Origin of petroleum dilemma

Inorganic or abiotic origin

vs.

organic origin

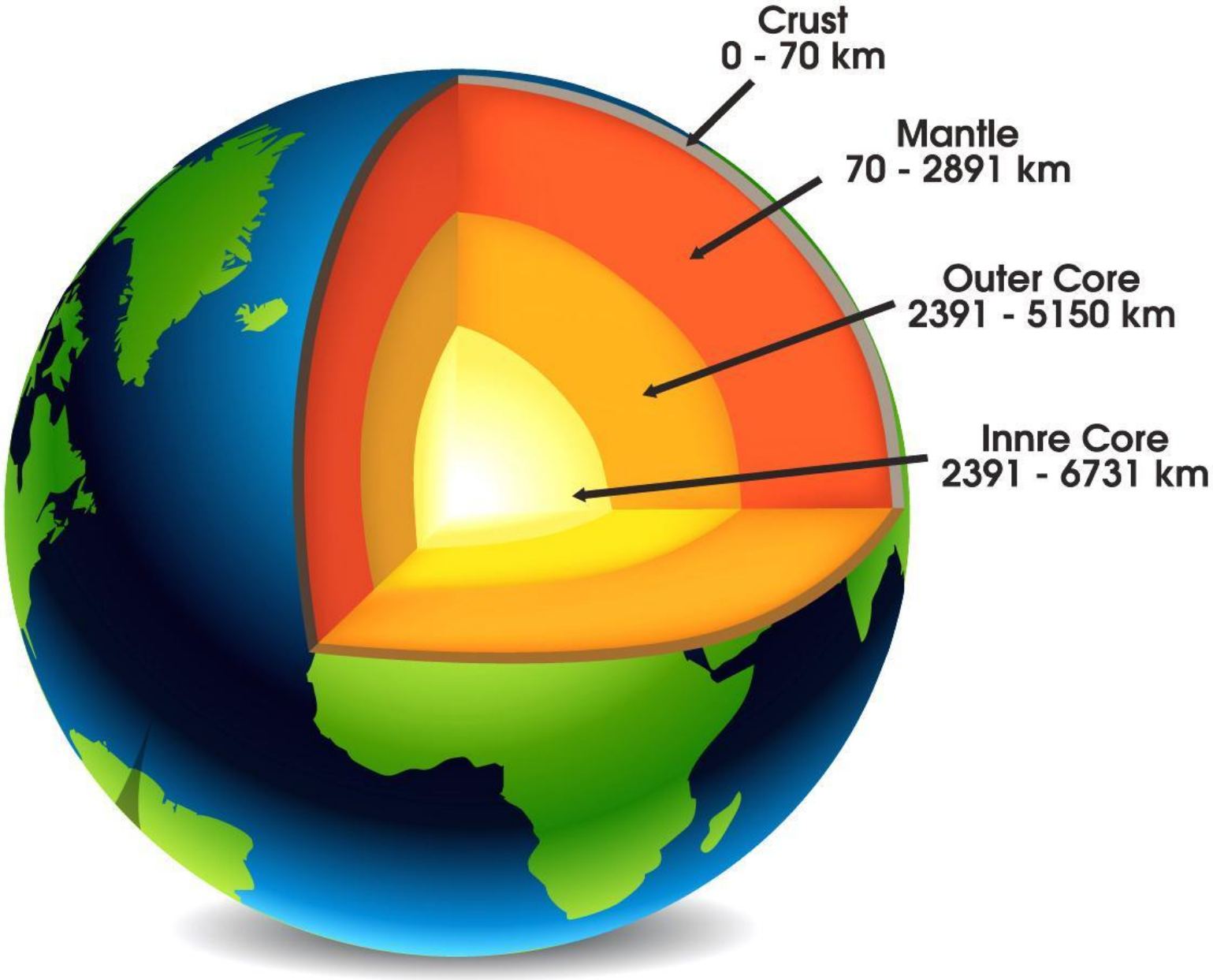
In 1877, Dmitri Mendele'ev postulated:

metallic carbides + water + high = acetylene (C_2H_2) = condensed to heavier HC.

modified by Berthelot in 1860 and by Mendele'ev in 1902:

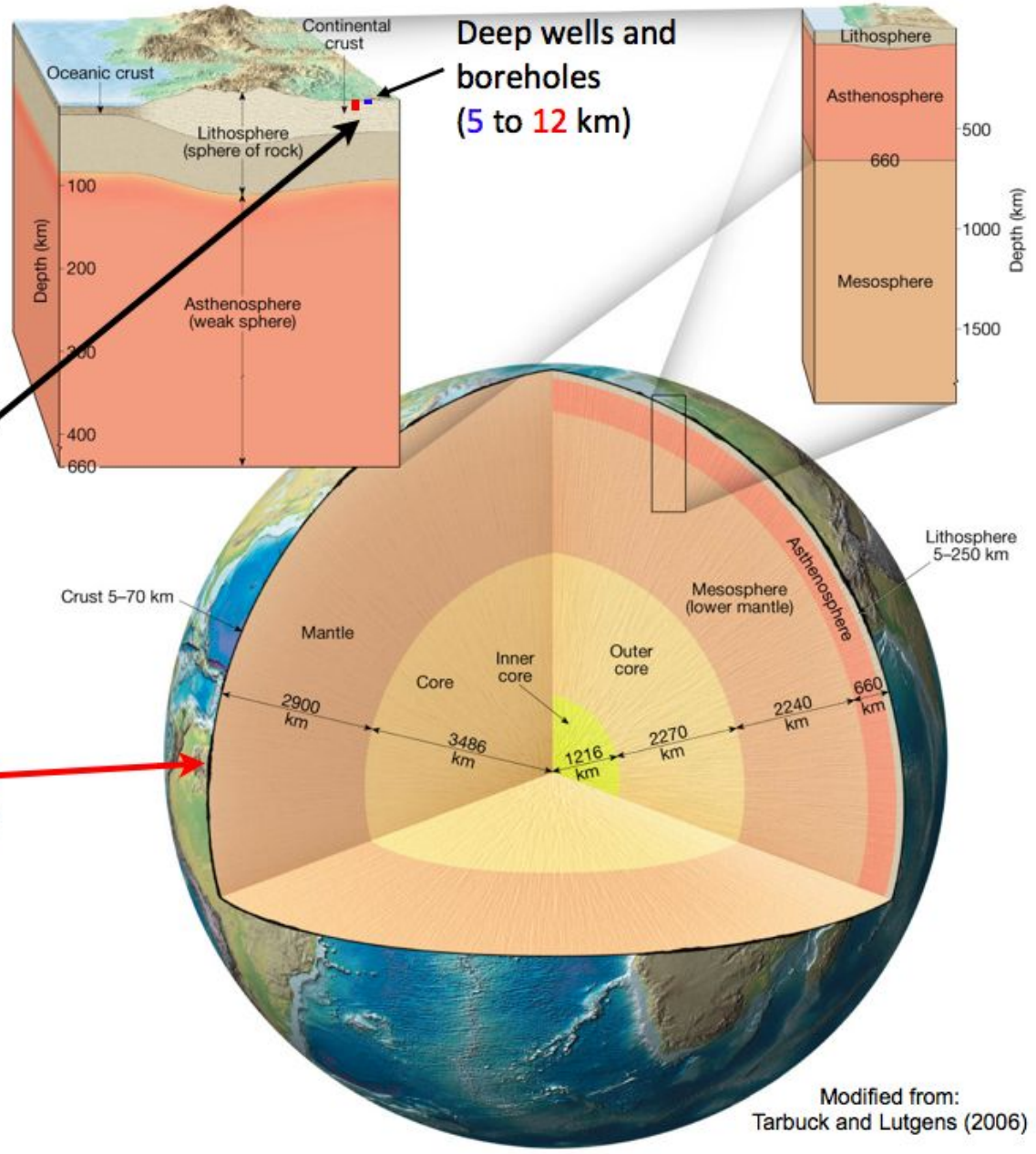
$FeC_2 + 2H_2O = CH_4 + FeO_2$

In 1890, Sokoloff proposed a cosmic origin for petroleum


Crust
0 - 70 km
Mantle
70 - 2891 km
Outer Core
2391 - 5150 km
Innre Core
2391 - 6731 km

Drilling of wells and boreholes has only penetrated about a third of the way into the Earth's crust.

