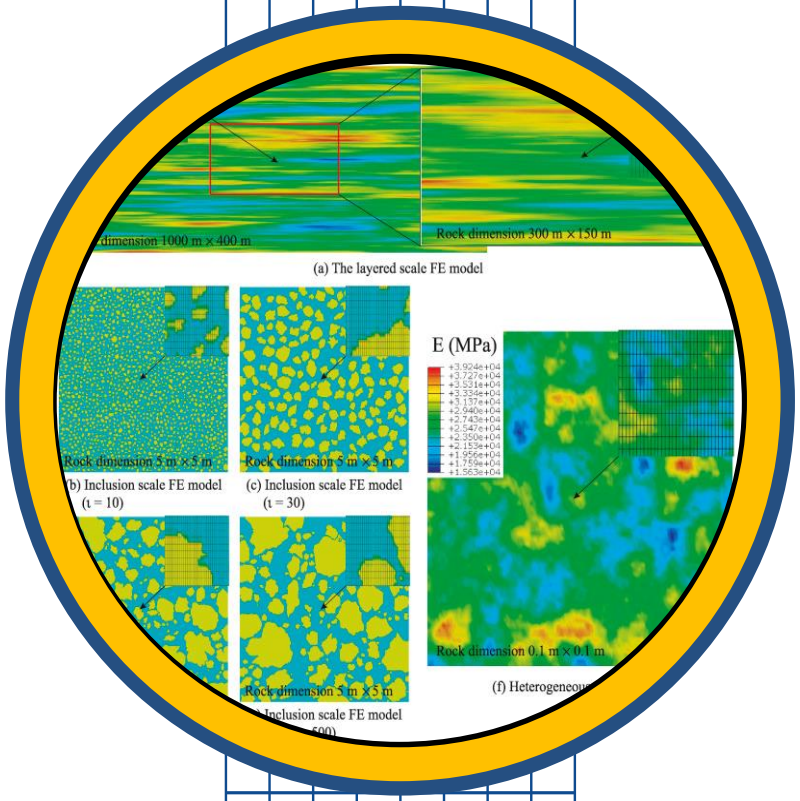
Reservoir Modelling

Heterogeneities



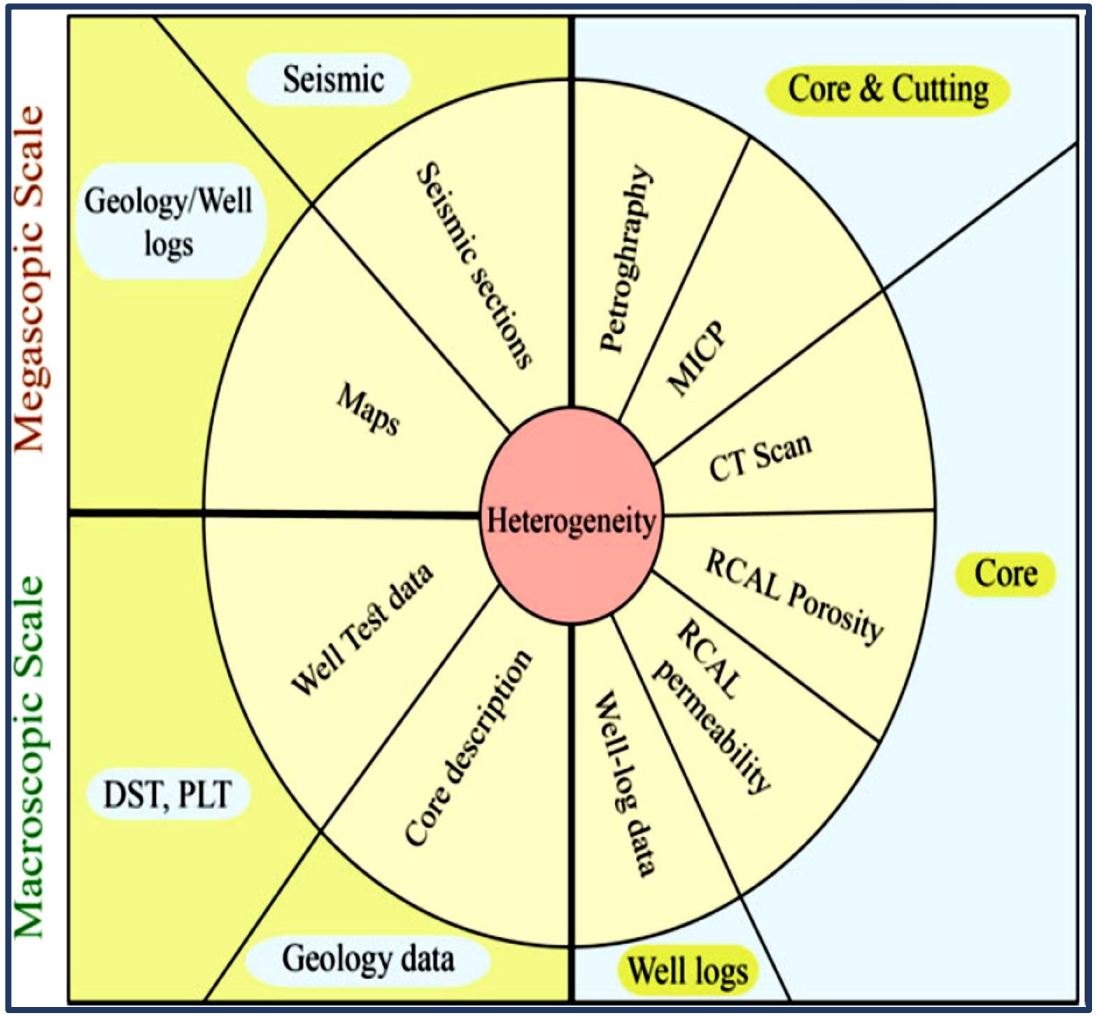
Petroleum & Mining Engineering Collage

Forth Year

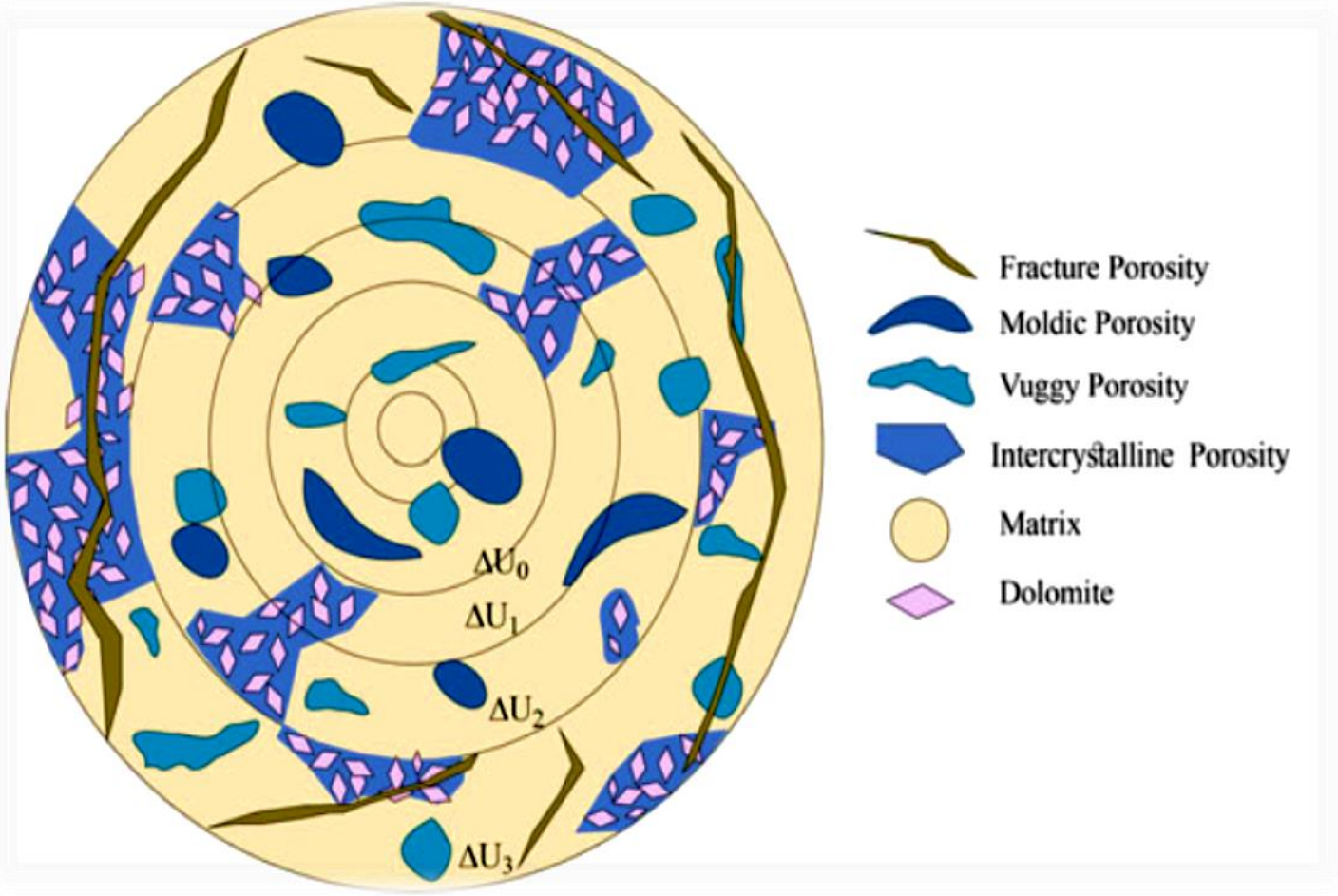
Dr. Maha Muneeb

Heterogeneities in Reservoir Geology

Heterogeneity is one of the most complex problems in subsurface formations. Fluid storage and flow in porous media are governed by a variety of geological and petrophysical variables, including structure, stratigraphy, facies, lithology, porosity, and permeability.



Many geological parameters affect subsurface fluids but control them differently, partly because of *the different physical nature* of these variables and partly because of their *scale differences*.



