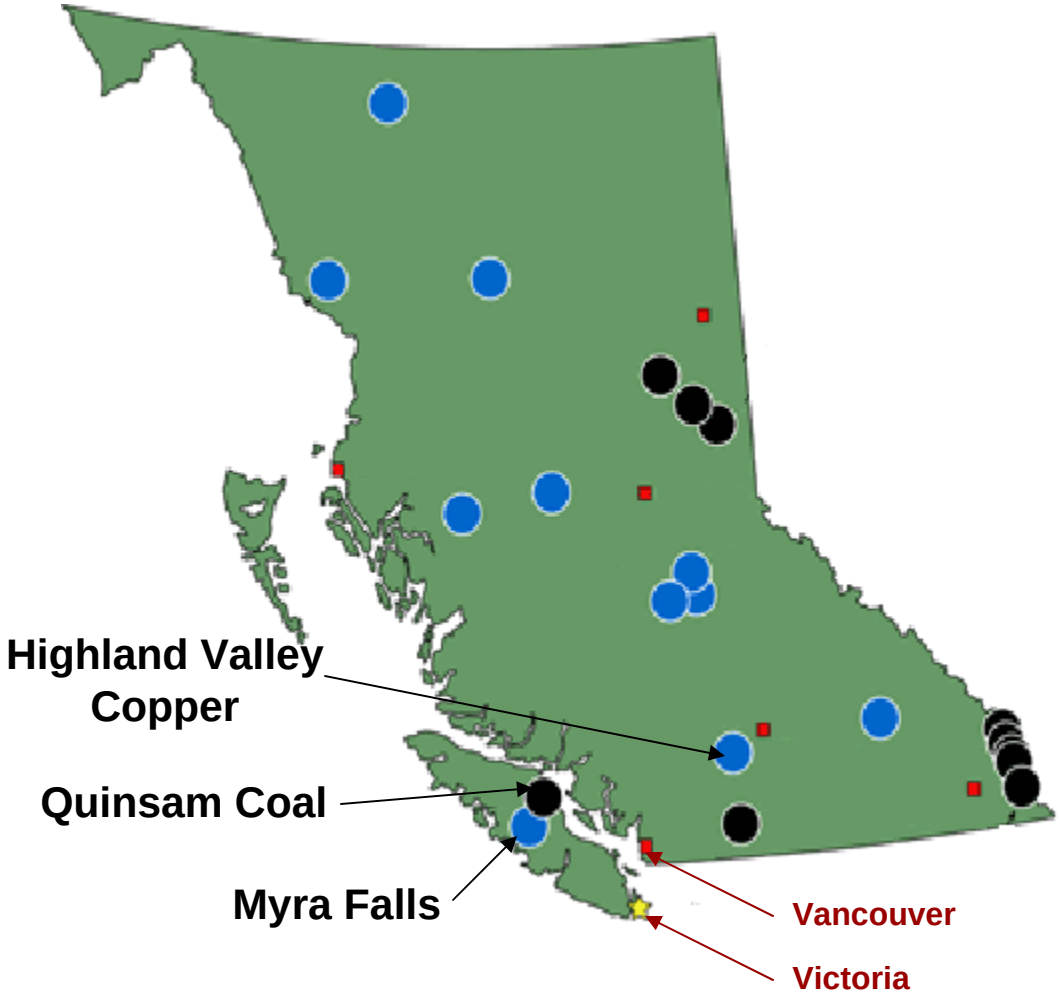
Third Year

- Further Specialization
  - Rock Mechanics (support)
  - Geomechanics
  - Underground Mine Design
  - Mining Economics
  - Mineral Processing
  - Flotation
  - Process Mineralogy
  - Drill and Blast Design
  - Mining and the Environment
  - Fundamental Circuit Analysis
  - Materials Engineering



Field Trips

- Highland Valley Copper
  - Copper, Molybdenum
- Myra Falls
  - Zinc, Copper, Gold, Silver
- Quinsam Coal
  - Metallurgical Coal

