Geoinform

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Applied Technology and Best Practices in CEE

Conference

THE DEVELOPMENT OF MUD GAS LOGGING SYSTEMS AND THEIR ROLE IN HYDROCARBON EXPLORATION

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Society of Petroleum Engineers

Natural Gases

- Helium
- Argon
- Radon
- Nitrogen
- Carbon Dioxide
- Hydrogen Sulfide
- Hydrogen
- Methane
- Ethane
- Propane
- Butane
- Pentane

Inorganic

Mixed

Mostly Organic

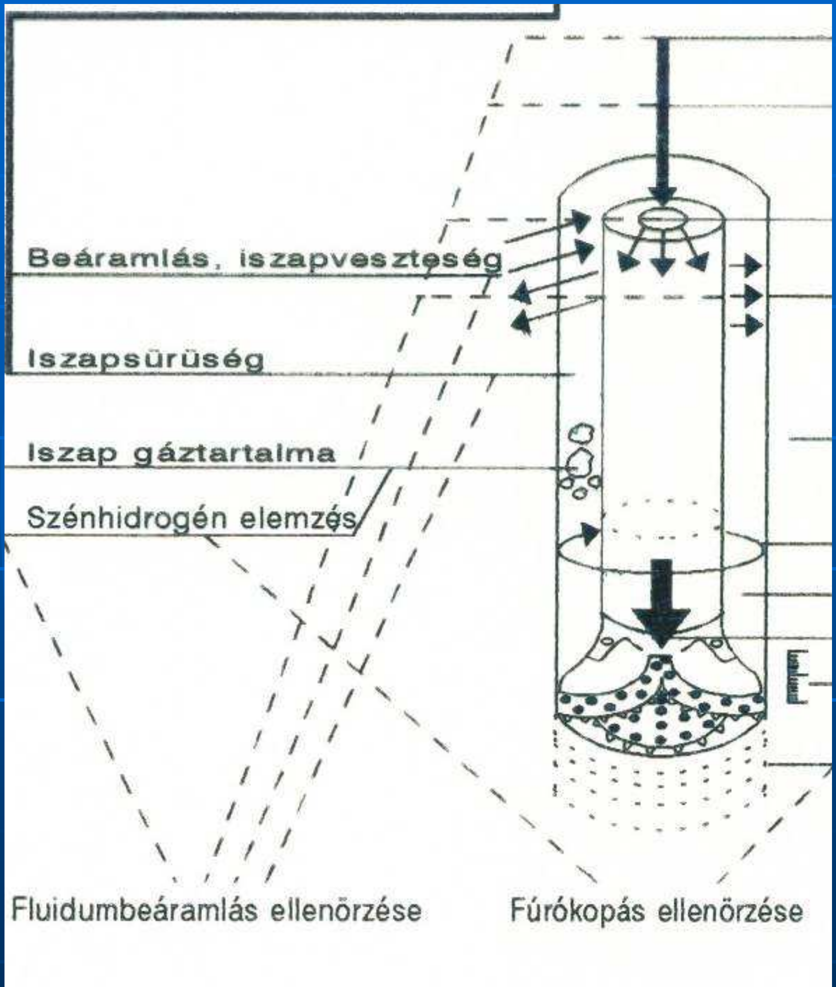
Typical Reservoir Gas

- Methane 70 to 100 %
- Ethane 1 to 10 %
- Propane
- Butane
- Pentane

(Propane, Butane, Pentane: < 1 %)

- Hexane ...& traces up to Nonanes C_9H_{20}

- Variable percentages of CO_2, N_2, H_2S, He



LIBERATED GAS:

The gas that enters the mud stream as a direct consequence of grinding action at the bit.

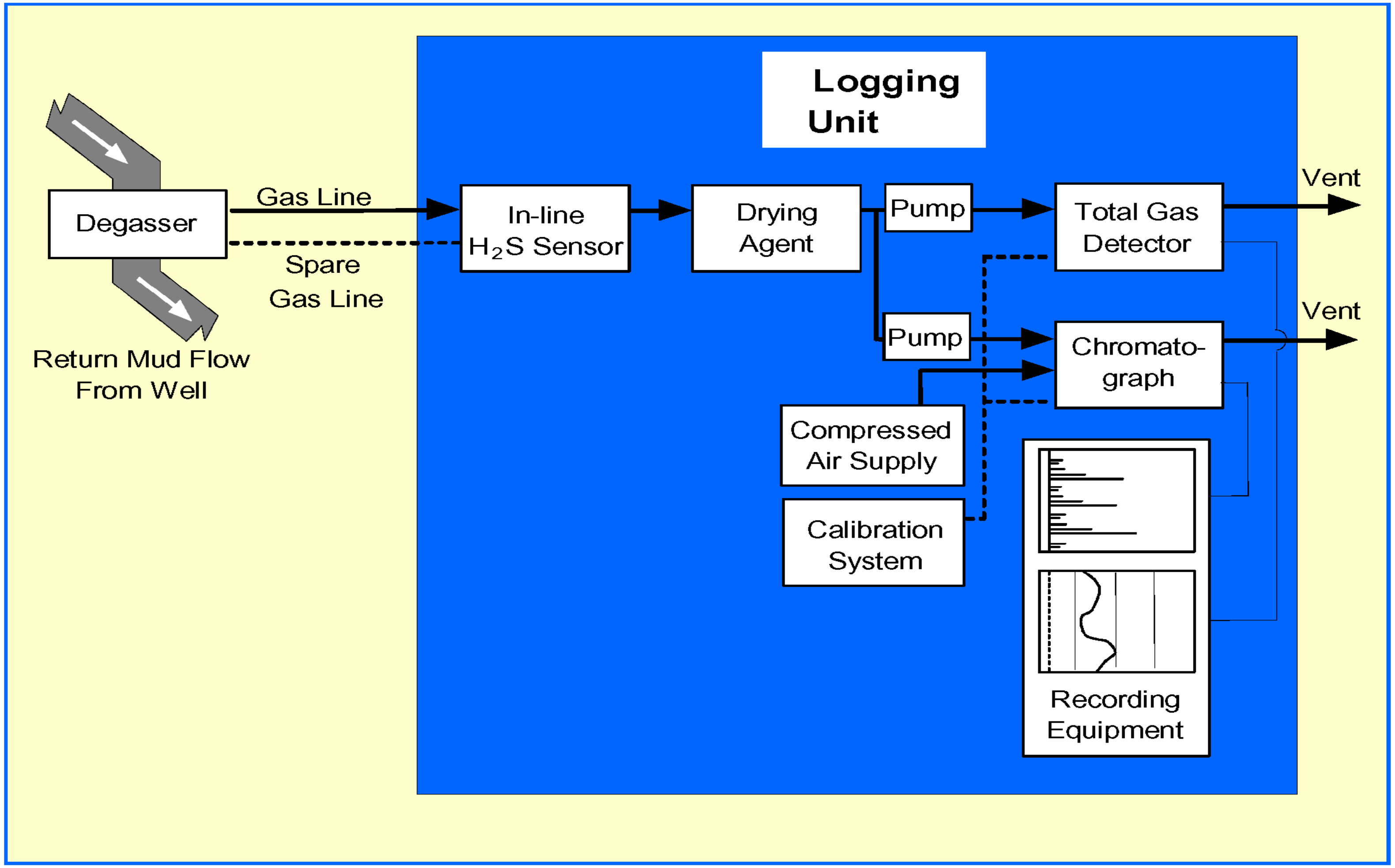
Further liberation of gases and liquids occurs throughout up hole travel.

Some part of this gas is dissolved in the mud, whilst the surplus gas is forming bubbles.

