Reservoir characterisation

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STRATIGRAPHIC RESERVOIR CHARACTERISATION

Reservoir Characterization is an interdisciplinary high-resolution geoscience model that incorporates various types of geological, geophysical and engineering information from pore to basin scale.

The principal **goal** of **reservoir characterization** is to outsmart nature to obtain higher recoveries with fewer wells in better positions at minimum cost through optimization.

Halderson and Damsleth 1993.

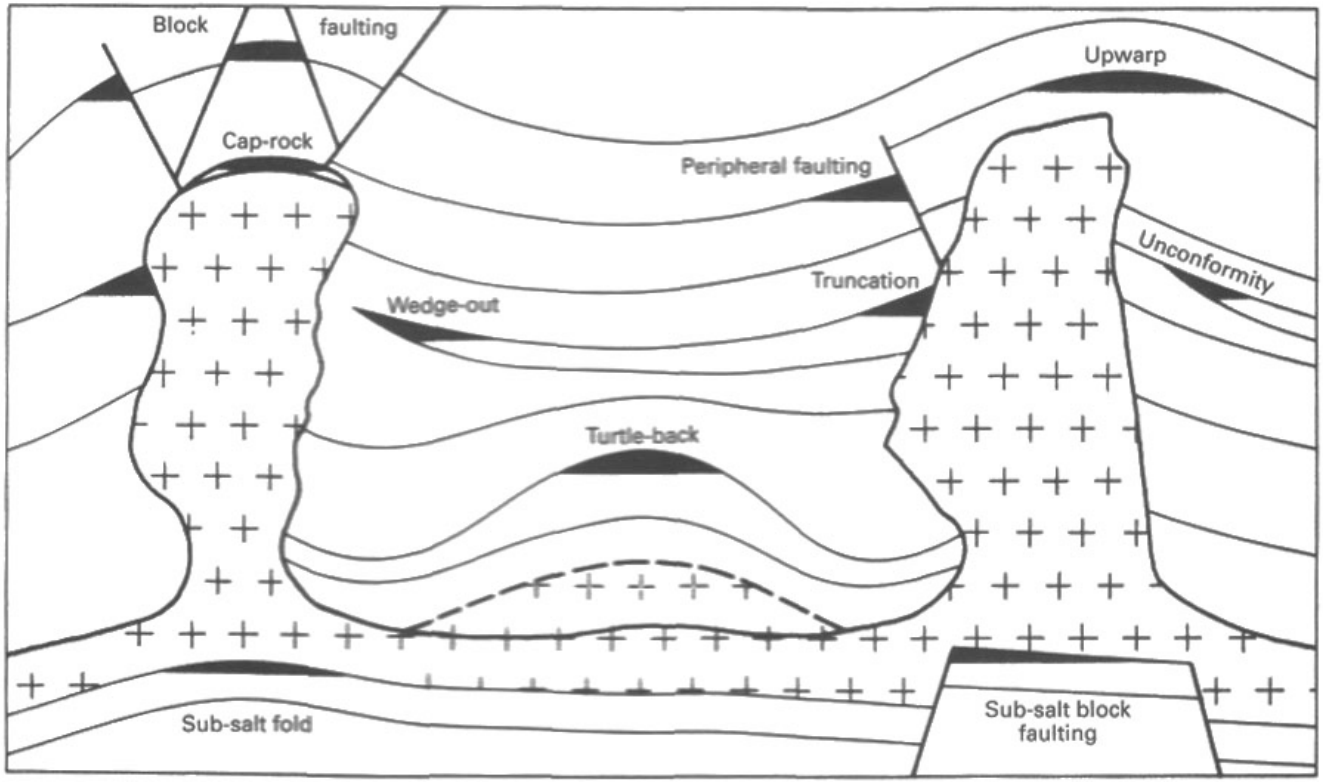
Today the field of reservoir characterization routinely involves disciplines of geology, geophysics, petrophysics, petroleum engineering, geochemistry, biostratigraphy, geostatistic, and computer science.

Reservoirs are stratigraphycally and structurally heterogene and unique!

Roger Slatt Rules of Reservoir Characterisation

- **1. Think small**

The reservoir is often affected by faults, stratigraphic pinchouts, and diagenetic cements. Thus, one must think small in order to identify important features of your reservoir that may have significant impact on fluid flow.



- **2. Think in terms of the rocks (instead of paper or images)**
- The reservoir is composed of rocks, fluids, and pores in various configurations and quantities. Geologic principles should always be applied when characterizing and interpreting a reservoir. For example, do not make a computer-generated map that is geologically impossible!!

