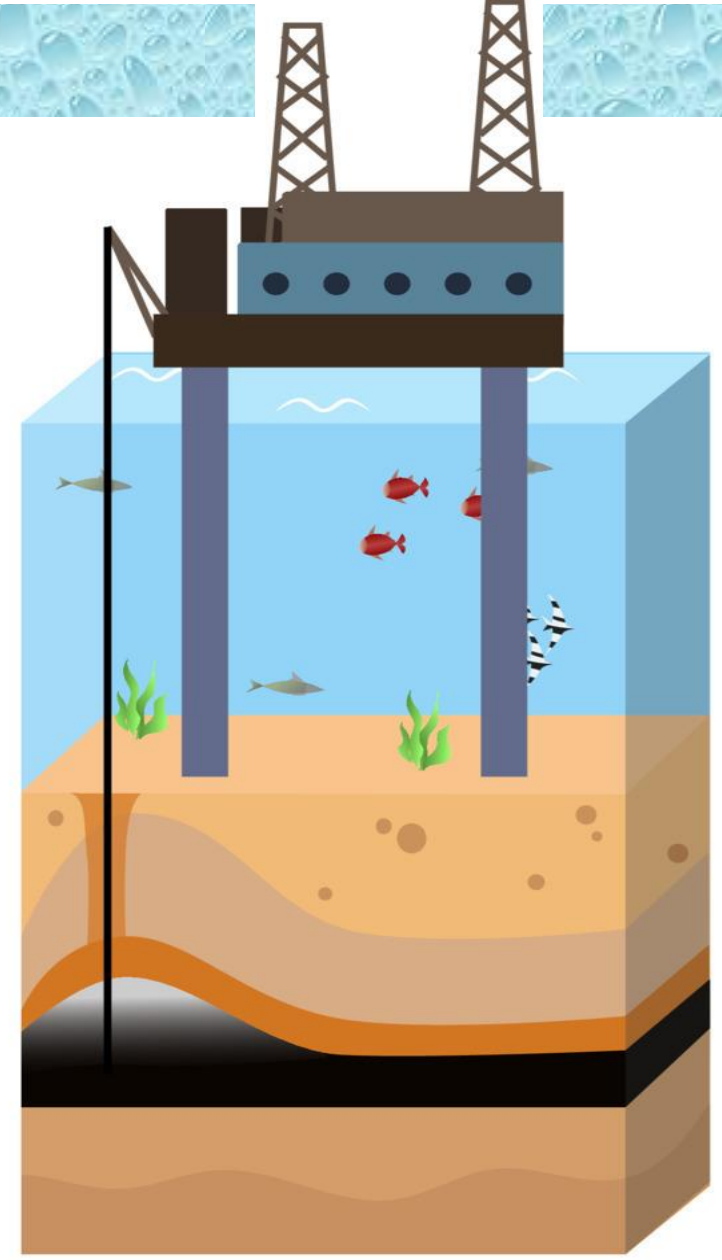
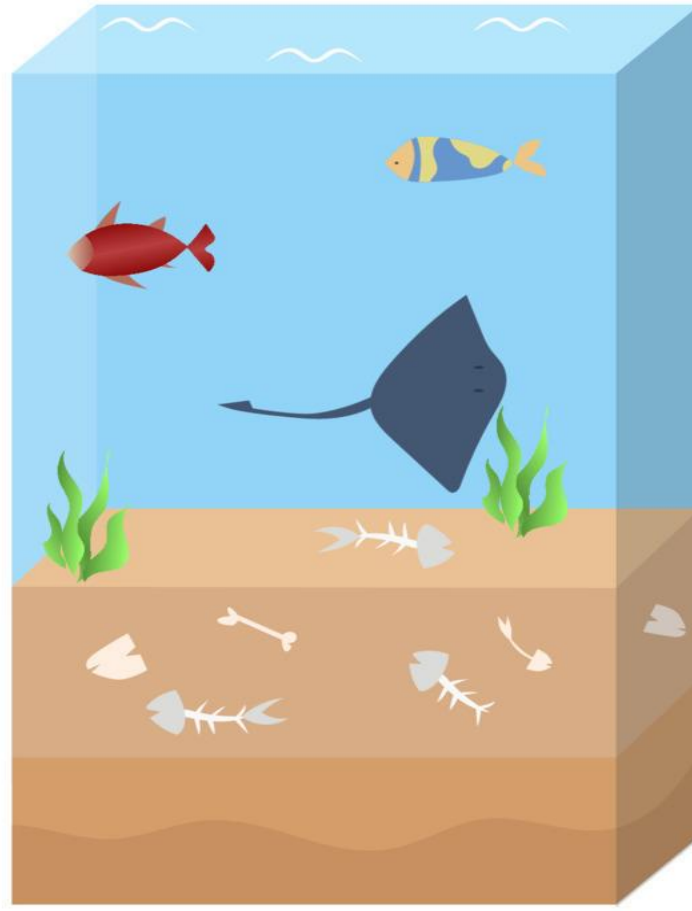
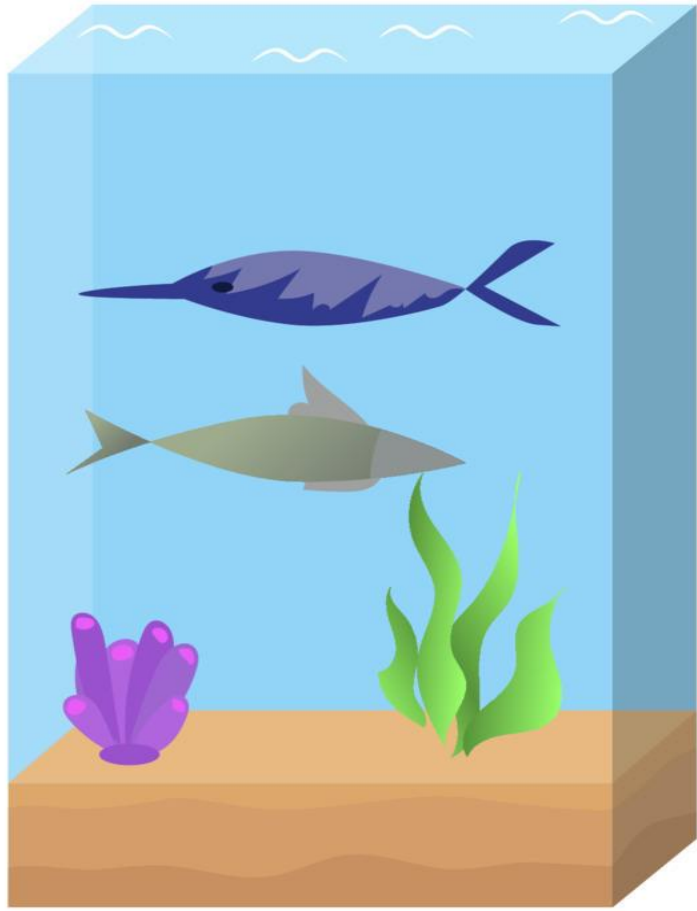


The Origin of Petroleum



Million of Years

Dr. Ali Kahal – 2024 – KSU

The Origin of Petroleum

Petroleum System

A Petroleum System is defined as a natural system comprising an active source rock and all associated oil and gas, along with essential geological elements and processes necessary for the existence of a hydrocarbon accumulation.

