Coring

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Life of a well

- 1. Drilling a well (chips/cuttings, sidewall cores, cores)
- 2. Testing a well

  - logging (info: lithology, HC content, porosity)

  - well tests (info: permeability, HC content)
- 3. a. Completing a well (if it is productive)
- 3. b. Plug and abandon (if it is dry)

Coring

The aim is: to get information on the exact lithology, stratigraphy and HC content of the well

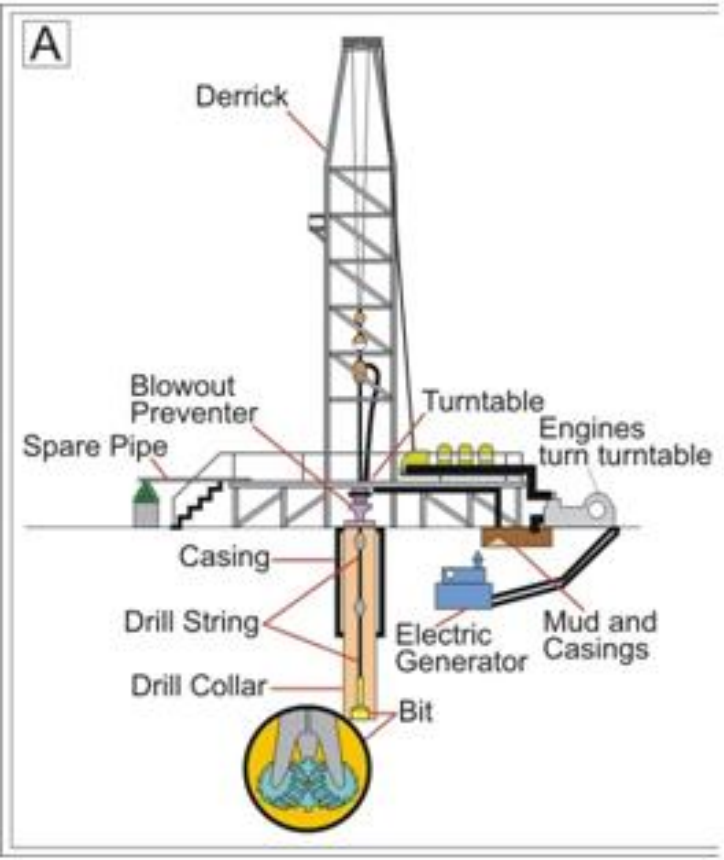
(samples from the penetrated rocks: cuttings/sidewall cores/cores)

Before drilling a well we have information on:

- structure (through seismic)
- theoretical stratigraphic column (based on previous wells and seismic)

Coring

- 1. Cuttings, chips (during drilling)
- 2. Sidewall core (after finishing the drilling)
- 3. Core (before reach the target layer)



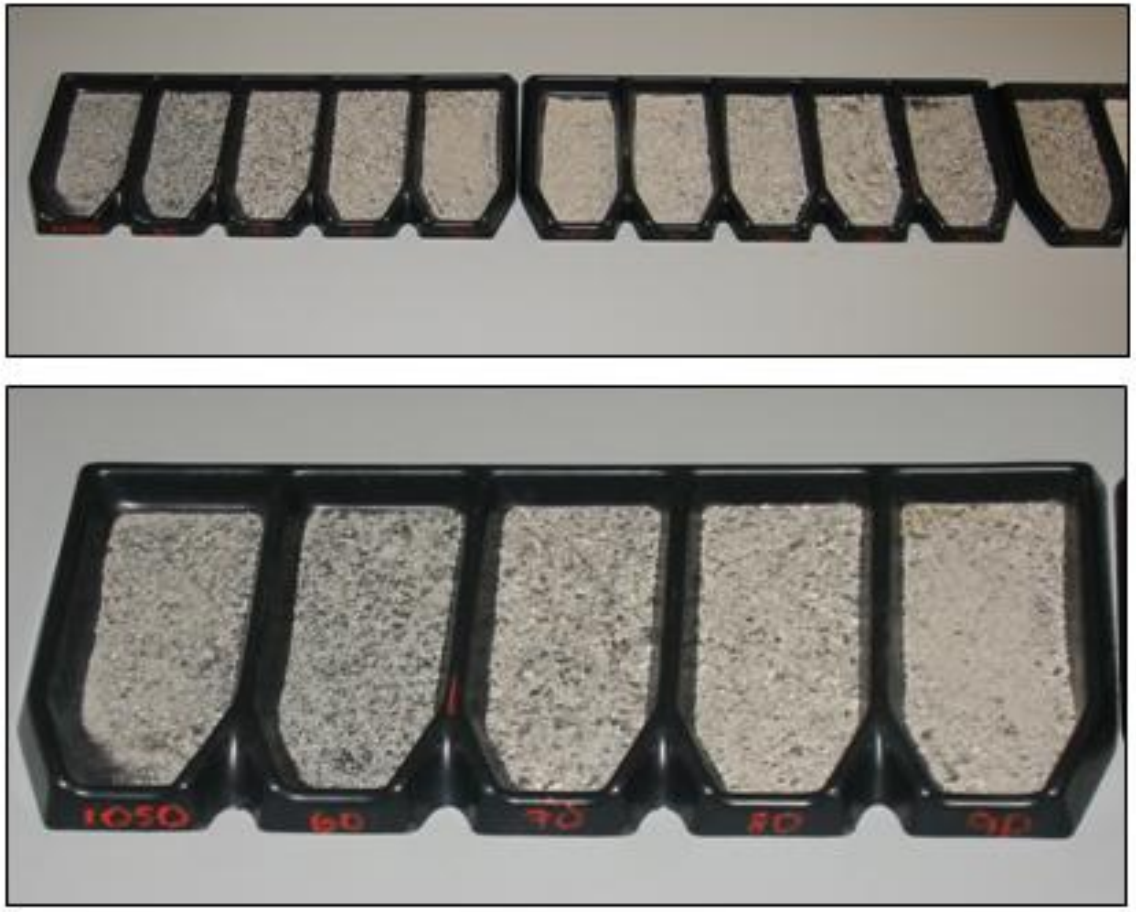


Figure 3.2: Example of cuttings trays. Each compartment holds ten feet of cuttings. These trays were used for the top 1000 feet of the cuttings, and the rest of the drill cuttings were poured into ice cube trays, which were laid out in a similar manner (end-on-end).