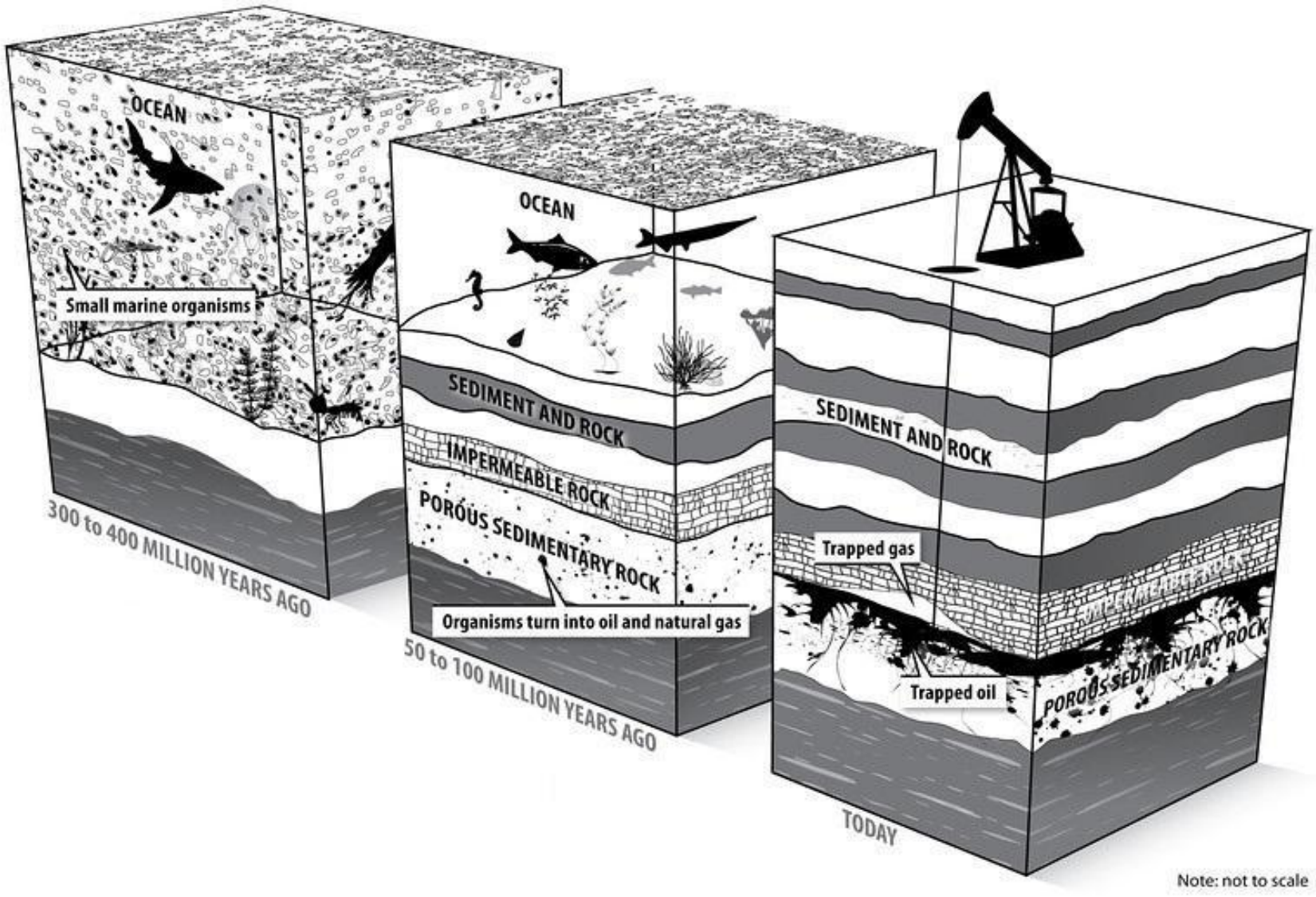
The crust is this very thin black line at the surface of the Earth.



Modified from:
Tarbuck and Lutgens (2006)

Organic theory

- First - carbon-hydrogen-organic matter connection
- Second - chemical characteristics of petroleum reservoirs with nitrogen and porphyrins found in all organic matter and in many petroleums.
- Third - physical characteristics
- Finally -time requirements may be less than 1MM years


OCEAN
Small marine organisms
300 to 400 MILLION YEARS AGO
OCEAN
SEDIMENT AND ROCK
IMPERMEABLE ROCK
POROUS SEDIMENTARY ROCK
Organisms turn into oil and natural gas
50 to 100 MILLION YEARS AGO
SEDIMENT AND ROCK
Trapped gas
Trapped oil
POROUS SEDIMENTARY ROCK
TODAY
Note: not to scale

Petroleum End Product

=

[Raw Material

+

Accumulation

+

Transformation

+

Migration]

