Case Study:
Tripling Well Productivity by applying new perforating job design & Combined perforation technologies

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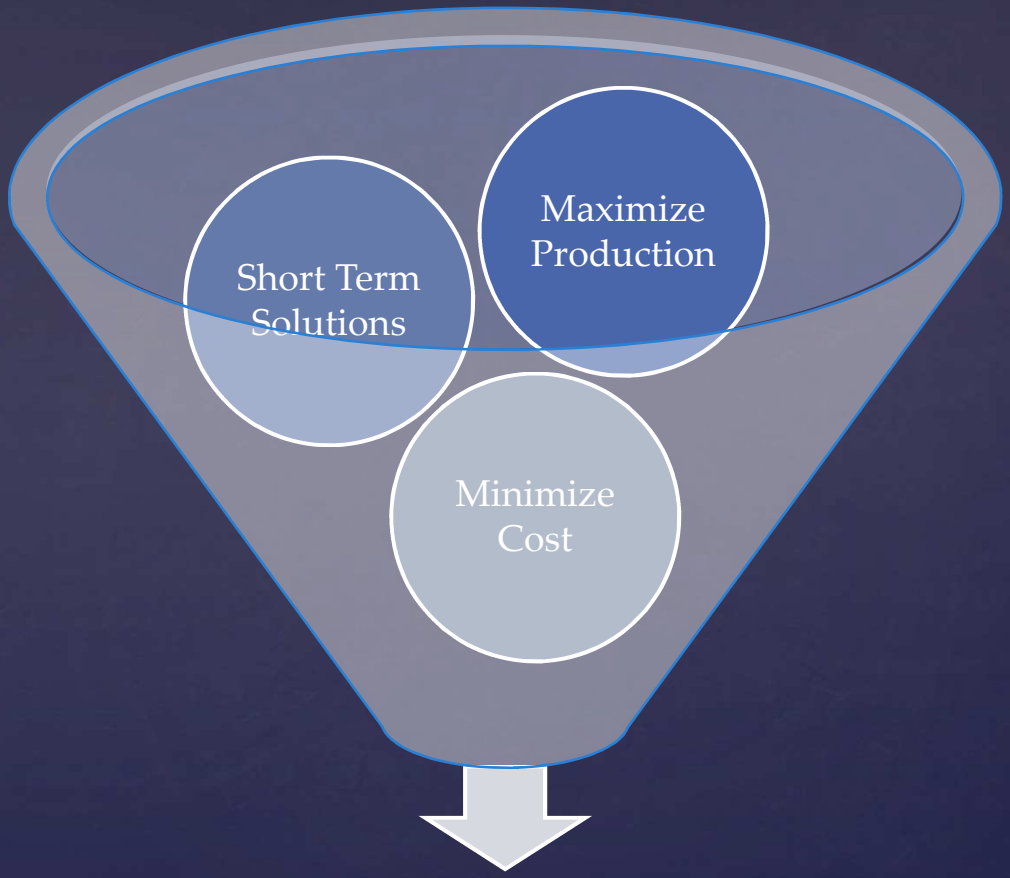
Outlines

- Objective
- Introduction
- Perforation Selection
- DUB Perforation Theory
- Rock Model Charges
- Results

Objective



New Perforation Technology

Introduction

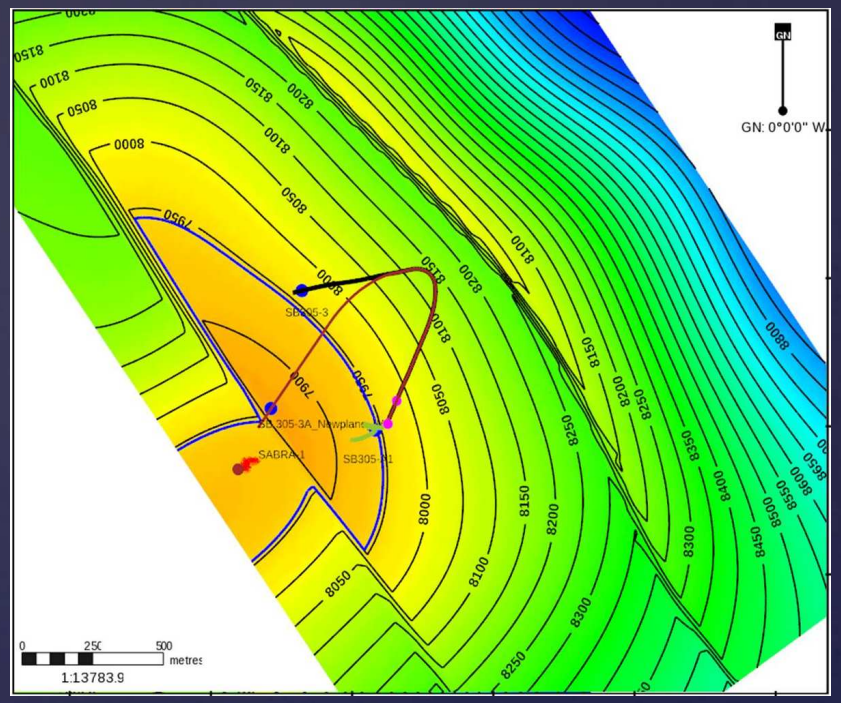
Gulf of Suez Petroleum Company - GUPCO - (EGPC & BP Joint Venture) is one of The Largest Oil Producers in Gulf of Suez Basin (EGYPT) Since 1960s.