- **3. Think in terms of numbers**.
- A geologist have to collaborate with reservoir engineer. He have to convert a geologic model into a reservoir simulation model. The reservoir engineer will better understand and utilize a flow unit or permeability-distribution map than a facies map.

4. Seeing is believing

There are a lot of small scale geologic features (i.e. faults, folds, strata) what are not observable on seismic. No matter how highly drilled a reservoir is, there is always space between wells.

If it is possible the geologist have to observe and measure strata and structure on the surface in the outcrops. Because the same depositional and tectonic processes formed the rocks on the surface as in the the subsurface the reservoir.

Go to the outcrop and see what geologic features look like, and how they might affect the performance of your reservoir!

5. Computers are tools, not brains

Tendency to generate a map, cross section, graph or 3D geologic characterization by inputting available data, clicking on the Run icon, and generating a very appealing and convincing image. The computer will automatically generate an answer or image. The map looks very attractive, but is geologically impossible!

Don’t become a ‘nintendo geologist’ by allowing a computer think instead of you!

6. „Where oil is first found in the minds of men (and women) „

Success= brains + geologic knowledge!!!!

The oil is not found on the computer screen, but is detected by using geologic insights to interpret maps, cross sections, and other forms of output that have been generated by the computer.

7. „Sweet the asset”

You should attempt to extract as much oil or gas out of your reservoir as is possible.

Use existing technology as well as by developing new ways to extract more of the hydrocarbons. Improving production from existing fields is going to become increasingly important as our finite supplies of oil and gas are utilized by an energy-hungry world

Hydrocarbon exploration is team work

The task of the team: to find the hydrocarbon and look for ways of getting more hydrocarbons out of it.

Production geologist:

- To understand and model the geological framework of the reservoir.
- Using computer software creats a presentation of it
- The model helps to understand how the geology 1)influences

fluid flow within a producing reservoir and 2) creates *dead ends* that could potentially trap hydrocarbons.

- Helps to identify and plan new well locations.

Geophysicist:

- interprets seismic data to define the reservoir structure and fault distribution.
- Where the seismic data allow, characterizes depositional environment, rock, and fluid properties.

Petrophysicist:

- to analyzes wireline logs to quantifies the rock and fluid properties of the reservoir at the well scale

Reservoir engineer

- predicts how much oil and gas a field is likely to produce,
- uses a computer simulation of reservoir performance to analyze how

the field will behave

Production chemist

metal corrosion, drilling fluids, wax formation, and solids precipitation between the reservoir and the surface facilities.

Drilling engineer (Well engineer)

- Plans the mechanical aspects of any well operations including drilling new wells.

Economist

- Calculates costs and evaluates any economic activity relevant to the subsurface.

Life of a field

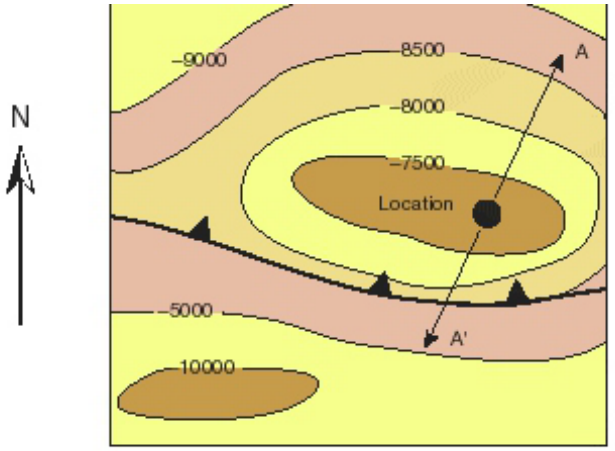
- **Exploration:**

The initial phase in petroleum operations that includes generation of a prospect or play or both, and drilling of an exploration well.

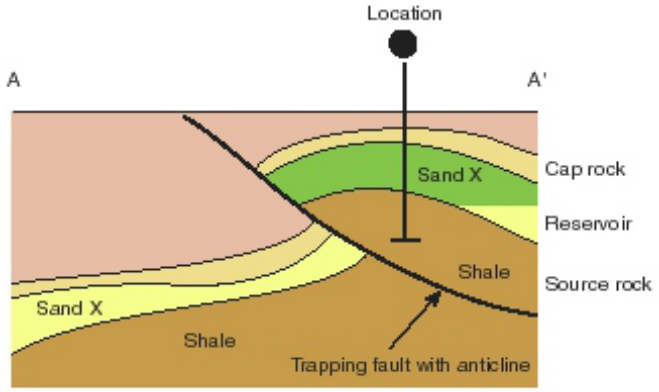
Prospect:

An area of exploration in which hydrocarbons have been predicted to exist in economic quantity. A prospect is commonly an anomaly, such as a geologic structure or a seismic amplitude anomaly, that is recommended by explorationists for drilling a well.

