Factors Affecting Well Production

KAPPA

FOUNDATION

PRODUCTION LOG

INTERPRETATION

COURSE

Module #2

Factors Affecting Well Production

Factors Affecting Well Production

The following module is designed to stimulate thoughts about the relevance of additional information in the interpretation process.

e.g.

- Open hole logs
- Core data
- Reservoir history
- Reservoir model & simulation
- Other available log data
- Completion design

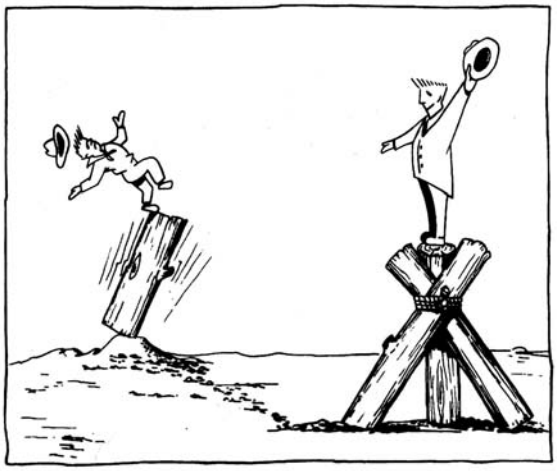
What Is PL Interpretation?

Production Logging is NOT just Flow Rate Measurements

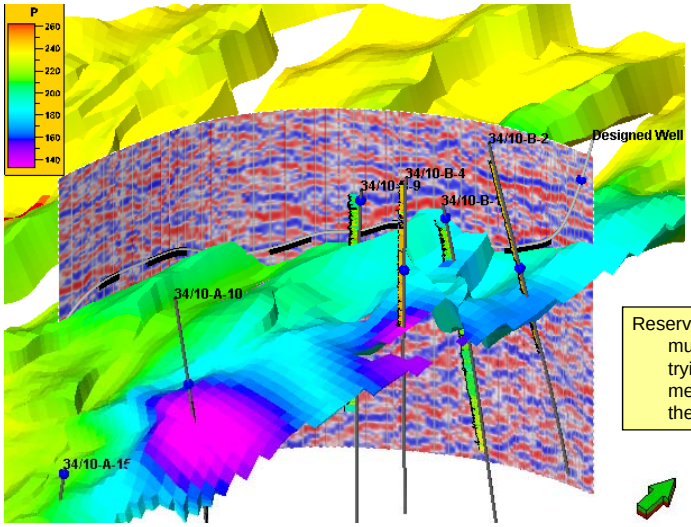
Flow Rates are accessed through a (complex) INTERPRETATION process

- Complex in mathematical analysis (iterations, models, correlations)
- Complex in the understanding of the completion, the reservoir, and it's history and behaviour.

PL INTERPRETATION?

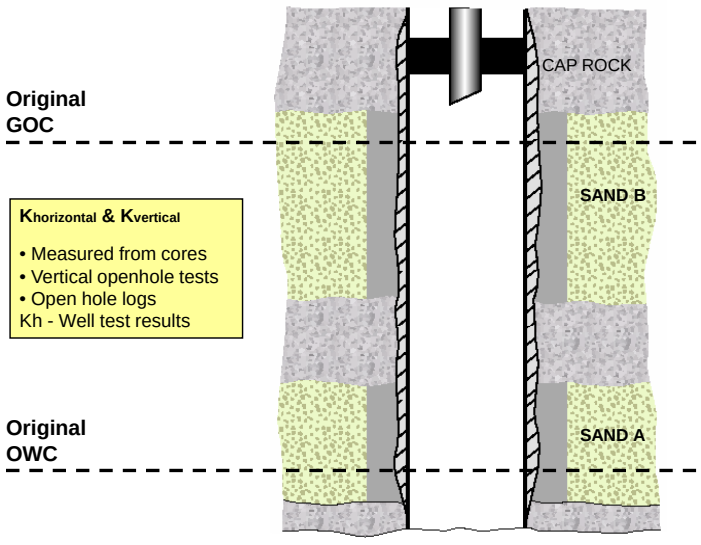


The Reservoir



Reservoirs are complex and must be considered when trying to interpret PL measurements taken in the wellbore.