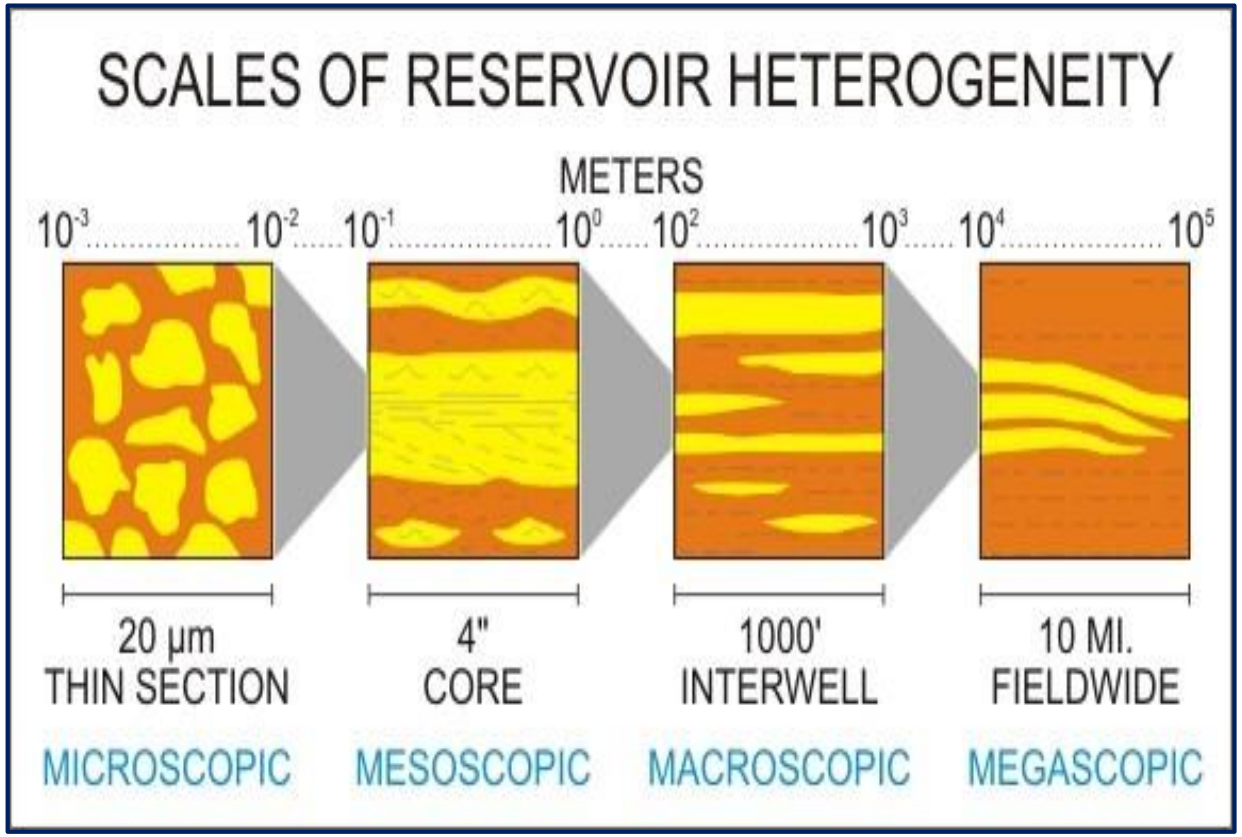
Subsurface Geological Parameters

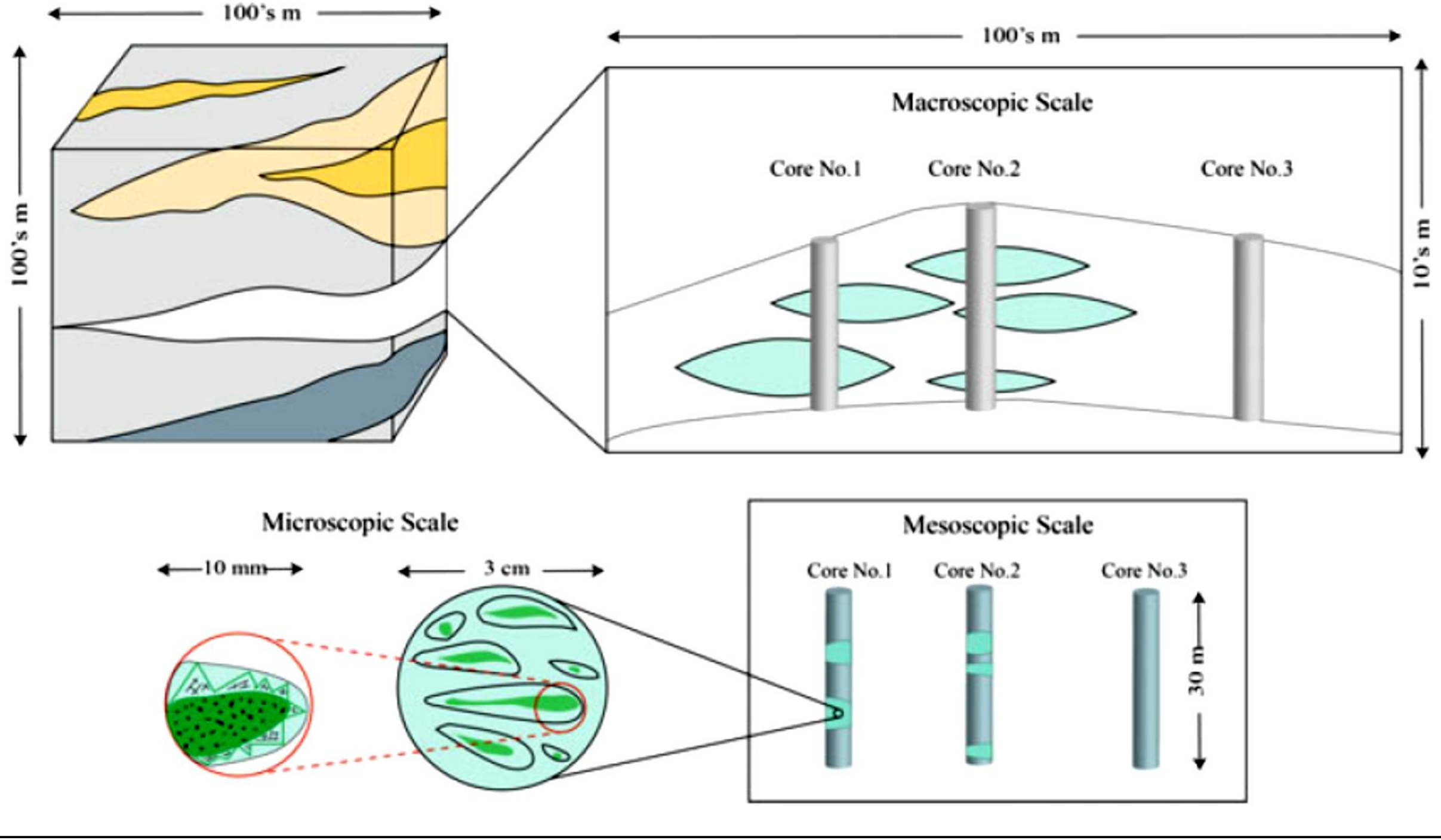
1 **Large-Scale Parameters**

controlling hydrocarbon storage

2 **Small-Scale Parameters**

governing fluid flow for hydrocarbon production




100's m
100's m
100's m
Macroscopic Scale
Core No.1
Core No.2
Core No.3
10's m
Microscopic Scale
10 mm
3 cm
Mesoscopic Scale
Core No.1
Core No.2
Core No.3
30 m

Categories	Entities/Variables[a]	Hydrocarbon storage[b]	Hydrocarbon flow[c]
Structural	Anticlines	Dominant	Weak-moderate
	Domes		
	Faults	Moderate-dominant	Moderate-dominant
	Fractures	Weak-moderate	Strong
Stratigraphic	Composite sequences	Strong	Moderate-strong
	Sequences	Strong	Moderate-strong
	Sequence sets		
	System tracts	Dominant	Moderate-strong
	Parasequences stacking patterns	Moderate	Moderate-strong
	Layers Pinchouts truncations	Moderate	Strong
	Bedsets bedding	Moderate-strong	Strong
Depositional environment and facies	Depositional facies	Moderate – dominant	Moderate – dominant
Lithofacies	Mineral compositions	Small scale	Dominant
Petrophysical properties	Porosity S_w, Permeability	Small scale	Dominant

Types of Heterogeneities

01 **Structural**

02 **Facies and Lithology**

03 **Petrophysical Properties**

1- Structural Heterogeneities

Anticlines

1

Anticlines provide one of the most common closed reservoirs.

