Unit 5:

Earth's Resources

Earth Systems 3209 - Unit 5 Lesson 1 - Economic Minerals

In the various resources in use today, almost all once existed as rock, thus Materials we use everyday were a part of the ground.

Mineral deposit - a volume of rock enriched in one or more minerals. In this sense a mineral refers to a useful material, this is different from the way we defined a mineral earlier the year.

Some mins are used as they are found and require no further processing. Ex: gemstones, sand, gravel, and salt (halite). Most mins must be processed before they are used. Ex: iron and aluminum only exist in mineral compounds and must be processed to extract the metal from the metallic ore.

Reference: Pages 52 - 55

There are costs in extraction, manpower, and energy. These vary, determining if a mineral deposit is economically viable also varies. So, the higher the concentration of the substance, the more economical it is to mine.

Ore - mineral deposit where one or more valuable substances can be extracted economically.

Economics control if a deposit is profitable to mine. Different minerals require different concentrations to be profitable. These include: demand for the substance and the cost of extraction.

An example of an economic mineral is Gold.

Gold prices vary on a daily basis. When gold prices are high, old abandoned mines re-open, when the price drops, gold mines close. The cost of labor is currently so high that few gold mines can operate profitably, but in third world countries, labor costs are lower, gold mines that have ore concentrations well below those found in N.A can operate with a profit.

NL contains a variety of ore minerals and many mines have developed in the past and present.

For Example:Advocate Mines and Nugget Pond, in Baie Verte. IOCC and Wabush Mines in Labrador.

Mineral Resources can be divided into two groups:

Metallic Mineral Resources

Resources in which metals such as copper, iron, gold, uranium and zinc can be recovered by smelting and other chemical processes.

Mineral	Element	Use
Bauxite	**Al**	**Airplanes and Pop cans**
Chalcopyrite	**Cu**	**Electrical wiring and Water Pipes**
Hematite **Magnetite**	**Fe**	**Steel and Nails**
Galena	**Pb**	**Weights**
Pentlandite	**Ni**	**Money**

Non-Metallic Mineral Resources

Resources that are used for their physical and chemical properties rather than for the elements they contain.

Mineral	Use
Halite	**Table and Road Salt**
Calcite	**Cement**
Gypsum	**Plaster and gyproc**
Quartz	**Glass**
Graphite	**Pencil Lead and Lubricants**
Diamond	**Gemstone (Jewelry) and Cutting Tools**

Economic Minerals

Mineral	Mineral Group	Element Extracted	Location
Hematite, Magnetite	Oxides	Iron	Lab. City & Bell Island
Chalcopyrite	Sulfides	Copper	Baie Verte
Galena	Sulfides	Lead	Buchans
Corundum	Oxides	Aluminum	Southern Labrador
Sphalerite	Sulfides	Zinc	Baie Verte
Diamond Graphite	Native Minerals	Carbon	Africa Russia
Gold	Native Minerals	Gold	Nugget Pond & Hope Brook
Silver	Native Minerals	Silver	Nugget Pond
Pentlandite	Sulfides	Nickel	Voisey Bay Ontario
Cassiderite	Oxides	Tin	Brazil

Questions:

1. What is the main mineral used in making plaster?
(A) barite (B) graphite (C) gypsum (D) pyrite

2. In which location of NL would an ore deposit containing nickel, copper, and cobalt be found?
(A) Baie Verte (B) Labrador City (C) Buchans (D) Voisey's Bay

3. Which best describes an ore mineral?
(A) composed entirely of iron
(B) contains many different varieties of useful elements
(C) contains useful elements that can be profitably mined
(D) large deposit

4. What is a mineral deposit?

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5. What are the two types of mineral resources? Give an example of each.

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6. Explain, with examples, why some minerals need to be processed before they can be used.

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Earth Systems 3209 - Unit 5 Lesson 2 – Mineral Deposits

There are 5 types of economic mineral deposits:

1. Magmatic
2. Hydrothermal
3. Placer
4. Secondary Enrichment
5. Metamorphism

1. Magmatic

Many of the world's most valuable metallic mineral resources are directly associated with magma that ultimately forms igneous rocks.

Certain metals are naturally enriched in certain magmas, but most only reach economically viable concentrations upon further enrichment during the cooling process.