Prospect



Map on Sand X



The structure map of sand x shows a prospective drilling location at the crest of the faulted anticline.
The cross section A-A' demonstrates essential elements of the prospect: reservoir, cap rock/seal, and trap.

- **Appraisal**:

during appraisal, delineation wells might be drilled to determine the size of the oil or gas field and how to develop it most efficiently.

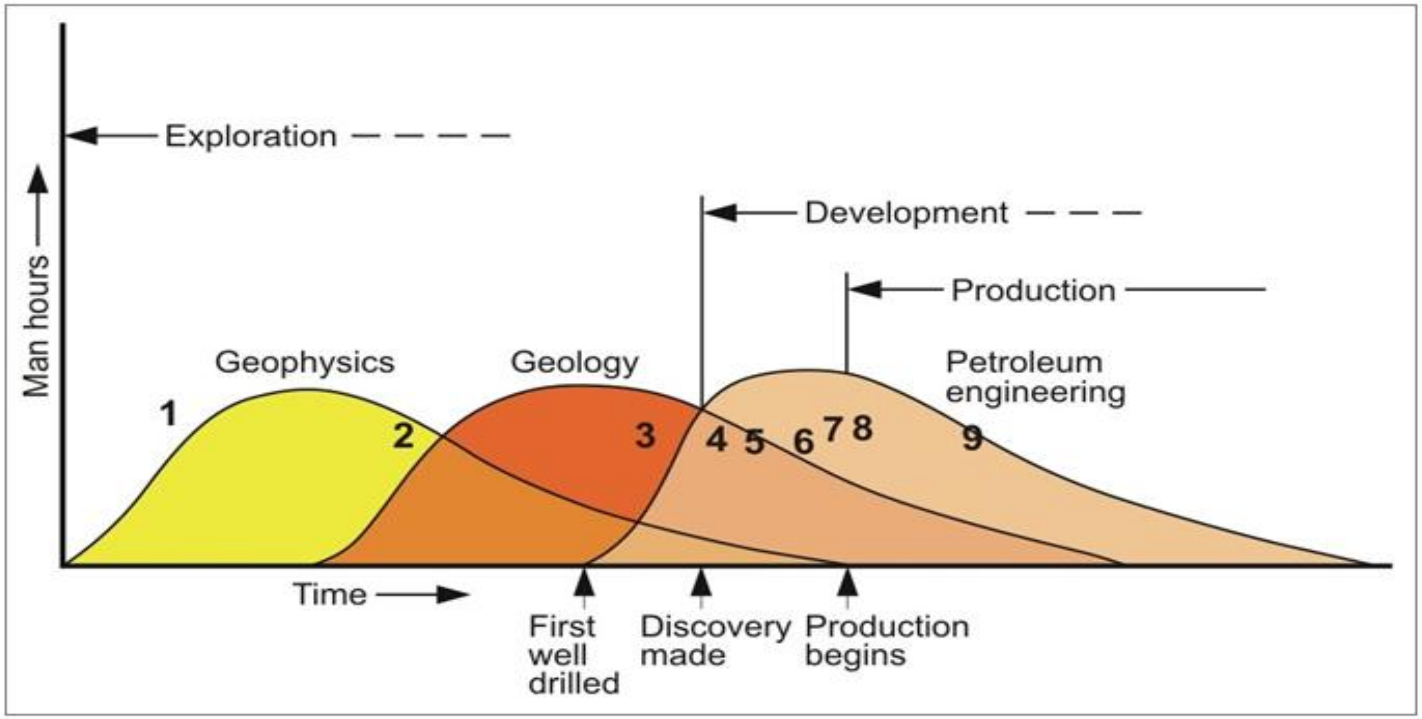
- **Development:**

The newly discovered oil or gas field is assessed during appraisal phase, a plan to fully and efficiently exploit it is created, and additional wells are usually drilled.

- **Production:**

hydrocarbons are drained from an oil or field.

