# 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

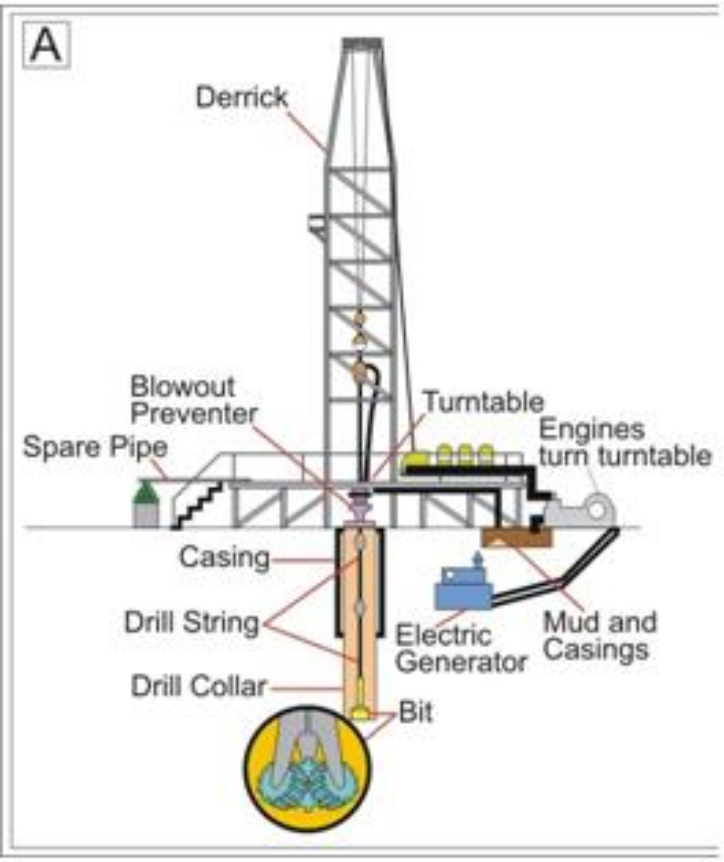
(samples from the penetrated rocks: cuttings/sidewall cores/cores)

**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)



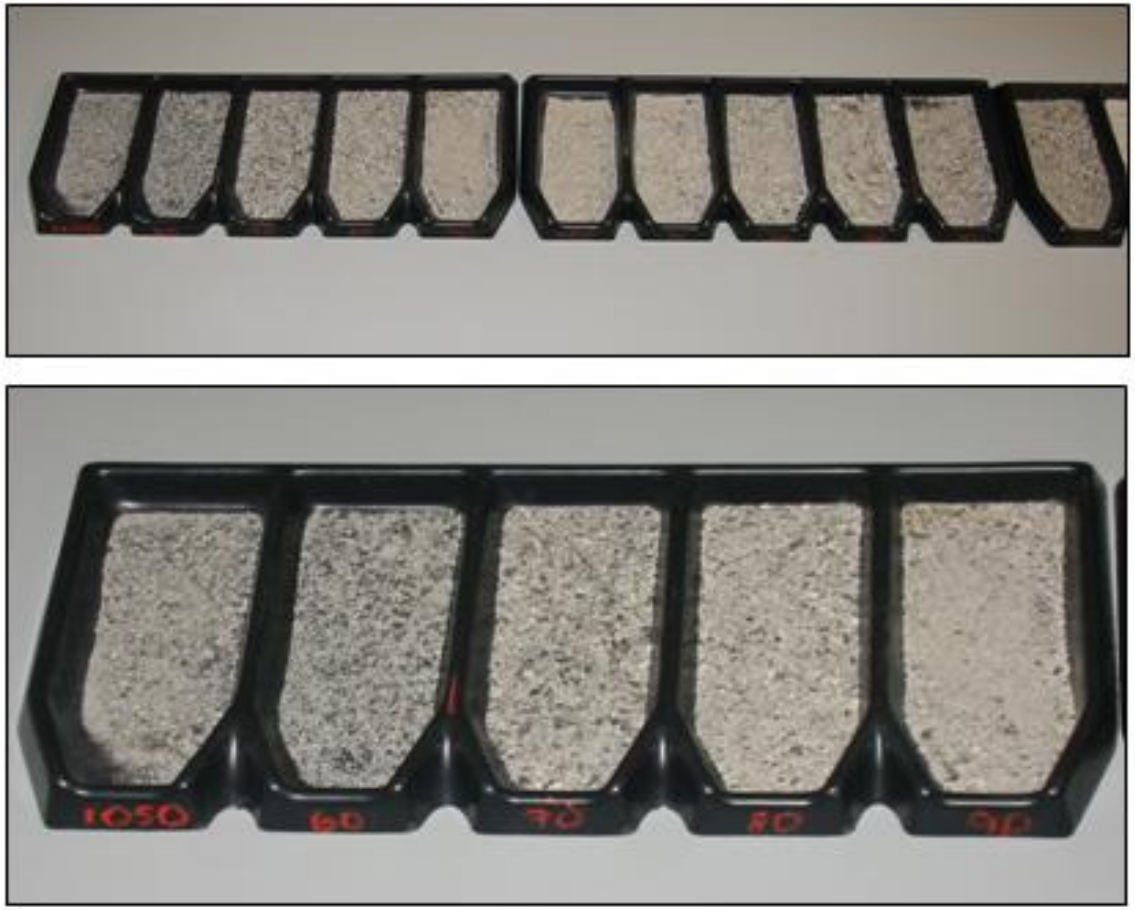




Figure 3.2: Example of cuttings trays. Each compartment holds ten feet of cuttings. These trays were used for the top 1000 feet of the cuttings, and the rest of the drill cuttings were poured into ice cube trays, which were laid out in a similar manner (end-on-end).

