

A photograph of a peat bog. The foreground shows dark, rich soil with some dead twigs and a small, grey, fluffy object. The background is filled with green grasses and small white flowers. The text is overlaid on the image.

Chemical Sedimentary Rocks

Introduction
Phosphates, Organic-rich Sediments

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A peat bog dark soil, indicating an elevated content of organic matter
Wickaninnish, Ucluelet (Vancouver Island), British Columbia, Canada

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Chemical Sedimentary Rocks

- **Carbonates** and **Cherts**, but also **Phosphorites** and **Organic-rich Materials** (Coal and Petroleum) form mostly as the result of biological activity
- **Iron-rich sedimentary rocks** and **Evaporites** (Rock Salt, Gypsum, Anhydrite) form from inorganic precipitation from solution
- Carbonates are the most common chemical deposit and will be dealt with separately
- Cherts will be discussed alongside carbonates
- Evaporites will also be dealt with on their own

Phosphorites

- While minor amounts of phosphate ions (PO_4^{2-}) are found in most sedimentary rocks, pure sedimentary phosphate deposits (phosphorites) are very rare

- Minerals:

- Fluorapatite $\text{Ca}_5(\text{PO}_4)_3\text{F}$

- most common

- Hydroxyapatite $\text{Ca}_5(\text{PO}_4)_3\text{OH}$

- Primary mineral in vertebrate bones and teeth
 - F in toothpaste is used to convert hydroxyapatite in the more decay-resistant fluorapatite



Apatite crystal

the phosphate ion PO_4^{2-}

- The phosphate ion comes either from hydrothermal deposits or weathering of fluorapatite
- Phosphate is essential for organisms because it is an integral component of RNA and DNA

Origin of phosphorite deposits

- in **nodules** along the outer edge of modern continental shelves (most common)
 - nutrient-rich water from the ocean bottom are responsible for algal blooms
 - blooms cause mass fish kills and their bones are turned into phosphorite deposits
- in (rare) **bone beds** concentration deposits
- from **leaching of guano** (fecal matter of birds or bats) into underlying rocks (rare)

Organic-Rich Sediments

- Coal, Petroleum (oil and natural gas), Oil Shale, solid hydrocarbons such as Asphalts in Tar Sands are not sedimentary rocks per se but rather accumulations of undecayed carbon-rich organic matter in said rocks
- Organic matter makes up the bulk of the material in coal, but all others are disseminated in pore and/or fracture spaces in sandstones, mudstones, limestones
- Overall, these are **fossil fuels**, that consist of undecayed organic tissue that are burned to produce thermal energy

Coal

- Coal consists of solid bits and pieces of undecayed plant material
- Coal is typically concentrated as individual layers (coal seams) within other sedimentary rocks
- Coal rank measures the purity of a coal
 - Peat (mostly plant remains, not a coal proper yet)
 - Lignite (brown coal, with abundant moisture)
 - Bituminous Coal (soft coal, up to 90% carbon)
 - Anthracite Coal (up to 100% carbon)

coal seams in sandstone



Coal seams in downtown Nanaimo, Vancouver Island, British Columbia, Canada

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Coal-forming conditions

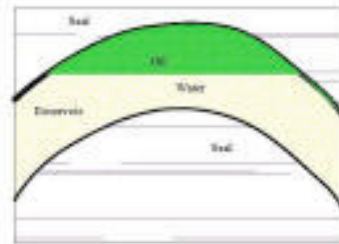
- Vegetative growth must be lush. Plant populations flourish best in a warm, moist (tropical) climate
- Environmental conditions should favor rapid production of large masses of dead vegetation that are buried quickly (so to avoid contact with oxygen)
- These conditions must occur at the same time and while other rocks are not deposited or at their minimum

Petroleum

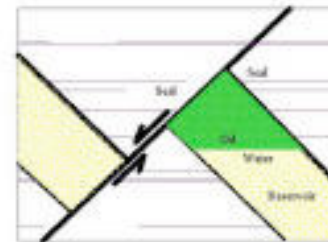
- Petroleum is carbonaceous organic matter disseminated in a liquid (**oil**) and/or a gaseous (**natural gas**, mostly methane, CH₄) state in the pore/fracture spaces of mostly sandstones and limestones
- Petroleum forms in source rocks, which are mostly fine-grained, deep marine ones
- Petroleum then migrates towards the surface and is dispersed in the environment, unless natural traps (structural or stratigraphic) block their ascent

hydrocarbon traps

Structural Traps

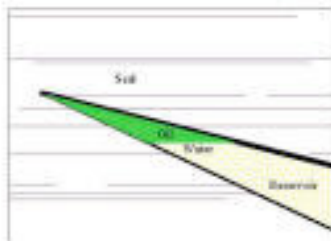


Anticline

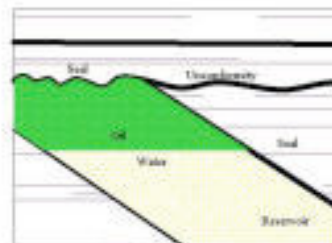


Fault

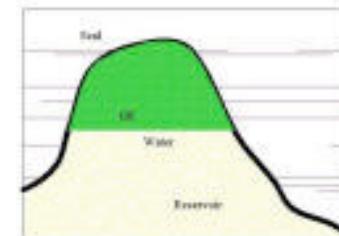
Stratigraphic Traps



Pinchout



Unconformity



Reef

Oil Shales

- Any shale that yield substantial quantities of oil when heated
- Often very finely laminated (layers are deposited in absence of oxygen, hence they are not disturbed by biological activity)
- More oil is thought to exist in these deposits than in conventional petroleum reservoirs (sandstones and limestones)
- Mostly Phanerozoic in age, like other petroleum deposits