Faults

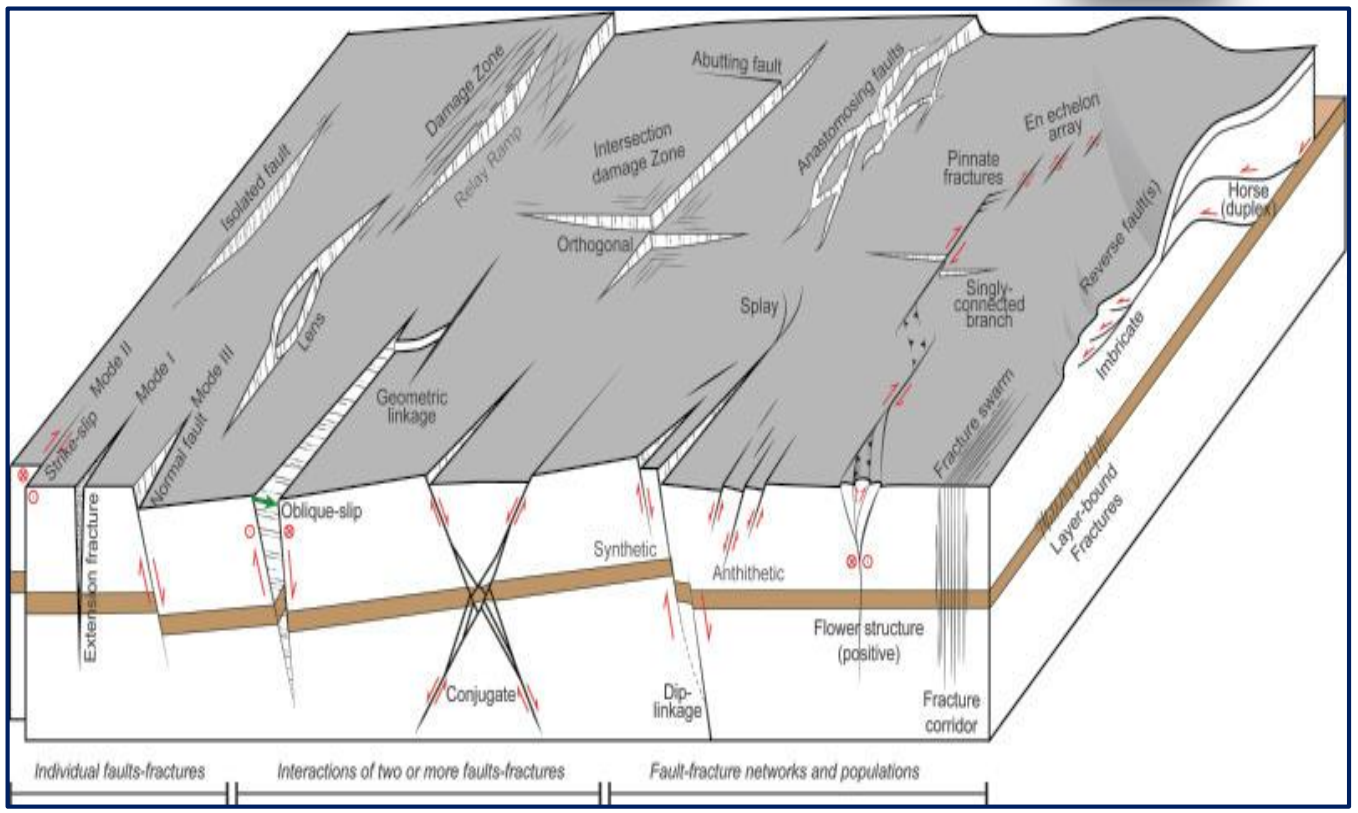
2

the size, quantity, geometry, and orientation of faults are influence on the heterogeneities of the reservoir

Fractures