The Well and Permeability

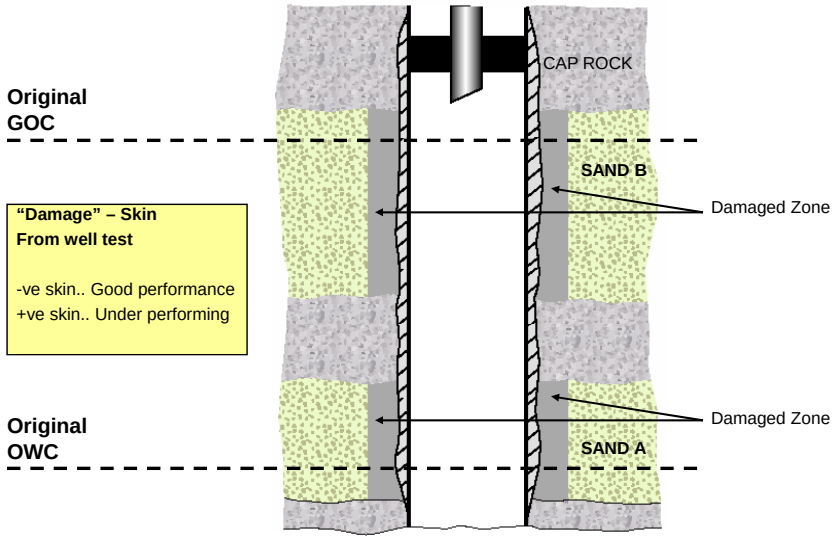


$K_{horizontal}$ & $K_{vertical}$

- Measured from cores
- Vertical openhole tests
- Open hole logs

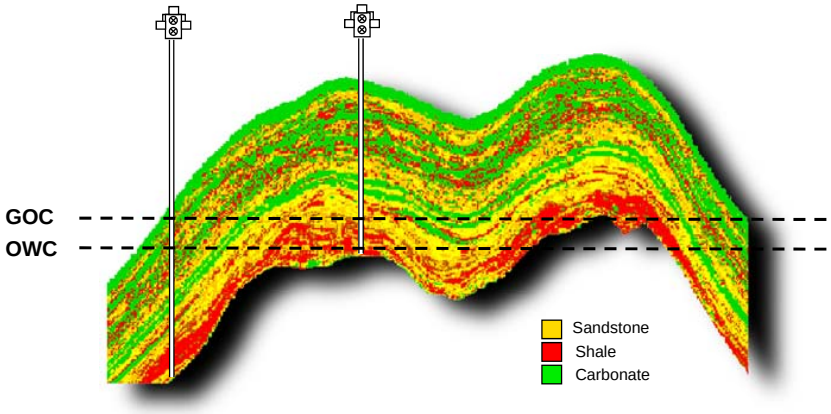
Kh - Well test results

The Well Damage



02

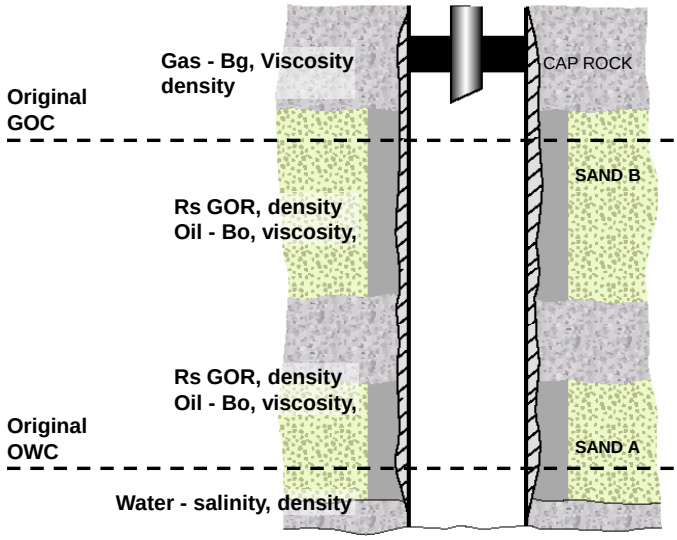
Reservoir Contacts



The location of the contacts in the reservoir are used to assist us in understanding our observations in the wellbore.