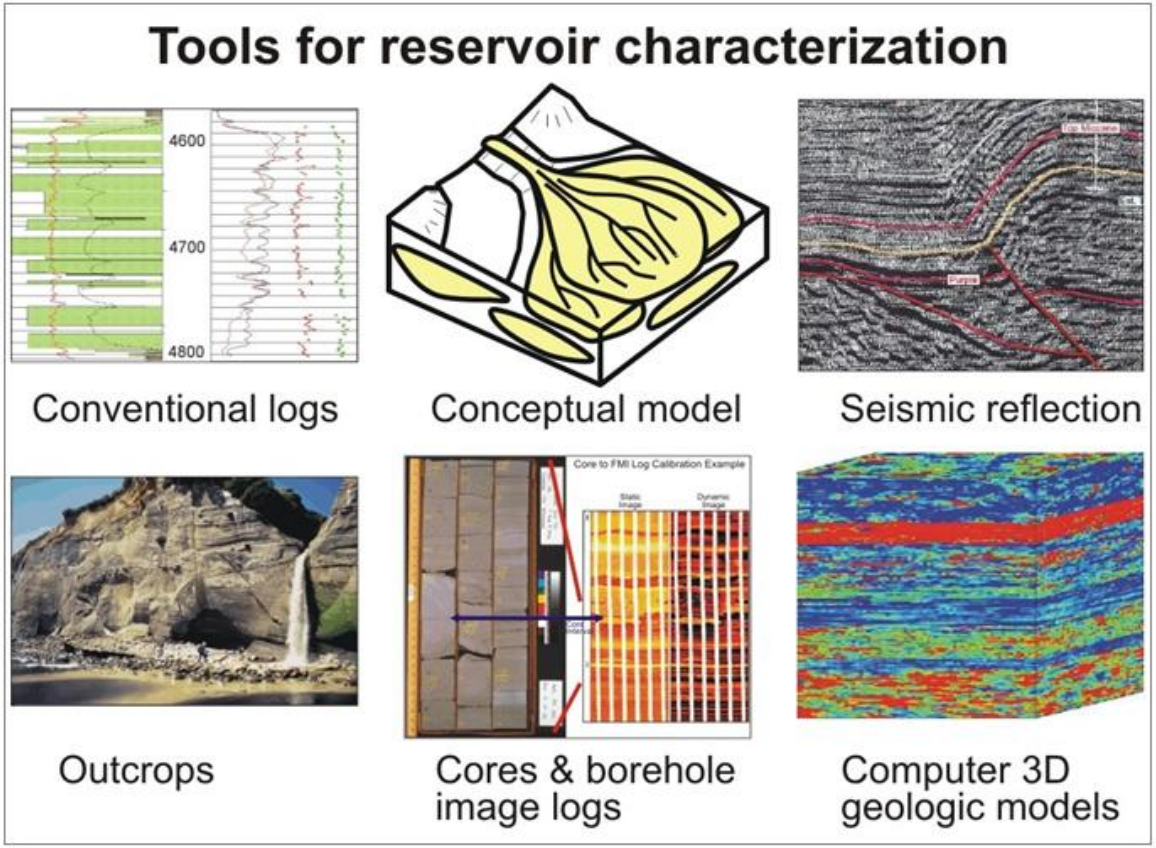
Life of a field



Exploration, discovery, development, and production stages in the evolution of a reservoir over time (steps 1through 9). Geophysics, geology, and petroleum engineering all play dominant roles at different

times in the life of a field.