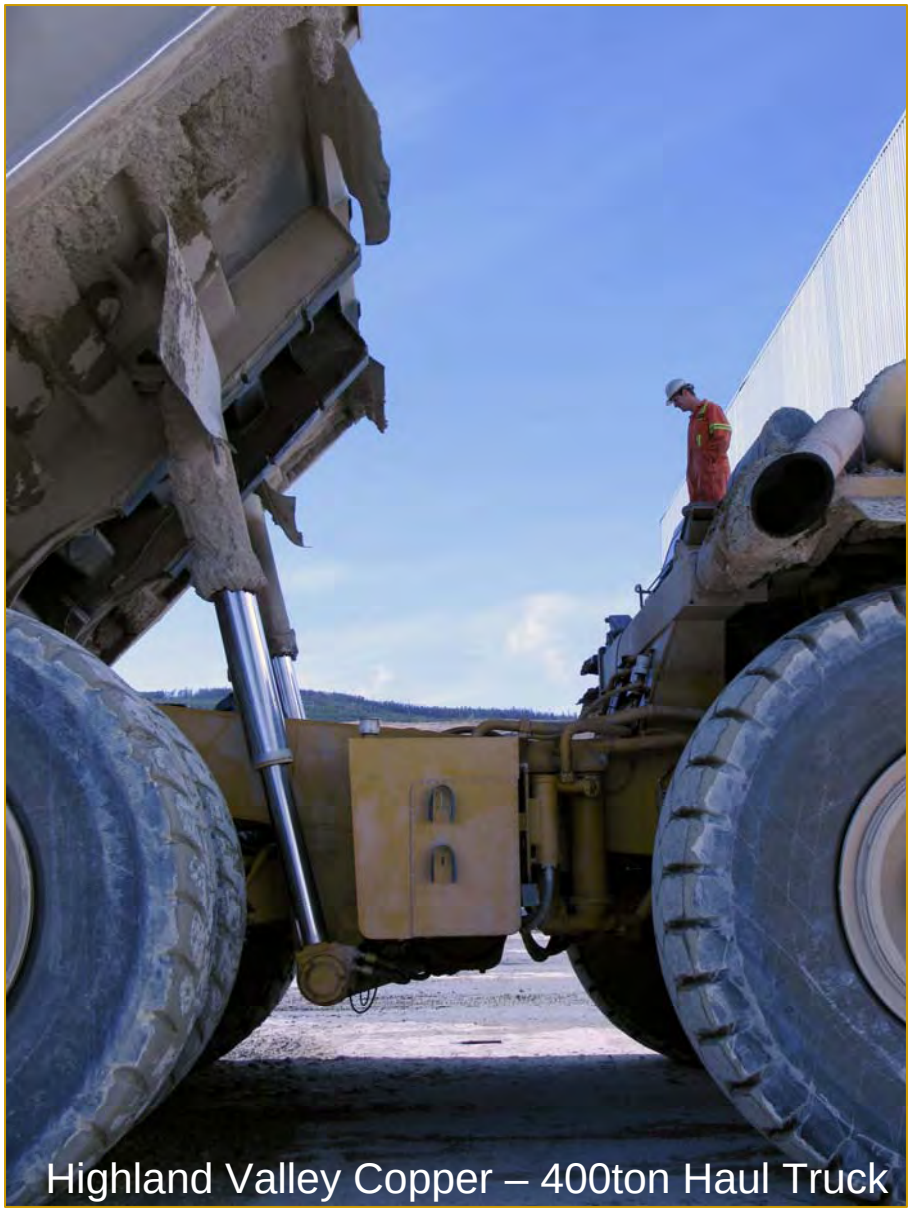


Highland Valley Copper

- Kamloops, BC
- Copper, Molybdenum
- Open Pit


TRINITY
793
CAT
94

Highland Valley Copper – Grinding Circuit



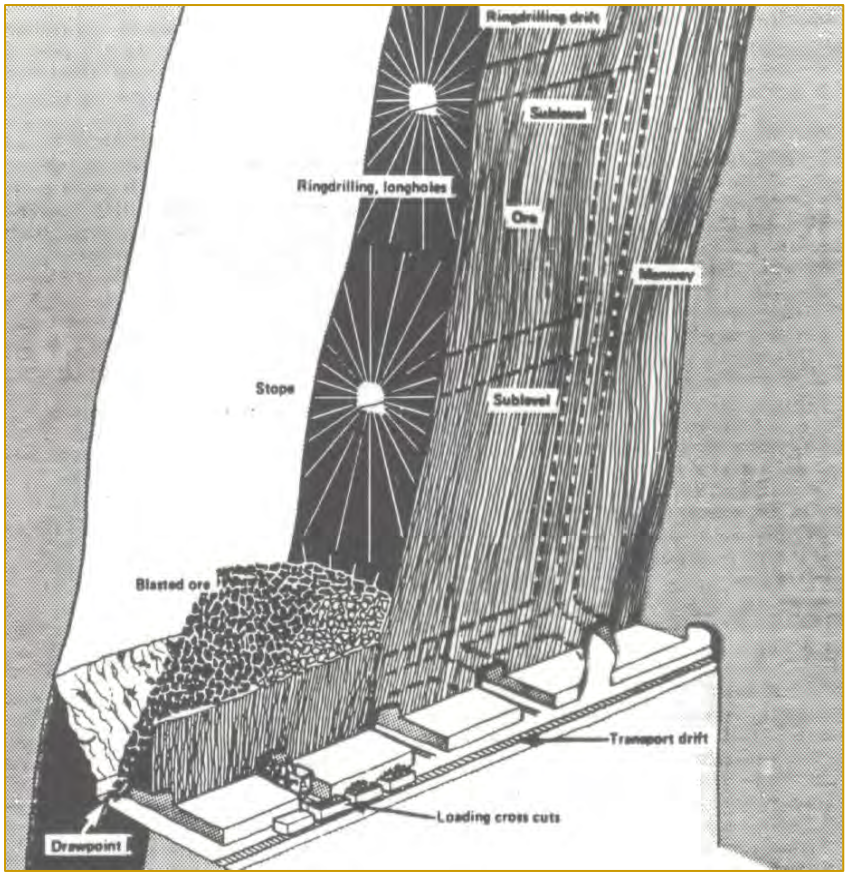
Highland Valley Copper – 400ton Haul Truck

Highland Valley Copper - Open Pit

Highland Valley Copper - Copper Flotation Circuit

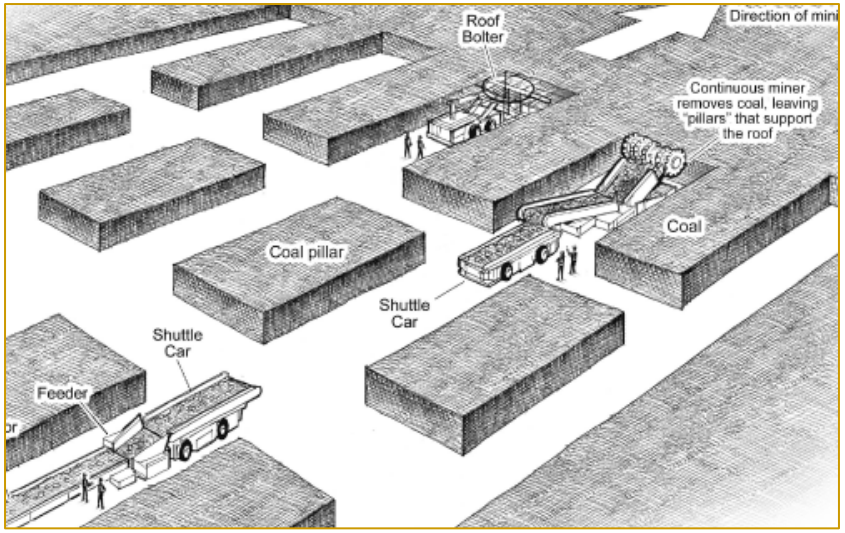
Myra Falls

- Vancouver Island, BC
- Zinc, Copper, Gold, Silver
- Sub-Level Stoping



Quinsam Coal

- Vancouver Island, BC
- Metallurgical Coal
- Room and Pillar



Engineering Role

- Peoples lives are in your hands
- You are held responsible to build safe structures that will serve the public for longevity
- Large amount of responsibility

Why Engineering

- You can make a difference

  Create new technologies to help solve our societies problems

  - Faster ways to drill
  - Cheaper ways to grind ore
  - Better ways to find ore/diamonds
  - More environmentally friendly ways to process ore and dispose of tailings

Why Engineering

- You will have options
  - Engineers work everywhere
    - Global degree
    - Rural/Urban
    - Outer space
  - Large variety of work environments
    - Open pit copper mining in Chile
    - 8km underground gold mining in South Africa
    - -50 Celsius mining diamonds in Canada

Why Engineering

- You will have money and job security

  An Engineering degree is the highest paid undergraduate degree in Canada

  - You graduate into an industry where you are in high demand
  - Graduate young with high salary, requirement of travel
  - The possibilities are endless

  There will always be a global demand for base metals

  - We are surrounded by materials that come from mining

    Steel, Copper, Aluminum, Gold, Silver, Nickel, Zinc, Diamonds

Masi Cho

Discussion and Questions

End Day 2