02

The Well Fluids



PVT used in:-

1. Downhole rate calculations

2. Conversion of downhole rates to standard conditions

The Well Fluids - PVT

Minimum PVT parameters required for EMERAUDE

WATER

- **Salinity ppm**

OIL

- **Gravity API**
- **Rs (Solution Gas-Oil Ratio).. Maybe not produced GOR!!!**

GAS

- **Specific gravity**

(Additional PVT parameters can be entered or derived from PVT correlations)

ALWAYS BE CAREFUL WITH YOUR UNITS!!

Problems - Producers

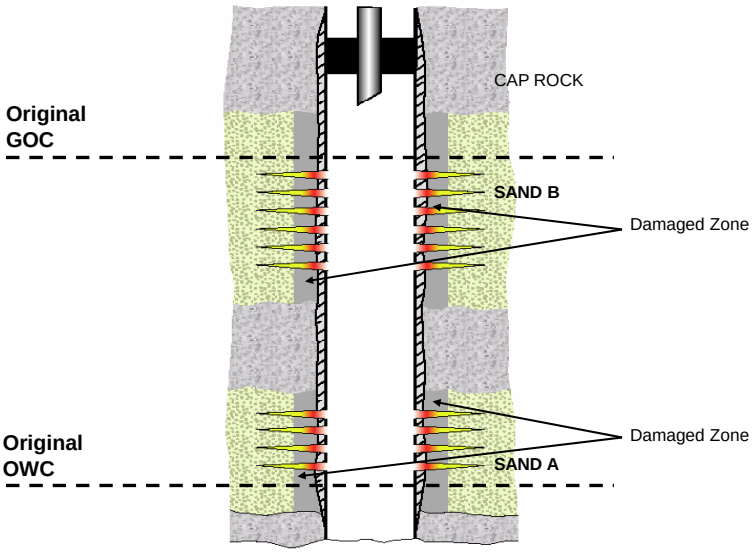
Measure well and reservoir performance

- Flow profile (generic)
- Multi-layer tests (specific methods, e.g. IPR per layer)

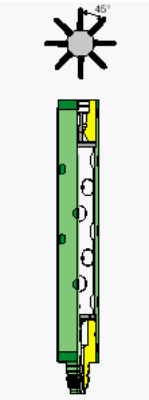
Diagnose well problems

- Perforations off depth / ineffective
- Crossflow
- Channeling
- Coning
- Leaks (casing, packer,etc)
- Zoned flows
- Fractures
- Early water/gas breakthrough

Perforations



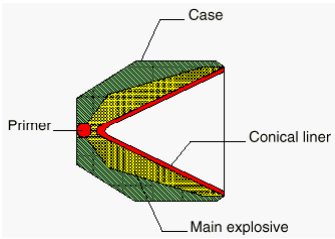
Perforation Gun



The perforating gun comes in a number of formats, density, phase

The common items are the detonator, prima cord and the shaped charge.

The gun used depends on the situation/local preferences.



15 million Psi!!!

Perforation and PL

Perforating parameters are important in PL Interpretation.

Need to know:

- Perforation intervals

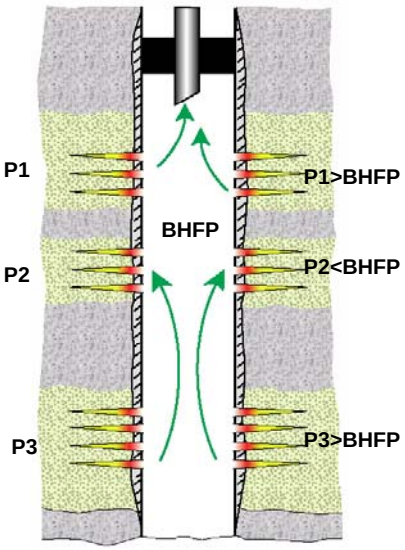
Nice to know:

- Shot density & phasing
- Charge type - big hole/deep penetrating
- Gun type – casing gun, through tubing gun
- Perforation performed overbalanced or under balanced
- Perforation history - timeline

Need to discover:

- Which perforations are producing
- Are the perforations on depth, or are they even there at all?