Two specific types of magmatic deposits we will look at are:

i. Gravitational
ii. Dissemination (Magma source hydrothermal)

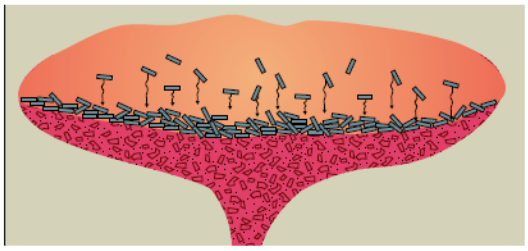
i. Gravitational

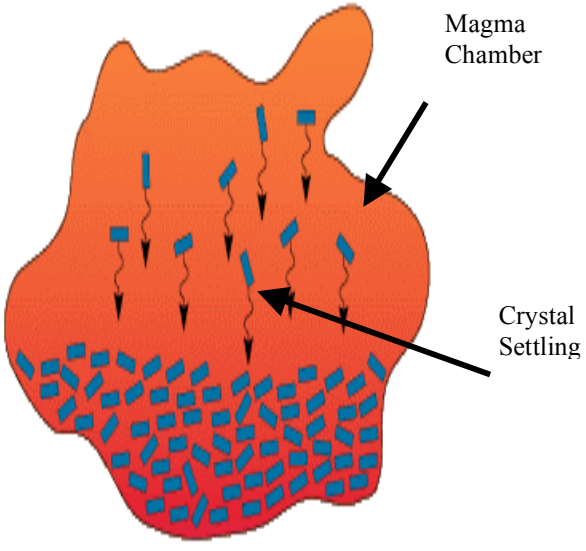
The igneous processes that generate some metal deposits are fairly straightforward. For example, some economically important minerals are concentrated by simple gravitational settling within a magma chamber.

In essence, crystals of heavy minerals that form during early stages of crystallization settle at the bottom of a magmatic body.

High-density minerals such as chromites and magnetite crystallize during the early stages of magma crystallization.

The crystals can sink to the bottom of the magma chamber, forming concentrated layers of these minerals.

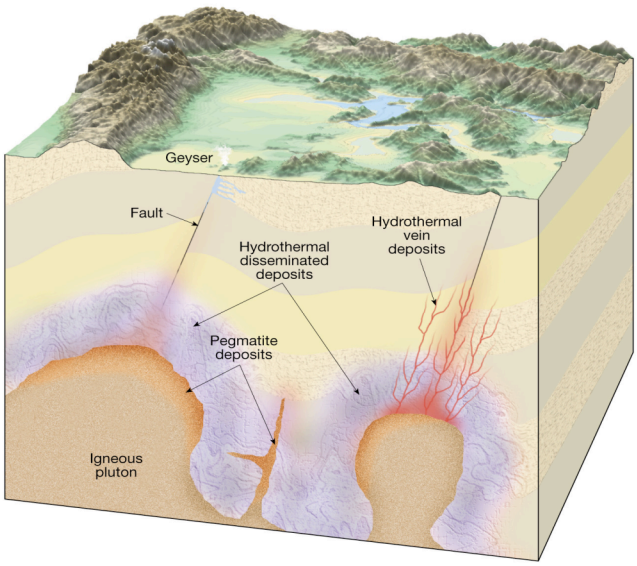




ii. Disseminated

Another important type of accumulation generated by magma-sourced hydrothermal fluids is called a disseminated deposit.

Rather than being concentrated in well-defined veins (as we will see later), these ores are distributed in small masses throughout a large rock body.

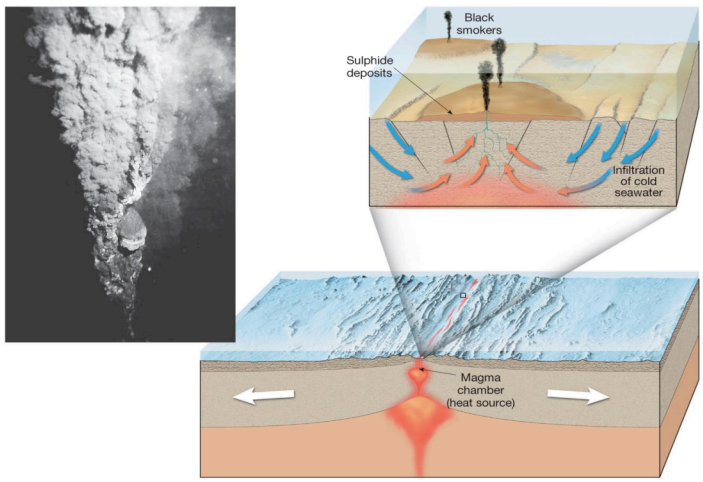


2. Hydrothermal

Among the best-known and most important ore deposits are those generated from hydrothermal (hot-water) solutions, which may be produced during the late-stage cooling of magma, by the heating of groundwater or seawater, or by metamorphic processes.