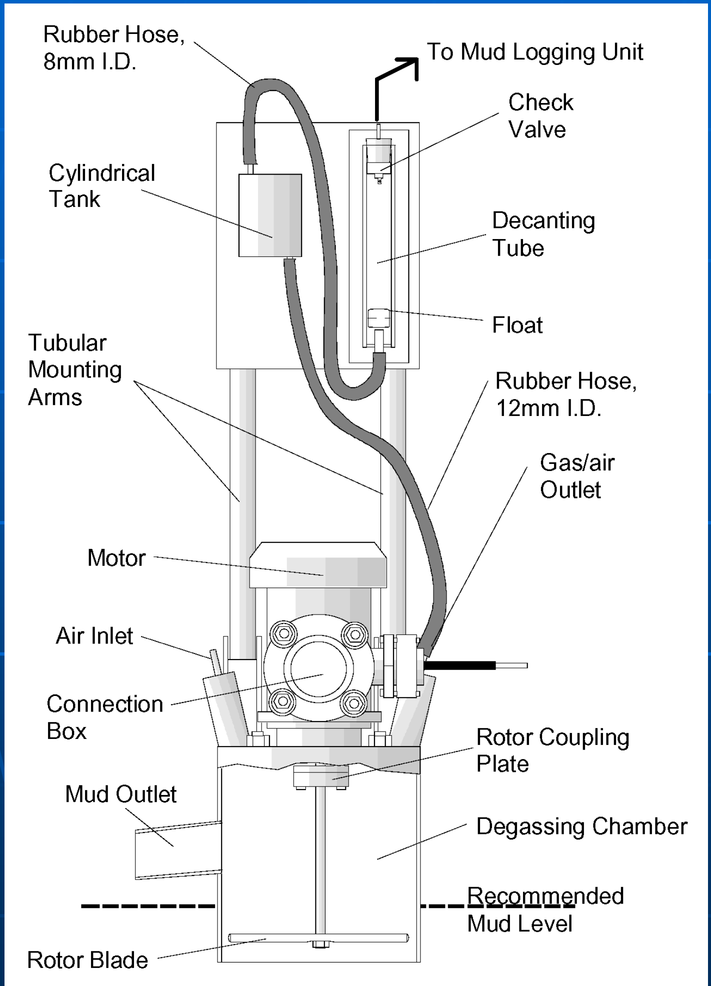
Hydrocarbons in mud - Generalities

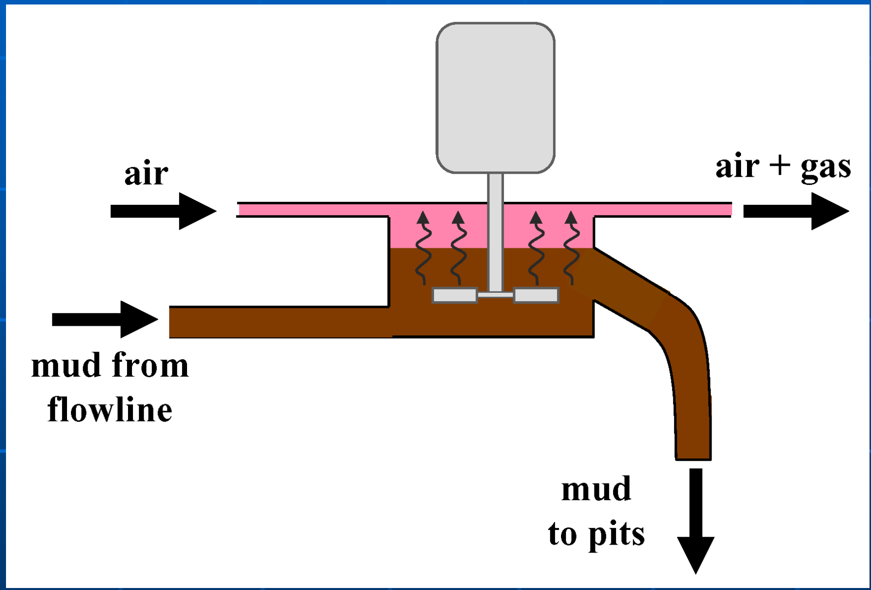
- **Mud systems are very complex**
  - Difficulty to build a precise model
  - Empirical approach is preferred
- **Hydrocarbons present in the mud are expected to be either:**
  - Dissolved, in water (low quantity) or oil mud base
  - Adsorbed on the solids contained in the mud
  - Free phase, gas bubbles or liquid droplets (mainly when mud is saturated)
- **Gas measurements**
  - Measurements are related to gas in air
  - Equilibrium between gas measured and gas remaining in mud