Cuttings--chips from borehole as the well is being drilled. Drilling mud [umped down the well circulates back up and carries the chips to the surface, where they are collected on a screen.

Removal of particles from mud



Shale shakers



Sampled over 2-5m of depth

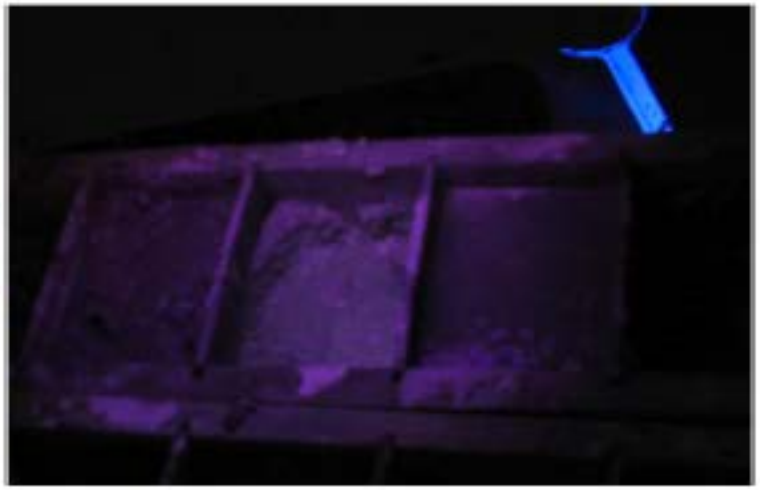
Washed

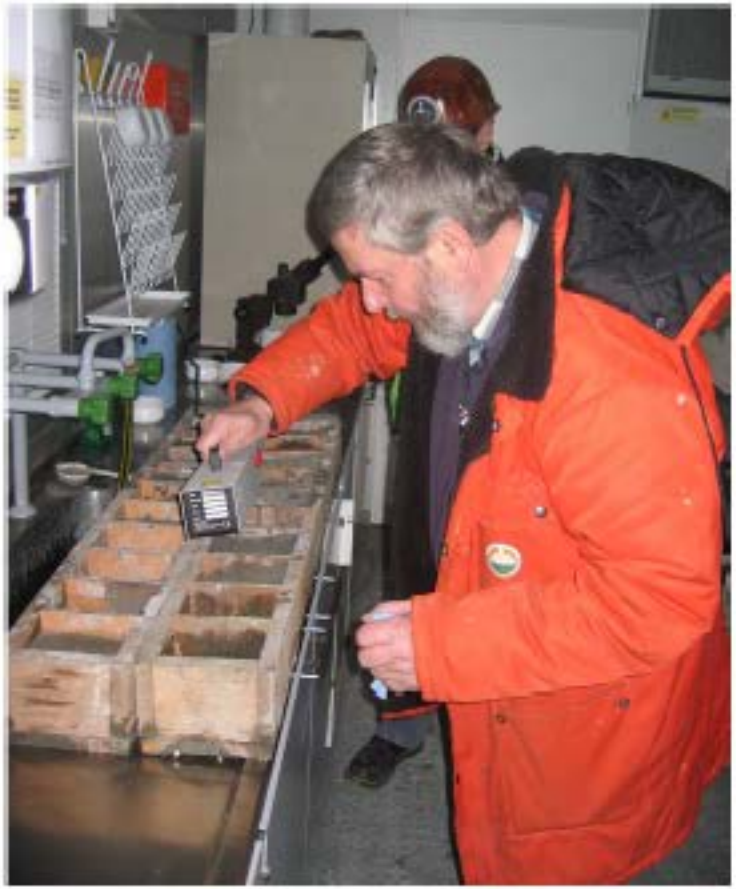
Lag time: the time, during the cuttings circulate from the bottom of the well to the shake screen (300 m/10 minutes in a 20 cm hole)