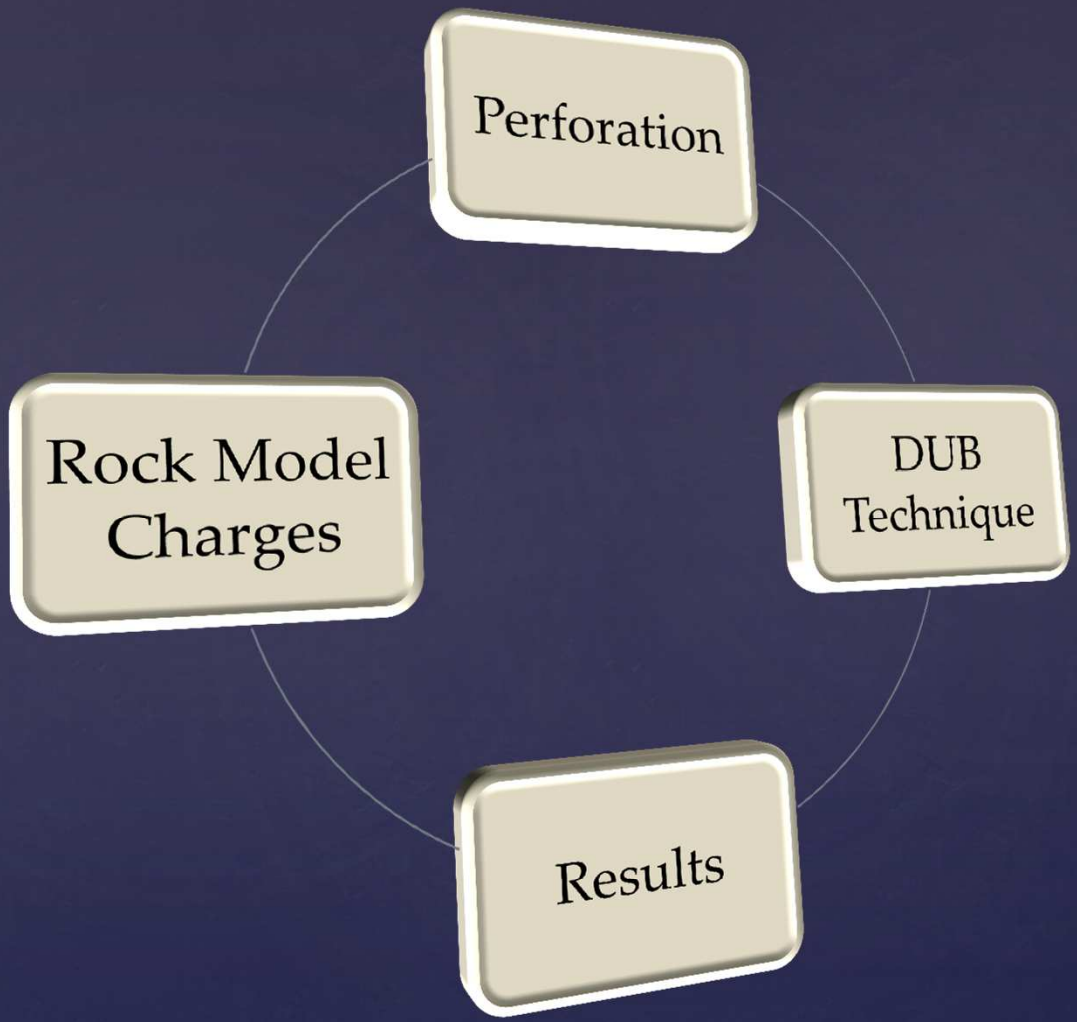
The main activity of the company is the production of crude oil and gas from offshore wells and to maintain the continuity of the production by a set of processes and activities in a row.

The average daily production for the Gulf of Suez area of 80,000 barrels of oil from a total of about 400 wells in Gulf of Suez area