Surface gas detection process



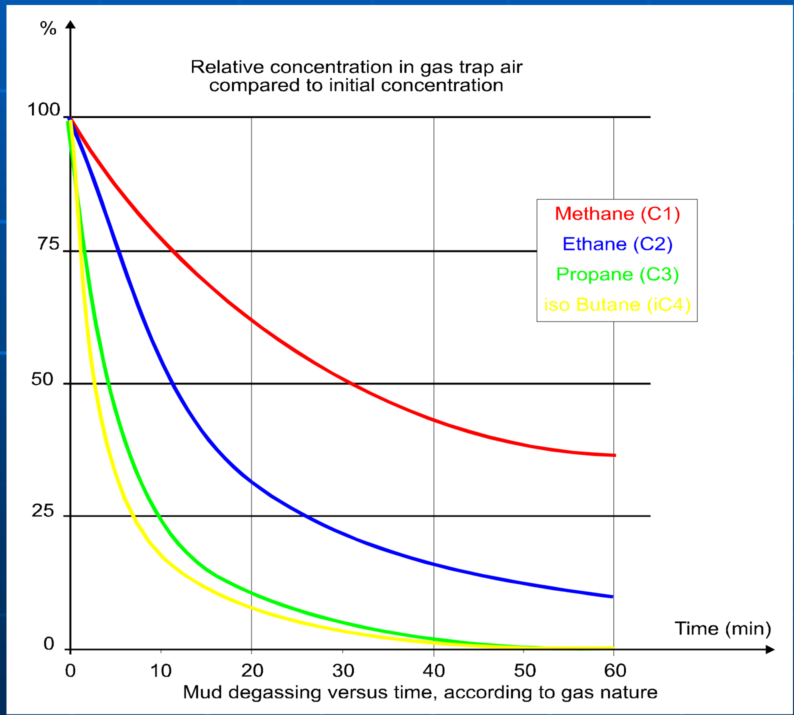
Extractor Schematic View



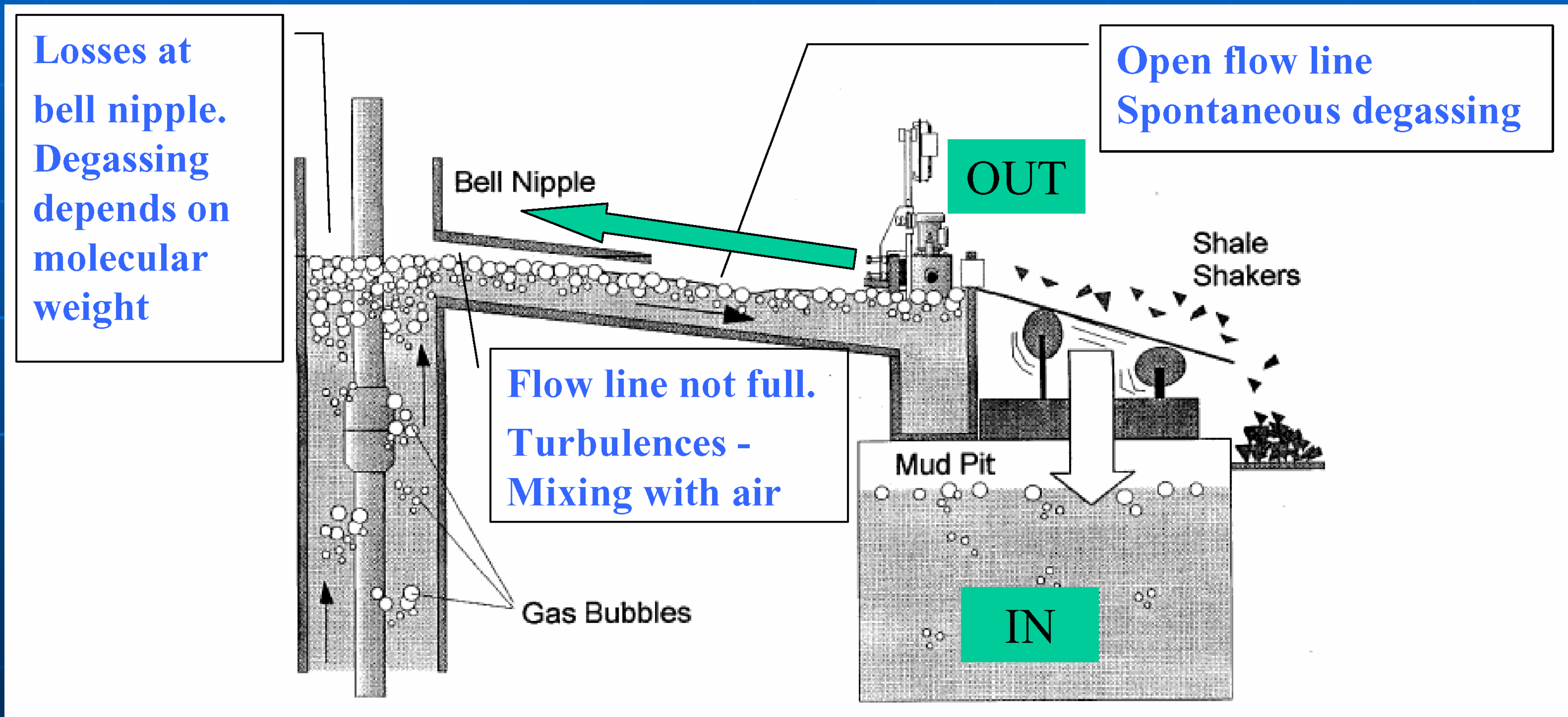


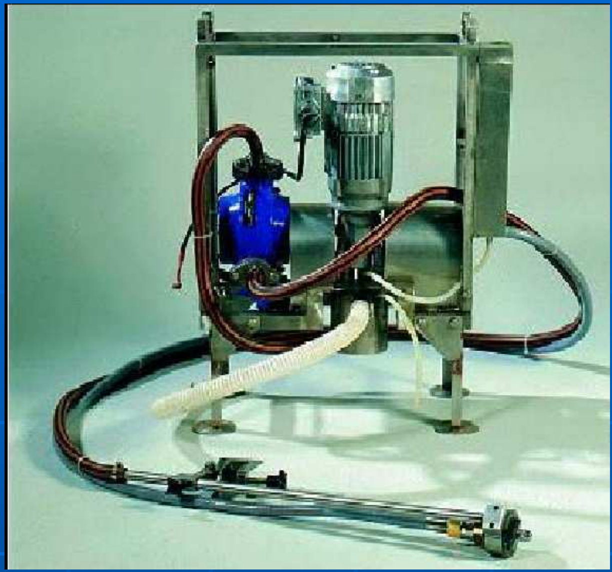
Factors which are helping the degassing effect:

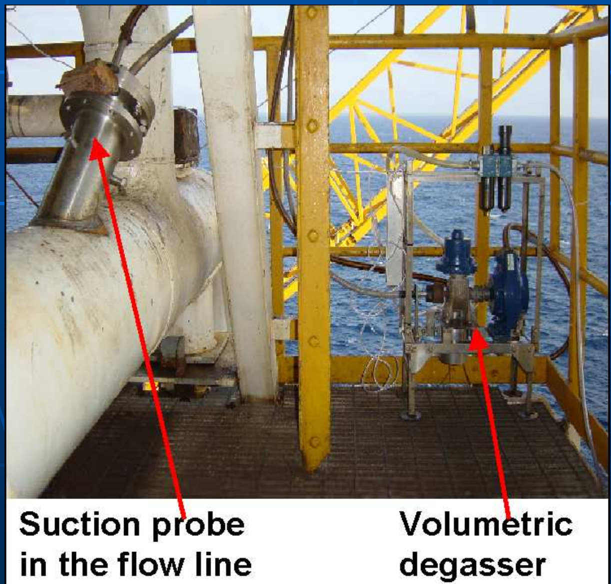
- High temperature of mud out
- Stirring of the mud
- Suction effect of the sample pumps placed in the mud logging unit.



Variables in measurement: Losses of gas along flow line







Volumetric degasser:

It takes the samples from closed flow line

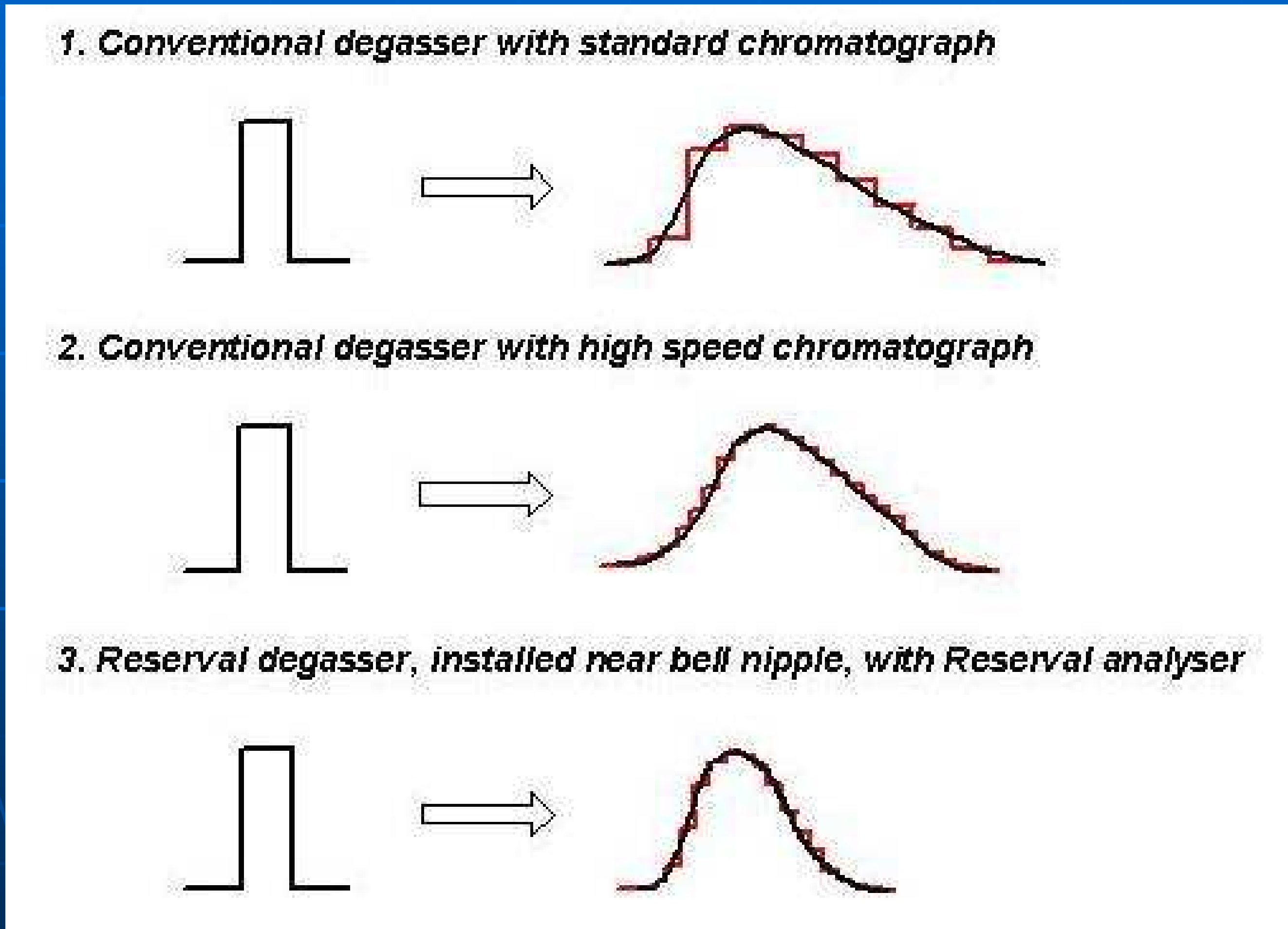
The changes in mud temperature and mud pressure are taken into consideration