**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



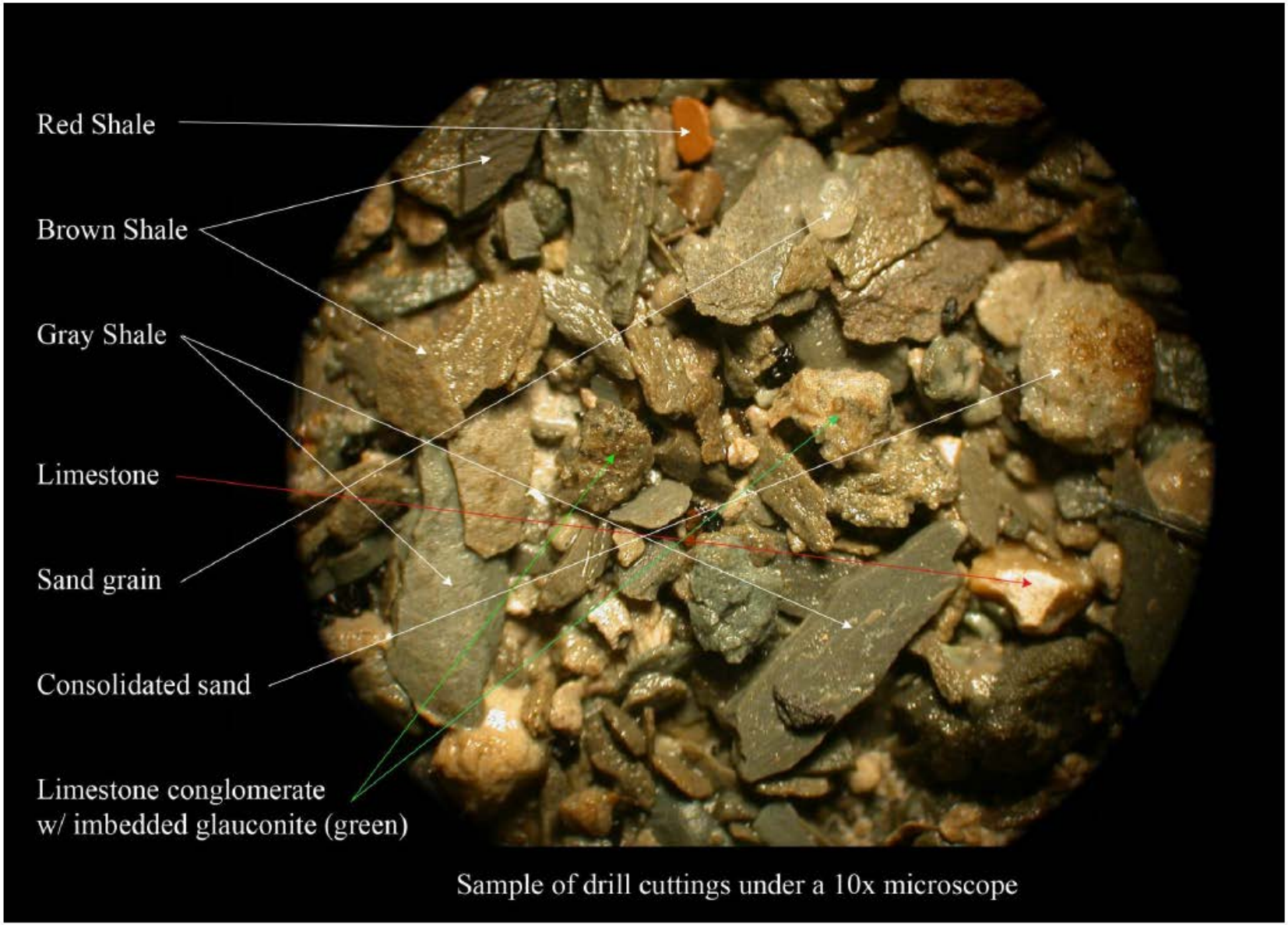

Sampled over 2-5m of depth

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

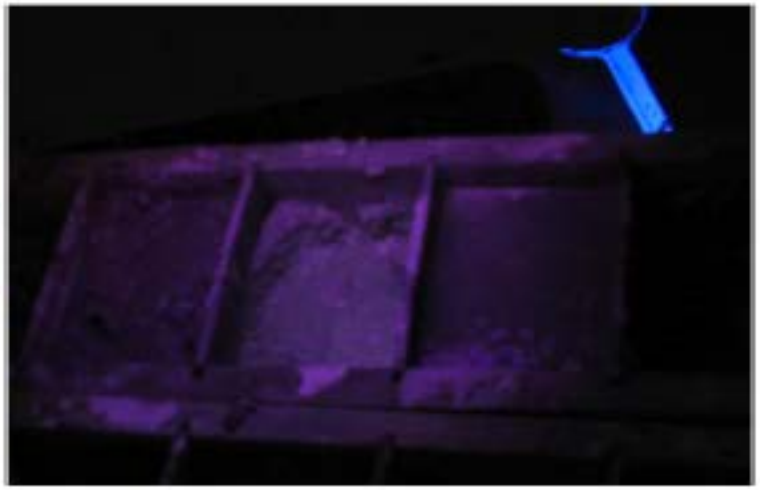
# Drill cuttings

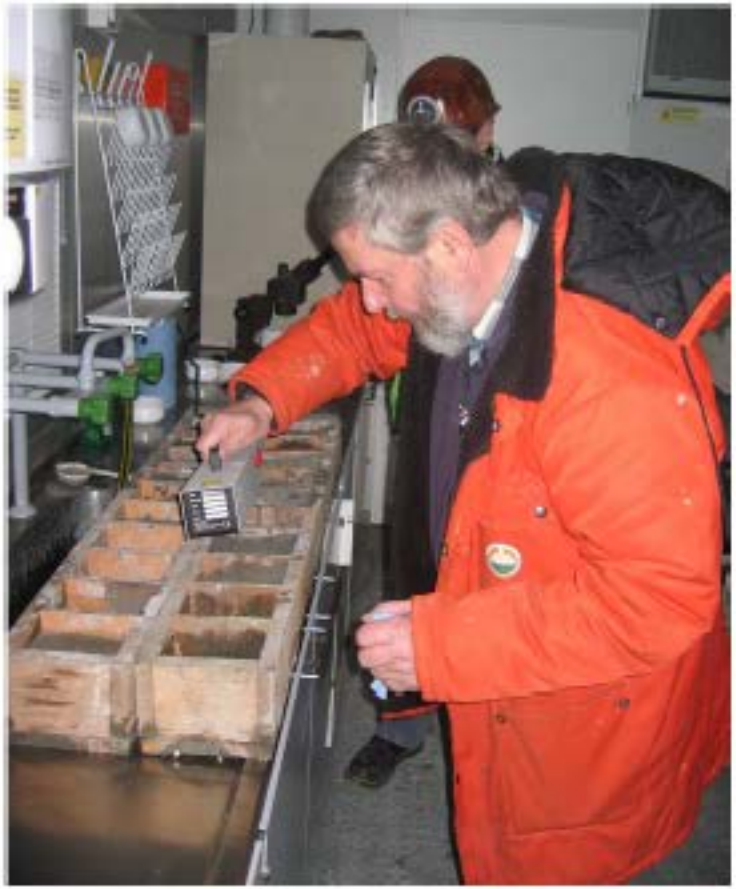



Sample of drill cuttings under a 10x microscope