Consists of a mixture of different rocks

Cuttings



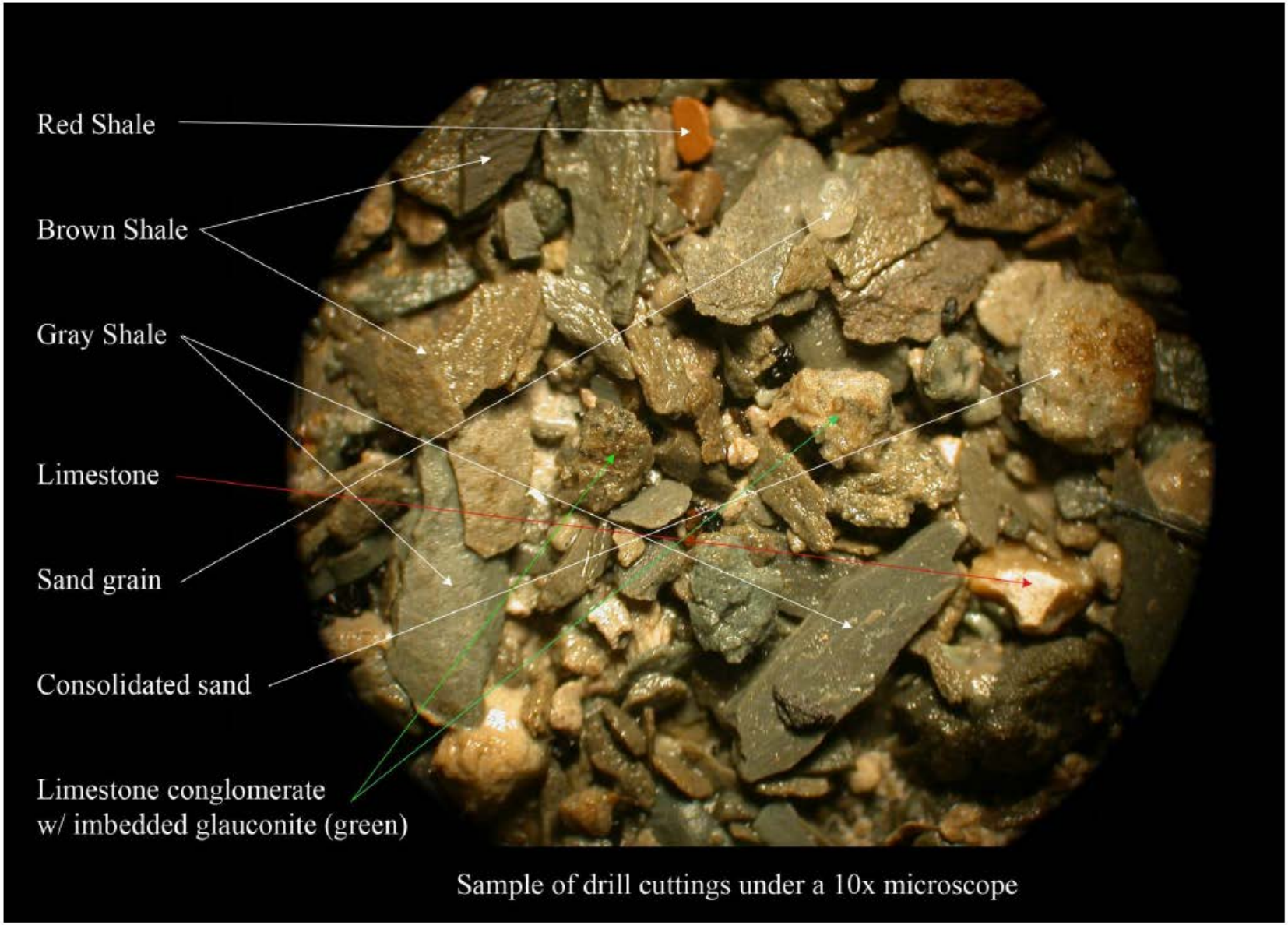






Sachsenhofer 2017

Drill cuttings



Sample of drill cuttings under a 10x microscope

Geological information

Benefits:

- Cutting are the only „continuous” visual record**.**
- Evaluation of HC shows

At the well site

- Rocktype and lithological composition
- Colour
- Texture: grain size, shape, sorting, sphericity
- Fossil content if any
- Matrix
- Porosity
- $CaCO_3/MgCo_3$ ratio

In the lab

Thin section: microfacies

Paleontological examination: age

Hydrocarbon indication

- Gas: total gas content, gas components
- Oil on washed and unwashed cuttings
- Visual stain/oil show: oil staining on the cuttings indicates, that hydrocarbons have been in the formation sometimes. However the lack of sample staining does not prove that the rock lacks productive hydrocarbons. Stain colour can be related to oil gravity: darker staining indicates heavier hydrocarbons.

- Fluorescence: the cutting fluerescence under UV light.

  A lack of fluorescence however doesn’t prove the absence of hydrocarbons in the zone of interest.
- Odor (during drying process: faint, fair, strong)

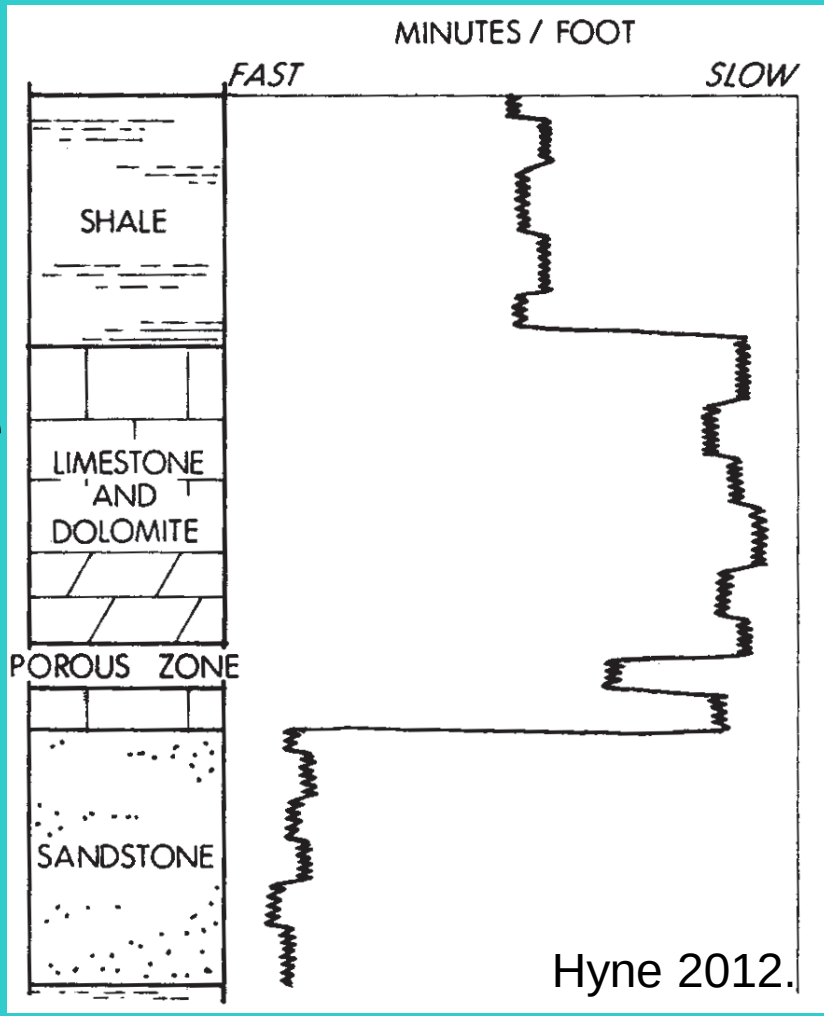
- **Advantage of the chips**:
  - the cheapest sample of the subsurface rock
  - information on lithology and CH content
- **Disadvantage of the chips**
  - porosity, permeability measurements are not possible

Mudlog

- is a chemical and visual analysis of the drilling mud and well cuttings for traces of subsurface natural gas and crude oil as the well is being drilled.
- The purpose of the mud log is to identify oil- and/or gas-bearing rocks in the subsurface.