Efficiency > 95 %

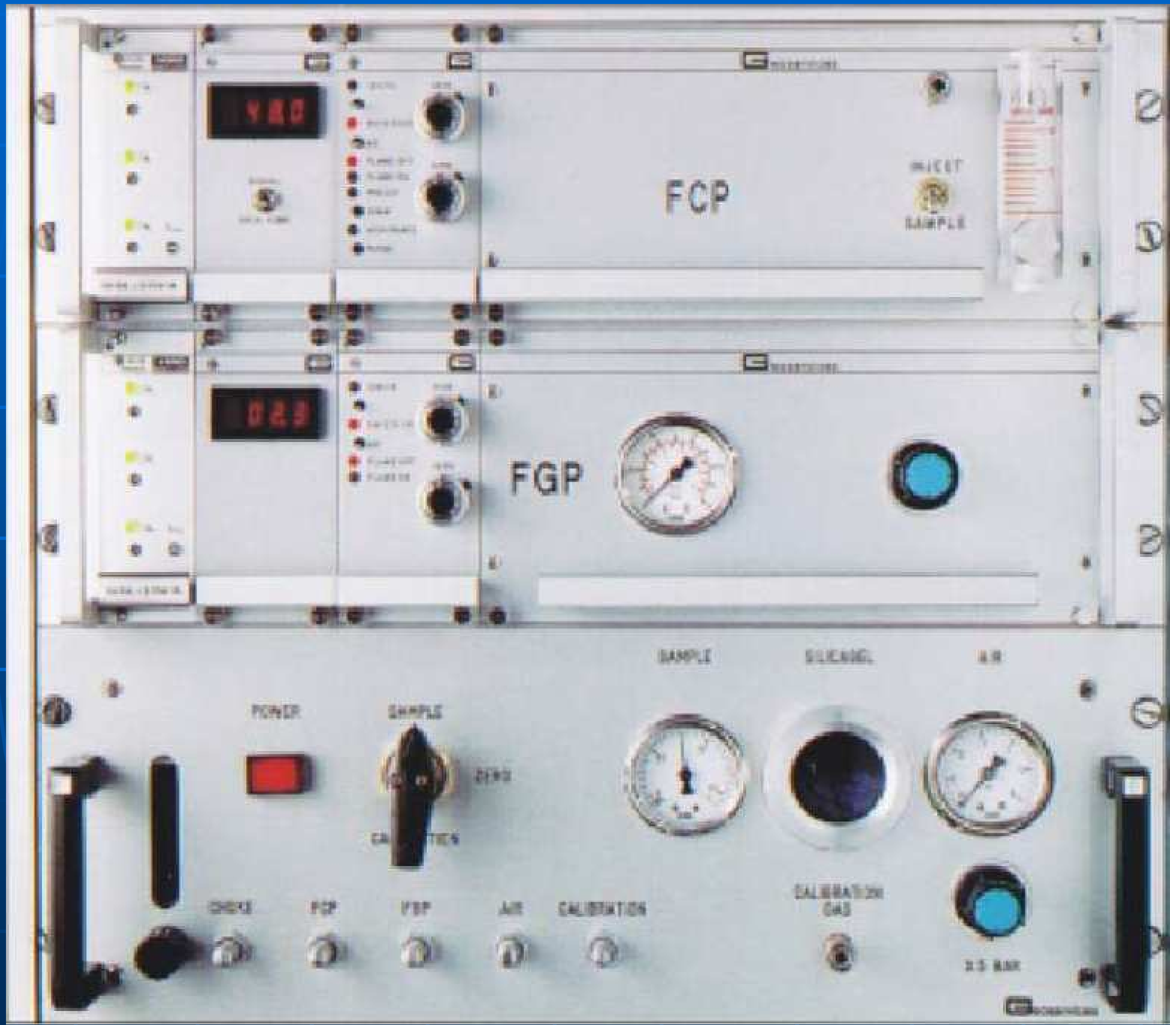
Development of Chromatographs

	TCD	FID	GFF
Sensitivity:	100 ppm	5 ppm	2 ppm
Measures Components up to:	nC4	nC5	nC5
Cycle time:	7,5 min.	5 min.	42 sec