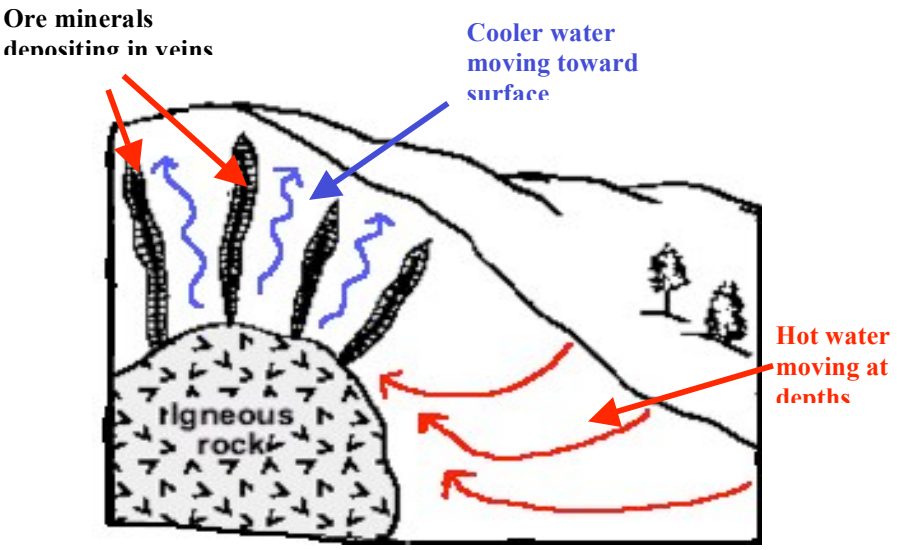
Studies of modern hydrothermal systems have shown that igneous activity serves as a powerful heat engine that drives the production and circulation of mineral rich fluids. (Yellowstone National Park)

The deposits are forming where heated seawater, rich in dissolved metals and sulphur, gushes from the seafloor as particle filled clouds called *black smokers.*



Vein Deposits

Hydrothermal fluids generated by cooling magmas can rise to the surface through fractures, faults, and other features resulting from the brittle deformation of the overlying rocks. Fluids passing through the fractures eventually cool, allowing minerals to precipitate



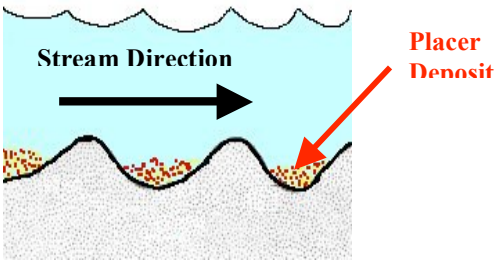
3. Placer Deposits

The formation of placer deposits relates to the sorting action of running water.

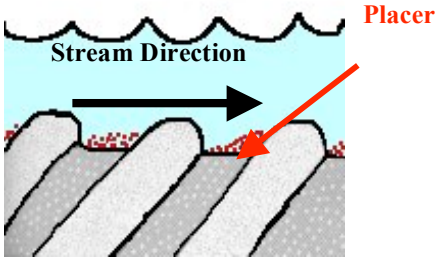
Mineral particles of high density can be concentrated due to the sorting out and washing away of mineral particles of lower density

Gold, Platinum and Diamonds are found in these deposits.

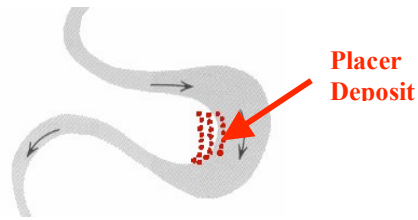
1) **between ripple marks**



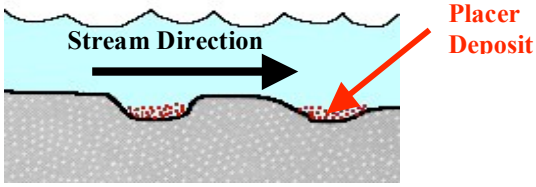
2) **behind rock bars**



3) **on the inside of meandering streams**



4) **in holes on the bottom of a stream**



4. Secondary Enrichment

Weathering creates many important mineral deposits by concentrating minor amounts of metals that are scattered through unweathered rock into economically valuable concentrations.

Such a transformation is often termed secondary enrichment and takes place in one of two ways.

In one situation, chemical weathering coupled with downward-percolating water removes undesirable materials from decomposing rock, leaving the desirable elements enriched in the upper zones of the soil.

The second situation is basically the reverse of the first. That is, the desirable elements that are found in low concentrations near the surface are removed and carried to lower zones, where they are re-deposited and become more concentrated.