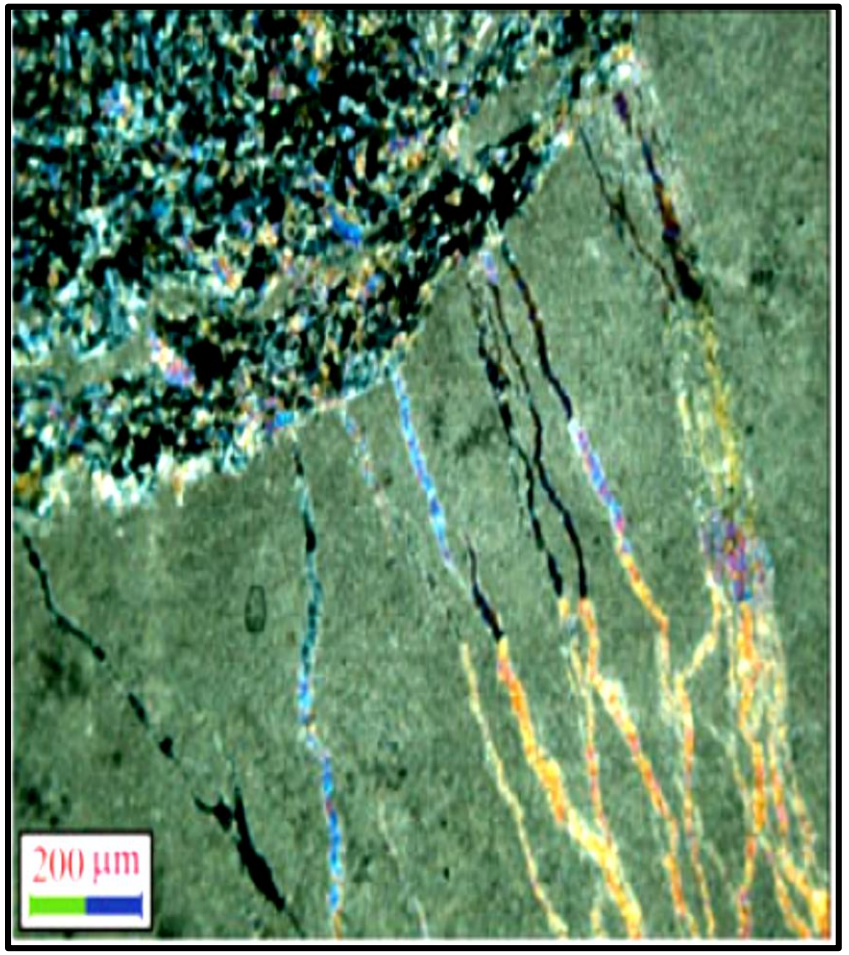
3

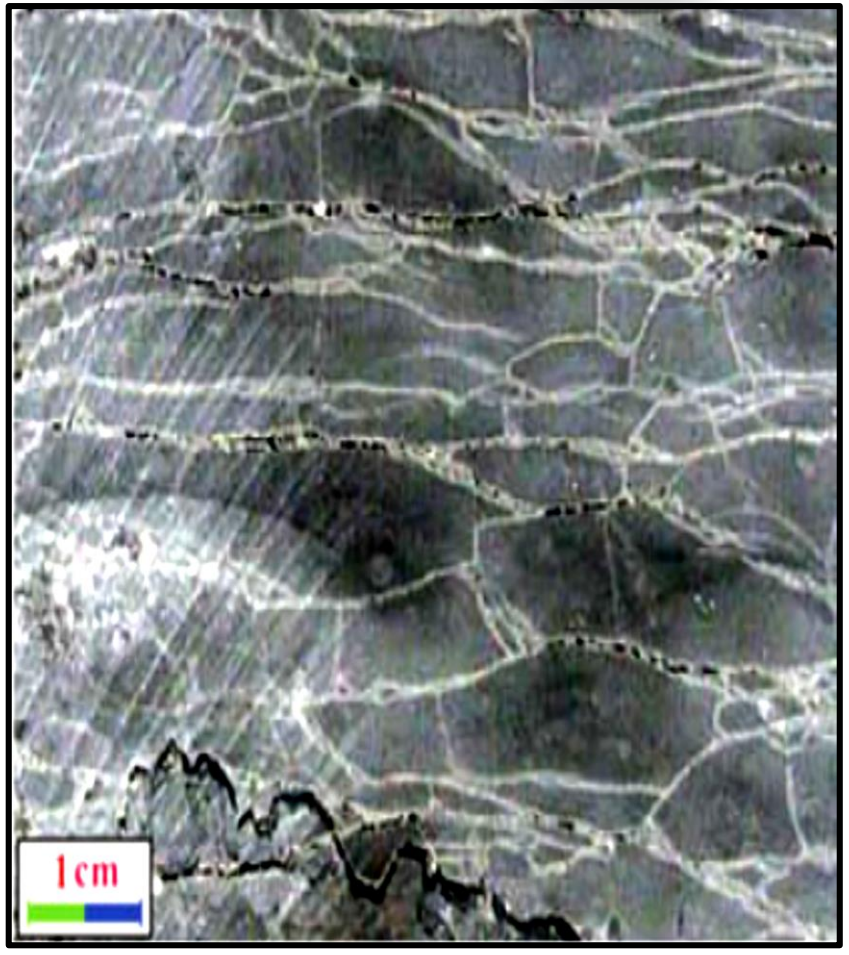
Fractures are small to microscopic cracks, and their quantity can be much greater than faults