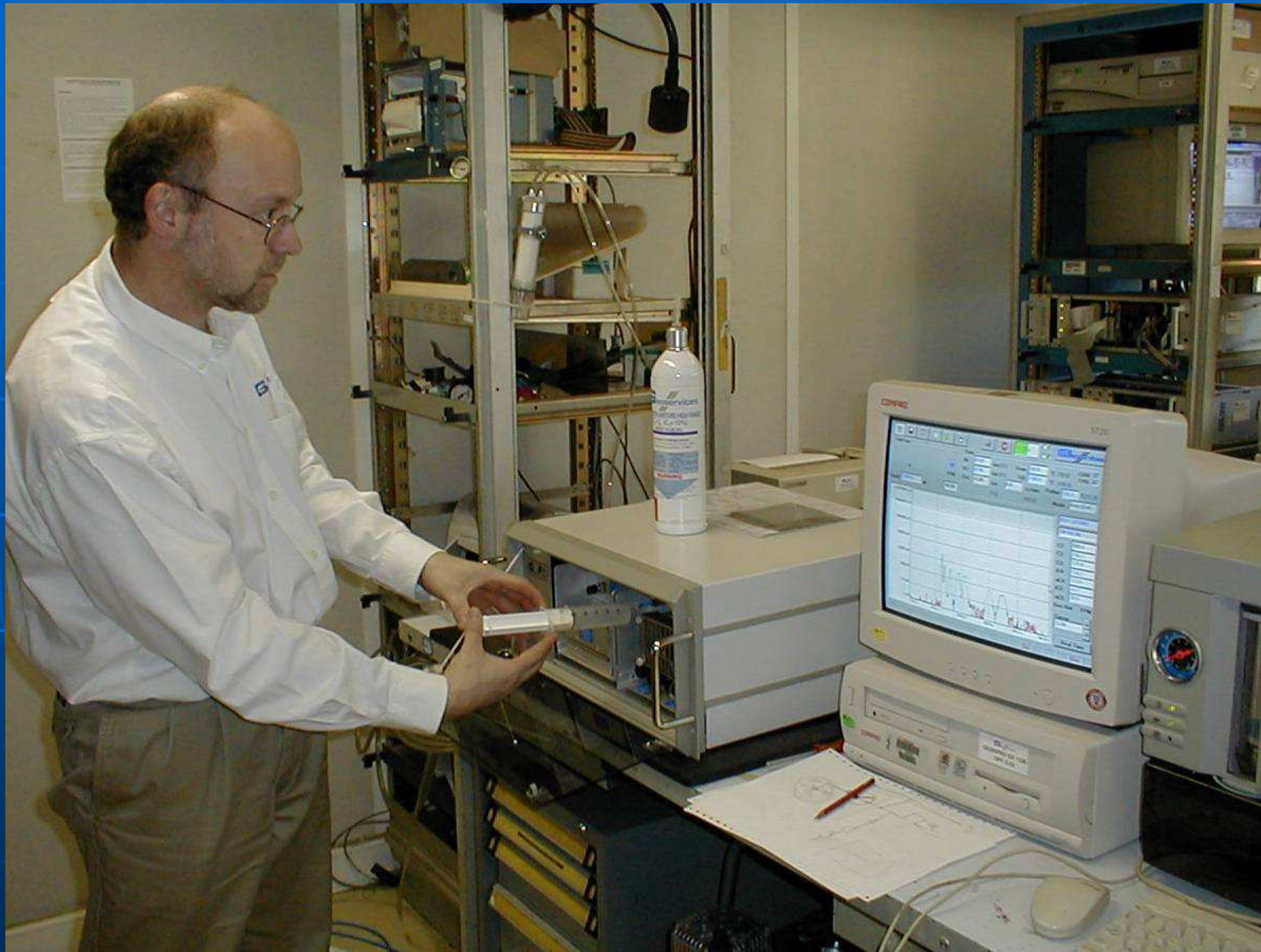
Shape of Chromatograms



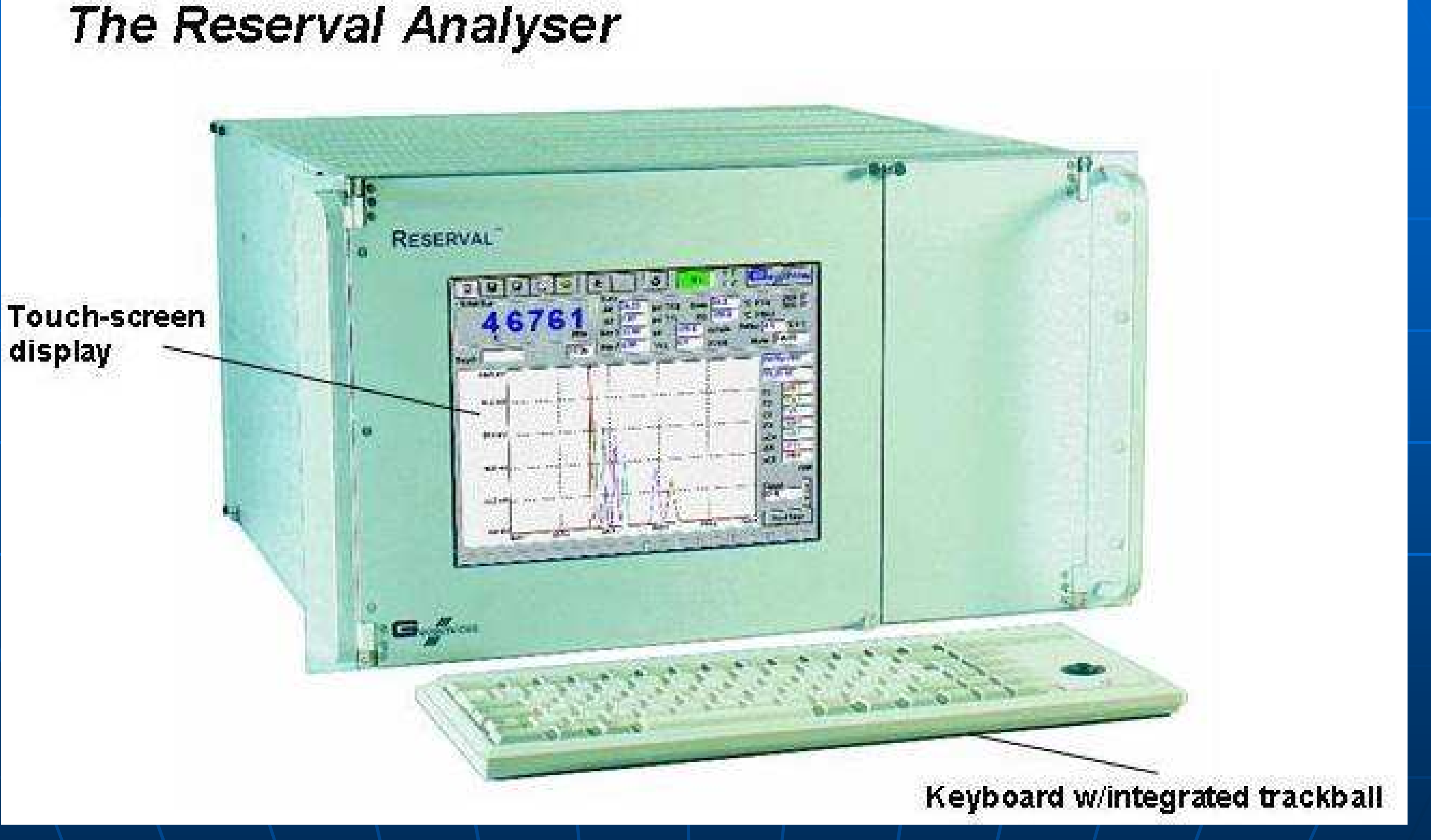
FID Gas detector and Chromatograph



GFF (Geo Fast FID) Chromatograph



Geoservices RESERVAL

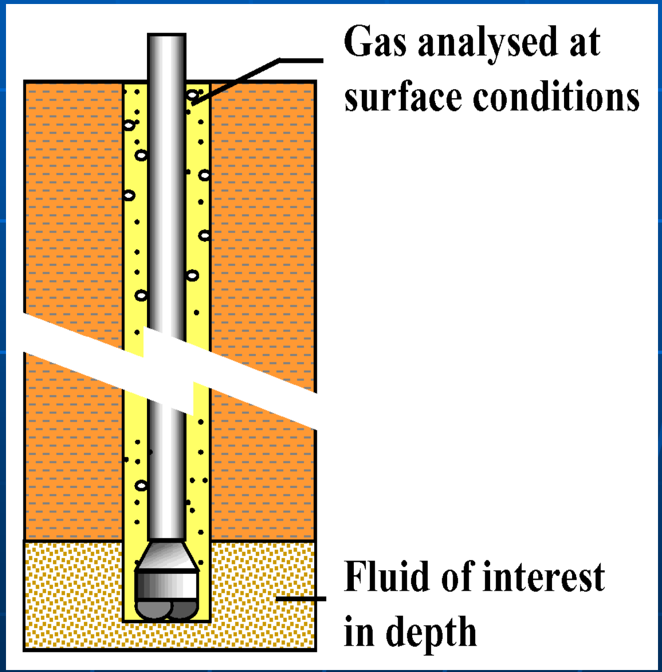


Gas Interpretation

Analysis at surface of the gases extracted from drilling mud for identification and characterization of formation fluids

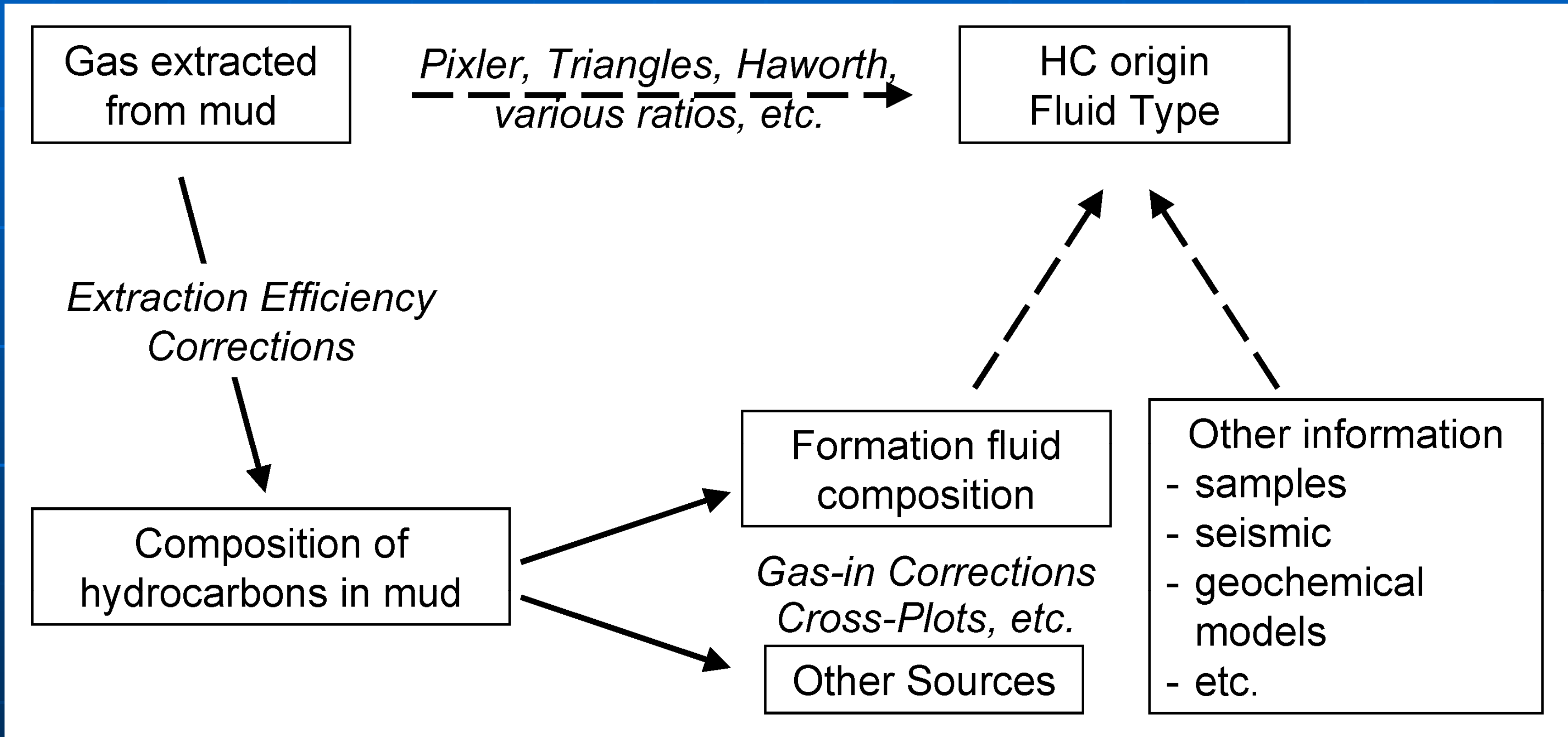
3 steps for gas interpretation:

- Gas detection
- Correction for drilling and mud environment
- Fluid interpretation



Evaluation of down hole fluid characteristics from surface gas analysis.