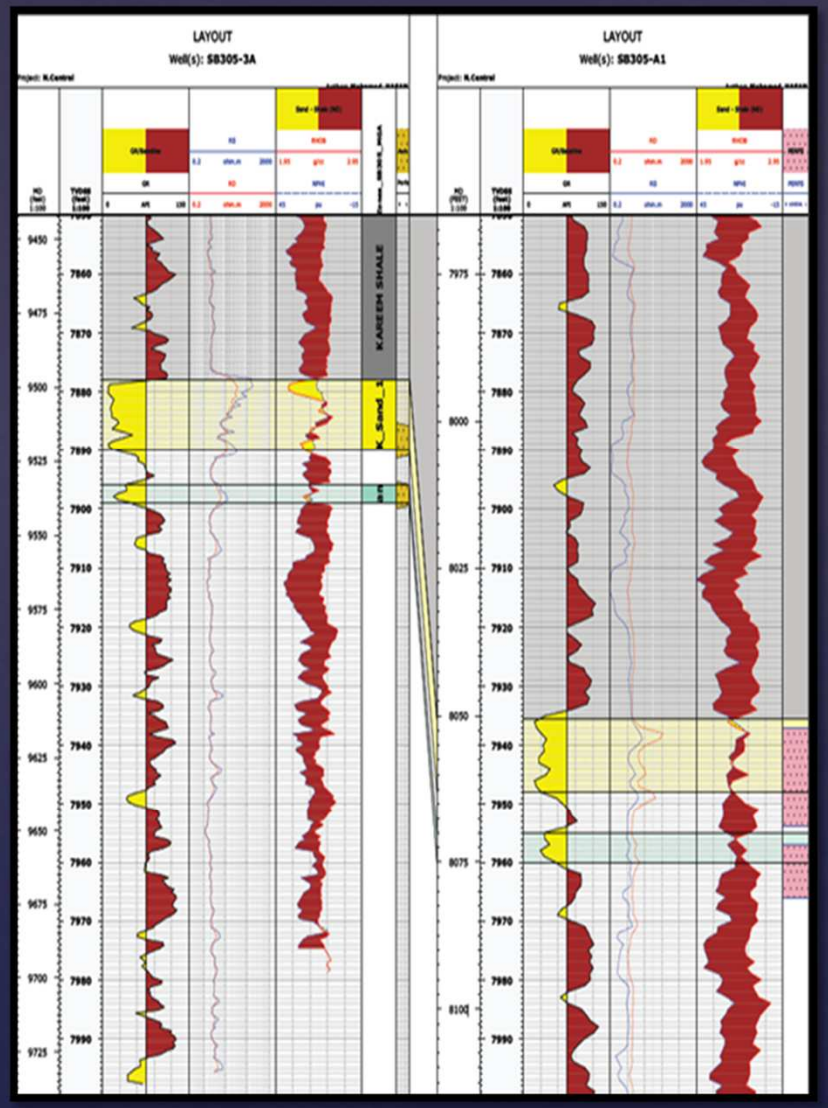
Background

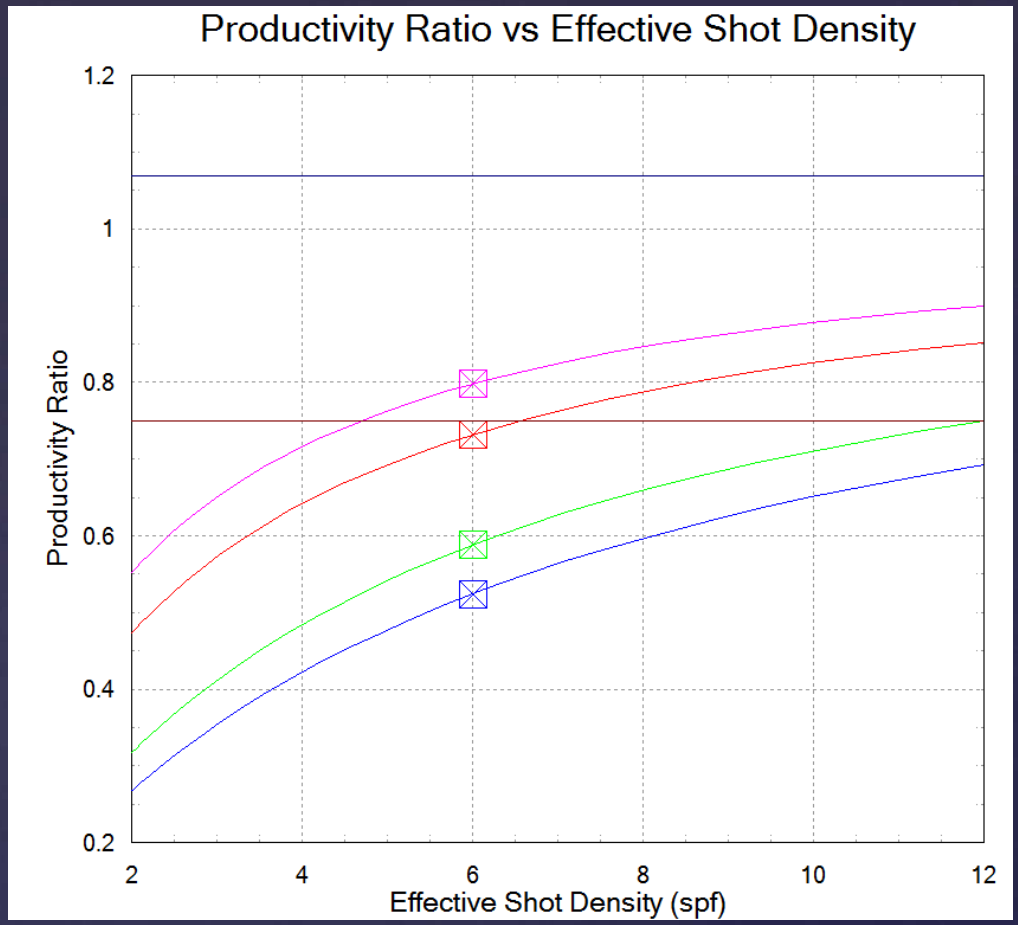
- The well was completed in Kareem formation to the west of a depleted well
- Calculated net pay found is 30 ft
- Only 17′ was perforated to avoid initial gas production
- Estimated initial production was 2000 BOPD