Elements

Source Rock

Fine-grained, organic-rich that have the potential to generate petroleum

Migration Route

It is the cracks, faults and pores in the rocks through which oil and gas move.

Reservoir Rock

Subsurface rock and sediment materials characterized by porosity and permeability, to allow the migration and accumulation of petroleum hydrocarbons

Seal Rock

A unit with low permeability that impedes the escape of hydrocarbons from the reservoir rock

Trap

A geological structure where petroleum accumulates within a layer (formation) of sedimentary rock and cannot move out of it

Processes

Generation

Burial of source rock to temperature and pressure regime sufficient to convert organic matter (kerogen) into hydrocarbons

Migration

Migration is the process of the oil and gas moving away from the source rocks

Accumulation

Hydrocarbons migrate into a trap faster than the trap leaks, forming a reservoir

Preservation

Hydrocarbons remain in the reservoir and are not destroyed by biodegradation or overheating

The Origin of Petroleum

□ Origin of Petroleum: Organic or Inorganic

➤ There are two different theories for the origin of petroleum:

❖ Inorganic theory :

- Inorganic theory of the origin of the petroleum starts that hydrogen and carbon came together under great temperature and pressure, far below the earth's surface and formed oil and gas.
- The oil and gas then seeped through porous rocks to deposit in various natural underground traps.

❖ Problems with Inorganic Theories

- No field evidence that inorganic processes have occurred in nature.
- Commercial accumulations are restricted to mainly sedimentary basins.
- Accumulations are absent from igneous and metamorphic rocks.

❖ Organic theory :

- Organic theory is the one most widely accepted
- According to organic theory the oil and gas are formed from remains of plants and animals

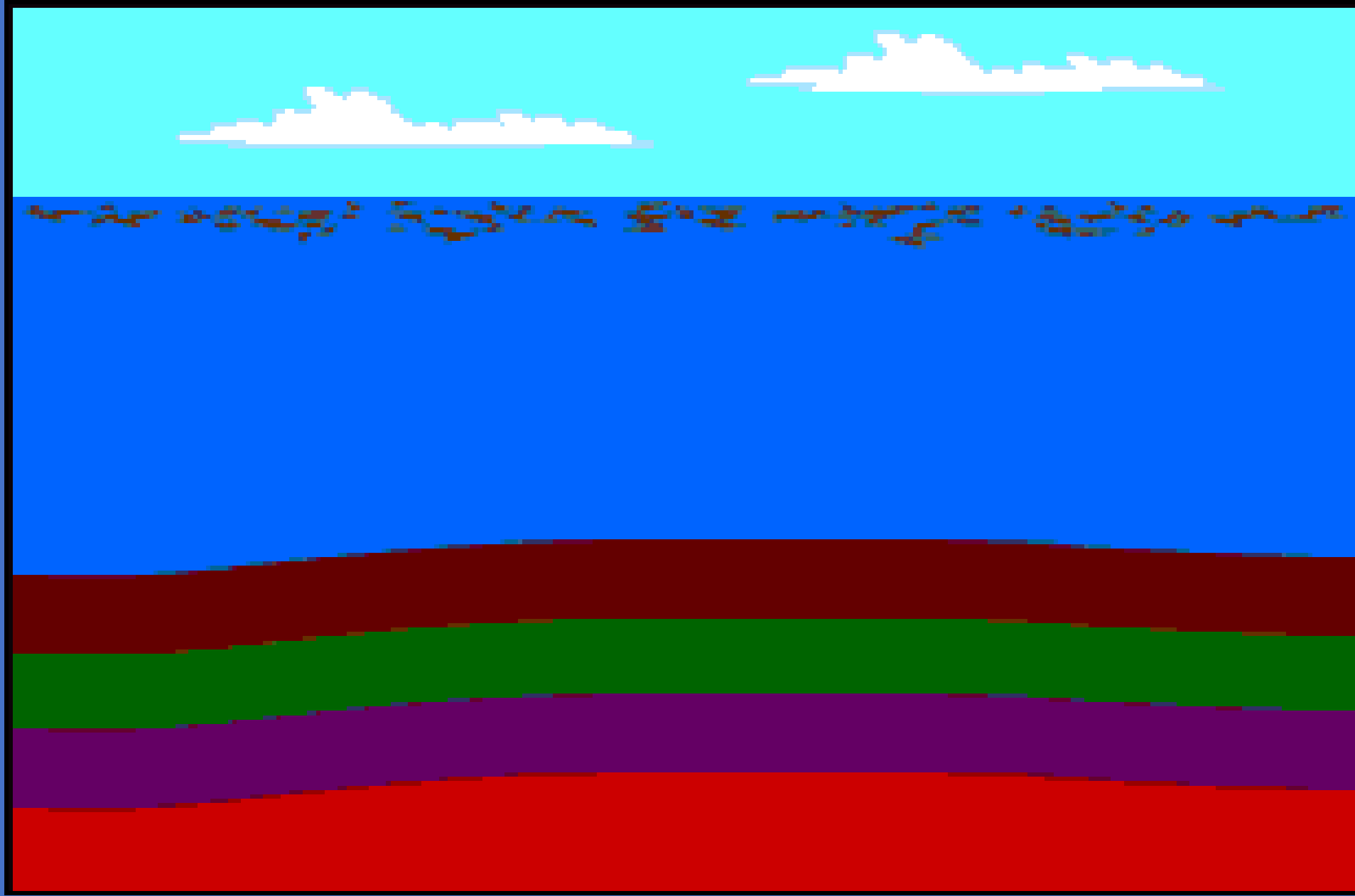
The Origin of Petroleum

Organic theory

Microscopic marine animals (zooplankton) and plants (phytoplankton) floating in surface waters



They die, fall to the bottom and get buried into an organic rich sedimentary layer



The Origin of Petroleum

Organic theory

At this point, organic matter (small marine and lake organisms) becomes mingled with sediment (sand, salt, etc.),

Being made up of carbon, hydrogen, nitrogen and oxygen, most organic waste is destroyed and digested by bacteria. But some was deposited on the beds of inland seas, lagoons, lakes, river deltas and other oxygen-poor aquatic milieus, and were thus protected from bacterial action.