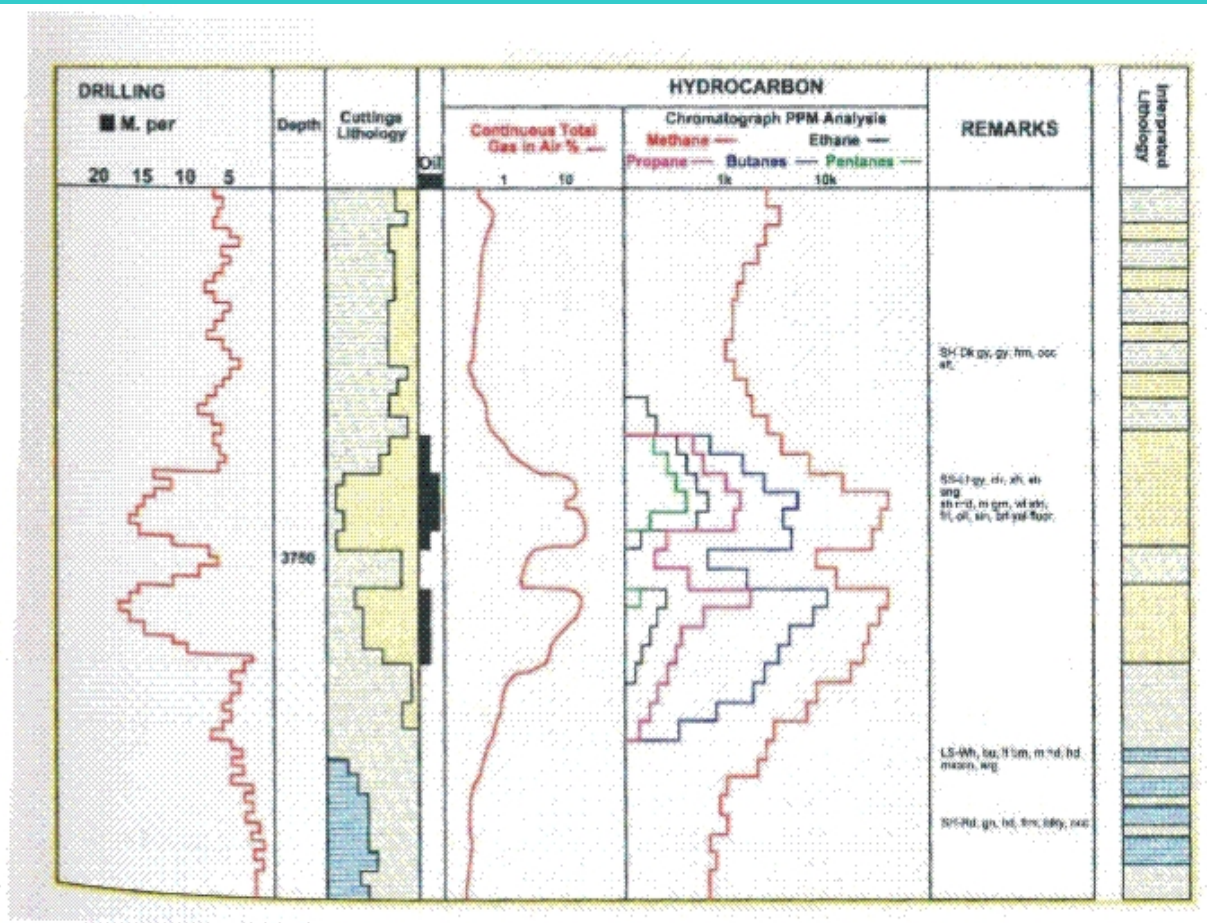
Rate of penetration (ROP)

- A *drilling-time log* is a record of the rate of drill bit penetration through the rocks (*rate of penetration*, or *ROP*).
- Because this log is recorded as the well is drilled, changes in the subsurface rocks are recorded instantaneously.
- Sandstones have the fastest drilling rate, shales are intermediate and carbonates are slowest



Hyne 2012.

Mudlog



- **Lithology, texture** of the cuttings
- **Total gas content**: Combustible gas in the air above the mud, which returns from the well bore
- **Gas components:** a gas chromatograph measures the percentages of methane (C1), ethane (C2), propane (C3), butane (C4), and pentane (C5).
- A black bar shows that the mud logger saw oil staining on the well cuttings. It is called a *show of oil*.

Sidewall core

- **Advantages**

- it can be taken after the well has been drilled and logged, but before casing
- the tools can be precisely positioned in zones of interest using gamma logs or SP logs
- provides small bits of formation material, suitable for geological and engineering studies
- a cost effective way to increase knowledge of formations

- **Disadvantages:**

- gives information only from one point, it could lead to misinterpretation of the geological sequence
- gives only qualitative info: lithology, fluid type