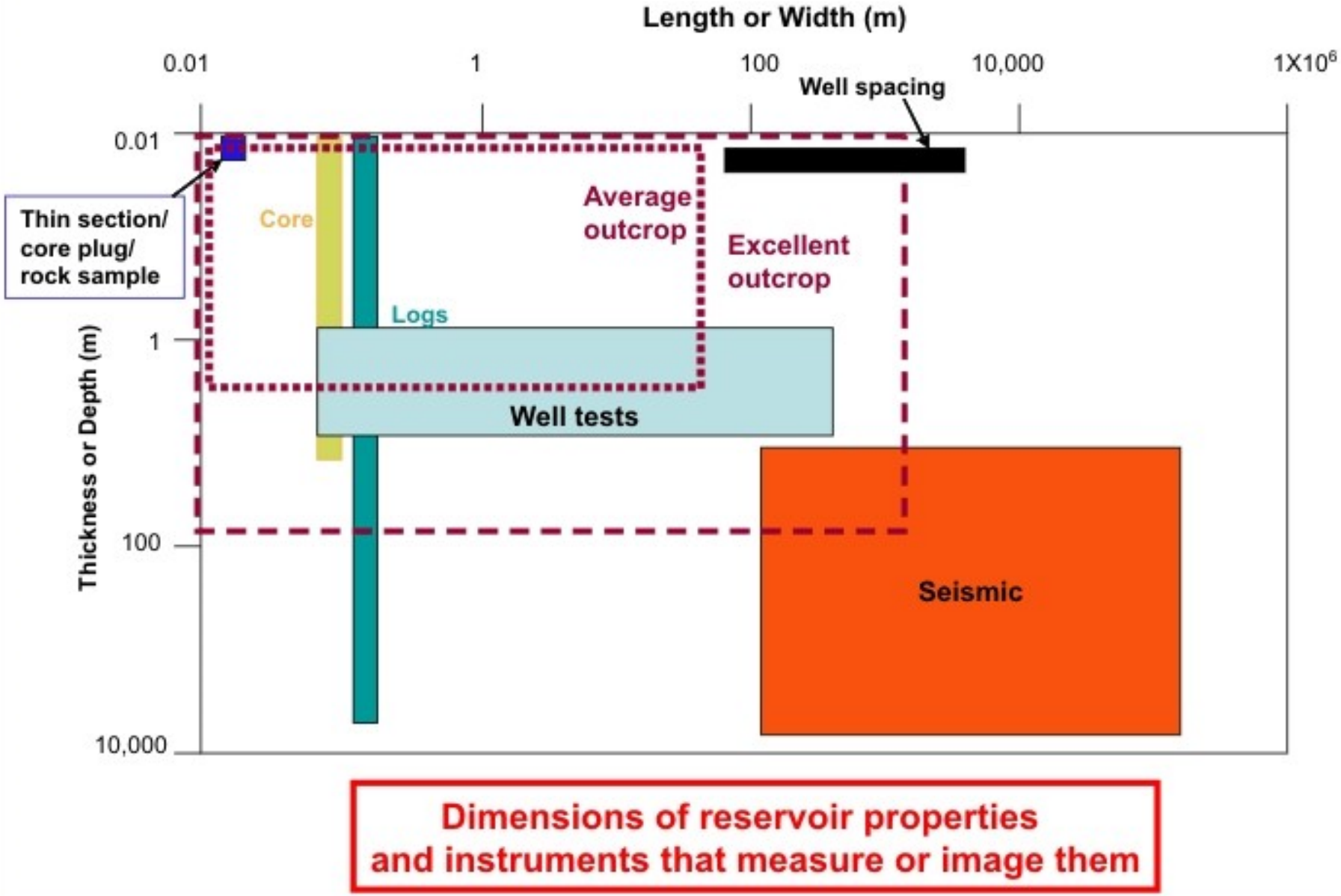
Data



+ geochemical- and biostratigraphic data

Figure 1

All geologic models deal with *Scale*



Dimensions of reservoir properties and instruments that measure or image them

Reservoirs are compartmentalised

- by

- facies changes (laterally, vertically)
- stratigraphic pinchouts
- diagenetic variations
- faults
- folds

Geologic features of sandstone reservoirs which control reservoir performance

- **Determined by deposition**:
- Size
- Geometry (shape)
- Bed dimensions, continuity, connectivity
- Grain size and composition
- **Post depositional**:
- Structural attributes (faults, fractures, folds)
- Porosity, permeability, capillarity
- Burial depth and history
- Drive mechanism

The reservoir is the result of all these processes!

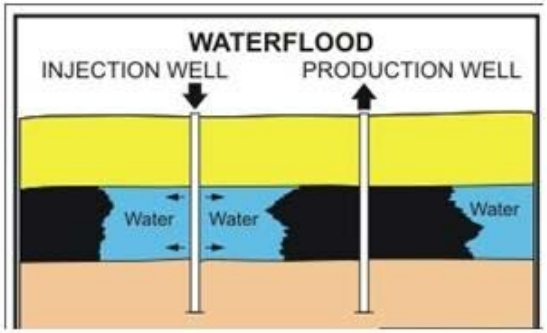
To predict the geology between two wells