For example: ***Bauxite***

Principal ore of aluminum
Forms in rainy tropical climates from chemical weathering and the removal of undesirable elements by leaching

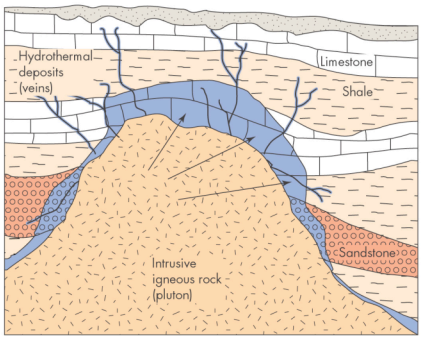
5. Metamorphism

The role of metamorphism in producing mineral deposits is frequently tied to igneous processes.

Many of the most important metamorphic ore deposits are produced by contact metamorphism.

Here the host rock is re-crystallized and chemically altered from heat, pressure, and hydrothermal solutions emanating from an intruding igneous body.

The most common metallic minerals associated with contact metamorphism are zinc, lead, copper and iron.



Contact metamorphic zone where mineral deposits may be present. Notice the zone is wider in the limestone than in the sandstone or shale. This results because limestone is chemically more active under contact metamorphism.

Questions to answer

1. List and give a short description of the five types of mineral deposits.

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2. What is the difference between Gravitational and Disseminated Magmatic mineral deposits?

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3. How does a hydrothermal mineral deposit occur?

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4. What is Bauxite and where does it form?

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5. What kind of minerals would you find in Placer Deposits? Why?

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6. Why is metamorphic ore tied greatly into igneous processes?

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Earth Systems 3209 - Unit 5 Lesson 3 – Mining and Exploration

There are two major types of mines:

1) Open pit
2) Underground

1) Open Pit

Open-pit mining is surface mining in which huge portions of earth are dug from the surface to extract the desired mineral within them, resulting in a large pit.

Open-pit mines are used when deposits of commercially useful minerals or rock are found near the surface.

As a result, the potential exists for considerable destruction to both surface soil and vegetation, and the release of significant amounts of mine dust.

Open pit mines are usually accessed by surface terracing, thereby allowing technological equipment to follow the shape of the deposit.

Open Pit Impacts

Clearing: First the bulldozing and preparation kills all existing floral and fauna species on the site.

Mining: Open-pit mining is infamous for its large amount of dust production. Also the noise created.

Chemical and Toxic Pollution: The chemicals and toxins exuded seep into the nearby water supply and pollute it.

Soil Degradation: Strong acidic or alkaline deposits begin to seep into the surrounding soil making them useless in terms of growth.

Exposure: The exposure to weathering erodes the soil much quicker. Some soils endure mass compaction.

Scree: Mining operations mountain sides start to cut into the earth creating a scree drop effect.

Pros and Cons

Open-pit mining in relation to underground mining are lower costs, greater safety, and mechanically easier operations.

Surface mining is more efficient than underground mining in terms of recovery, grade control, economy, and flexibility of operation.

However, many deposits, are too small or irregular, and or deeply buried to be extracted efficiently by surface mining methods and the mine must be converted to underground operations or abandoned.

2) Underground Mining

Underground mining is done when the rocks, minerals, or gemstones are too far underground to get out with surface mining or is dictated by the shape of the ore body.

Some techniques are:

Drift Mining
Shaft Mining
Slope Mining

Accessing underground ore can be achieved via a decline (ramp), inclined vertical shaft, adit (horizontal entrance) or an elevator.

Levels are excavated horizontally off the decline or shaft to access the ore body. Stopes are then excavated perpendicular (or near perpendicular) to the level into the ore.

The deepest mines in the world are the TauTona (Western Deep Levels) and Savuka gold mines in the Witwatersrand region of South Africa, which are currently working at depths exceeding 3,900 m (12,800 ft).

Ore Exploration techniques

Seismic records
Remote sensing
Prospecting
Observing drill cores
Cross sections
Geological mapping
Magnetic survey
Gravity survey
Geochemistry

Ore Processing Techniques

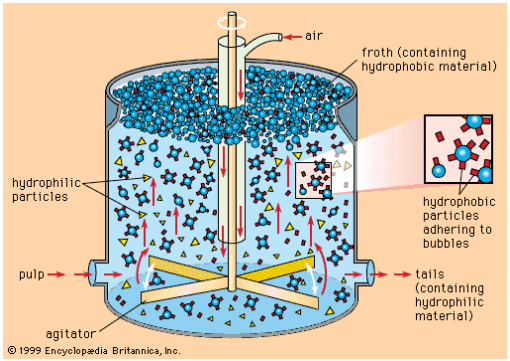
1. Floatation
2. Gravity separation
3. Heap leaching
4. Pyromet
5. Hydromet

1. Flotation

Floatation involves mixing grounded ore with water, oil, and chemicals.