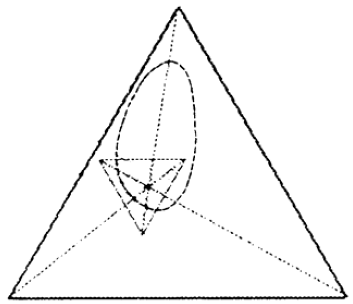
Gas interpretation work flow



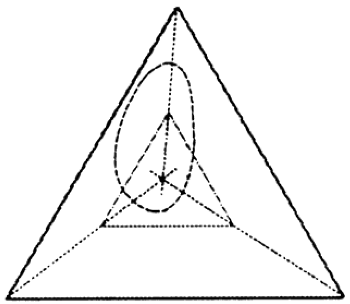
Triangle method

Method based on gas fraction study

Indicates zone types



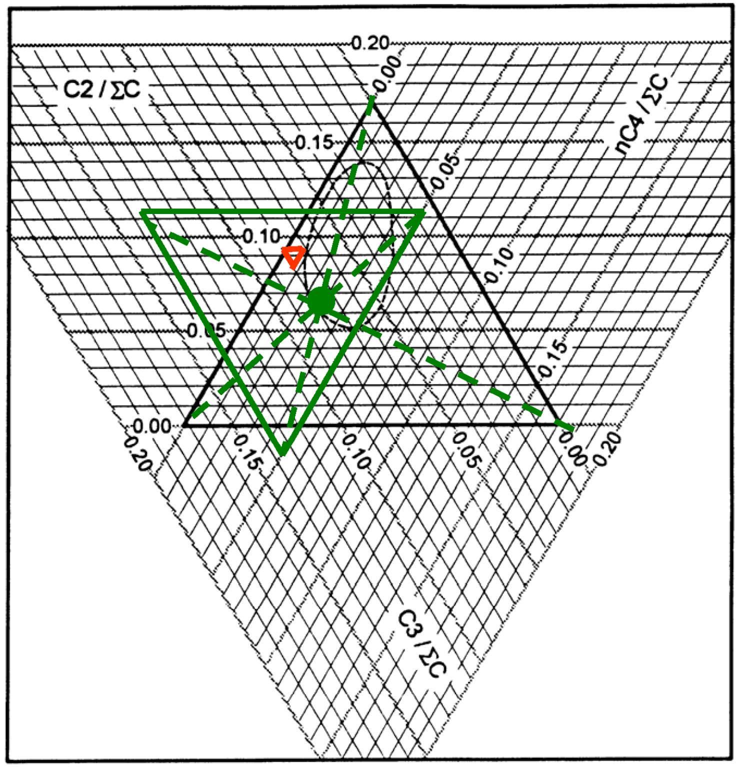
Triangle downward
Oil-rich zone



Triangle upward
Gas-rich zone

Oil	
C2/ΣC	0.11
C3/ΣC	0.14
nC4/ΣC	0.05

Condensate	
C2/ΣC	0.12
C3/ΣC	0.05
nC4/ΣC	0.01



Pixler method

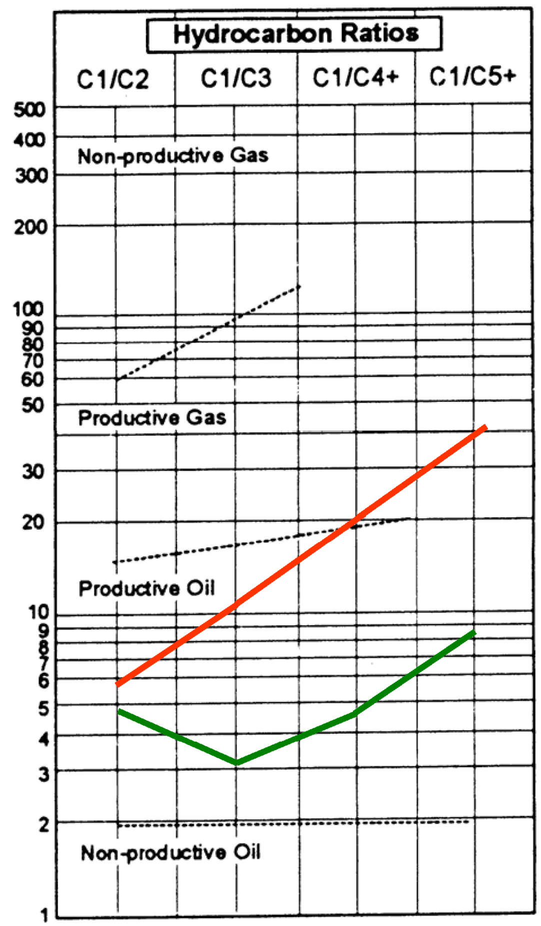
Analytical method based on

- Study of light hydrocarbon compounds
- Classification in four different types
- Indication of oil/gas quality

Oil	
C1/C2	4.87
C1/C3	3.08
C1/C4	4.79
C1/C5	8.89

Condensate	
C1/C2	5.74
C1/C3	10.36
C1/C4	21.02
C1/C5	38.76

Modified from Ferrie, 1981



Wetness, Balance and Character

Three different parameters

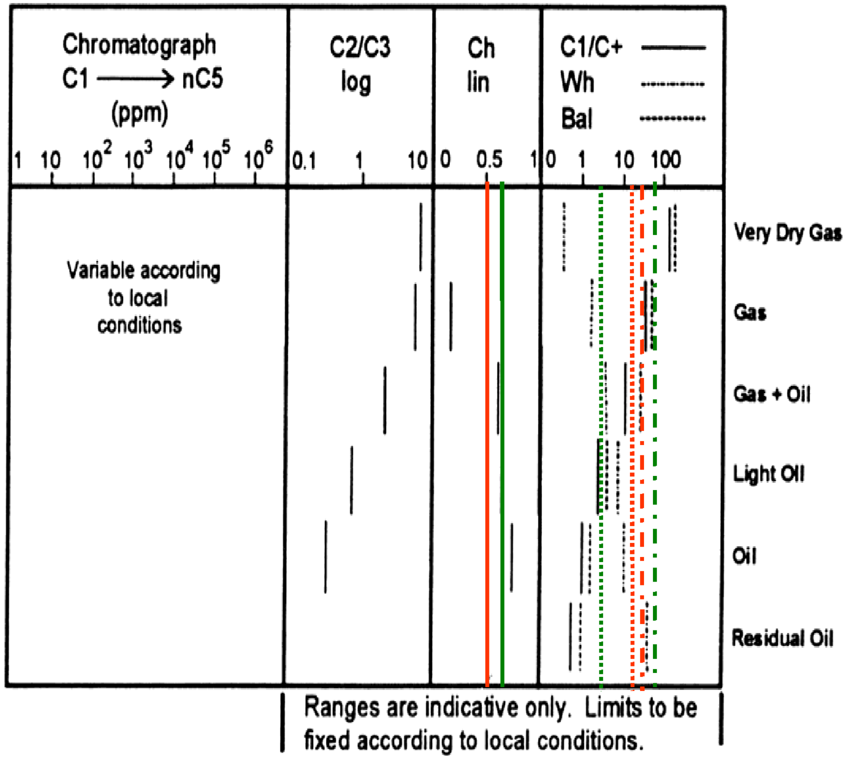
Wetness $Wh = \frac{C2 + C3 + C4 + C5}{C1 + C2 + C3 + C4 + C5} * 100$