Perforation
DUB Technique
Results
Rock Model Charges

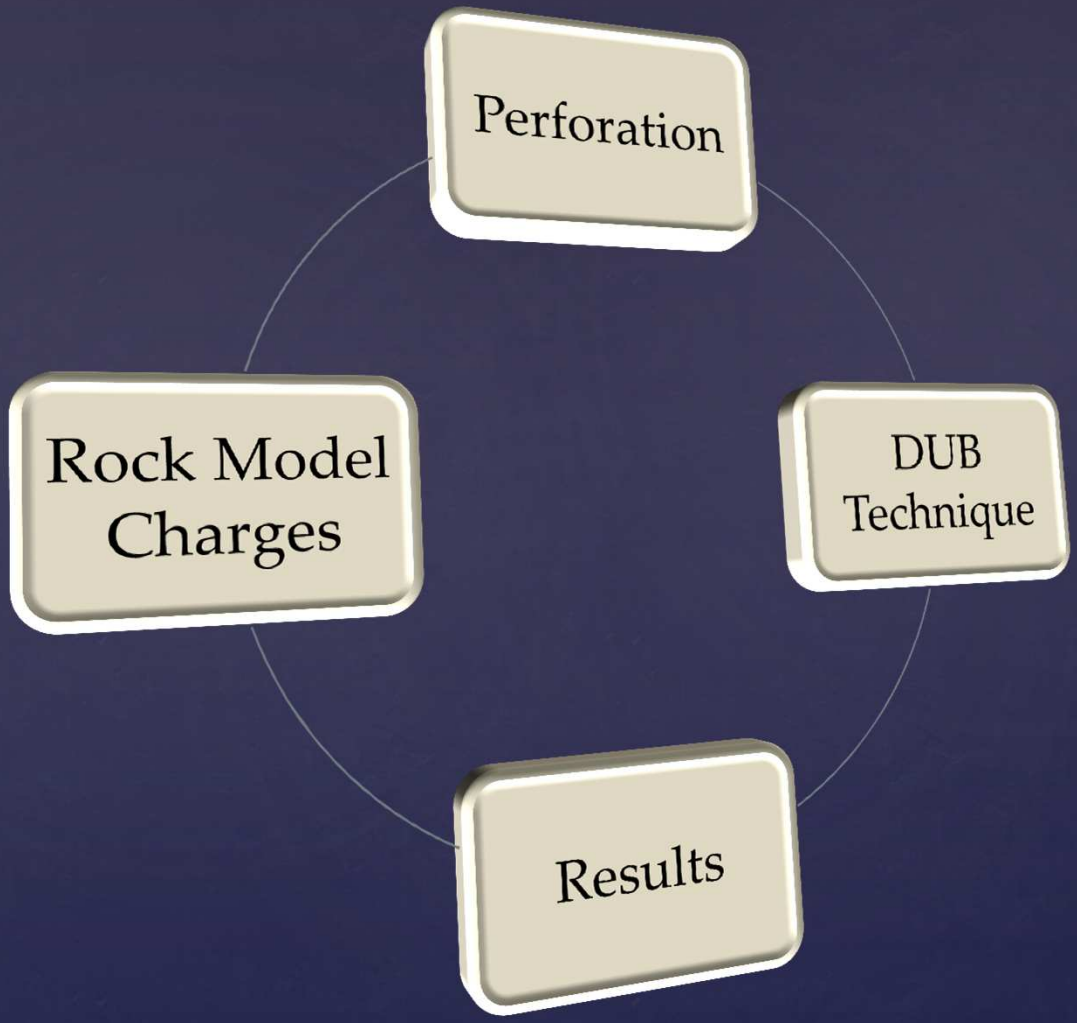
Perforation Selection





Productivity Ratio (PR) - is defined as the ratio of the expected production rate of the "perforated well" to the "ideal" openhole flow rate. The "ideal" well is assumed to have no damage and to be fully open to flow. For a vertical or deviated well, the performance is measured against an *openhole vertical well*. For a horizontal well, the performance is measured against an *openhole horizontal well*. Turbulent, non-Darcy, flow effects are not included in the Productivity Ratio calculation.

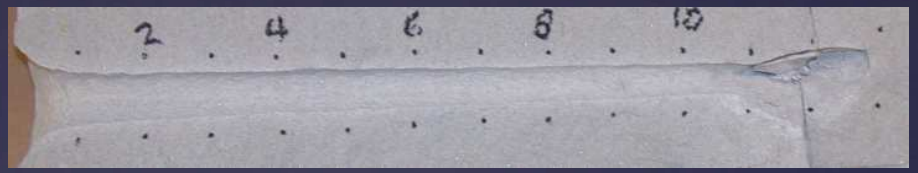
$$PR = \frac{q_{(perforated)}}{q_{(openhole)}} = \frac{\text{Perforated Well Flow}}{\text{Undamaged Open Hole Flow}}$$


Perforation
DUB Technique
Results
Rock Model Charges

DUB perforation technique

Pore fluid: GAS (Dry N2)