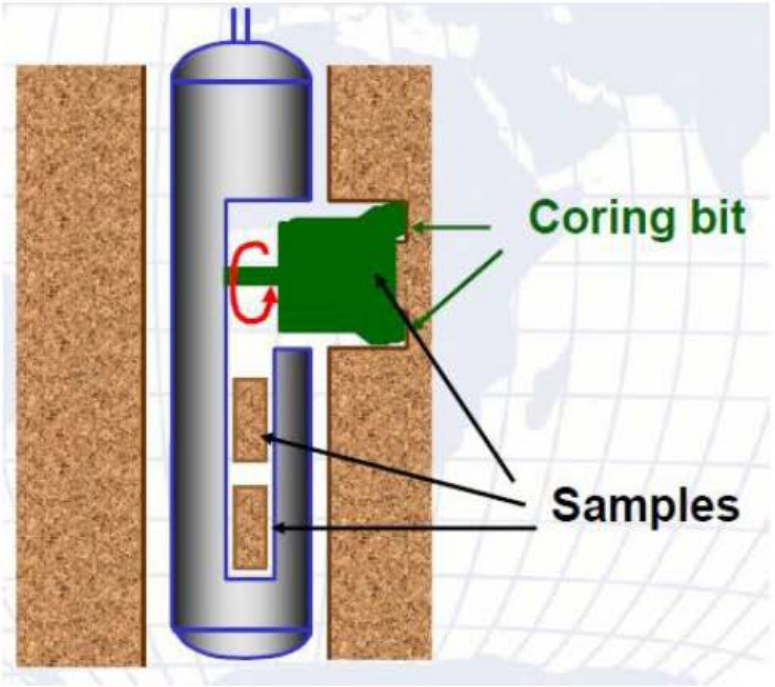
- **Geological information:**

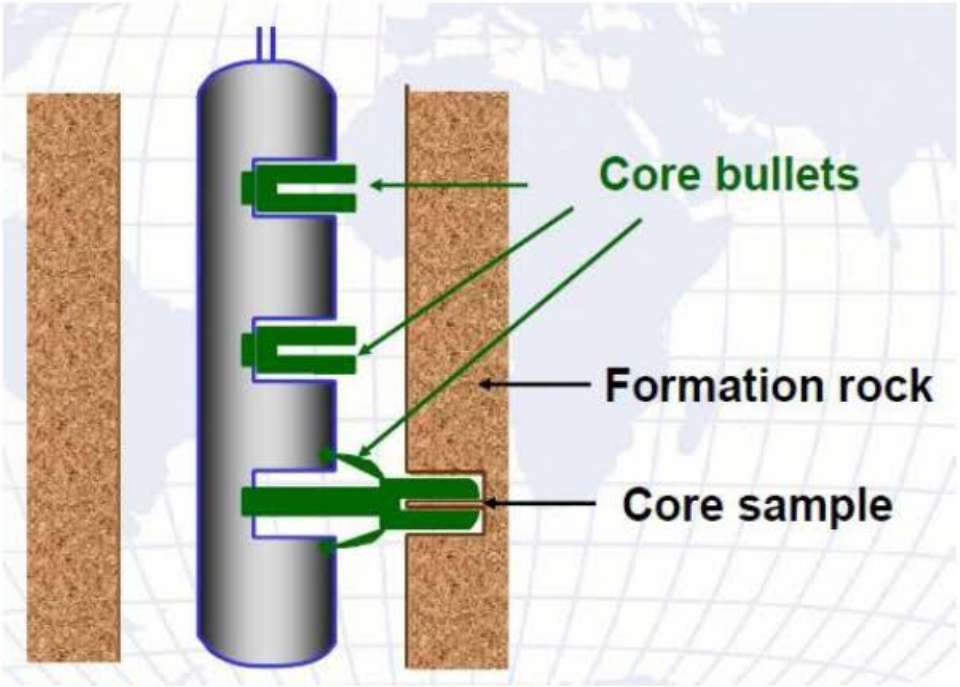
- Lithology
- Microfacies analyses
- Diagenesis
- Paleontological examination: age determination

Petrophysical information

- Porosity
- Permeability
- Saturation

Sidewall coring







Cores

- **Advantage**

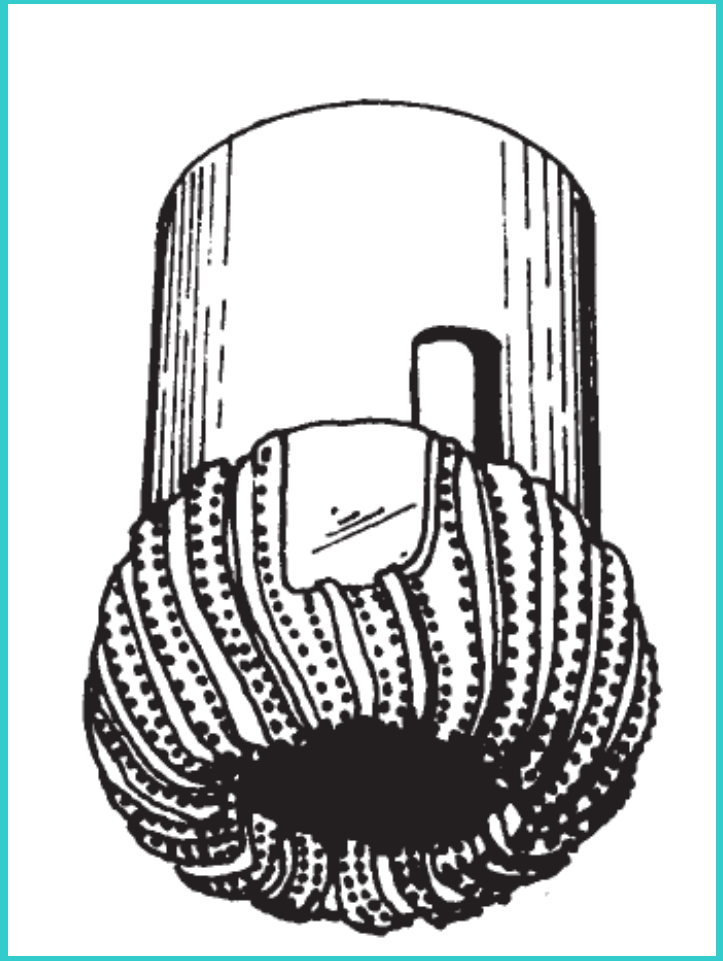
- The only means of obtaining high quality samples for geological examinations and petrophysical measurements (porosity, pemeability).
- Allows direct observation of grain size, sorting and sedimentary structures, which leads to interpretation of the depositional environment.
- Depositional environment is used to assigning geometry and architecture in reservoir models.
- Allows calibration to logs, thus enabling direct interpretation from logs in other well in the reservoir.

Disadvantage

- Very expensive

The only physical contact with the reservoir. Logs, seismic are a form of remote sensing.

Rotary coring bit



Hyne 2012.