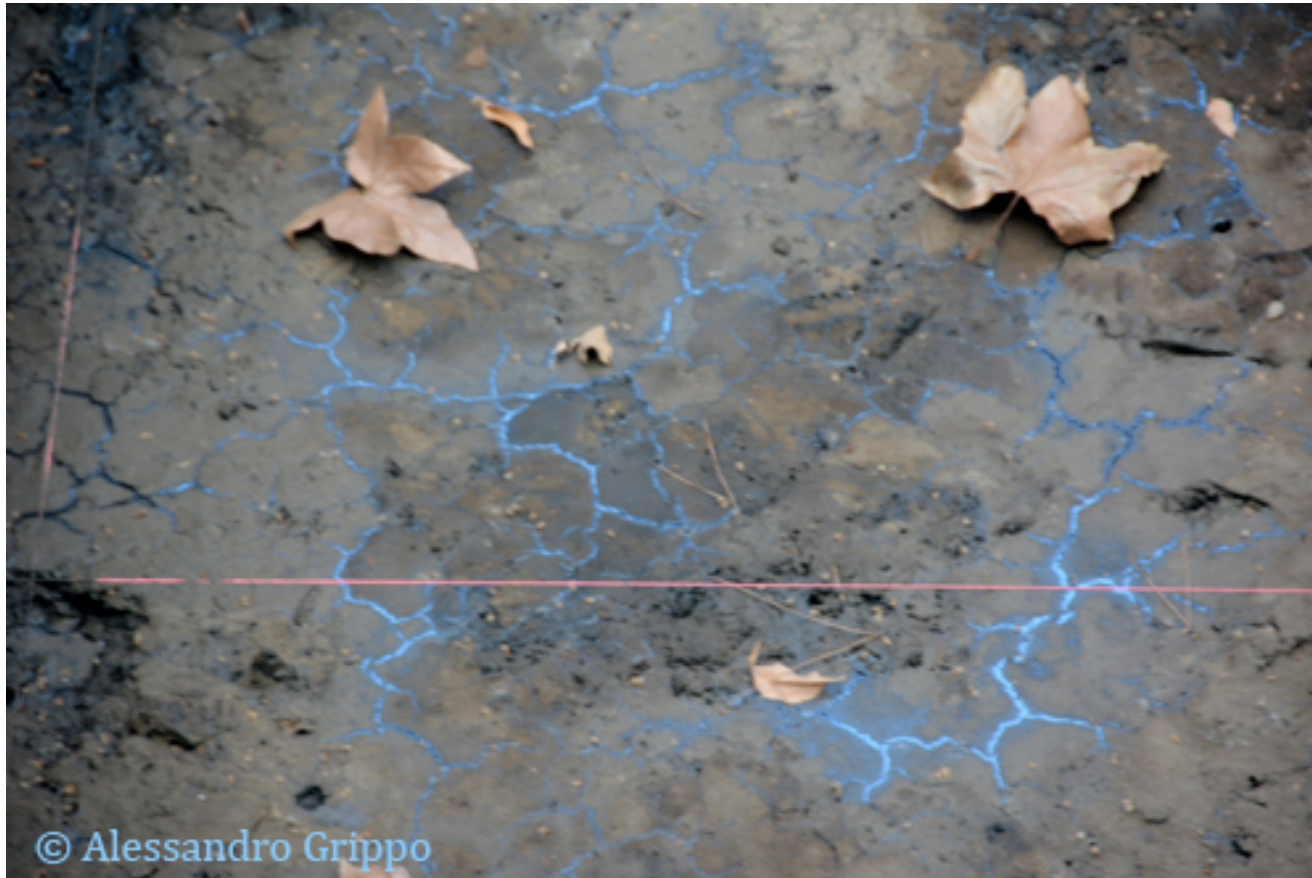
Oil shales releasing gas shale



solid hydrocarbons

- Several types of highly viscous hydrocarbons occur in sedimentary rocks
 - Asphalts (semisolid)
 - Bitumens, mineral waxes (solid)
- All derive from conventional petroleum and occur as surface pools, solid intrusions in rocks, and the fill of porous sandstone
- Examples:
 - Pleistocene La Brea Tar Pits (asphalt seep) in Los Angeles CA
 - Cretaceous Athabasca Tar Sands of Alberta

seeping asphalt



The bottom of an asphalt pit at the La Brea Tar Pits
Los Angeles, California

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Biochemical Sedimentary Rocks
(except for Carbonates and Cherts)

Summary

- Phosphorites
 - Rocks rich in phosphate ions (PO_4^{2-}), mostly derived from vertebrate bones or leaching of phosphate-rich materials like guano
 - Uncommon, but important for society
- Organic Rich-Sediments
 - Sediments that contain high amounts of organic carbon, usually preserved because of deposition, burial, diagenesis in environments with little or no oxygen (anoxic, or euxinic)