And then accumulates in layers over many millions of years, the oldest layers being buried beneath more recent ones.



The Origin of Petroleum

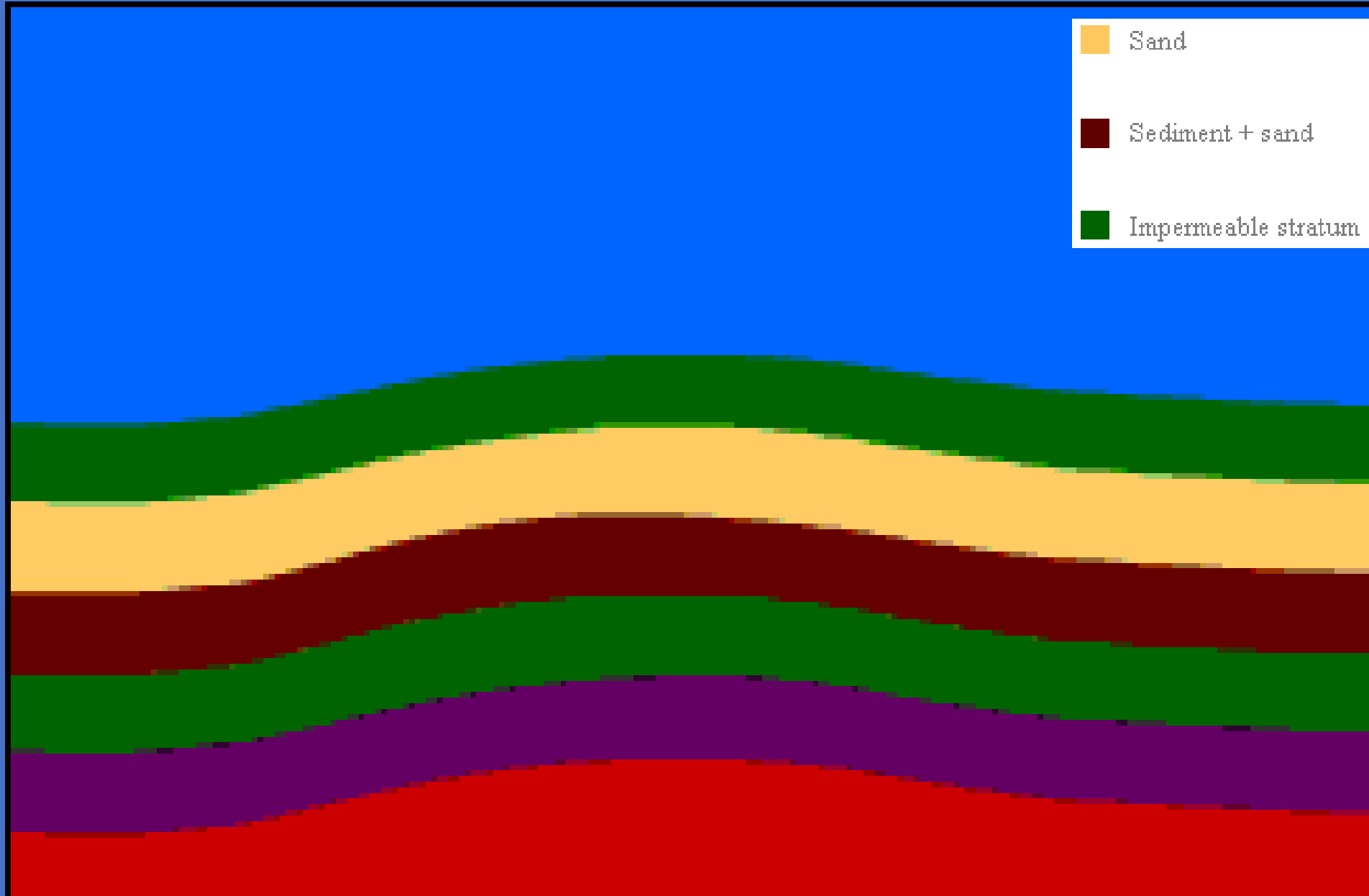
Organic theory

By their sheer mass, these sedimentary layers sink more deeply into the Earth's crust.

Plate movements and related tectonic stresses appear to be responsible for structural developments highlighted three type of traps (anticline and fault)