Sealing and semi-sealing faults can have a great impact on both reservoir connectivity and sweep efficiency


1 cm


200 µm


1 cm

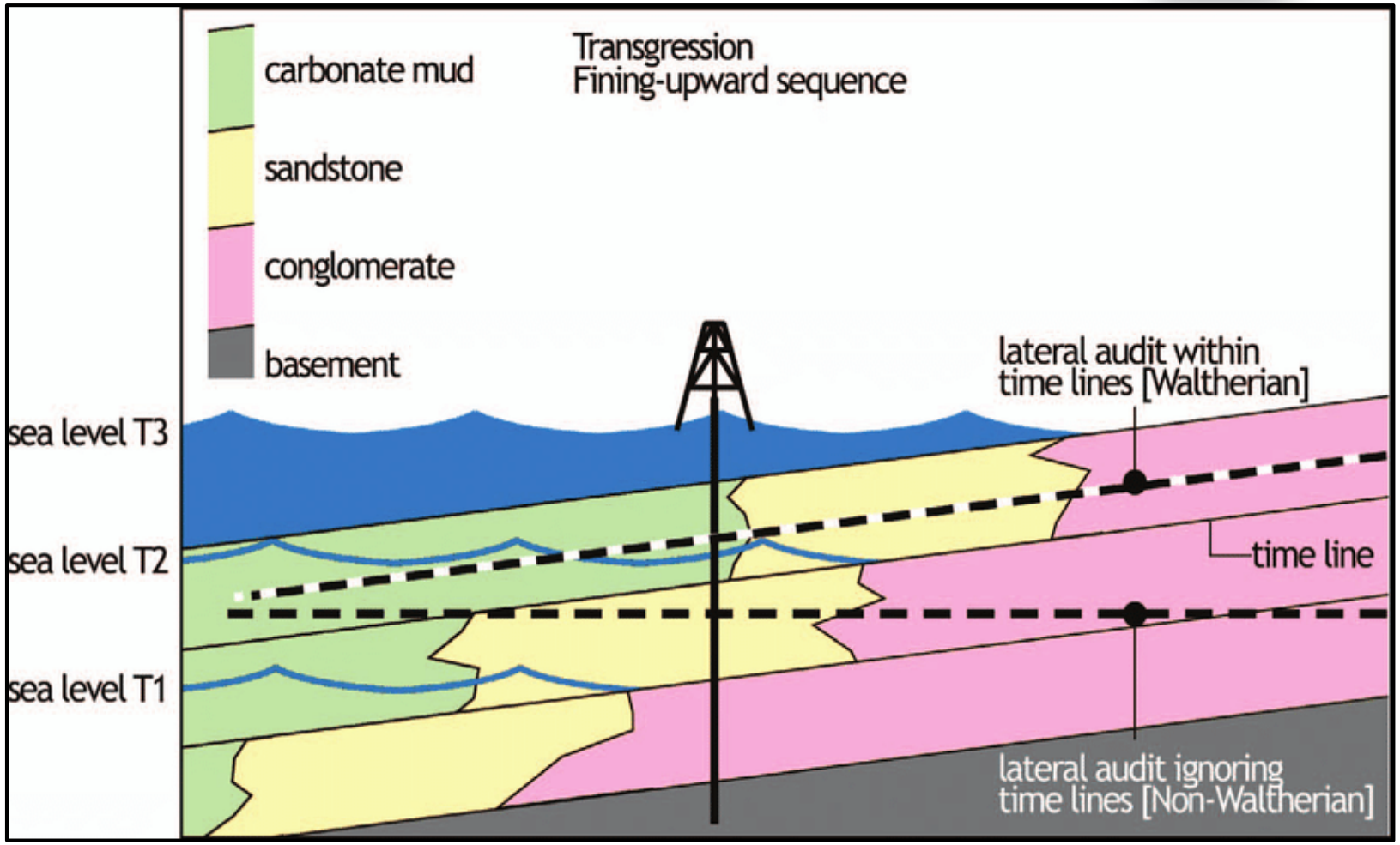
2- Facies and Lithology

1- Facies Lateral and Vertical Trends

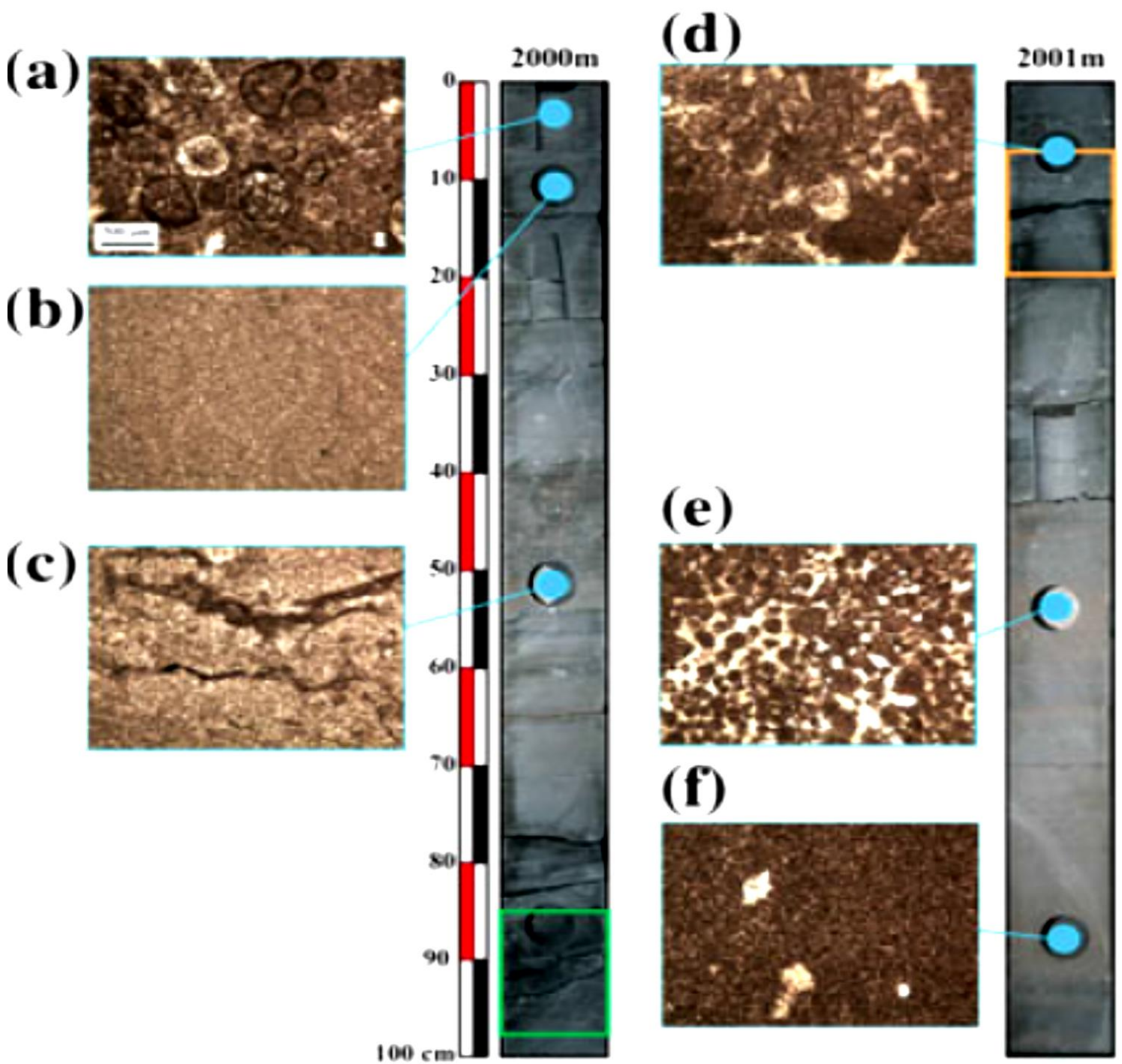
Sediments can exhibit several types of depositional facies. These lead to a type of heterogeneity—the spatial trend.

2- Lithology Compositional Trends

Facies are typically made of a variety of lithologies



Facies boundaries can act as barriers to flow when the permeability contrast is significant, the change between a channel body and the floodplain.