Reservoir Characterization: Welcome to the Real World

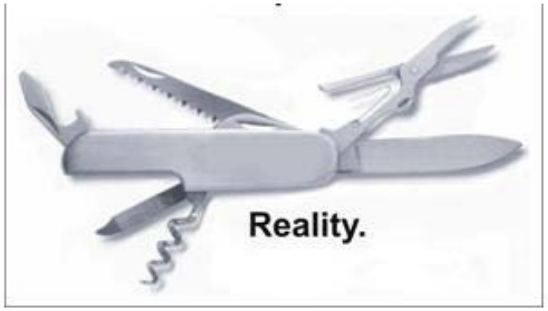
Course by: Roger M. Slatt

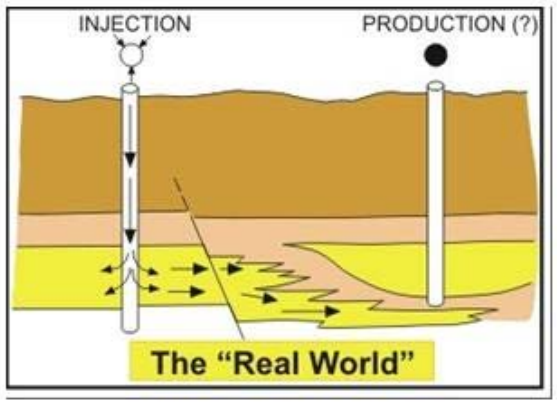
Waterflood is designed





The idea:
the sandstone reservoir is continuous between the two wells





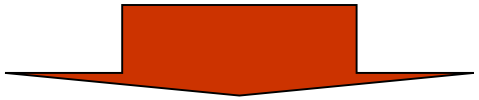
In fact:
there are structural and stratigraphic discontinuities between the wells.

The waterflood is failure!

Reservoir characterisation: to detect and delineate compartments!!