The movement of Salt mass cause salt dome

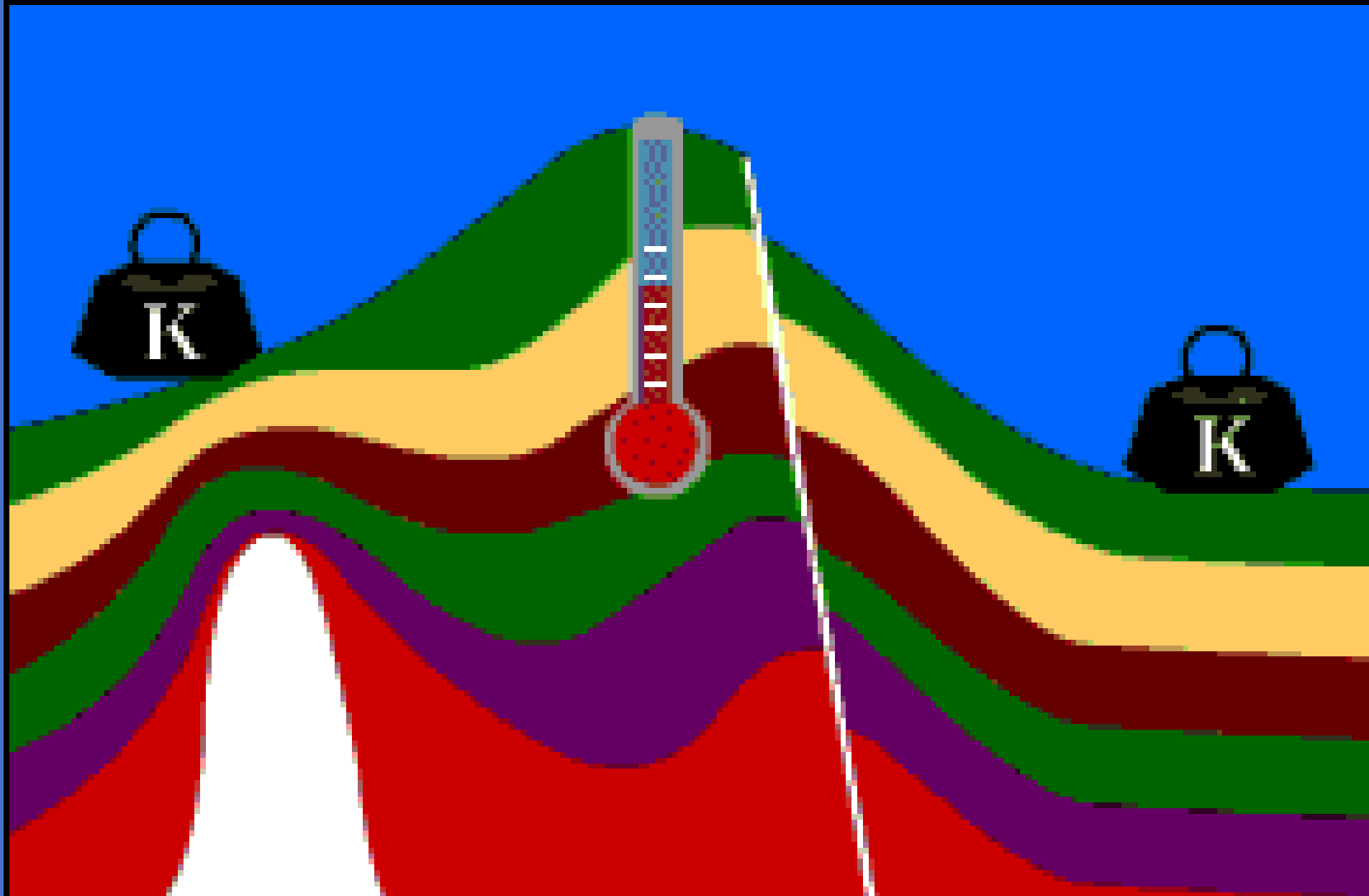
According to lithological deformation that might have been happen, the cap rock may be found in various types.



The Origin of Petroleum

Organic theory

- Accumulates more layers over many millions of years, as older layers are buried deep within the Earth
- Owing to the increasing temperature and pressures with depth,
- Plankton - rich layer are buried, kerogens (organic rock fragments) undergo chemical and physical changes that result in formation of oil and gas and excess formation pressure.

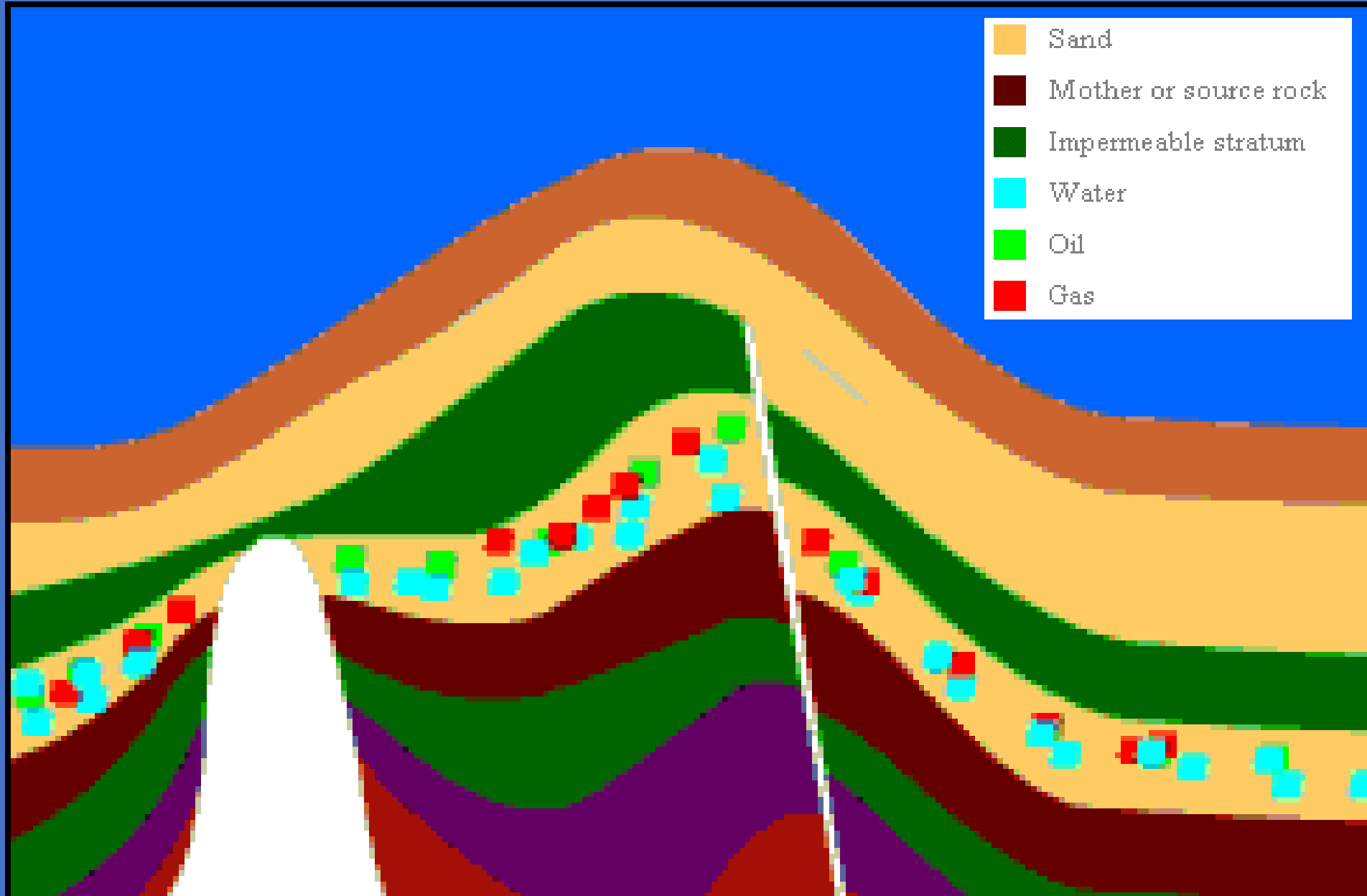


The Origin of Petroleum

Organic theory

Inside this reservoir rock, oil and gas flows upwards and accumulates in traps, the gaseous hydrocarbons slowly rise above the oil.