Crossflow

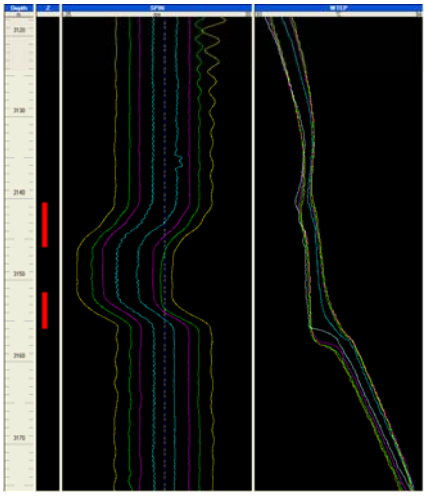


- Three layers were initially perforated
- Layer 2 pressure has somehow dropped. Possibly due to high permeability, therefore experiencing preferential production, and depleted faster. Or maybe it was just a smaller reservoir which has depleted prematurely.
- A point was reached where the pressure in layer 2 is lower than the BHFP
- The Crossflow behaviour in to layer 2 should increase during shut in

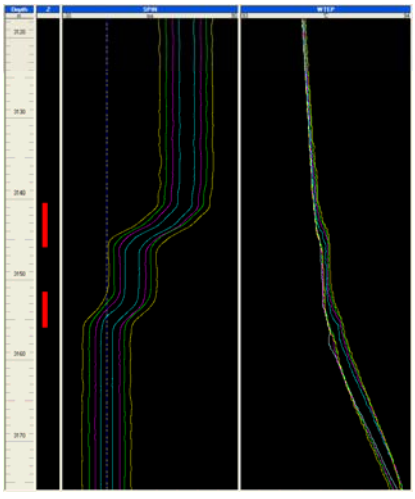
Solutions:
- Flow well at higher flowrate – lower BHFP
- Reperforate only layers 1 and 3
- Recomplete layer 3 through a different tubing than layer 2
- Close off, or somehow straddle layer 2

Crossflow

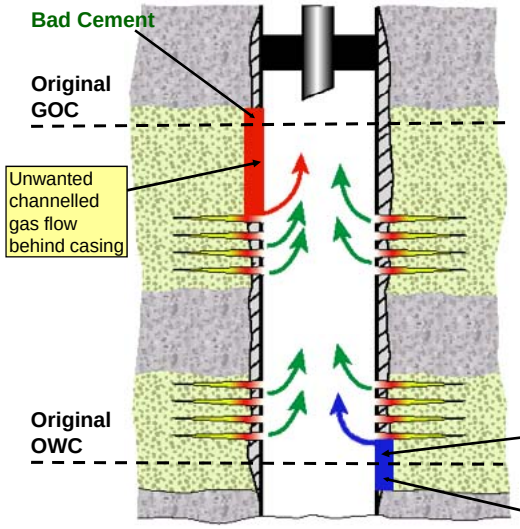
SHUT IN



FLOWING



Channeling



The obvious reason for a channel is a poor primary cement job

This is repaired by a squeeze if the channel is identified in time (before running the completion and/or perforating)

Channels identified during production logging are difficult to repair, though modern cementing technology can help.

Cementing

Cement quality is affected by many parameters

- Bottom hole temperature
- Pressures
- Formation stability
- Fluids present, especially gas
- Casing centralization
- Well deviation and doglegs

The most common cause of a poor cement job is poor centralization of the casing.

Cement Evaluation

There are a number of tools capable of measuring the cement quality:

Cement Bond Logging – Acoustic

- transmitter & receiver
- looks at the average bond around the pipe (CBL)
- interpretation is difficult
- only tool to “see” the formation - cement bond (VDL)