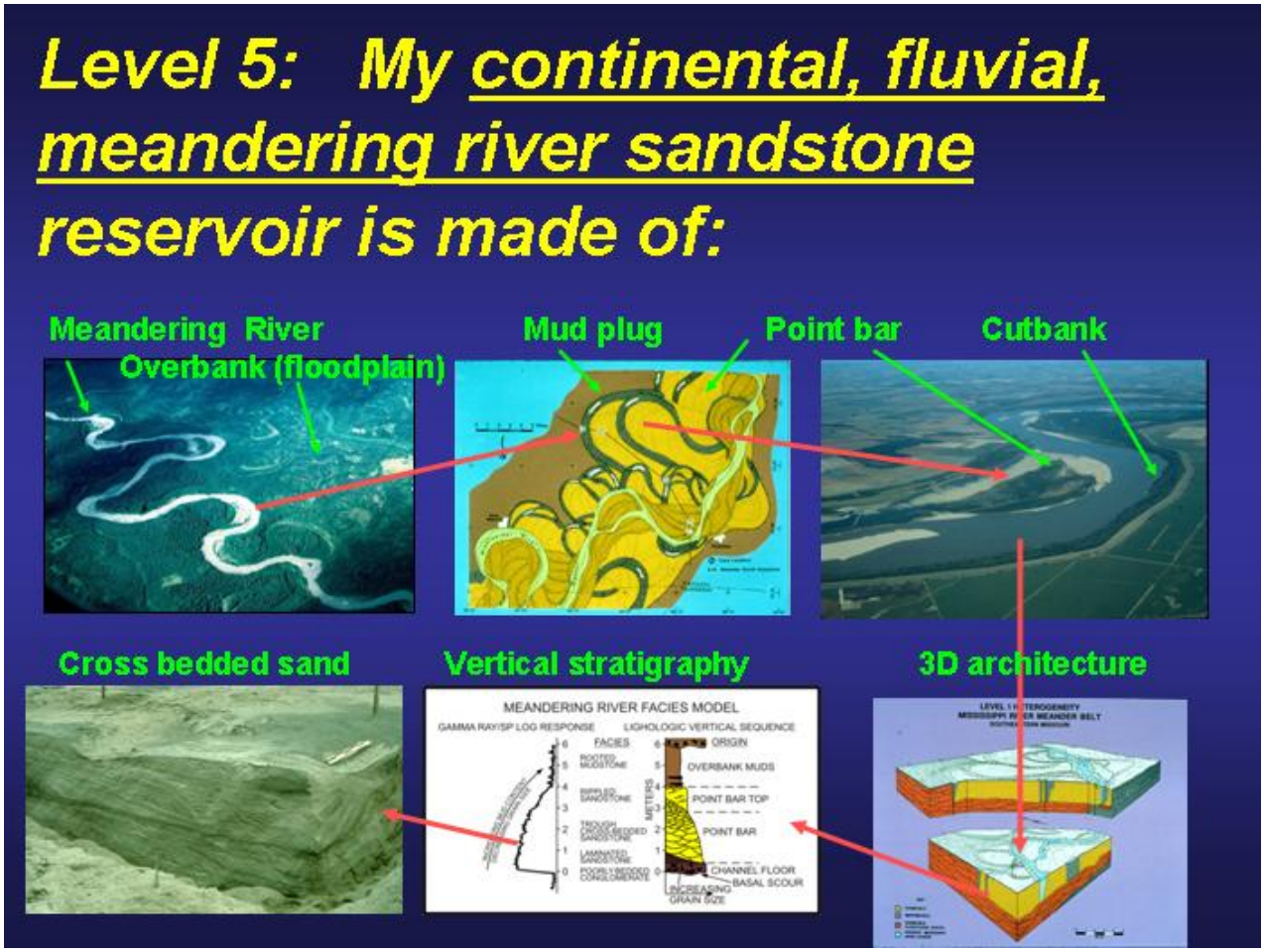
Compartmentalised reservoir

The reservoir is segmented by stratigraphic and structure features into descrete isolated geologic units (i.e. sand bodies). Each unit has its own production characteristics.

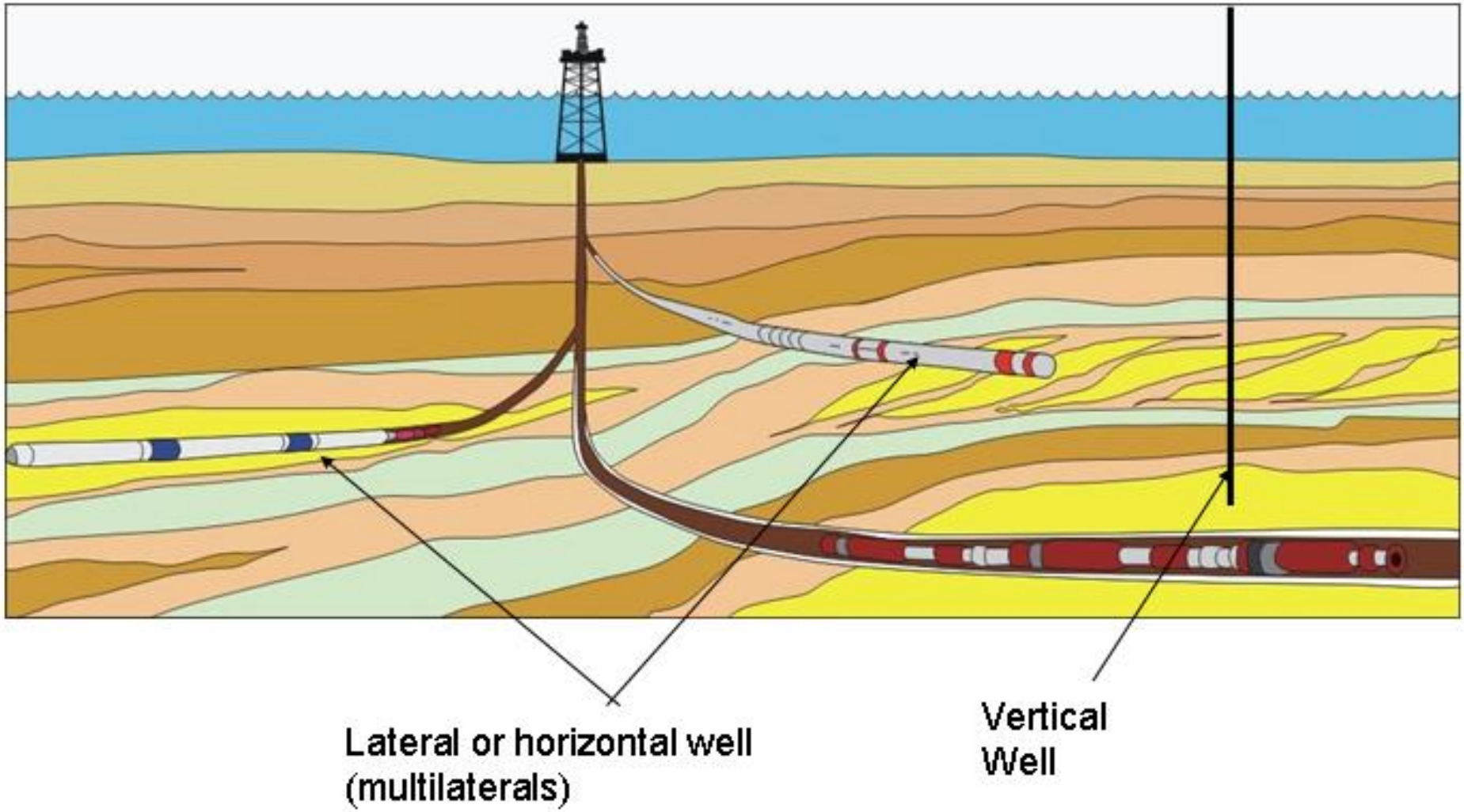


The degree and style of compartmentalization controls the number of wells, well spacing, the type of well (vertical, horizontal, slant), and the direction (for horizontal and slant wells).