Static UB

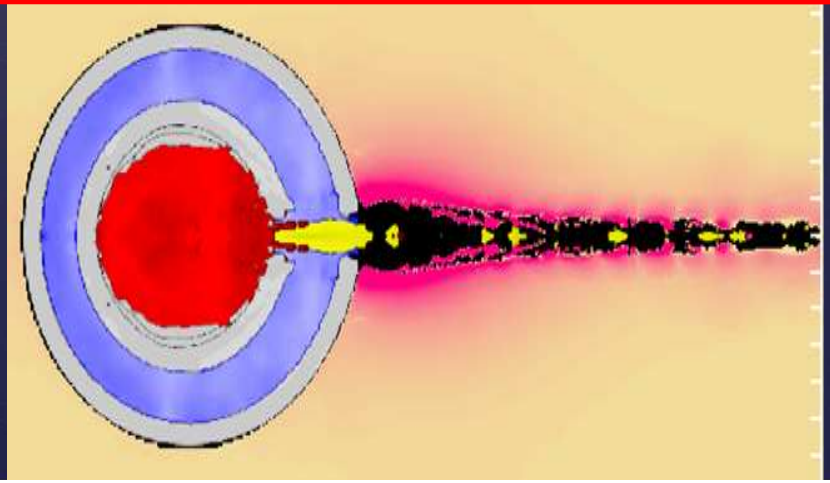


DUB

Pore fluid: LIQUID (brine)

Static UB

DUB



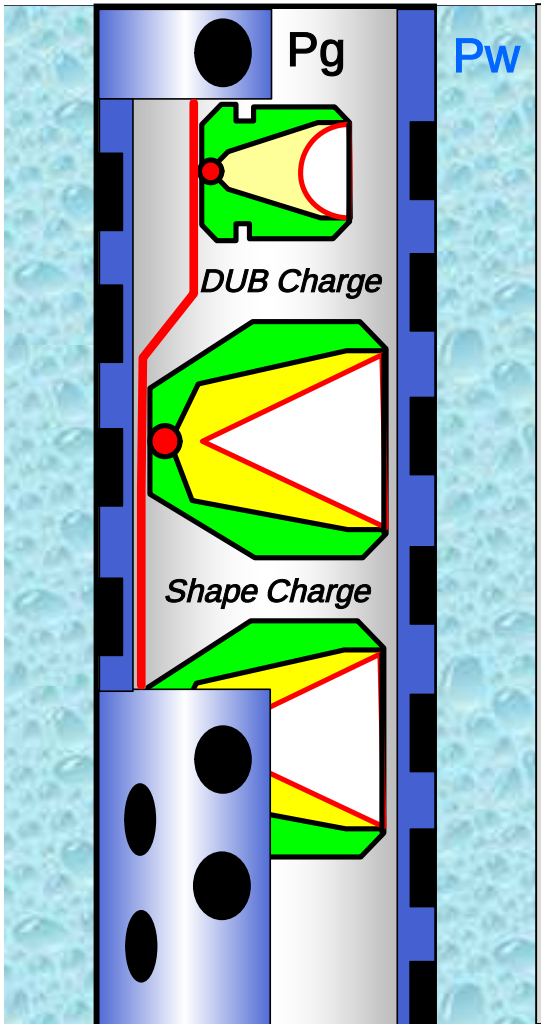
Perforation & DUB Timescale

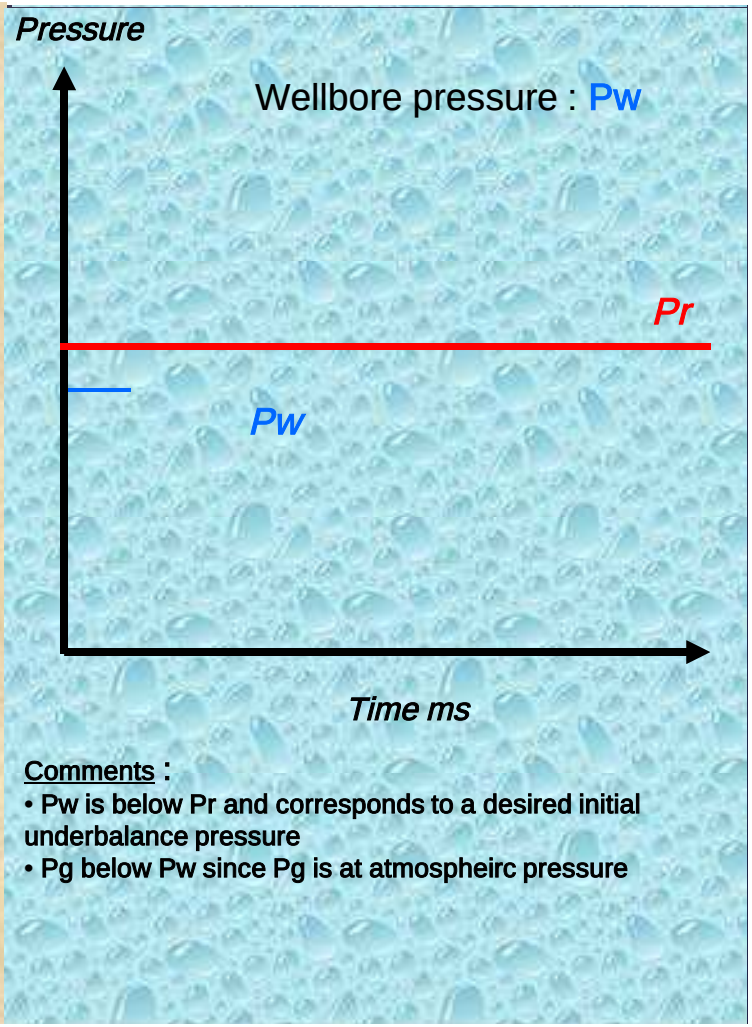
1 : Gun positioned on depth

Shape Charge Detonation
Gun Pressure : **Pg**
Pw > Pg

Perforation Tunnel
&
Reservoir Pressure : Pr

DUB Condition : YES
Pr > Pw > Pg





Comments :
- Pw is below Pr and corresponds to a desired initial underbalance pressure
- Pg below Pw since Pg is at atmospheirc pressure