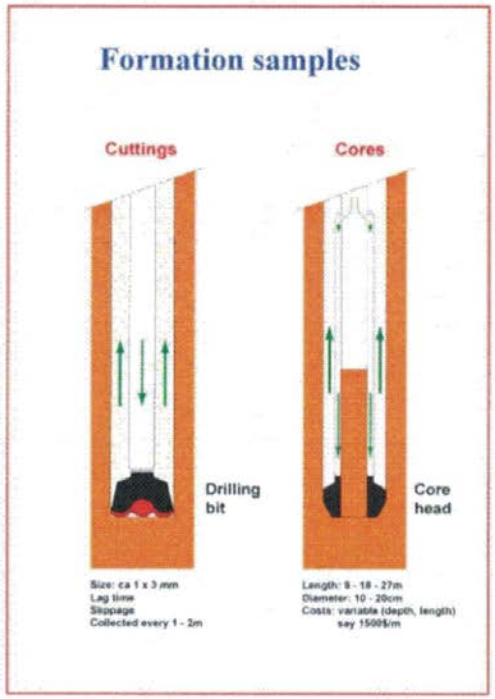


Figure 1 - Coring Process

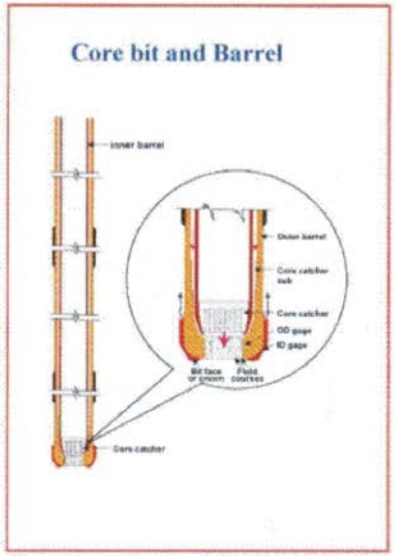


Figure 2 - Core Barrel

Cores are very expensive

- Interrupt the drilling
- Drilling string has to pulled up, unscrewed, put aside
- The core barrel has to screwed on
- The whole string has to run into the hole again
- Core from 2500 m takes one day!

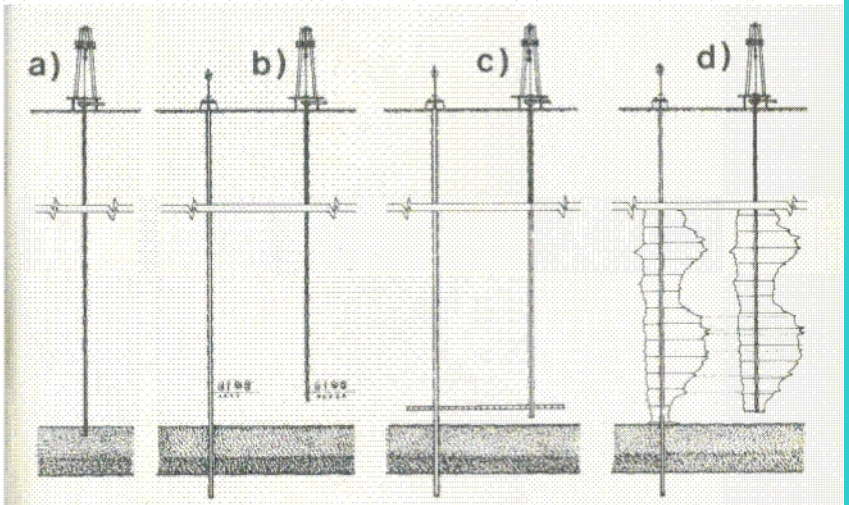


Fig. 87 How to begin coring at the correct depth. a) The cuttings are controlled very quickly and very exactly. As soon as brickles of the pay formation appear, the drilling string is hauled up and the core barrel is run in. Anyhow the first meters of the pay will get lost. b) Micropaleontological comparison with a nearby well. The cuttings and their microfossils are inspected very quickly and very carefully. Some special horizon some meters above the pay may enable a good sampler to begin coring just at the top of the pay. c) Petrographical comparison with a nearby well. Some special petrographical components some meters above the pay may be used in a similar way. d) If there are no possibilities to date the top of the pay by microfossils or by petrology, a bore hole log should be run. The top of the pay may be calculated after correlation with the log of a nearby well.

- How to begin the coring at the correct depth?
- 1. Cutting (lag time: the first meters of the pay zone will get lost)
- 2. Micropaleontology (special horizon above the pay zone)
- 3. Petrological comparison with a nearby well
- 4. Log comparison with the the log of the nearby well.

Routine Core Analysis

- Description of the lithology of the core.
- **Measurement** of
- - porosity: does the rock contain fluid-filled space?
- - saturation: does it contain hydrocarbons in that space
- - permeability: can those hydrocarbon fluids be produced (permeability)?

- Core gamma logging provides a link of the core depth to wellbore logging depth
- Core computed tomography (CT) scans indicate the core heterogeneity.
- Core photographs taken in both white and ultraviolet light are used for both documentation and core description.

We will discuss

- How the core should be handled on the well site
- Routine core analyses for petrophysical properties (porosity, permeability)
- Plug preparation