The grounded ore becomes suspended in the water and is subjected to bubbles of air.

This causes the minerals and/or elements of value to float to the top where they can be skimmed off.

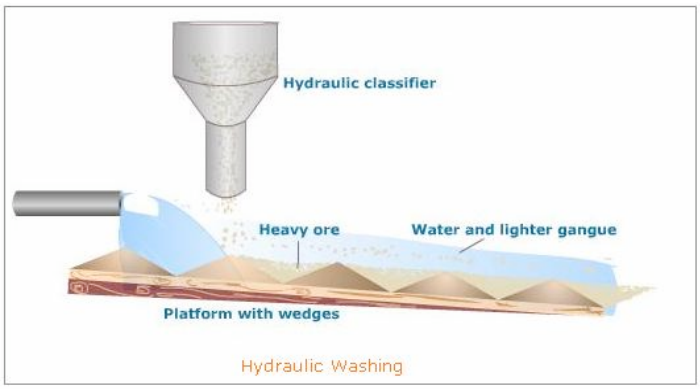


2. Gravity Separation

Gravity separation involves feeding grounded ore into a pulsating body of water, which serves to settle out the heavy material while floating away the light material.

If the heavy material is what you wish to keep, then it is taken from the bottom.

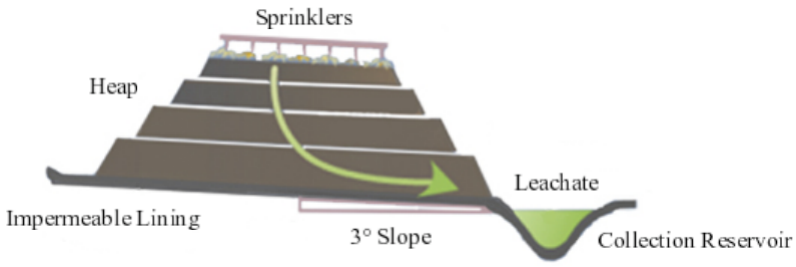
If the light material is what you wish to keep, then it is taken from the top.



3. Heap Leaching

Heap leaching commences by placing the grounded ore as a layer onto impermeable material.

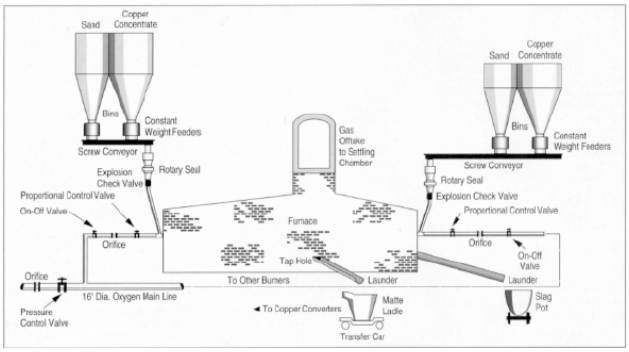
The “heap” of material is sprayed with a liquid, which percolates down through dissolving away the valuable minerals and/or elements.



4. Pyromet

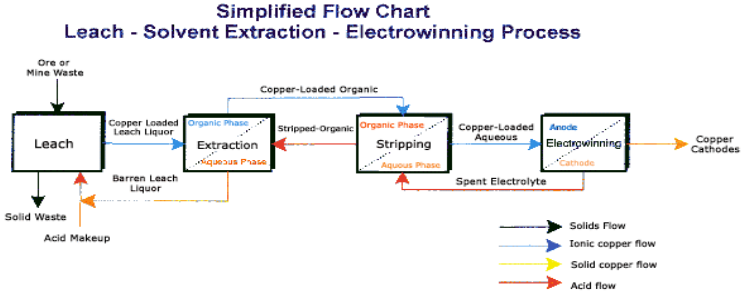
Pyromet involves using heat to separate the minerals and/or elements of value from the ore.

Heating separates the materials by density and the desired minerals and/or elements can be removed.



5. Hydromet

Hydromet is a chemical method that involves oxidation and acid leaching to separate out the desired minerals and/or elements.



Questions

1. List and briefly describe the two types of mining.

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2. Describe three impacts of open pit mining.

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3. Why is open pit mining both a good, and a bad thing?

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4. List five ore processing techniques, then describe any two (with diagrams)

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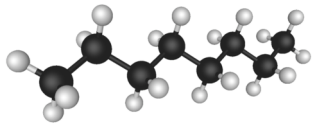
Earth Systems 3209 - Unit 5 Lesson 4 – Extracting and Refining Hydrocarbons

3 key terms:

1) Petroleum
2) Crude Oil
3) Hydrocarbons



1) Petroleum is a naturally occurring flammable liquid that is found in geologic formations below Earth's surface and consists of a mixture of hydrocarbons.