+

Geologic Time

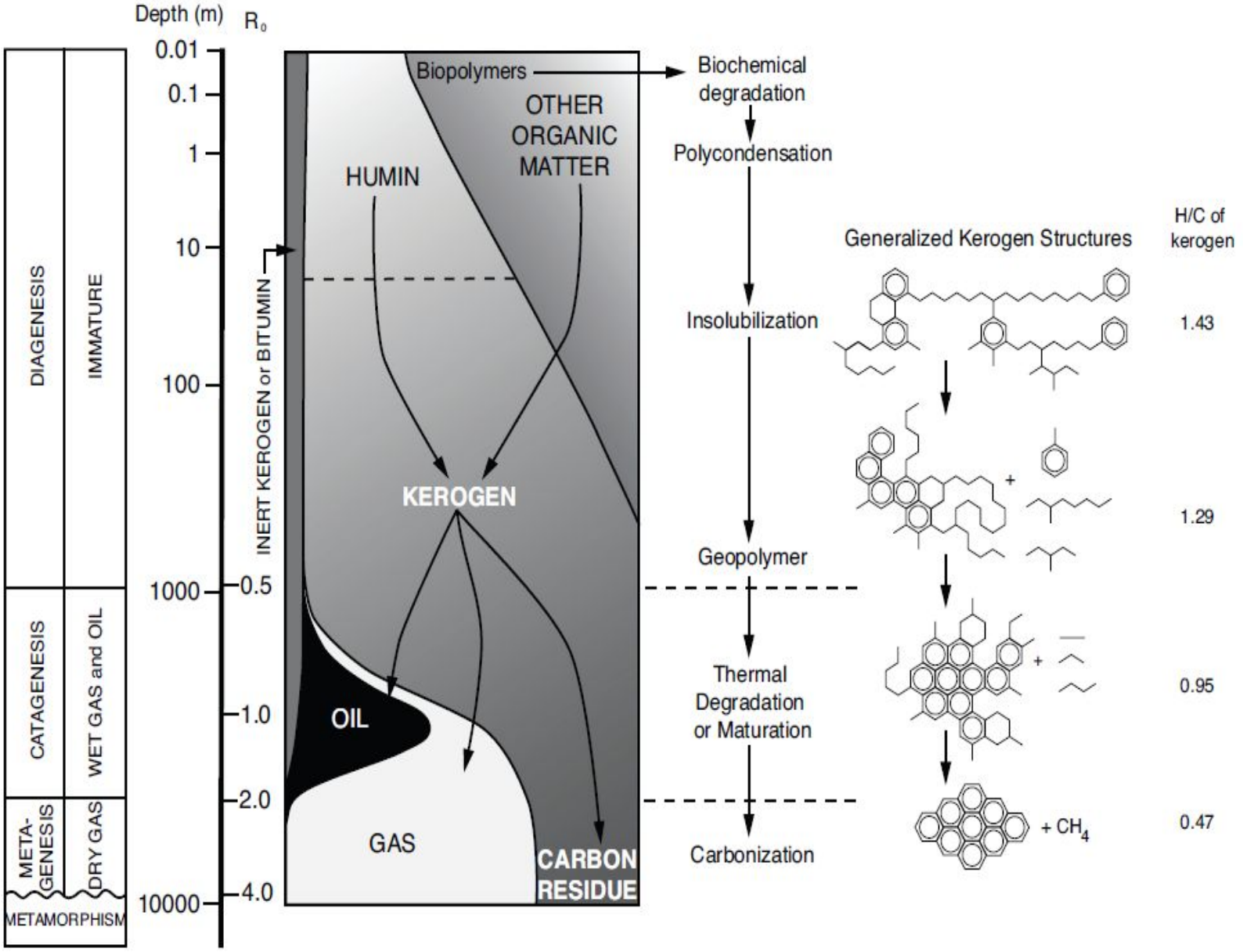
Diagenesis-catagenesis-metagenesis

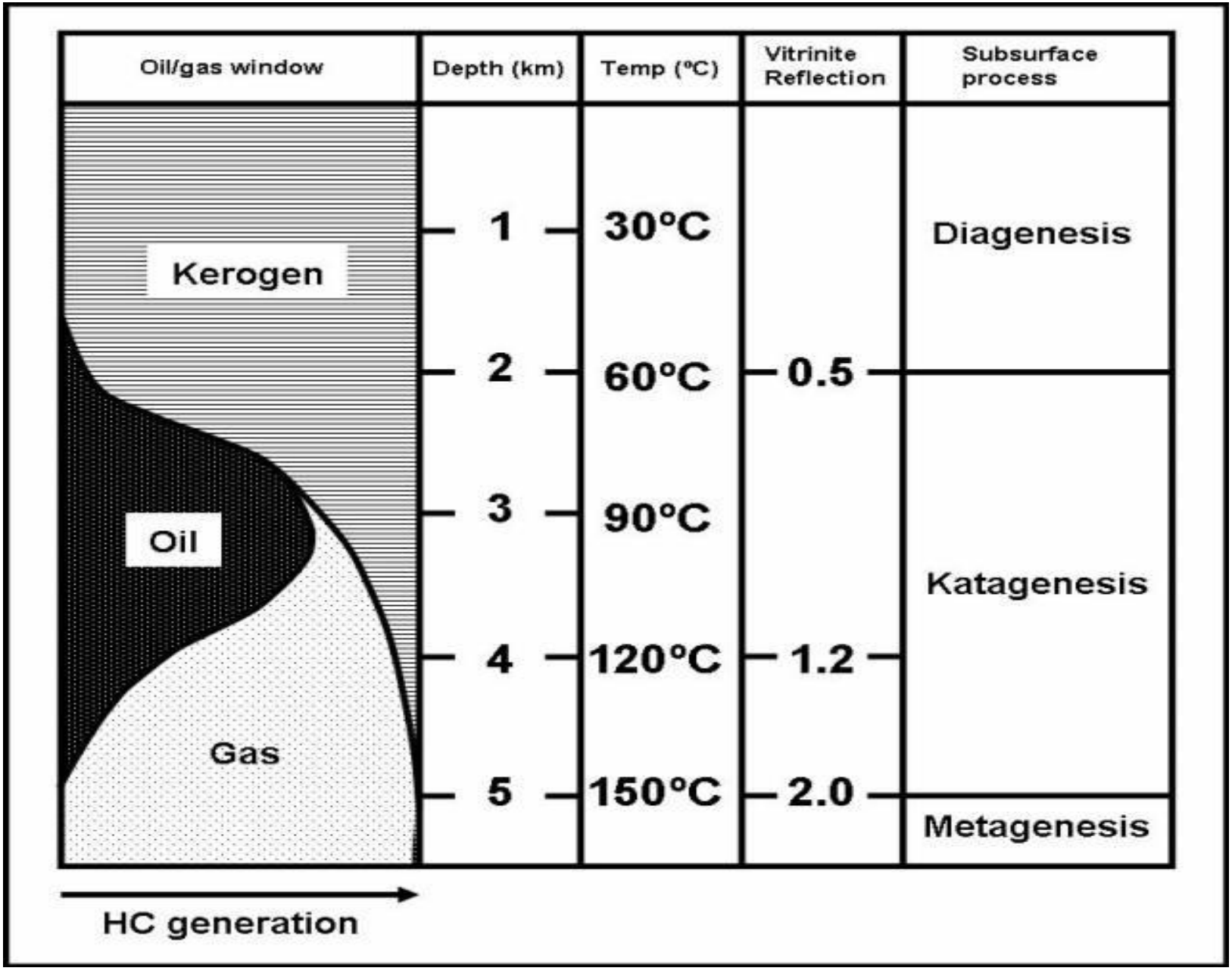
The maturation process needs several stages, they are:

- Diagenesis, this stage is the decomposition process occurs and there is a reduction in the oxygen content of organic material with abiotic reactions that produce methane and carbon dioxide kerogen. At this stage the organic material is still immature.

- Catagenesis, burial process continues and the fluid content of hydrocarbons starts out with an initial form of fluid and then the temperature rise resulting gas. At this stage, the percentage of H / C decreases but the O / C is not too reduced.

- Metagenesis, the process continues as a large burial pressure and temperature almost reached metamorphic phase. The end result can be either graphite.

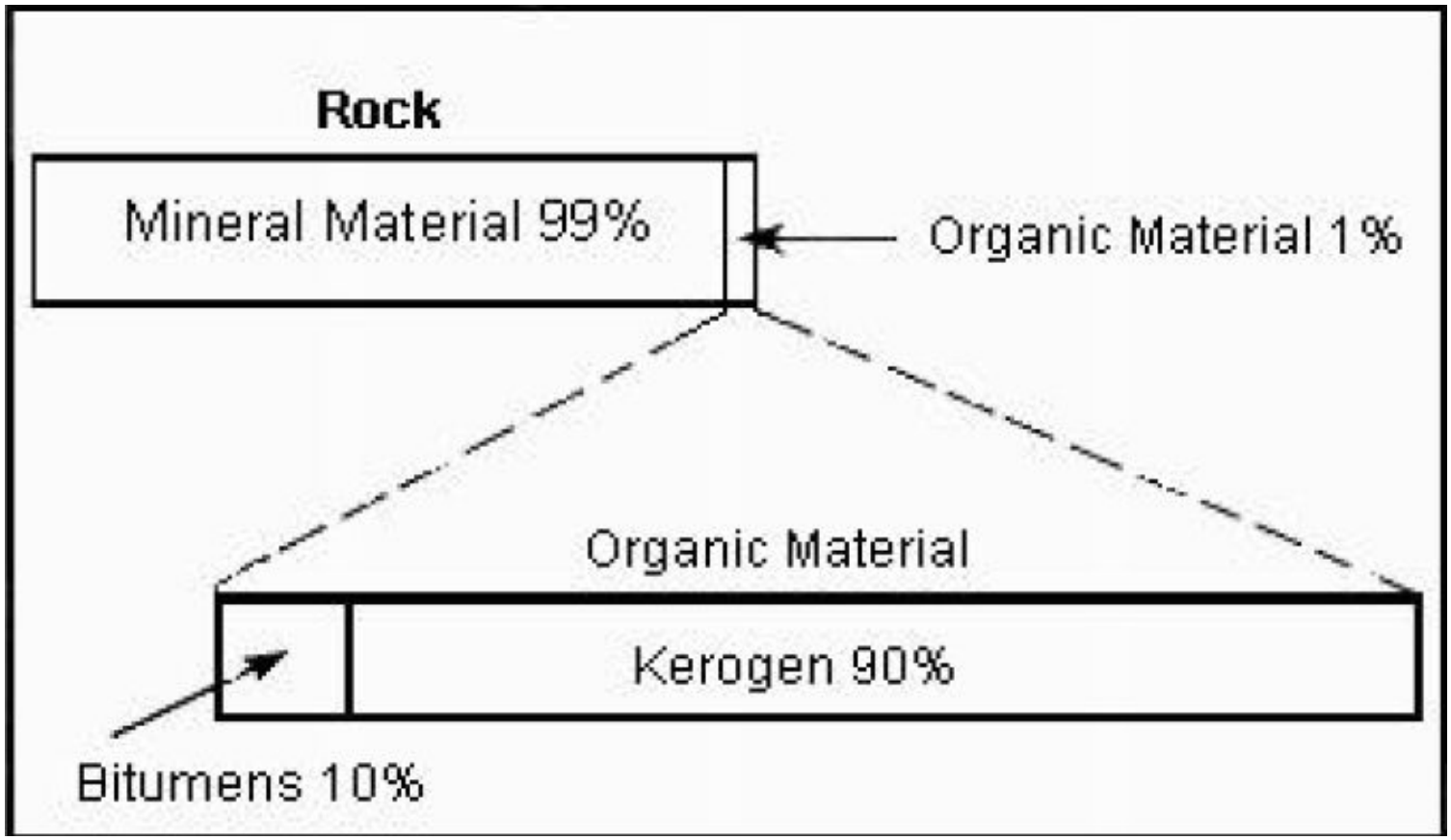

Depth (m)