# Cuttings









Sachsenhofer 2017

# 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)

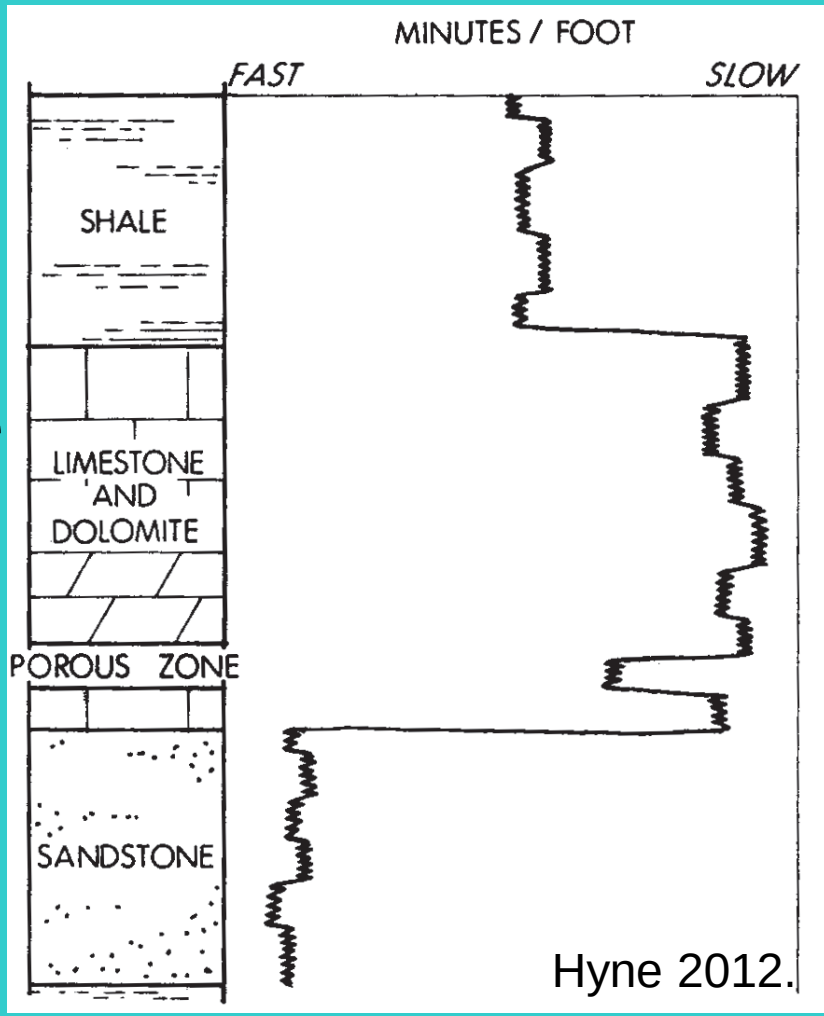
- **Advantage of the chips**:
  - the cheapest sample of the subsurface rock
  - information on lithology and HC content
- **Disadvantage of the chips**
  - porosity, permeability measurements are not possible