2) Crude oil is a mixture of hydrocarbons that exist in a liquid state in underground reservoirs and remain in a liquid state once subjected to atmospheric conditions.

3) Hydrocarbons are chemical compounds that involve hydrogen and carbon atoms. Examples include: butane, propane, ethane, and methane (i.e. wet gases).

Origin and the Process of Formation of Petroleum

Two key terms:

1) Organic Material
2) Preservation Potential

1) Organic Material

The origin of petroleum comes from microscopic marine animals (zooplankton) and plants (phytoplankton).

They are the main sources of *organic matter* in the production of petroleum.

Examples of such microscopic species are:

- Diatoms
- Foraminifera
- Radiolarian
- Benthic algae

The abundance of organic matter is determined by the amount of light, water depth, latitude, water temperature, water turbidity, and the abundance of nutrients preferred by plants (e.g. phosphates and nitrates).

Preservation potential means the conditions that favour the preservation of organic matter.

The two most important conditions are:

1. Anaerobic conditions (low oxygen content)
2. Rapid sedimentation by fine-grained material

Anaerobic conditions can exist in swamp and lagoon environments.

Examples of fine-grained material include mud-size, silt-size, and sand-size particles.

The formation of petroleum is another example of the interconnectedness of the Earth's spheres and thus is a direct reference to a systems approach.

Processes and Techniques Involved in Extracting and Refining Hydrocarbons

Key term

Kerogen:
- a mixture of organic matter in sediments from which petroleum is released.

The three phases in the evolution of organic matter to petroleum:
1. Diagenesis
2. Catagenesis
3. Metagenesis

1. Diagenesis:

During diagenesis there is shallow burial of organic matter at near normal temperature and pressure as well as some decay.

Methane, carbon dioxide, and water are released leaving behind the complex hydrocarbon called kerogen.

2. Catagenesis:

Deeper burial results in increased temperature and pressure.

Petroleum is released from the kerogen

- first oil is released
- second gas is released.

3. Metagenesis:

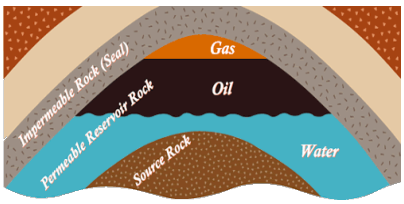
The metagenesis phase involves even higher temperature and pressure verging on metamorphism.

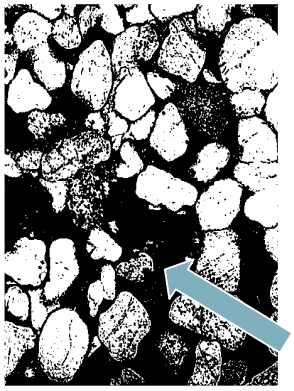
The only hydrocarbon that is released during this phase is methane.

At this point the petroleum has matured enough to migrate to traps.

Components Involved in the Formation of Petroleum Traps.

1. Source rock
2. Reservoir rock
3. Cap rock





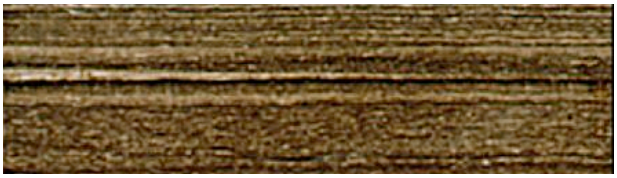
As oil migrates it fills up the pores

1. Source Rock

Source rocks must contain an abundance of organic matter. Petroleum is often created and released from the source rock while lithification is occurring.

Examples of source rocks are shale and limestone.

Where sediment contains more than 5% organic matter, it eventually forms a rock known as a Black Shale.



2. Reservoir Rock

Reservoir rock requires high porosity and high permeability since it is the rock which petroleum moves through and is stored in.

Note: **Porosity** is the volume of pore spaces or holes between sediment grains.
Permeability is the inter-connectiveness of the pores, thereby allowing the movement of the petroleum.(rate of flow)

Porosity of a material is influenced by:

i) particle shape
ii) particle size
iii) the degree of sediment sorting.

Large, rounded, well-sorted particles offer higher porosity, particularly if the amount of cement between them is limited.

Usually, the higher the porosity and the larger the pore spaces, the higher the permeability.

Examples: sandstone, dolomite, and conglomerate.

All have both high porosity and permeability.