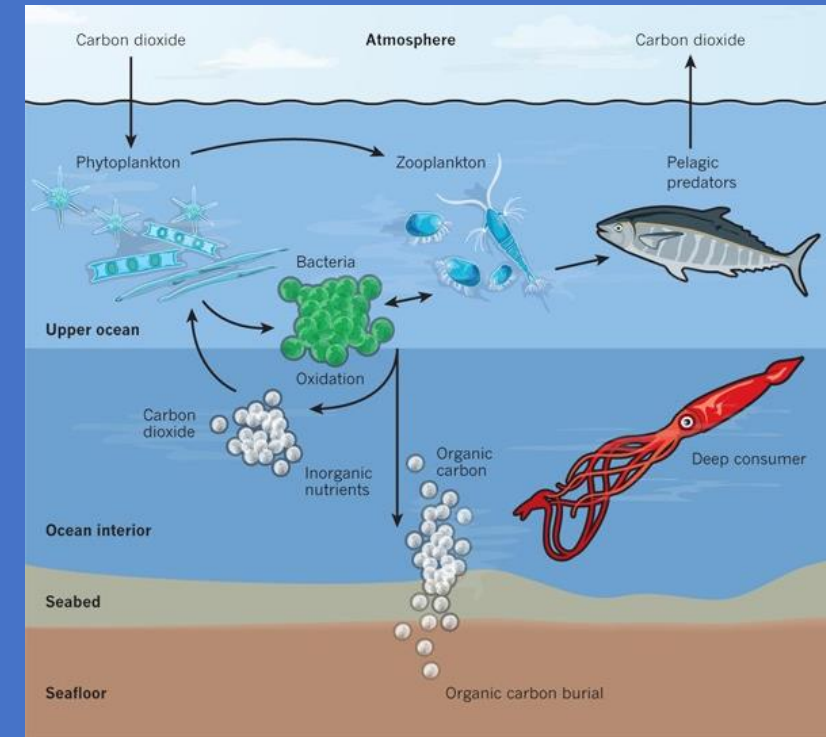
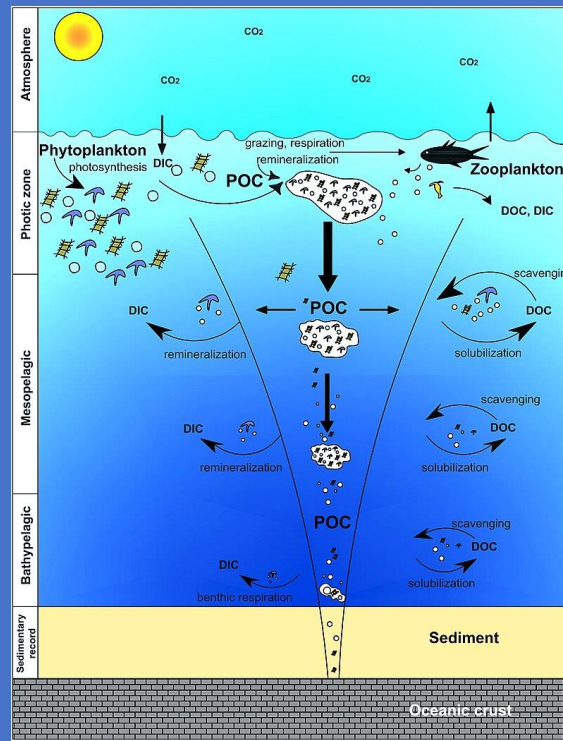
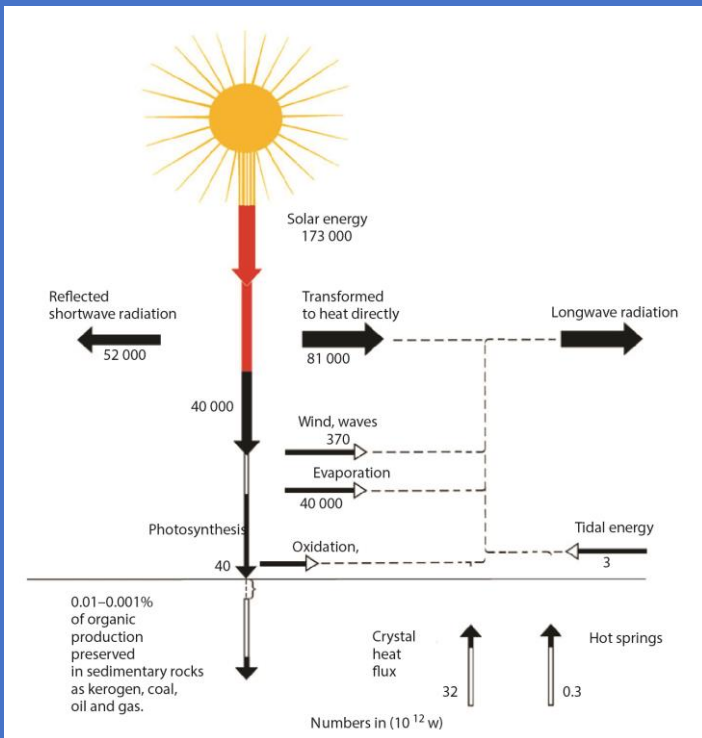
The migrating oil and gas may travel up through the spaces between the sand grains that make up the rock (called pores) or they may find their way up through cracks, fissures, and faults in the overlying rocks.



The Origin of Petroleum

Accumulations of Organic Matter

- The organic matter from which petroleum is derived originated through photosynthesis, i.e. storage of solar Energy
- Transformation of solar energy to fossil fuels by photosynthesis. Only a small fraction of the solar energy is used for photosynthesis and most of the produced organic matter is oxidised. As a result very little organic matter is buried and stored in sedimentary rocks and very little of this is concentrated enough to become a potential source rock



Transformation of solar energy to fossil fuels by photosynthesis

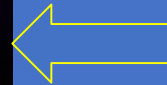
Photic zone: 0–100 m; Mesopelagic: 100–1000 m; Bathypelagic: 1000 to abyssal depths. Below 1000 m depth carbon is considered removed from the atmosphere for at least 100 years.

Phytoplankton drive a biological pump that uses the Sun's energy to move carbon from the atmosphere to the ocean interior, bringing down the atmospheric levels of carbon dioxide.

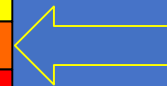
The Origin of Petroleum

Accumulations of Organic Matter

- Phytoplankton provides nutrition for all other marine life in the oceans. Zooplankton feed on phytoplankton and therefore proliferate only where there is vigorous phytoplankton production.
- Organisms sink after they have died, and may decay so that nutrients are released and recycled at greater depths.