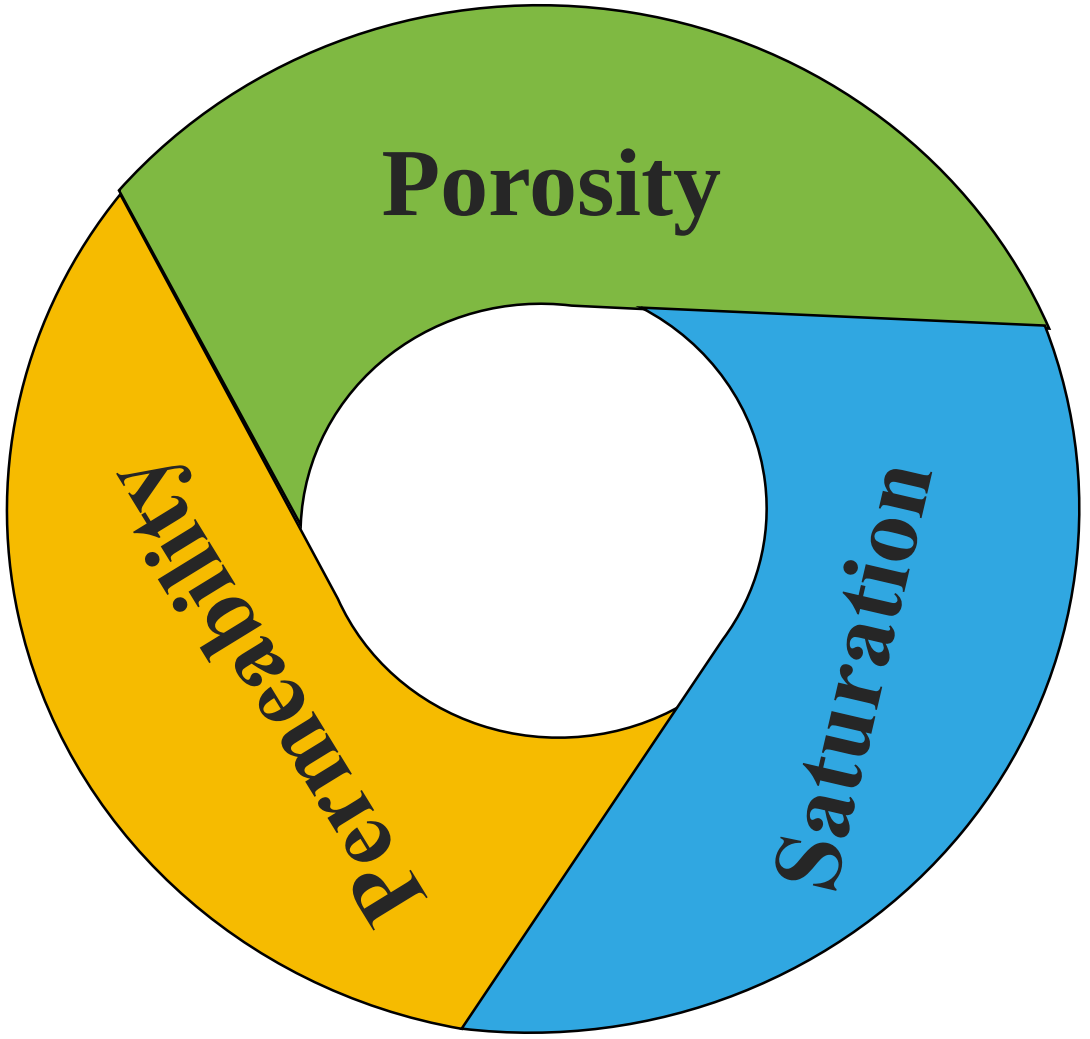
Facies and Diagenetic Heterogenety

3- Petrophysical Properties

They directly control ***storage and flow of subsurface fluids*** and are used ***to determine the hydrocarbon resources, productivity, recovery, and field development plans***

There are several ways for evaluating heterogeneities of these parameters, including:

- ***Statistical Descriptions,***
- ***Geospatial Descriptions,***
- ***Dynamic Descriptions***



Data and Measurements for Describing Heterogeneities

Vertically, core and well-log data have much higher resolutions than seismic data and can provide information for descriptions of high-frequency heterogeneities.

Laterally, core and well logs have ***limited coverage*** by individual vertical wells and they are generally sparse between different wells.

Fluid Data:

- Fluid Properties
- Pressure and Temperature Data

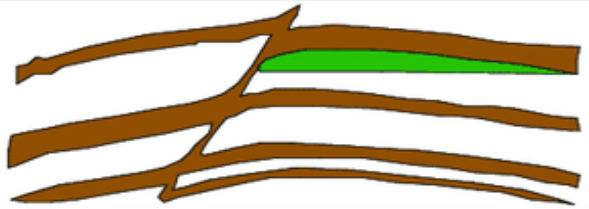
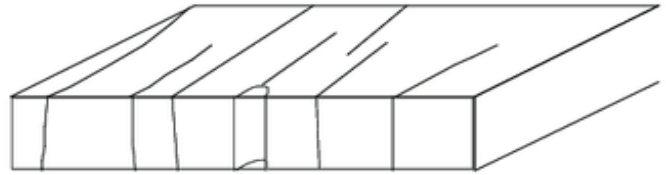
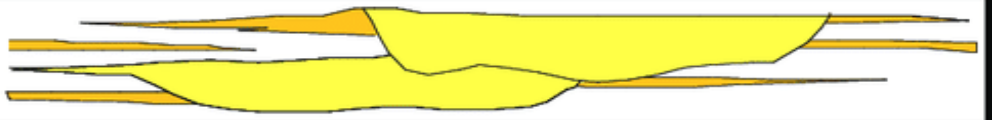
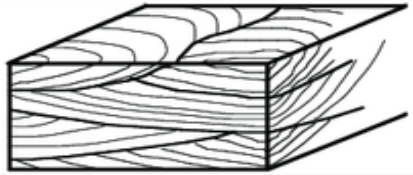
Impact of Heterogeneities on Subsurface Fluid Flow and Production

Examples:

- **Stratigraphy and spatial distributions of lithofacies** can have a significant impact on the **productivity** of hydrocarbon.

- **Spatial variations in permeability and other reservoir properties** are ubiquitous in all permeable media and are among the most influential factors to **fluid flow, hydrocarbon production, and recovery rate.**

Summary

Scale	Reservoir heterogeneity types	
Giga (>300 m)	Sealing to nonsealing faults	
	Fracturing	
Mega (10–100 m)	Genetic unit boundaries	
	Permeability zonation within genetic units	
Macro (in meters)	Baffles within genetic units	
	Sedimentary structures	
Micro (μm)	Microscopic heterogeneity