How to handle on the well site



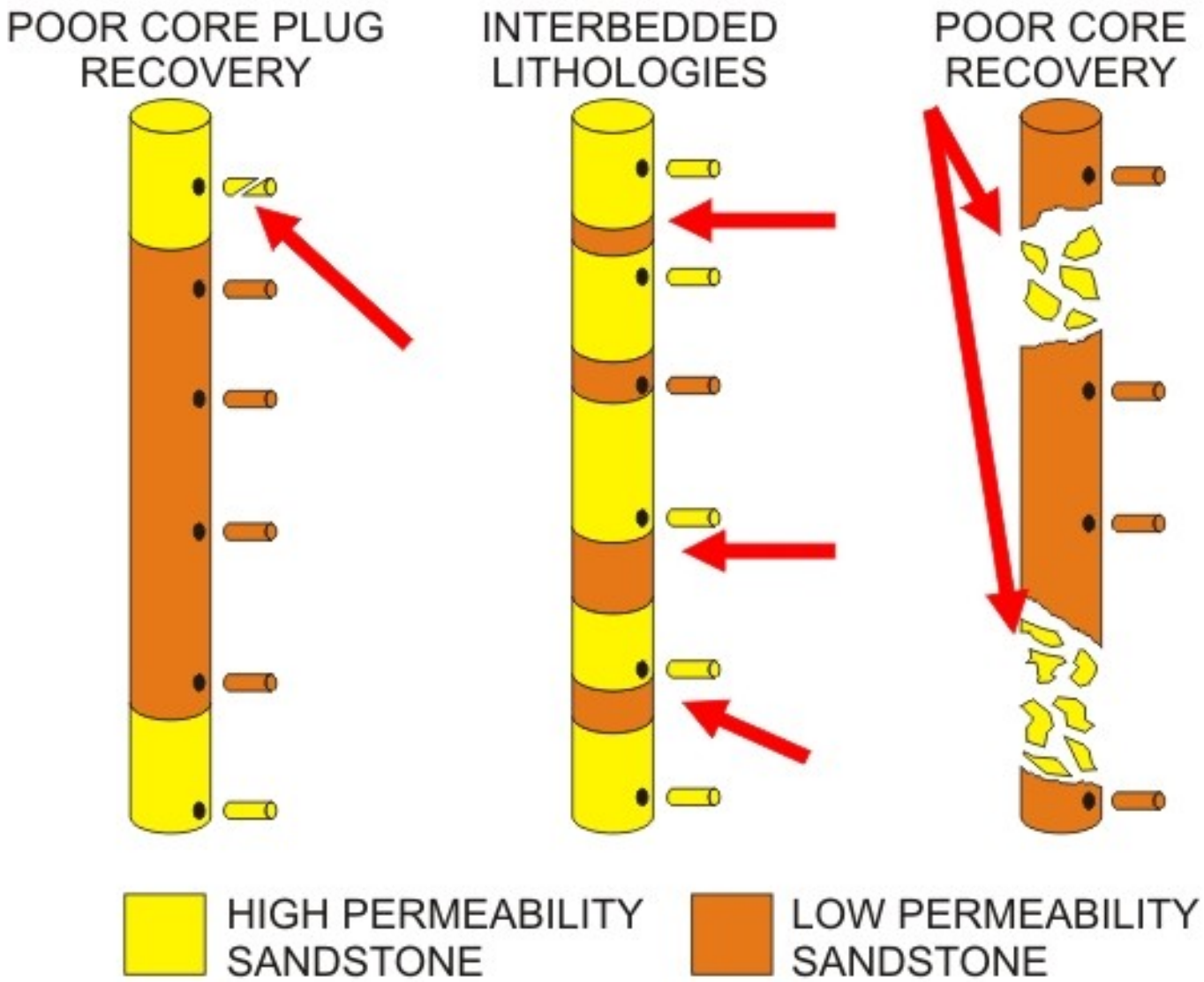


- To take plugs for porosity, permeability measurement

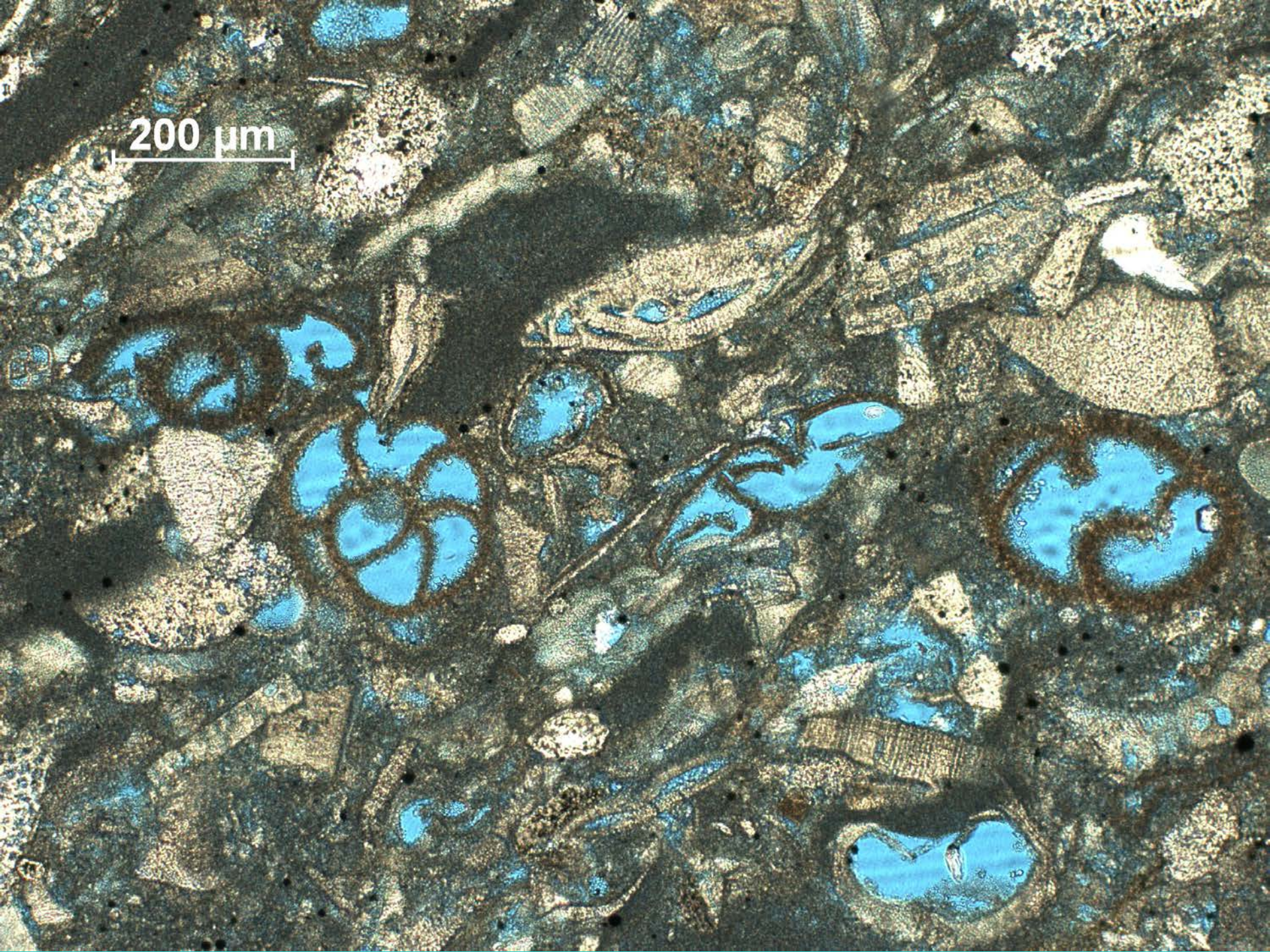
- 1. Take plugs from the same distance
- 2. To adjust the pugs to the sedimentological features.

Plugs must be representative!!

CORE PLUG SAMPLING BIAS



(Vavra and Kaldi)


200 µm

Core are cut lengthwise in two pieces (Slabbing)



Slabbing is essential for adequate reservoir description



Take colour photos

Provide permanent record of core plug sites, depths, etc.