When the plankton dies it rains down on sea bed to form an organic mush

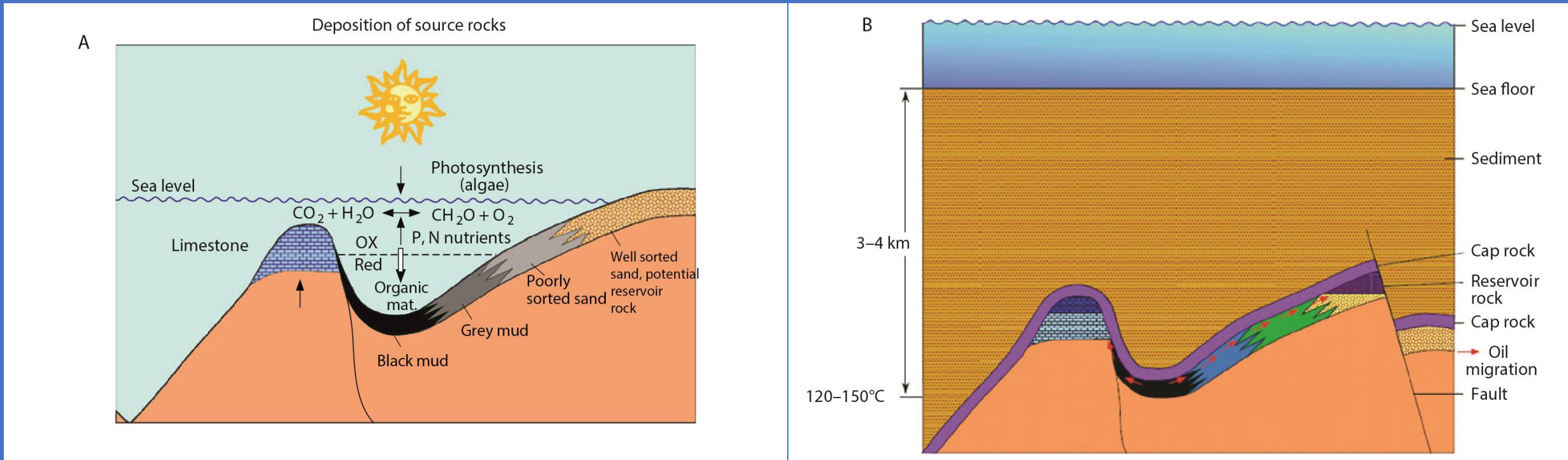


If there are any animals on the sea bed these will feed on the organic particles

The Origin of Petroleum

Accumulations of Organic Matter

- Basins with restricted water circulation will preserve more organic matter and produce good source rocks which may mature to generate oil and gas (Fig. 1.2a, b).

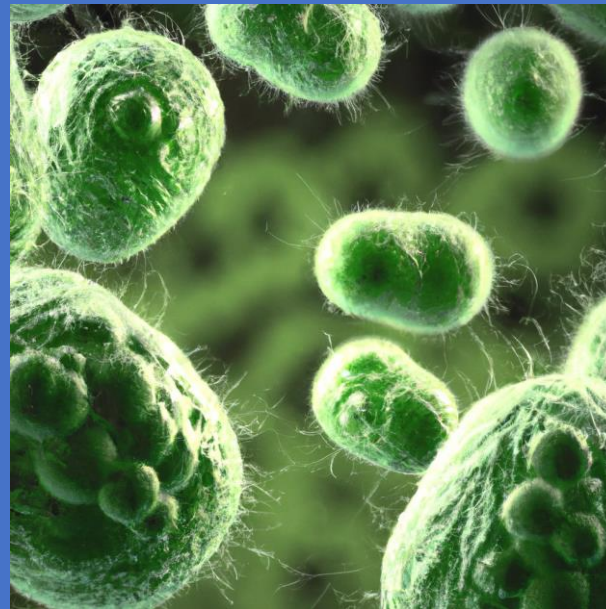


- (a) Depositional environments for potential source and reservoir rocks. Depressions on the sea floor with little water circulation provide the best setting for organic matter to be accumulated before it is oxidised.
- (b) Migration of petroleum from source rocks into reservoir rocks after burial and maturation. The carbonate trap (e.g. a reef) is a stratigraphic trap, while the sandstone forms a structural trap bounded by a fault

The Origin of Petroleum

Accumulations of Organic Matter

- Cyanobacteria, also known as blue-green algae, are a group of photosynthetic microorganisms that are found in a wide range of aquatic environments, such as rivers, lakes, and oceans. They are considered to be one of the oldest forms of life on Earth, and have been around for more than three billion years.
- Diatoms are an important group of phytoplankton. They contain a silica skeleton and may reach 1 mm in diameter



- Lake Erie experienced the worst blue-green algae bloom in decades (Photo Credit: MERIS/NASA; processed by NOAA/NOS/NCCOS)

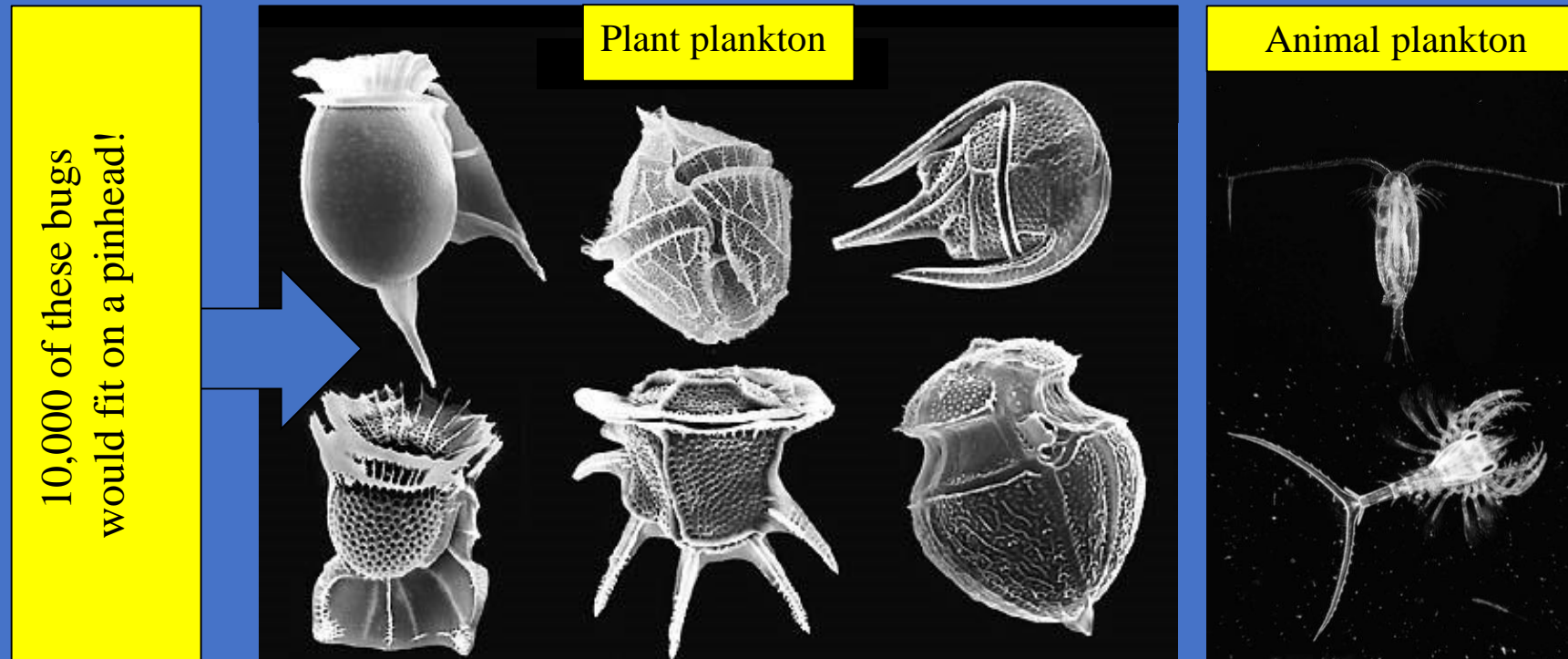
- Blue– green algae (cyanobacteria)