R_o
0.01
0.1
1
10
100
1000
10000
0.5
1.0
2.0
4.0
DIAGENESIS
IMMATURE
CATAGENESIS
WET GAS and OIL
META-GENESIS
DRY GAS
METAMORPHISM
INERT KEROGEN or BITUMIN
Biopolymers
OTHER ORGANIC MATTER
HUMIN
KEROGEN
OIL
GAS
CARBON RESIDUE
Biochemical degradation
Polycondensation
Insolubilization
Geopolymer
Thermal Degradation or Maturation
Carbonization
Generalized Kerogen Structures
H/C of kerogen
1.43
1.29
0.95
0.47
+ CH_4


Oil/gas window
Depth (km)
Temp (°C)
Vitrinite Reflection
Subsurface process
Kerogen
Oil
Gas
1
2
3
4
5
30°C
60°C
90°C
120°C
150°C
0.5
1.2
2.0
Diagenesis
Katagenesis
Metagenesis
HC generation

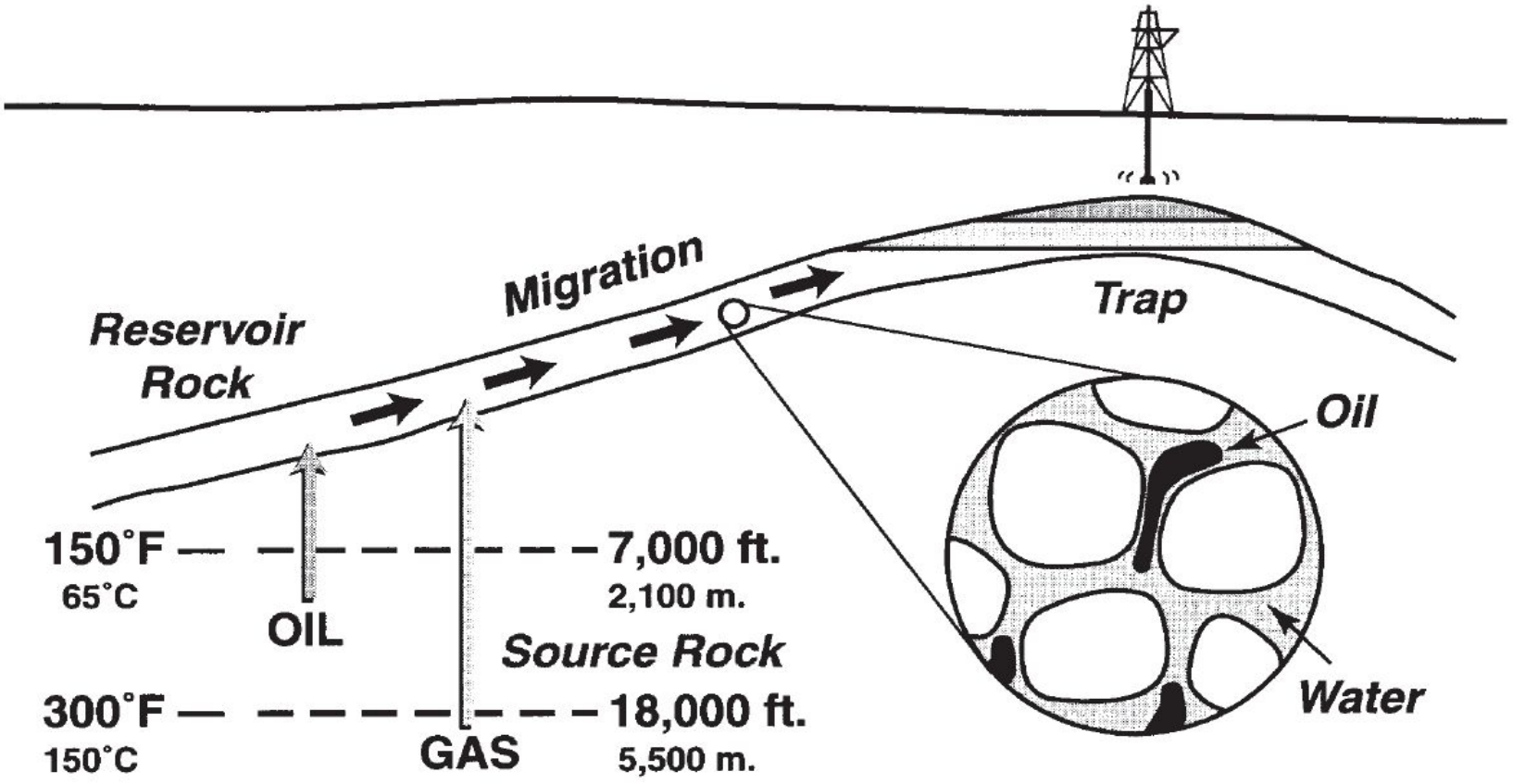
Types of Kerogen and Their Hydrocarbon Potential