Reveal features which may later be rendered invisible by subsequent drying of deterioration



3 cm thick slab is cut lengthwise, one side is polished and put into resin





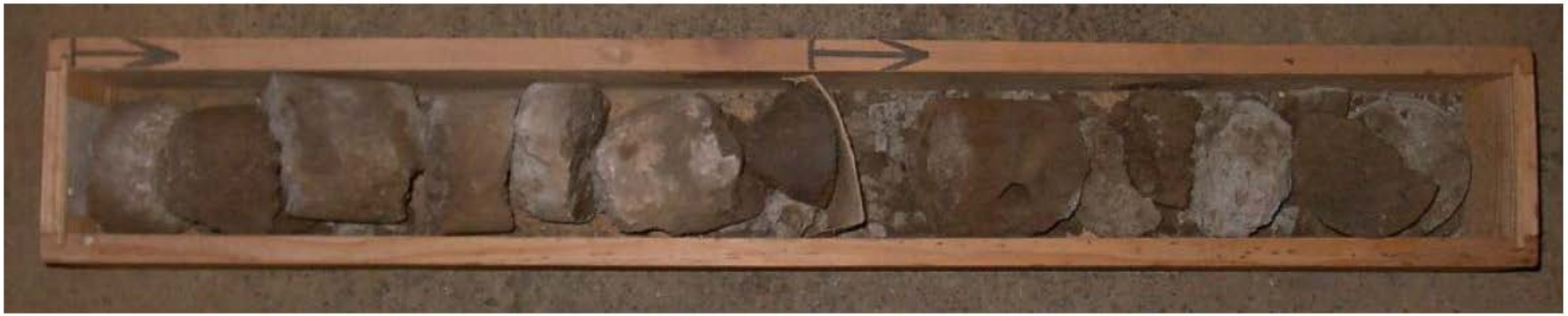

TOYOTA


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Core boxes





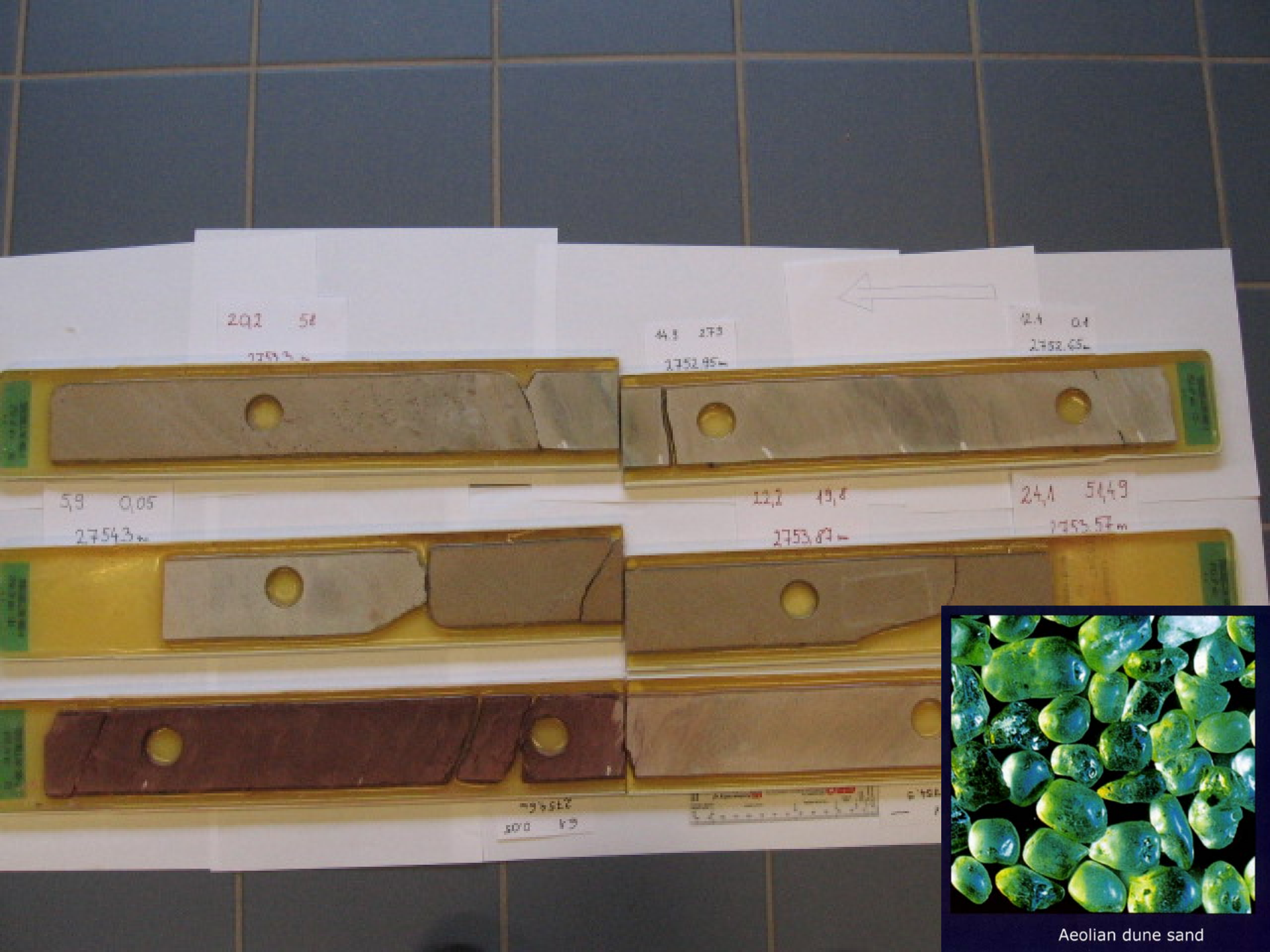


Core storage






DE WADDENZEE


Aeolian dune sand

Exercise

- You are a geologist. Your task is to prepare a list of measurements and examinations to get the most geological information and petrophysical data from the planned well.
- Make two lists one at minimum price, one on maximum price about the coring type, geological examinations, measurement sequence.
- You have to convince the management about the importance and necessity all of your planned measurement.
- Write the advantages and the disadvantages for every planned step.