# 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.

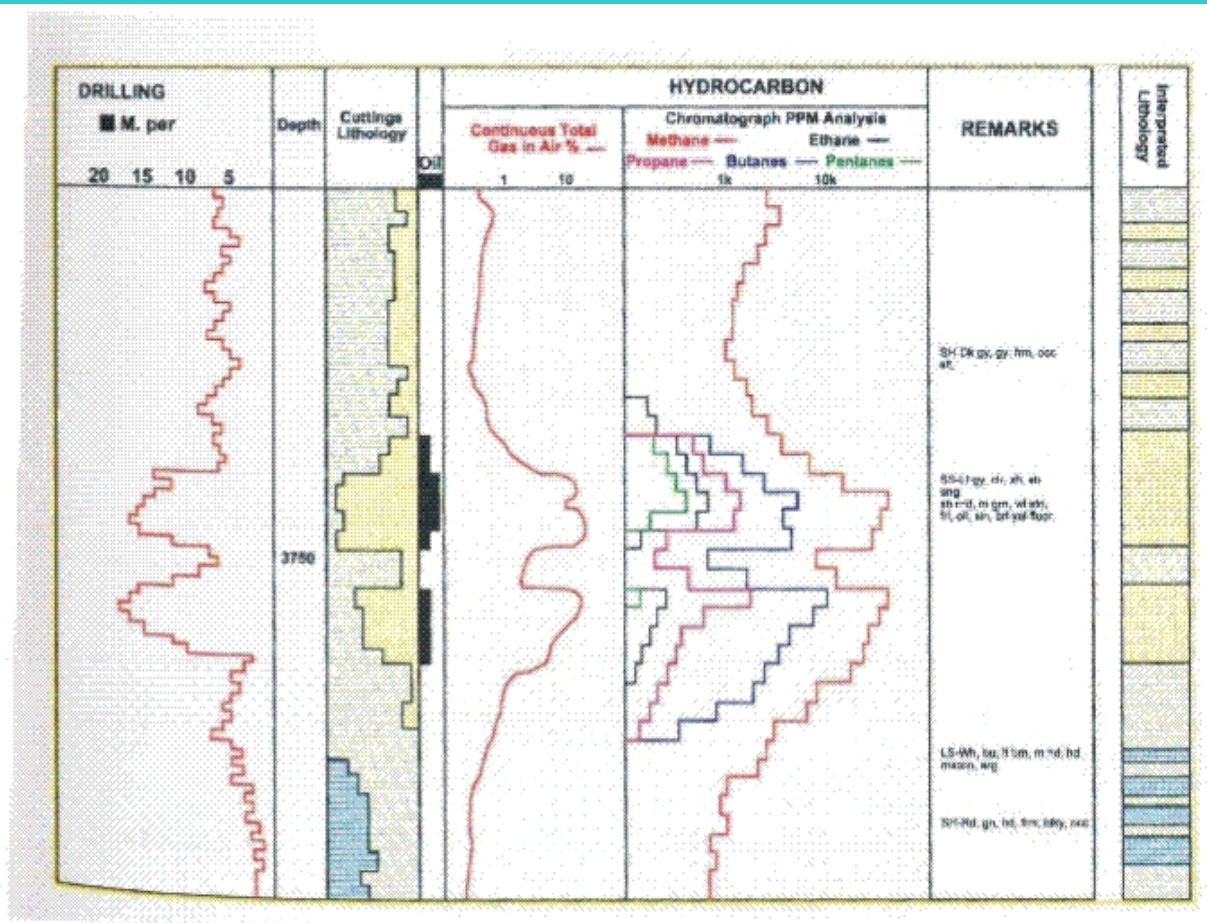
# Rate of penetration (ROP)