- The sedimentary environment (facies) controls the size and geometry of the reservoir sand bodies. E.g. sand bodies deposited at the sea side have elongated shape, whereas meandering river has labyrinth type.
- Clay intercalations confine the fluid flow.
- Different facies has different permeability profile: e.g. channel filling: permeability decreases upwards, whereas a progradational succession increases upwards.



Various components: muddy floodplain, mud plugs, point bar (reservoir) sands, cutbank, sedimentary structures such as cross bedding, and the nature of the vertical sequence. These component parts occur within a 3D framework and give rise to a complex, but typical reservoir type.



Horizontal drilling technology has dramatically improved production from fields, particularly those that are stratigraphically and/or structurally compartmentalized.

The Perfect Reservoir Analog



Rooms = Reservoir sands

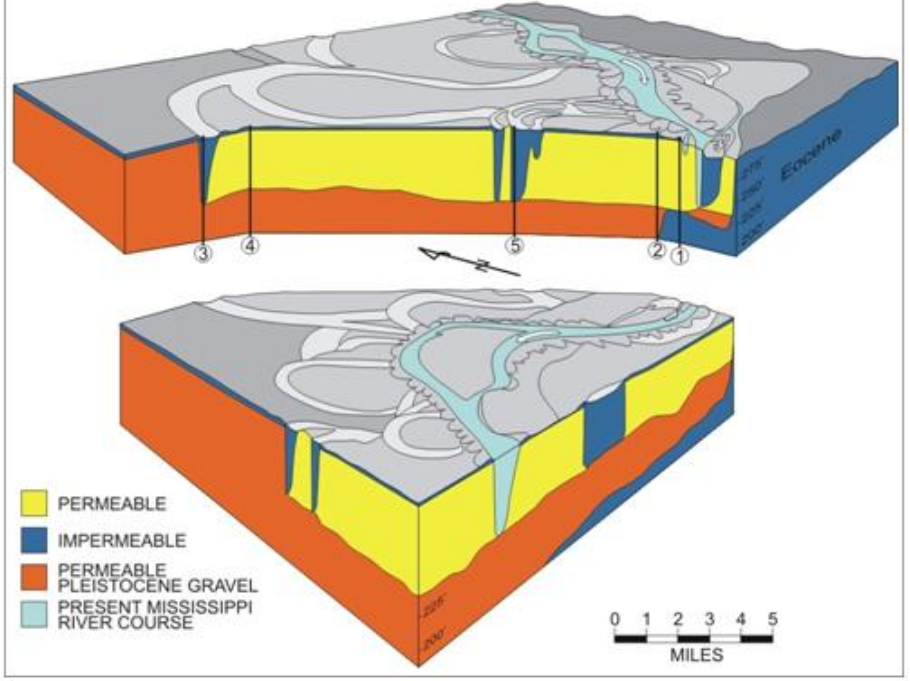
Floors and Ceilings = Reservoir seals (compartments)

Walls = Sealing faults/stratigraphic pinchouts

But……..Not all rooms are the same:
- -Offices
- -Dining area
- -Rest Rooms (WC)
- -Conference Rooms
- -Commercial stores

Seismic reflection does not image 'subseismic' scale features…but,

Reservoir performance is often governed by features that are often beneath seismic resolution or detection ('sub-seismic scale')



Block diagrams showing the internal complexities characteristic of the portion of the Mississippi River illustrated in F meandering river deposit sits atop Pleistocene gravel. The active channel is shown in light blue. Permeable point-ba particular channel becomes abandoned, it fills with mud and organic matter, which, when buried, will become imper plugs, as they are often called, provide vertical barriers to fluid migration in an analog reservoir and horizontally com Illustration courtesy of D. Jordan.

Principle of Compartmentalization

The building is compartmentalized into a series of rooms of different dimensions, and sometimes different orientations. If the rooms are considered reservoir sands, they can be separated by non-permeable shales, which are equivalent to floors and ceilings, and they can be mutually separated by stratigrapihic pinchouts or sealing (non-permeable) faults, which are analogous to walls.