- Diatoms

The Origin of Petroleum

Accumulations of Organic Matter

- The most important of the zooplankton which provide organic matter for petroleum are:
 - I. Radiolaria – silica shells, wide distribution, particularly in tropical waters.
 - II. Foraminifera – shells of calcium carbonate.
 - III. Pteropods – pelagic gastropods (snails) with a foot which has been converted into wing-shaped lobes; carbonate shells.

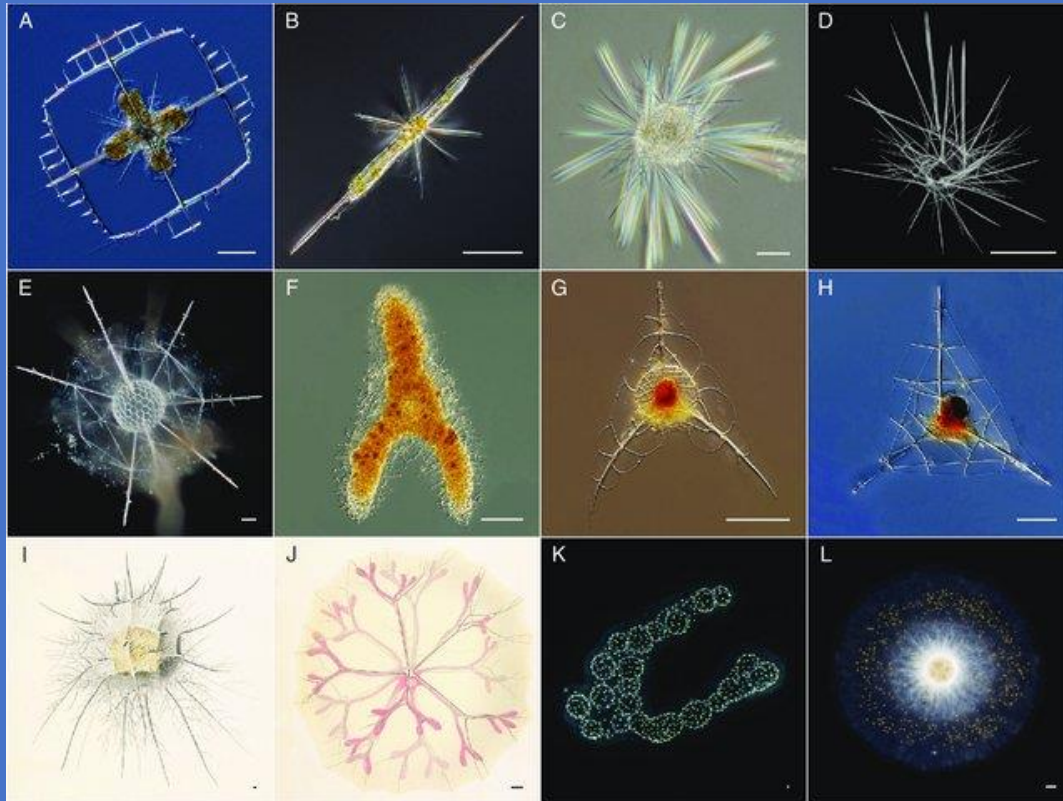


- Microscopic marine animals (zooplankton) and plants (phytoplankton) are the main sources of organic matter. Such microscopic species are diatoms, foraminifera, radiolarian, and benthic algae.

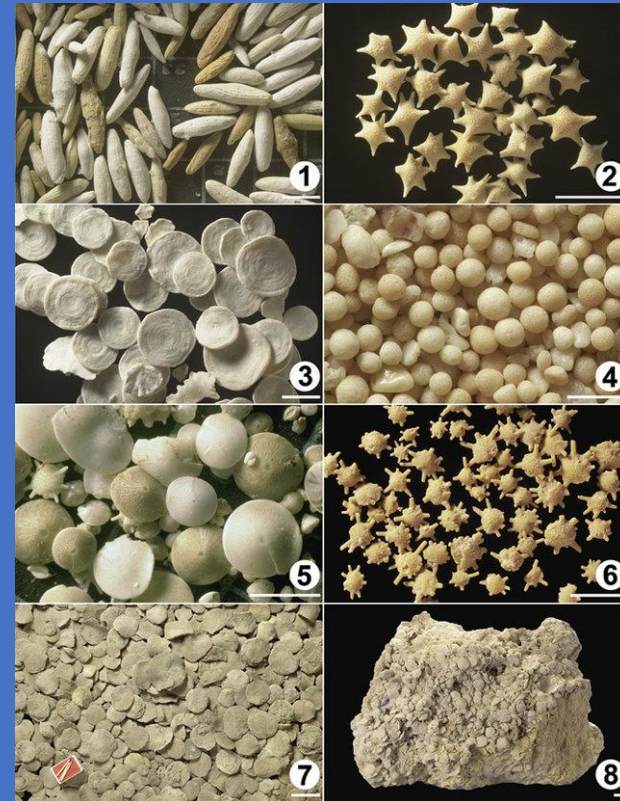
The Origin of Petroleum

Accumulations of Organic Matter

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■ Diversity of the different extant Radiolaria orders