Balance $Bal = \frac{C1 + C2}{C3 + C4 + C5}$

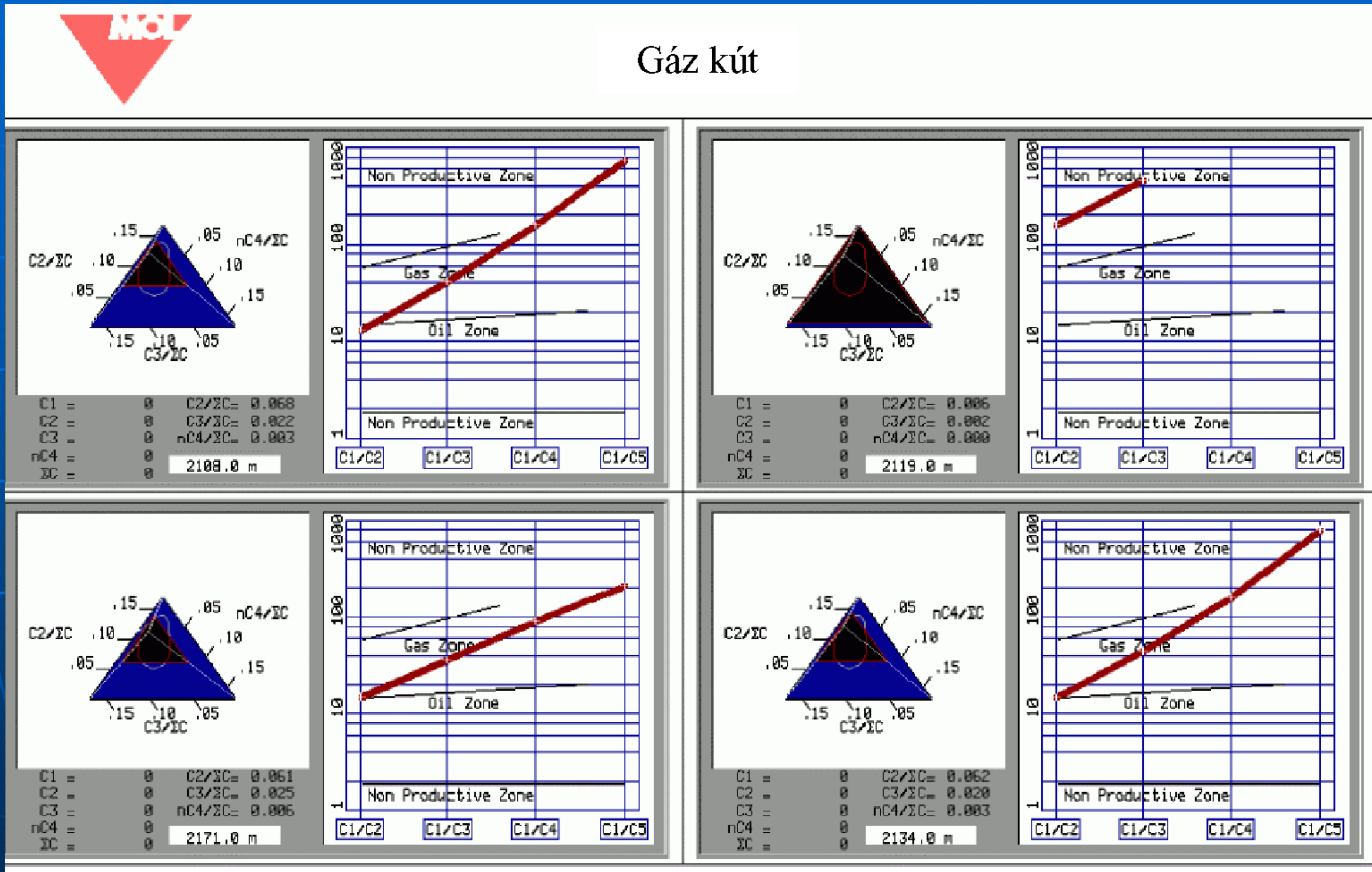
Character $Ch = \frac{C4 + C5}{C3}$

Oil	
Wet.	34.14
Bal.	3.37
Char.	0.64

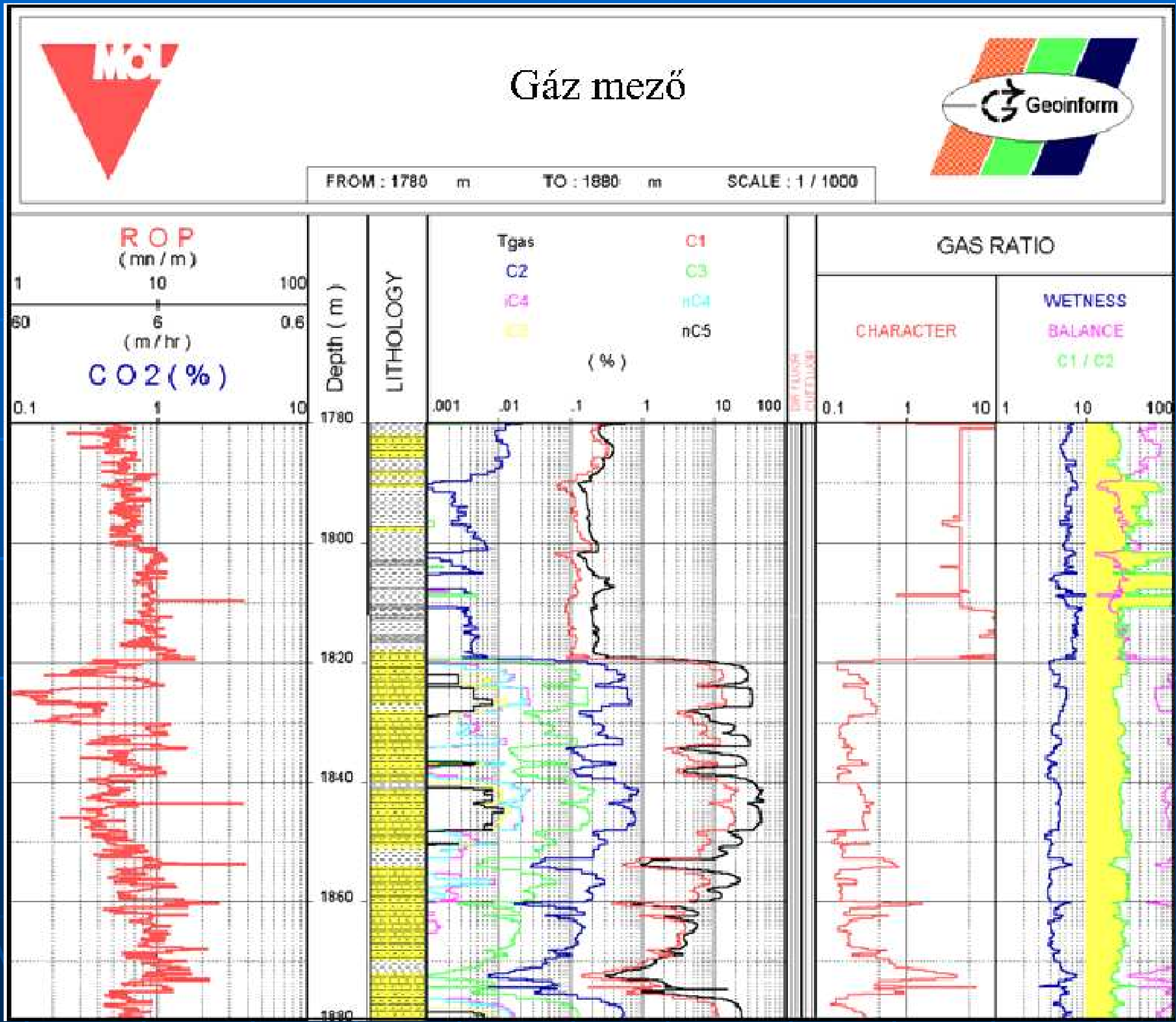
Condensate	
Wet.	19.30
Bal.	12.20
Char.	0.49