- 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

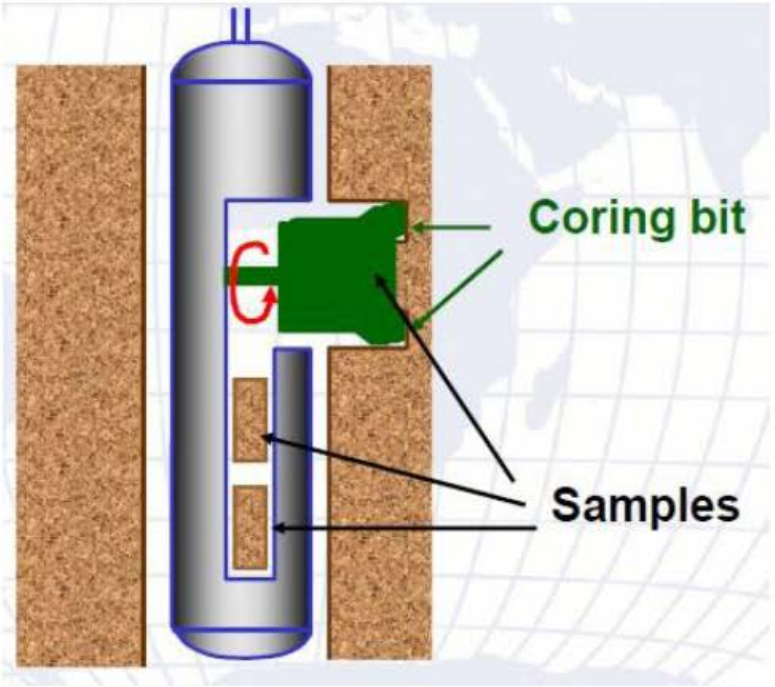
- **Geological information:**

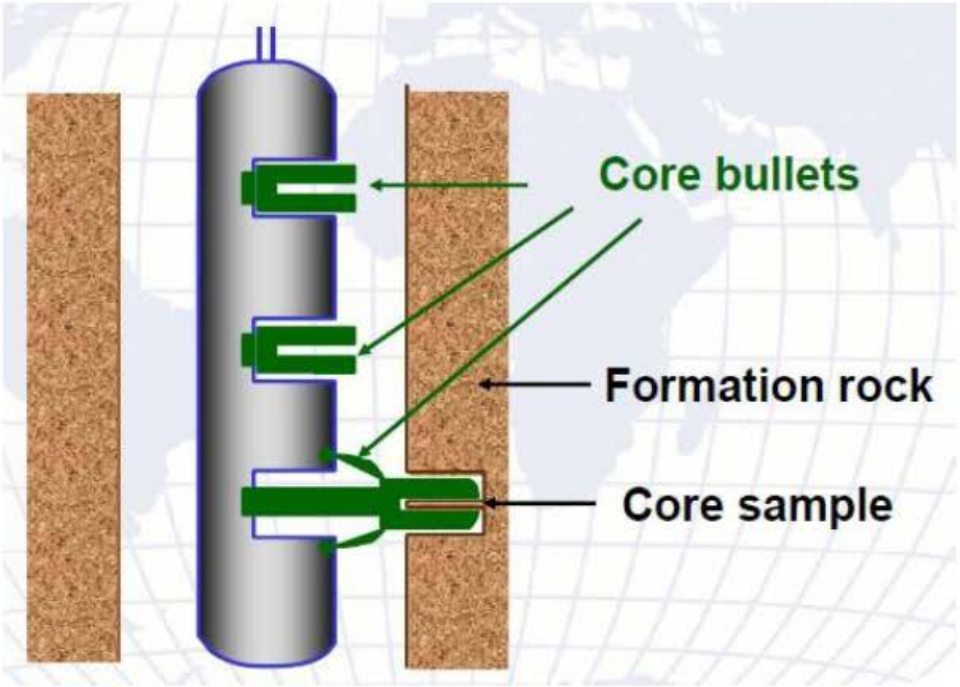
- Lithology
- Microfacies analyses
- Diagenesis
- Paleontological examination: age determination

**Petrophysical information**

- Porosity
- Permeability
- Saturation

# Sidewall coring






# Cores

- **Advantage**

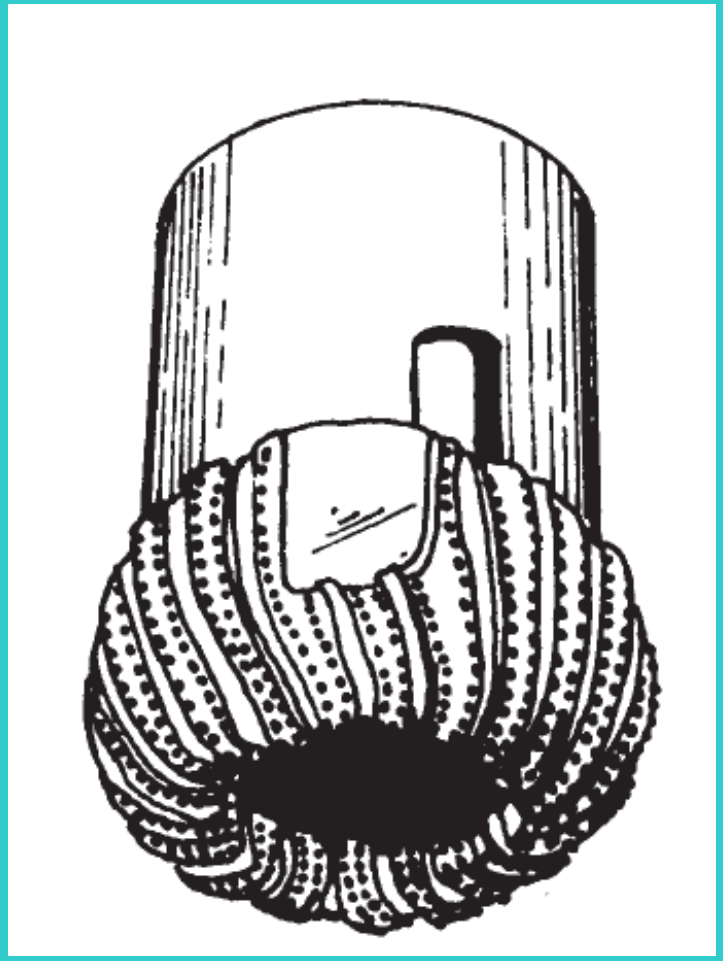
- High quality samples for geological examinations and petrophysical measurements (porosity, pemeability).
- Allows direct observation of grain size, sorting and sedimentary structures, which leads to interpretation of the depositional environment.
- Depositional environment is used to predict geometry 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.