■ Foraminifera

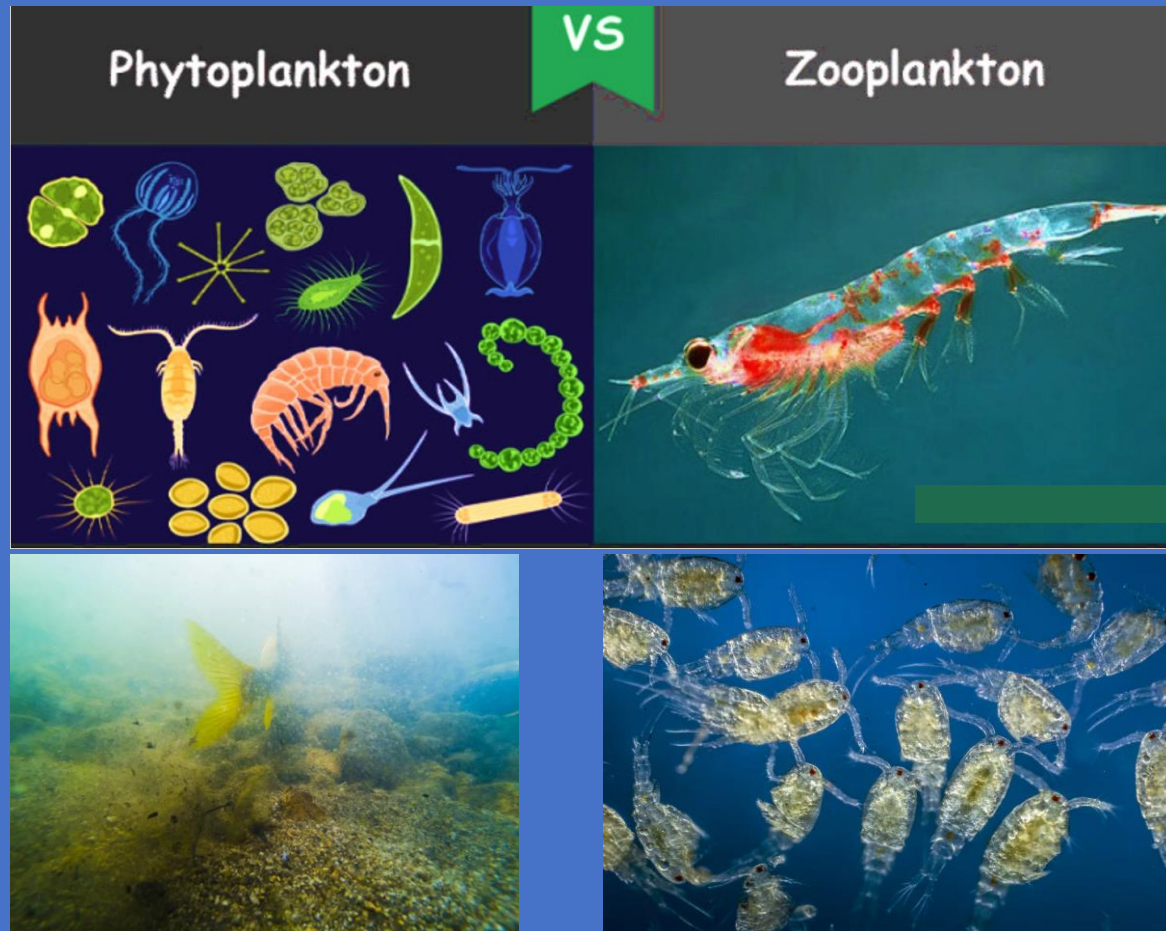


■ Pteropods, or “wing-footed” sea snails.

The Origin of Petroleum

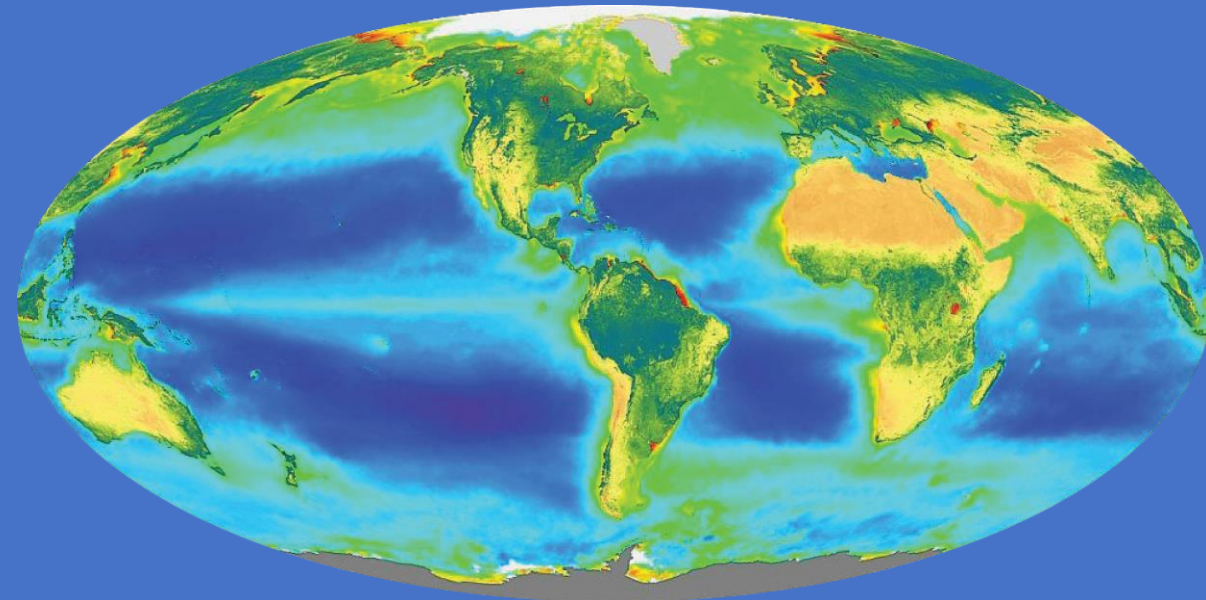
Accumulations of Organic Matter

- There are two basic forms of plankton: zooplankton and phytoplankton. Zooplankton (also known as "animal plankton") can be found in both saltwater and freshwater. There are estimated to be over 30,000 species of zooplankton.



■ Phytoplankton

■ Zooplankton



- Distribution of phytoplankton (primary producers of organic matter in oceans) depicted as concentration of chlorophyll. (Source: NASA)