Environment	Kerogen Type	Kerogen Form	Origin	HC Potential
Aquatic	I	Alginite	Algal bodies	
		Amorphous Kerogen	Structureless debris of algal origin	Oil
			Structureless planktonic material, primairly of marine origin	
Terrestrial	II			
		Exinite	Skins of spores and pollen, cuticle of leaves and herbaceous plants	
	III	Vitrinite	Fibrous and woody plant fragments and structureless, colloidal humic matter	Gas, some oil
				Mainly gas
	IV	Inertinite	Oxidized, recycled woody debris	None

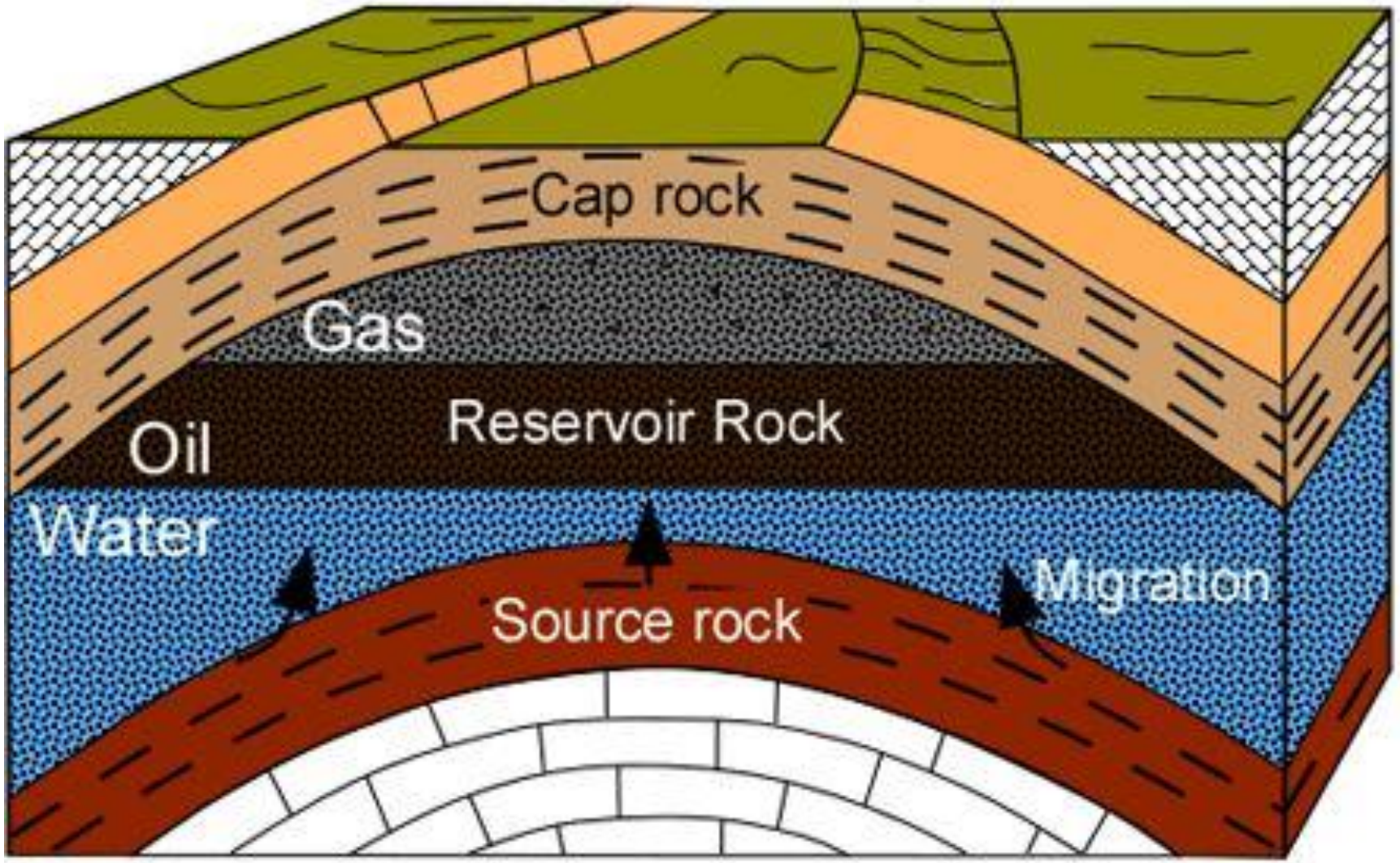
- **Kerogen**


Rock
Mineral Material 99%
Organic Material 1%
Organic Material
Kerogen 90%
Bitumens 10%