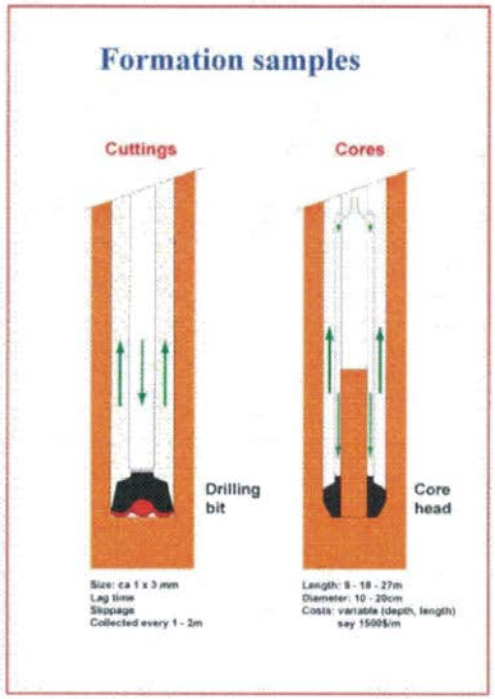



*Figure 1 - Coring Process*

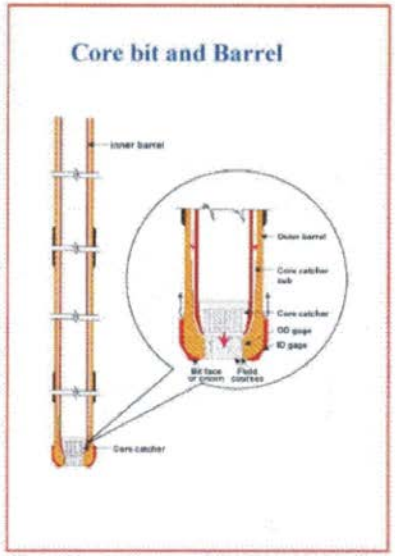



*Figure 2 - Core Barrel*

## 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!

# 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