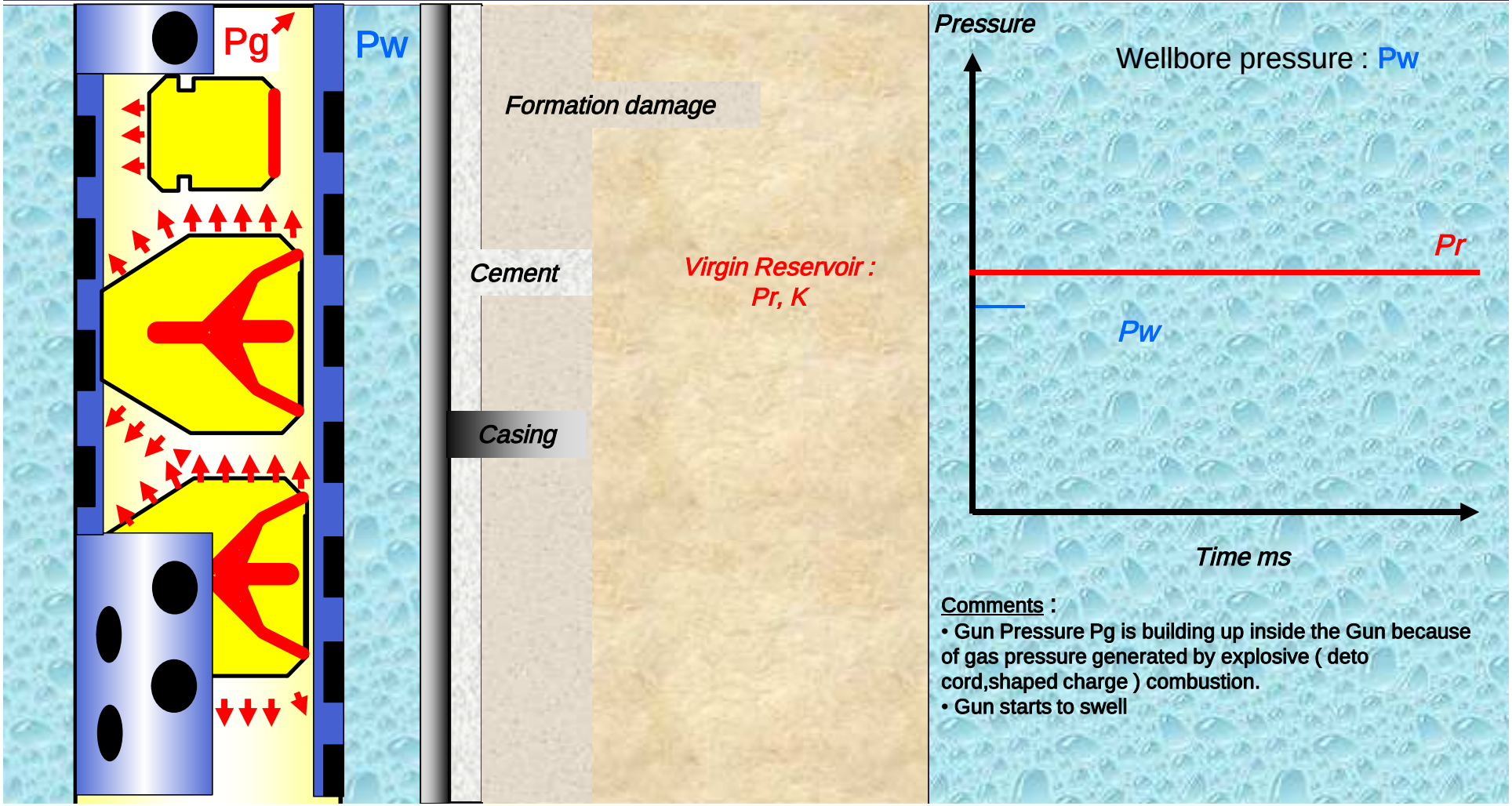
Perforation & DUB Timescale

2 : Fire guns

Shape Charge Detonation
Gun Pressure : **Pg**
Pw < Pg

Perforation Tunnel
&
Reservoir Pressure : Pr

DUB Condition : NO
Pr > Pw < Pg



Comments :
- Gun Pressure Pg is building up inside the Gun because of gas pressure generated by explosive (deto cord,shaped charge) combustion.
- Gun starts to swell