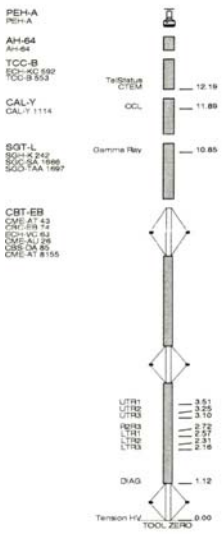
Radial Cement Bond Logging - Acoustic

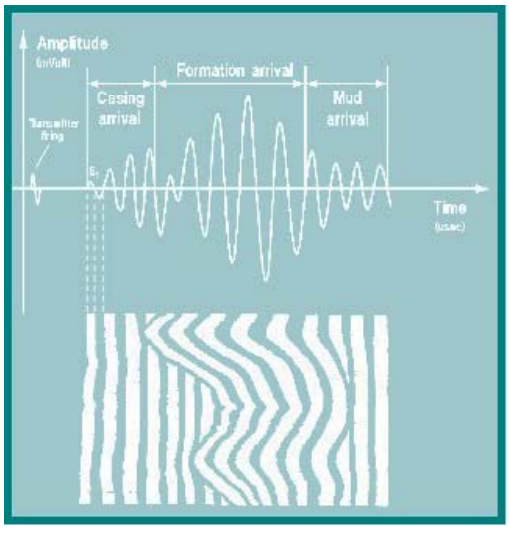
- as above but radially distributed transmitters/receivers

Pulse Echo Logging – Ultrasonic (CAST, USI)

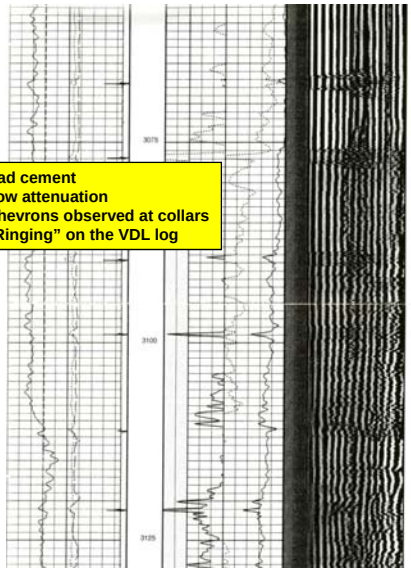
- images all around the casing
- interpretation is simple
- has a corrosion measurement as well

CBL-VDL

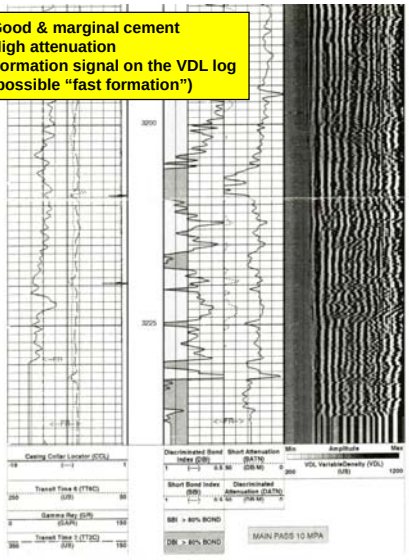




CBL-VDL

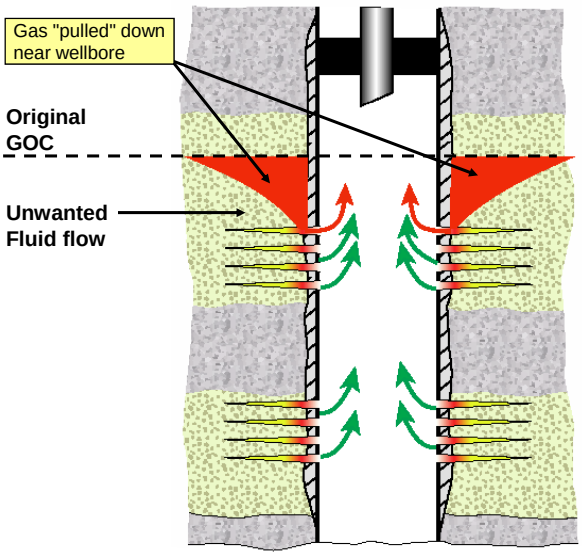


Bad cement
Low attenuation
Chevrons observed at collars
"Ringing" on the VDL log



Good & marginal cement
High attenuation
Formation signal on the VDL log
(possible "fast formation")