Migration of oil



Petroleum system

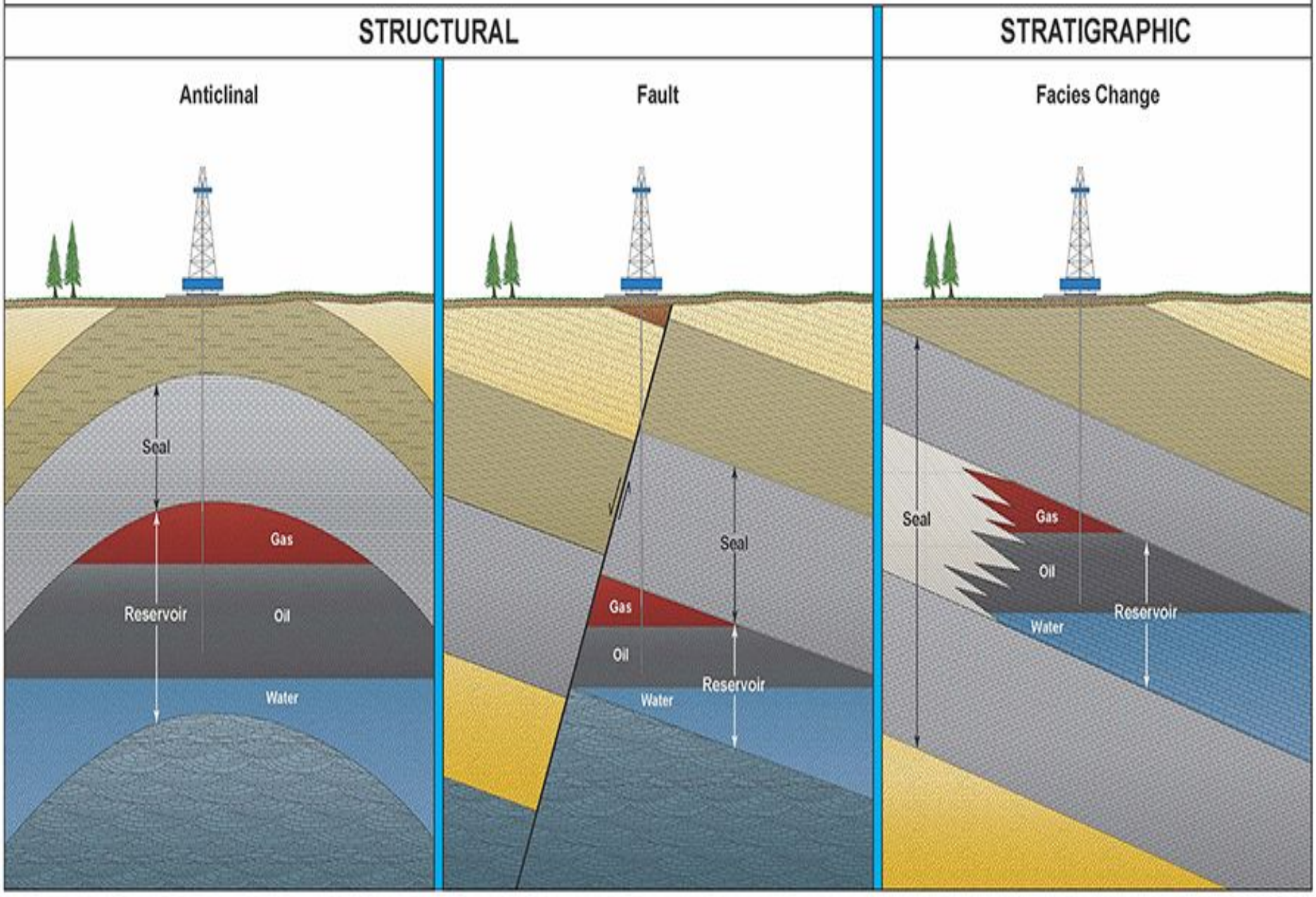


To organize their knowledge about the occurrence of oil and gas discoveries, explorationists defined the ***petroleum system*** as the geologic elements and processes that are essential for the existence of a petroleum accumulation:

- ***Trap***—a barrier to the upward movement of oil or gas
- ***Reservoir***—porous and permeable rock to receive the hydrocarbons
- ***Source rock***—a rock formation containing organic matter
- ***Generation***—temperature and pressure conditions to convert the organic matter into hydrocarbon fluids
- ***Migration***—buoyancy conditions and pathways for the fluids to move from the source rock into the reservoir
- ***Seal***—an impermeable cap to keep the fluids in the reservoir
- ***Preservation***—conditions that maintain the nature of the hydrocarbons.

When these elements and processes occur in the proper order, chances are good that a petroleum accumulation exists

TYPES OF OIL AND GAS TRAPS



Oil Traps - Salt