3. Cap Rock

Cap rock is an impermeable rock that serves to trap petroleum from either escaping to the surface or spreading throughout the rock as opposed to being confined.

Note: petroleum exists within reservoir rock between sediment as opposed to being confined as a whole volume of liquid petroleum.

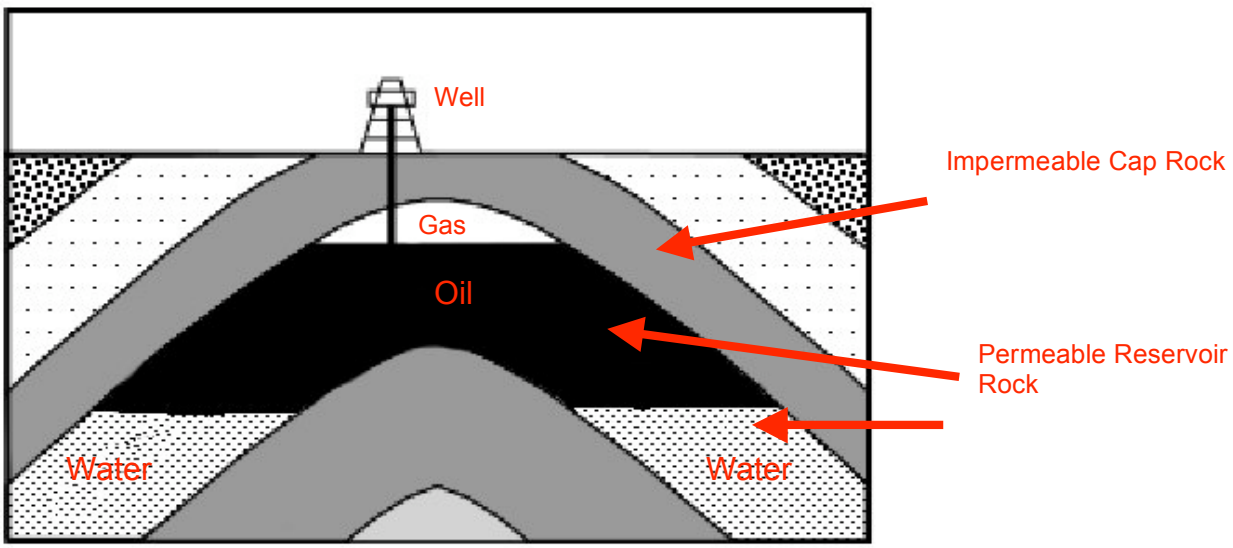
“There are no ponds of petroleum in the ground”.

Types of Petroleum Traps

1. Anticline trap
2. Fault trap
3. Salt dome trap
4. Stratigraphic trap

1. Anticline Trap:

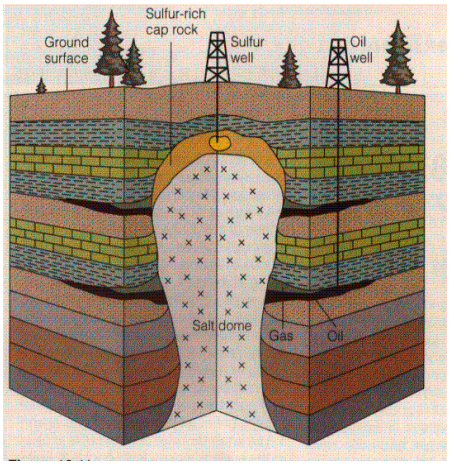
If a permeable rock like sandstone or limestone is located between impermeable rock layers like shale and the rocks are folded into an anticline, oil and gas can move upward in the permeable reservoir rocks, and accumulate in the upper region of the anticline.



2. Salt Dome Trap

Here we see salt that has moved up through the Earth, punching through and bending rock along the way.

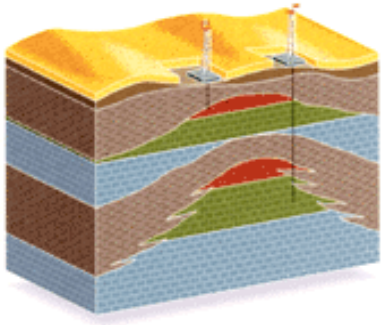
Oil can come to rest right up against the impermeable salt, which makes salt an effective trap rock.



3. Limestone Reef Trap

Limestone reef trap is a type of **stratigraphic trap**, see *page 604* text.

When impermeable sediments bury coral reefs they can form excellent oil sources and reservoirs.



How it works

The physical property density is what distributes petroleum in a reservoir.

Water is denser than oil and oil is denser than gas. Therefore, when drilling into a petroleum trap, gas is encountered first followed by oil and then water.