Cone Down

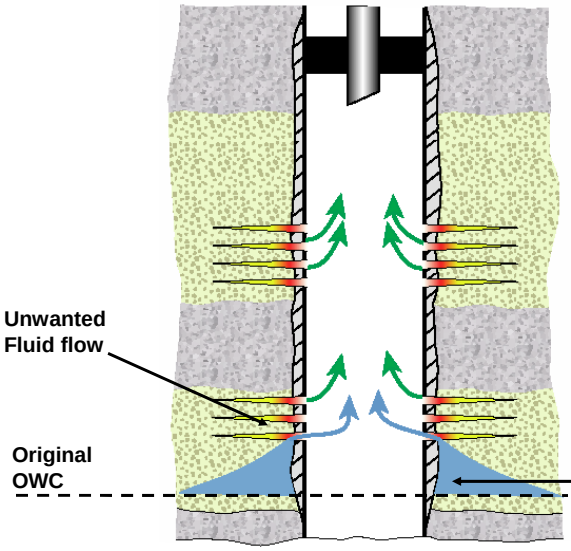


For coning interpretation we need:-

- Vertical flow path Kv/Kh
- Proof of good cement
- Proof of GO contact depth
- Source of fluid for coning
- High drawdown

Choking back the well may reduce this coning effect

Cone Up

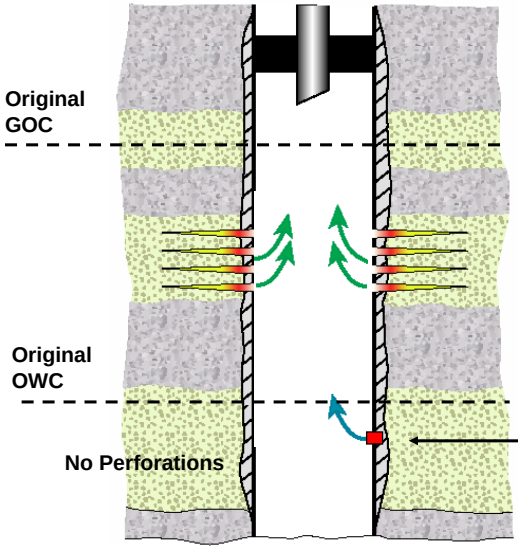


For coning interpretation we need:-

- Vertical flow path - Kv/Kh
- Proof of good cement
- Proof of OW contact depth
- Source of fluid for coning
- High drawdown

Choking back the well will probably not reduce this coning
The effect of the coned water is to "wet" the formation

Casing Leak

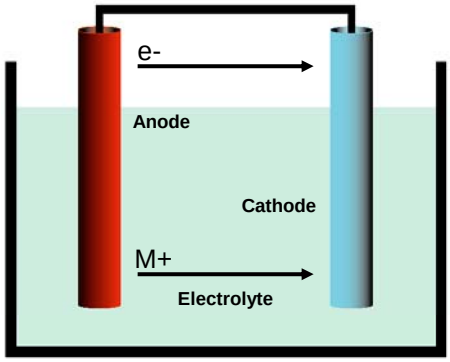


Leaks occur because of corrosion in the casing or tubing.

This can happen at any time in the life of the well.

Logs are used to identify corroded pipe

Corrosion Mechanisms

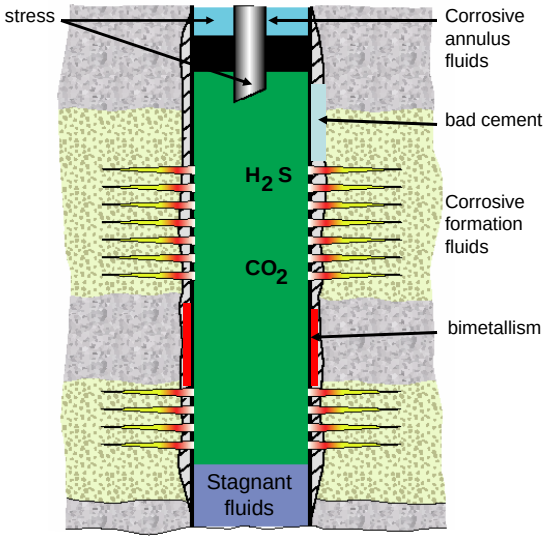


Two metals in an electrolyte act as a battery.

One is an anode the other the cathode.

Metal moves from the anode to the cathode.