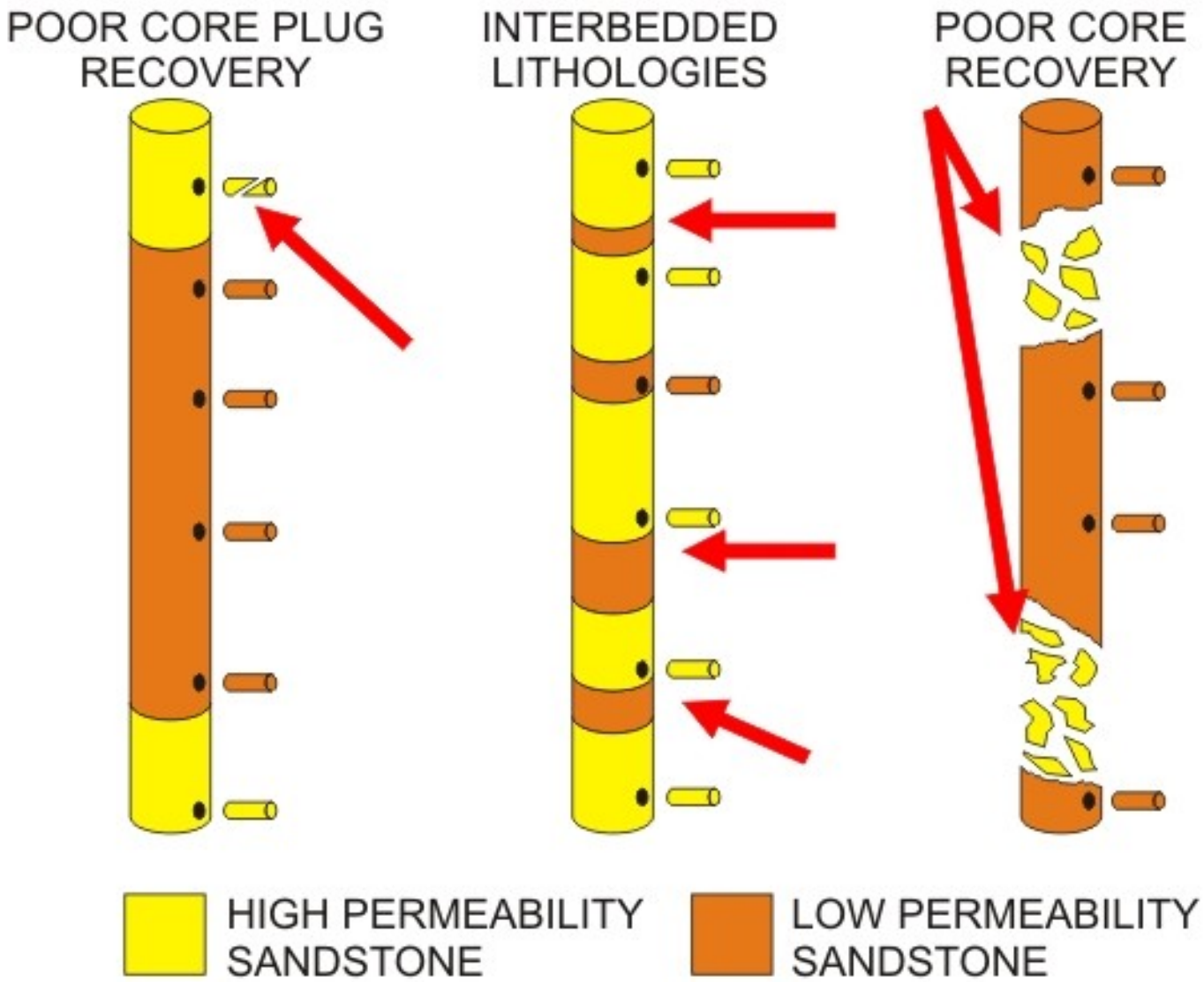


- To take plugs for porosity, permeability measurement

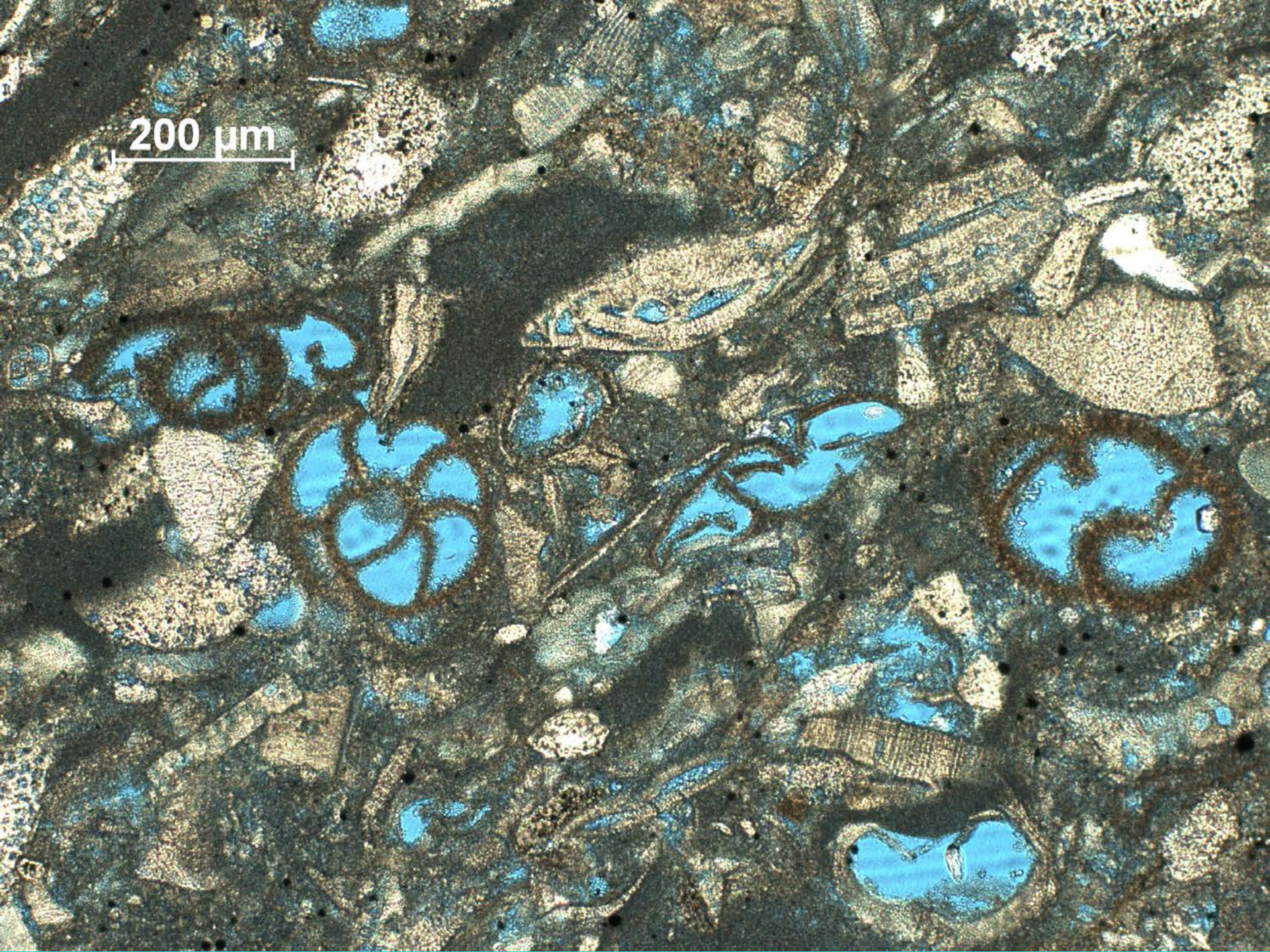
- 1. Take plugs from the same distance
- 2. To adjust the pugs to the sedimentological features.