Some reservoirs may have all three components, whereas some reservoirs may only have two components or one component.

Processes and Techniques Involved in Extracting and Refining Hydrocarbons

The two main means of extracting petroleum from Earth, include:

1. Drilling
2. Surface extraction (open pit mining)

1. Drilling

Drilling can take place on land, ice, or water.

A proportion of petroleum in a trap is under natural pressure and therefore, will be released naturally when tapped by a drill.

Another proportion of petroleum that will remain in the trap due to loss of pressure. Other techniques e.g. pumping in water, gas etc. and filling the reservoir will be required to get the remaining oil from the trap.

2. Surface Extraction (open pit mining)

Alberta oil sands,(tar sands)

Petroleum extracted directly from the surface (open-pit mining).

The petroleum migrated towards the surface and volatiles (e.g. water) were lost to the atmosphere.

The increased viscosity (i.e. thickness), prevented the oil from spreading out and/or dissipating.

The reservoir consisted of loose (unconsolidated) sediment that exhibited high porosity and permeability, but no cap rock.

In some instances, steam is injected directly into the tar sands to mobilize the hydrocarbons, which are then recovered from pumps much like conventional crude oil.

Fort McMurray's Athabasca oil sands is a good example.

Methods of Refining Petroleum.

1. Distillation

Crude oil contains hundreds of different types of hydrocarbons all mixed together.

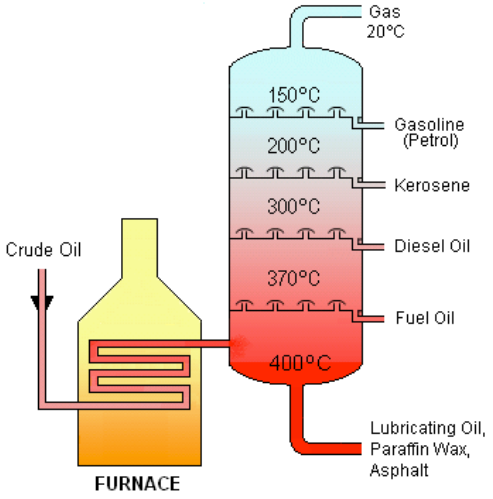
Different hydrocarbon chain lengths all have progressively higher boiling points, so they can all be separated by distillation (heating).

2. Cracking

Cracking processes breaks down heavier hydrocarbon molecules (high boiling point oils) into lighter products such as petrol and diesel. Catalytic cracking or, thermal cracking does this.

3. Reforming

This is the conversion of straight chain hydrocarbon into branched chain hydrocarbon, such as gasoline. Involves heat, pressure, and the use of catalysts (speed up reaction rates) to reform different hydrocarbon compounds.



<u>Sustainable Development</u> - the decisions we make today will impact our future.

What is meant by sustainable development? _____

_____

How does it relate to extracting and processing Earth Resources? _____

_____

What are other economic, environmental, political/social/cultural aspects relate to extraction of resources? _____

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DO STSE #5 Next

Questions:

1. What are Hydrocarbons?

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2. What is Kerogen? How does it turn into oil?

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3. How does a petroleum trap form?

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4. List the four types of traps. Choose one, and with the aid of a labelled diagram, describe how it works.

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5. How is density important to the extraction of oil?

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6. What are the methods for refining oil? Choose one, and explain how it works.

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Earth Systems 3209 Unit 5 Test Review

Please answer the following completely and on your own paper. You may type them, or handwrite them legibly.

Definitions (Terms to know)

Economic Minerals	Ore	Magmatic (layered and disseminated)
Hydrothermal (vein deposits)	Placer	Secondary enrichment (sedimentation)
Metamorphism	Floatation	Gravity separation
Heap leaching	Pyromet	Hydromet
Petroleum	Crude Oil	Hydrocarbons
Diagenesis	Catagenesis	Metagenesis
Source rock	Reservoir rock	Cap Rock
Anticline trap	Fault trap	Salt dome trap
Stratigraphic trap	Distillation	Cracking
Reforming		

Review Questions

1. Describe the different types of economic mineral deposits
2. Identify the 2 types of mines
3. Identify exploration techniques
4. Describe techniques for processing ore deposits
5. Describe the origin and the process of formation of petroleum
6. Identify the three phases in the evolution of organic matter to petroleum
7. Describe the components involved in the formation of petroleum traps
8. Describe the types of petroleum traps
9. Describe the distribution of petroleum in a reservoir.
10. Describe the two main means of extracting petroleum from Earth
11. Describe the methods of refining petroleum
12. Describe sustainable development in relation to the use of Earth's resources
13. Identify and describe core components involved in the sustainable development of Earth's resources