

Introduction to Petroleum Geology

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Key concepts, processes, and terminology for understanding how oil and gas are formed, trapped, and recovered.

1. What Is Petroleum Geology?

- **Definition:** The branch of geology that studies the origin, migration, accumulation, and preservation of hydrocarbon resources (oil and natural gas) in the Earth's subsurface.
 - **Goal:** Locate economically viable reservoirs and assess their potential for production.
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2. Fundamental Concepts

Concept	Description	Relevance to Petroleum
Source Rock	Organic-rich sedimentary rock (e.g., shale, carbonate) that generates hydrocarbons when heated.	Determines the quantity and type of hydrocarbons that can be produced.
Maturation	Thermal cracking of organic matter as temperature rises (60–150°C for oil, >150°C for gas).	Controls whether a source rock yields oil, gas, or both.
Migration	Movement of generated hydrocarbons from the source rock into more permeable rocks.	Drives hydrocarbons toward traps; can be vertical (buoyancy) or lateral (through faults, fractures).
Reservoir Rock	Porous and permeable rock (sandstone, limestone, dolomite) that stores hydrocarbons.	Provides storage space; quality measured by porosity & permeability.
Seal (Cap Rock)	Low-permeability rock (shale, evaporite, tight carbonate) that prevents upward escape of hydrocarbons.	Essential for forming a trap; failure leads to leakage.
Trap	Structural or stratigraphic configuration that concentrates hydrocarbons in a reservoir.	The target of exploration; must combine a reservoir, seal, and appropriate geometry.

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Petroleum System	Integrated set of source, migration pathway, reservoir, seal, and trap, plus timing.	Whole-system view is required for successful exploration.

3. The Petroleum Generation Process

1. Deposition of Organic Matter

- Marine, lacustrine, or terrestrial environments accumulate plankton, algae, plant debris.
- Anoxic conditions favor preservation.

2. Burial & Diagenesis

- Sediment loading increases pressure and temperature.
- Early diagenesis: organic matter transforms into kerogen.

3. Maturation (Catagenesis)

- **Oil Window:** ~60–120°C ? liquid hydrocarbons dominate.
- **Gas Window:** >120°C ? dry gas (CH₄) becomes prevalent.
- Measured using vitrinite reflectance (Ro) or Tmax from Rock-Eval.

4. Migration

- **Primary Migration:** From source rock into adjacent carrier beds.
- **Secondary Migration:** Long-distance movement through permeable pathways to traps.

5. Accumulation

- Hydrocarbons collect in pore spaces of reservoir rock, capped by a seal.
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4. Types of Traps

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Trap Type	Formation Mechanism	Typical Examples
Structural	Deformation of rock layers (folds, faults).	Anticlines, fault-blocked reservoirs, salt domes.
Stratigraphic	Changes in rock type or depositional pattern.	Pinch-outs, unconformities, reef buildups, channel sands.
Combination	Both structural deformation and stratigraphic variation.	Fault-controlled reef, tilted blocks with stratigraphic pinch-outs.

5. Reservoir Characteristics

| Property | Definition | Typical Values (good reservoir) | |-----