Corrosion

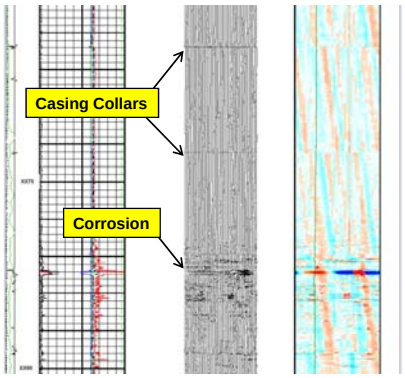


Several tools exist to measure corrosion

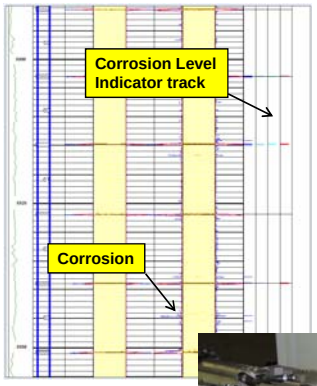
- Mechanical calipers
  internal corrosion only
- Imaging tools - ultrasonic
  internal and external
- Electromagnetic
  internal and external
  multiple strings

Corrosion Log - examples

Multifinger Caliper Log

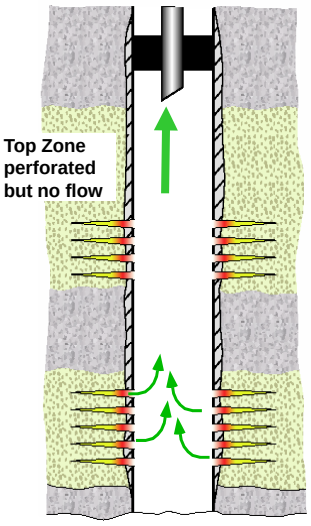


Magnetic Flux & Eddy Current Log



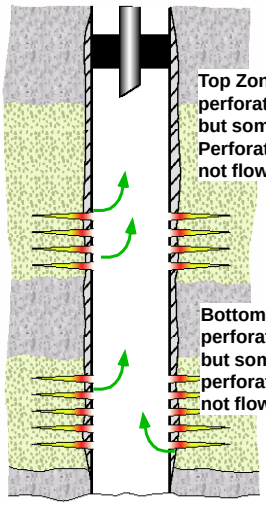
Courtesy
SCHLUMBERGER
SONDEX
SPARTEK

Problem: Zoned Flow

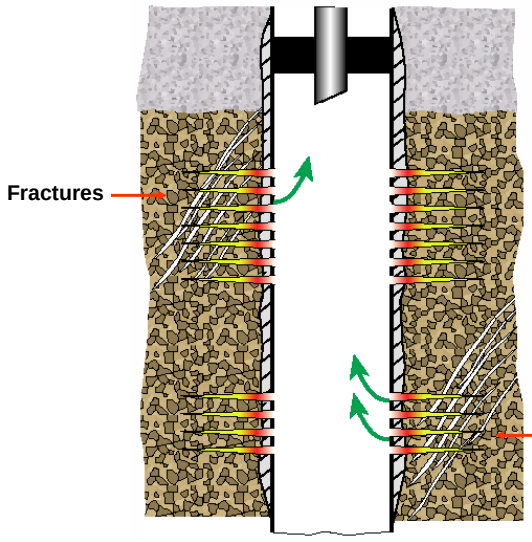


- zones of widely differing permeability, high permeability will flow preferentially, low perm zones may not flow at all

- perforations plugged, debris from the perforation gun, mud entering while perforating overbalanced, crushed rock in the perforation tunnel



Fracture Production



Some perforations are crossing fractures

These give high flow rates, and often strong jetting effects.