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





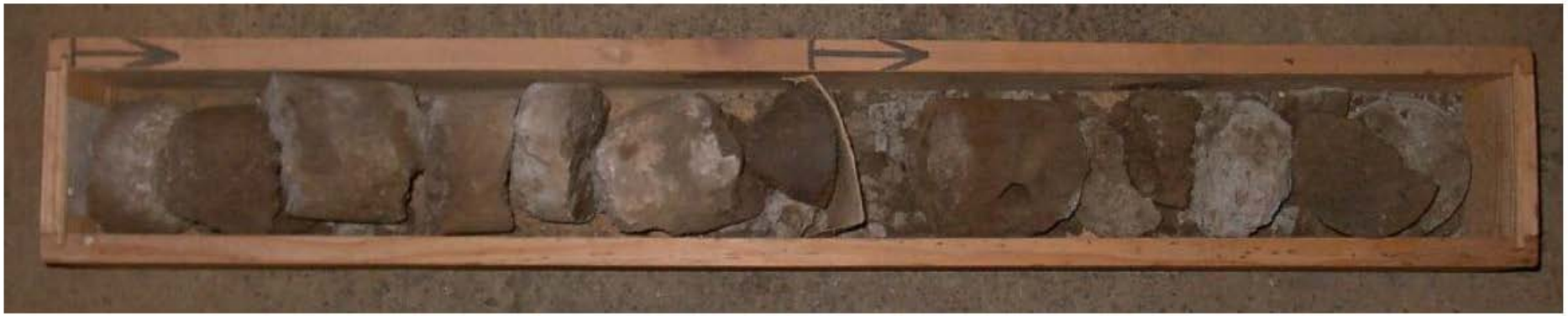

TOYOTA


B 34
B 33
B 32
B 31
B 30
B 29
B 28
B 27

# Core boxes





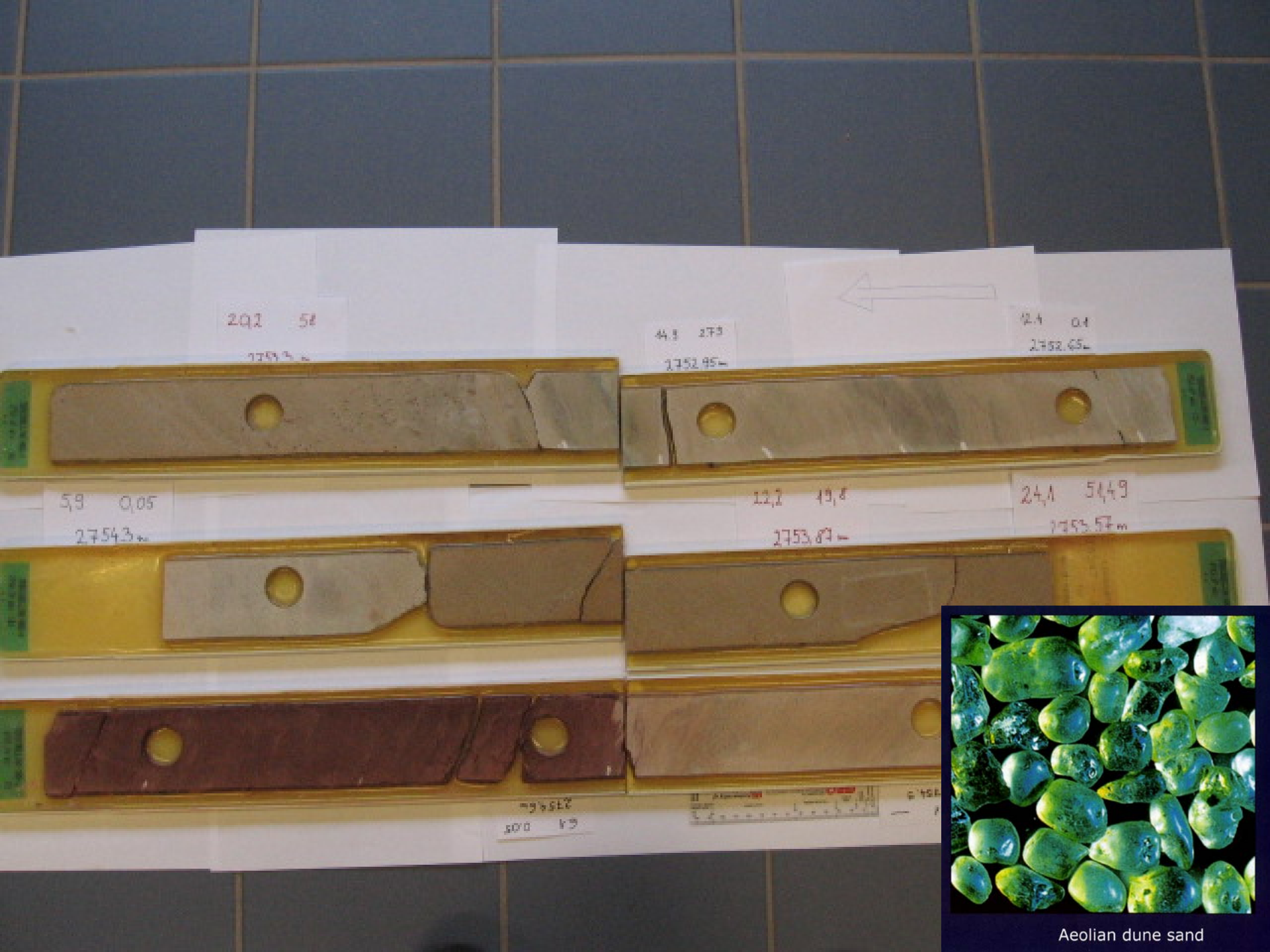



# Core storage






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.