Examples for Triangle- and Pixler Diagrams



Typical Gas Log Example



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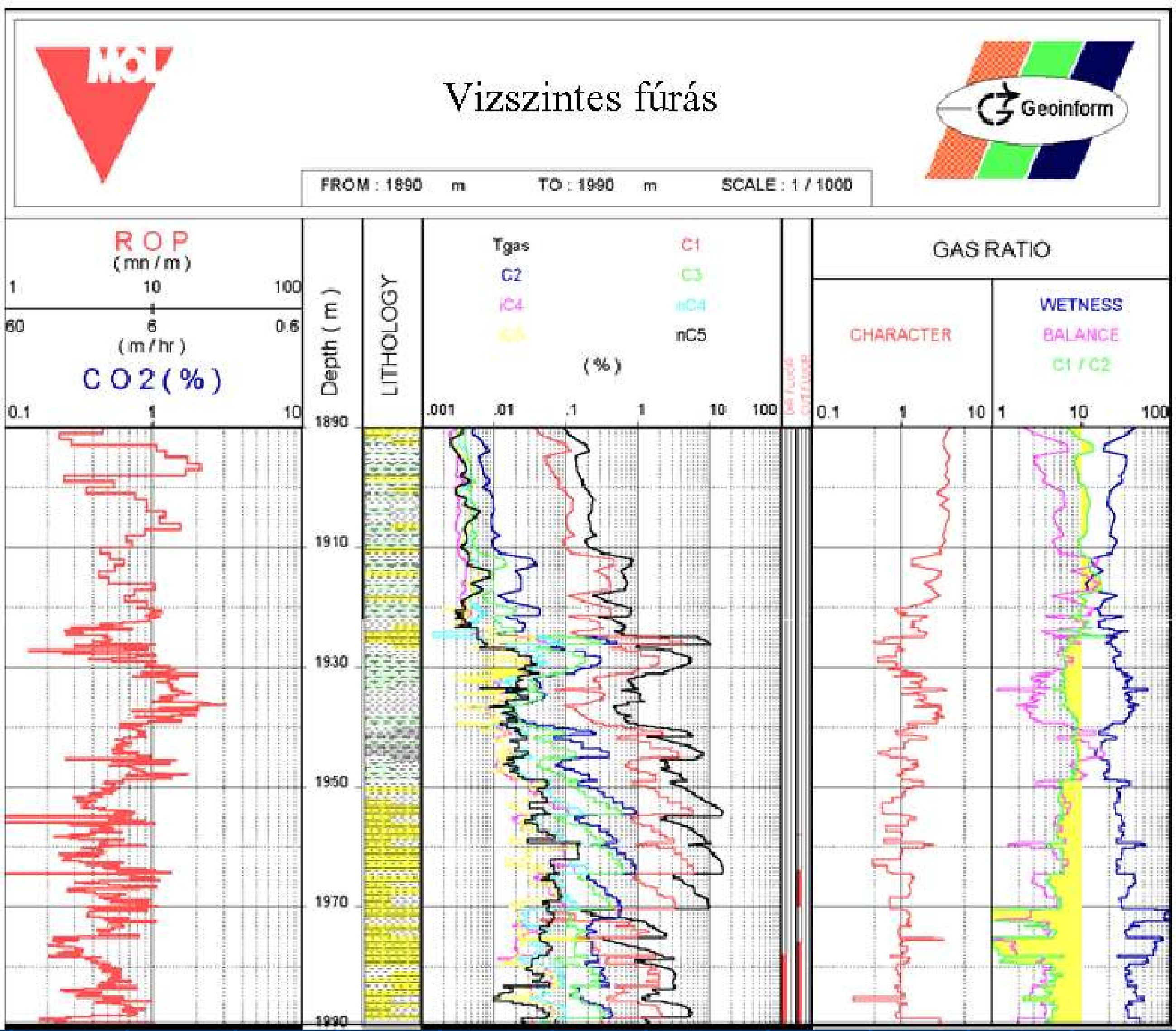
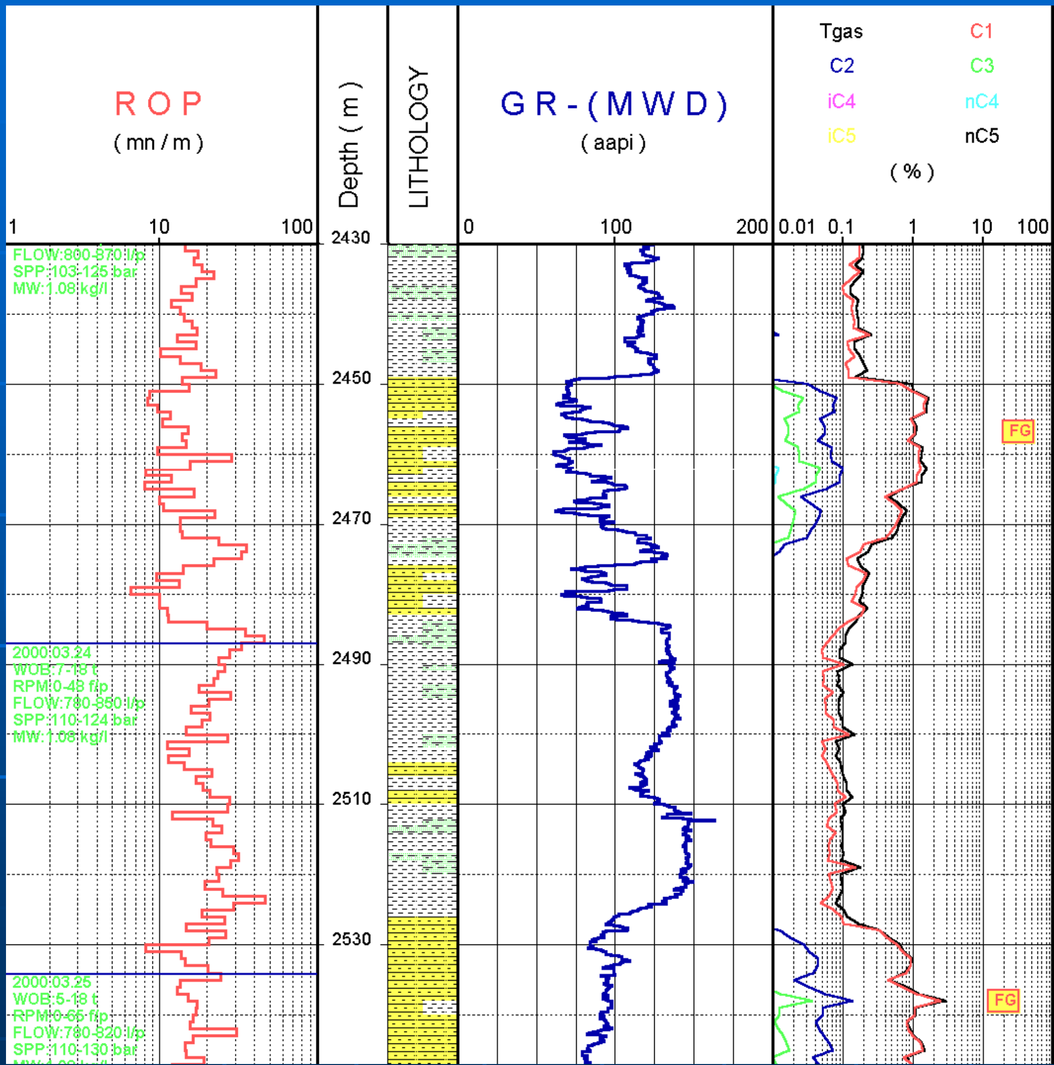
Entering into an oil bearing zone





Geo-steering of horizontal wells

Accurate positioning of all porous and productive drains, and also immediately detect dry zones.

The monitoring of any changes becomes the mud loggers primary job.

When the reservoir looks poor a change in the well path must be made.

CONCLUSIONS

- The gas data provided by the mud logging service (qualitative analysis of hydrocarbons from C1 to nC5) is one of the first sources of information when drilling a well.
- A good quality gas chain (from the gas trap to the analyzer including the data management) is compulsory for hydrocarbon fluid behavior differentiation.
- High-speed chromatography becomes of prime importance. In a multi-layer situation or when thin markers are being looked for, this becomes essential since thin layers can be missed if the analyzing rate is not fast enough.
- Besides technical recommendations on the different parts of the gas chain, special attention should be paid to data management, in particular to the choice of gas data when the time database is converted into depth database.

Thank you for your kind attention!