The remaining perforations may produce nothing

Fracture Topography

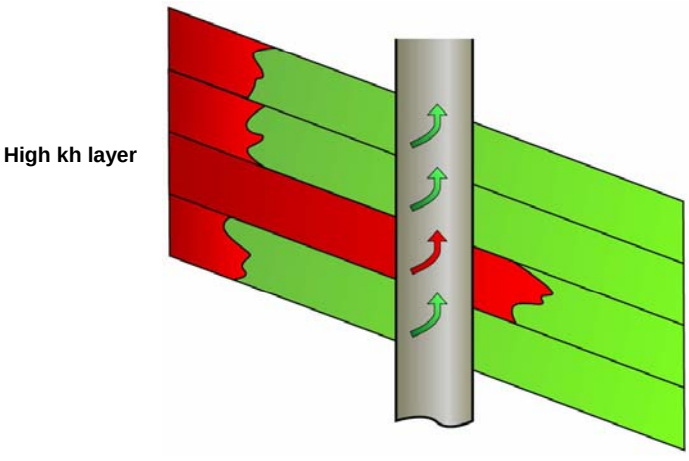
- Fractures occur primarily in carbonates and they are usually in a consistent direction.
- They may appear at random in the well
- They are the major flow paths for the reservoir
- They may connect with the gas above or the water below the oil zone and create unwanted fluid entries
- The fractures may conduct the flow of water, while the matrix still remains hydrocarbon saturated

Fracture Evaluation

There are a number of methods of fractures detection during open hole logging.

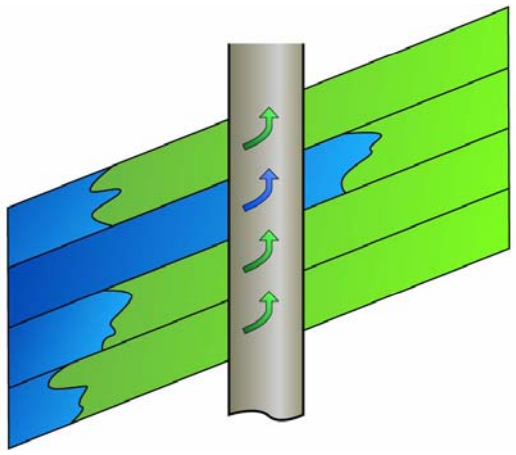
- Resistivity imaging
- Core sample analysis
  A detailed examination will give fracture density, exact location and possibly aperture.
- Well test interpretation will possibly be affected by the presence of fractures. (Often masked by the effect of wellbore storage)
- Drilling Records e.g. losses

Early gas breakthrough



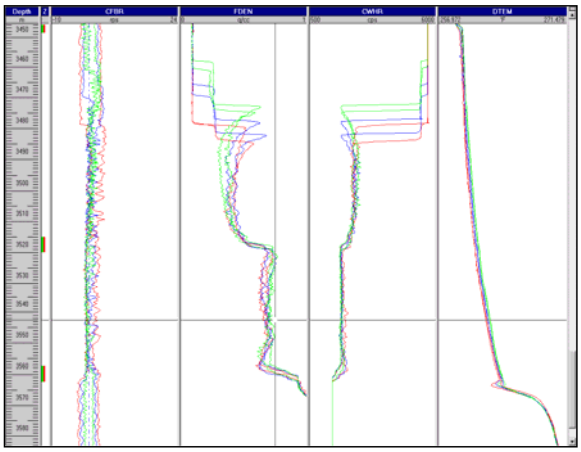
Early water breakthrough

High kh layer



Production Logging: More Info

There is often more information than just calculations:
Moving water column with changing BHP



Shut-in Pass: Water column moving up

Problems - Injectors

The objective of the injection well is to get the fluid into the selected zones.

Are all zones taking fluid – Injection Profile

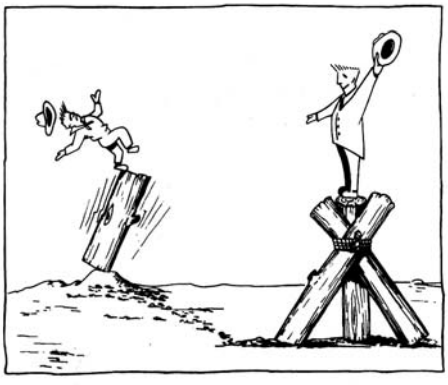
Is any zone taking “extra” fluid – Thief zone

Is fluid going into anywhere it shouldn’t
Casing leak, squeezed perfs?

Is there flow behind casing – channeling?

Is there crossflow?

PL INTERPRETATION?



Validate the interpretation against all known completion, and reservoir information.