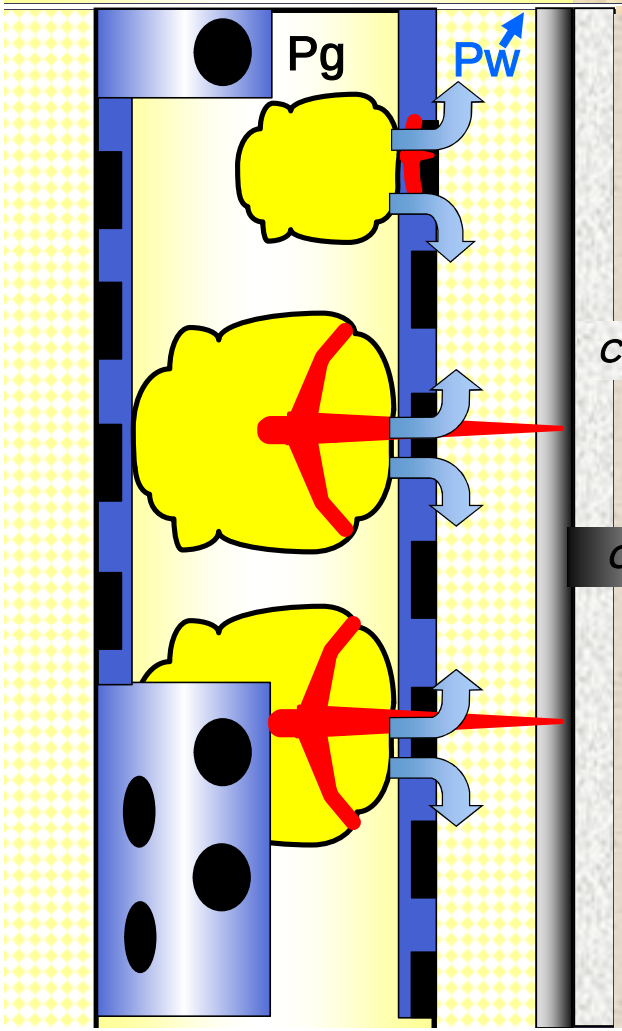
Perforation & DUB Timescale

3 : Gun pressure released

Shape Charge Detonation
Gun Pressure : **Pg**
Pw < Pg

Perforation Tunnel
&
Reservoir Pressure : Pr

DUB Condition : NO
Pr < Pw < Pg

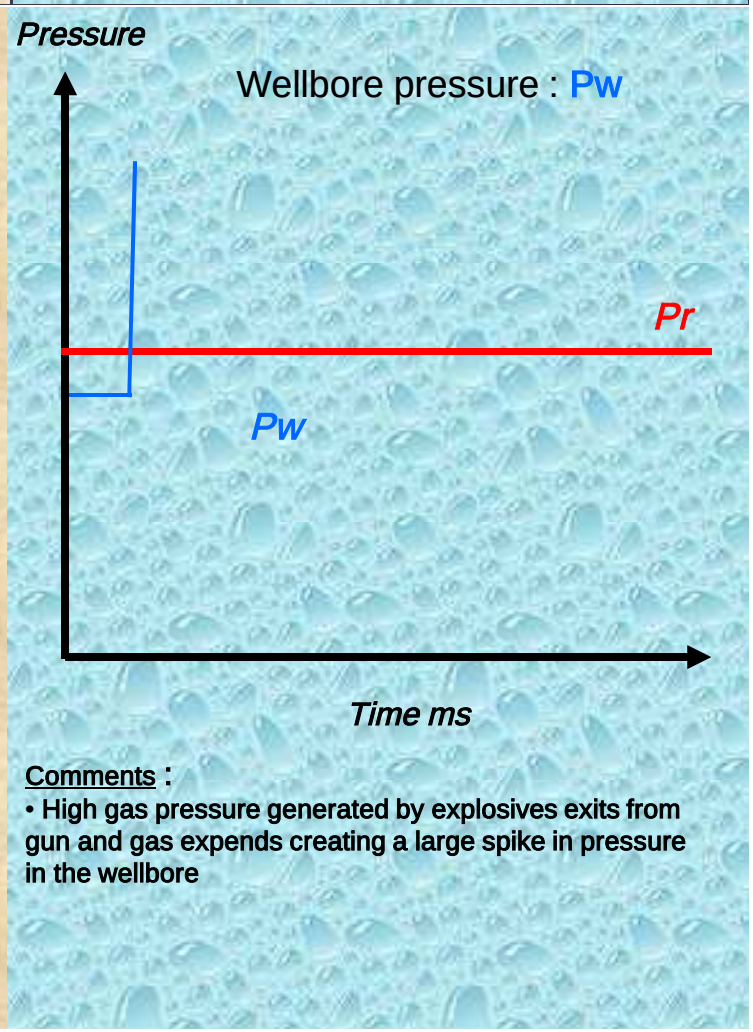


Formation damage

Cement

Casing

Virgin Reservoir :
Pr, K



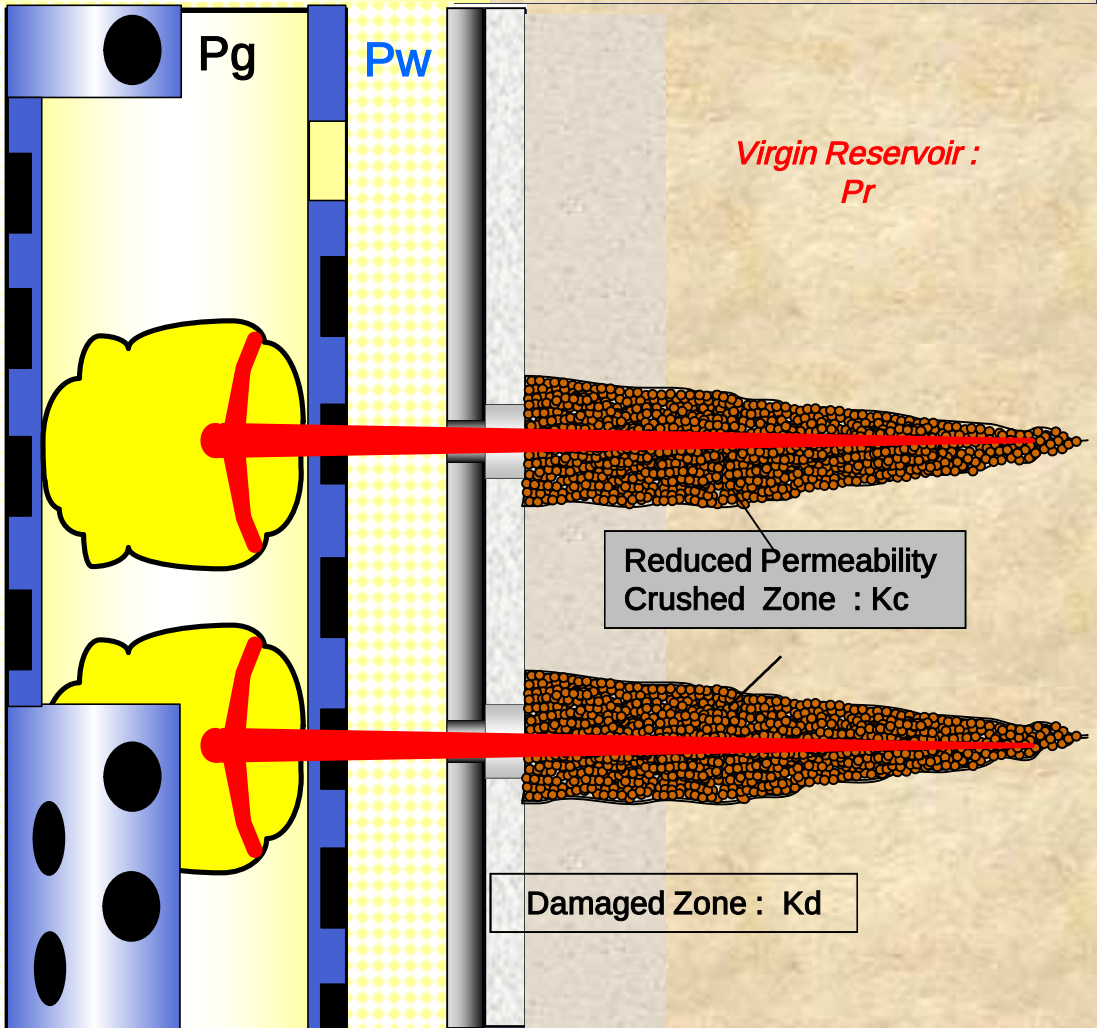
Comments :
• High gas pressure generated by explosives exits from gun and gas expends creating a large spike in pressure in the wellbore

Perforation & DUB Timescale

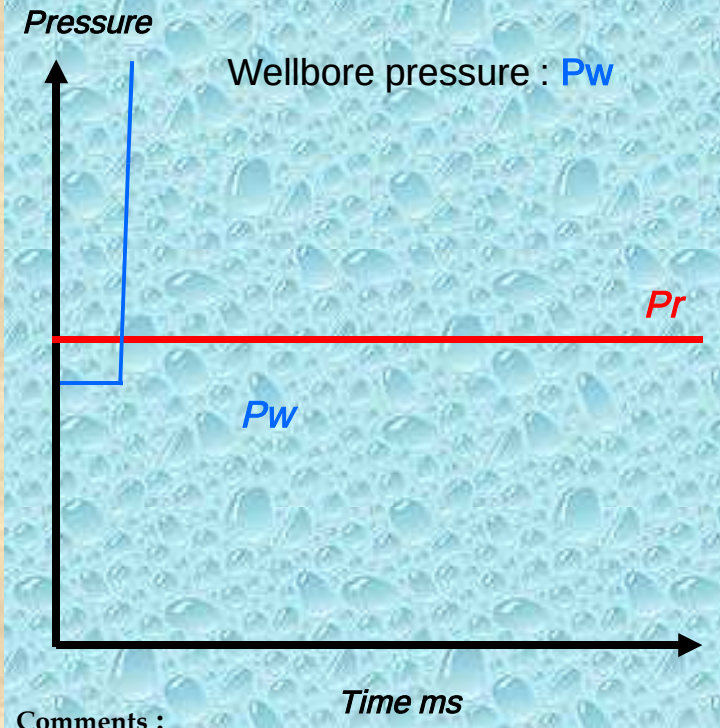
4 : Creation of perforation tunnel

Shape Charge Detonation
Gun Pressure : **Pg**
Pw < Pg

Perforation Tunnel
&
Reservoir Pressure : Pr



DUB Condition : NO
Pr < Pw < Pg



Comments :

- High impact jet on reservoir pulverizes formation rock grains causing a change in the matrix rock that results in a low-permeability crushed zone immediately surrounding the perforation tunnels and creating potential for migration of fine particles
- The process also leaves some residual charge debris inside the perforations.
- Gas fully expanded in wellbore

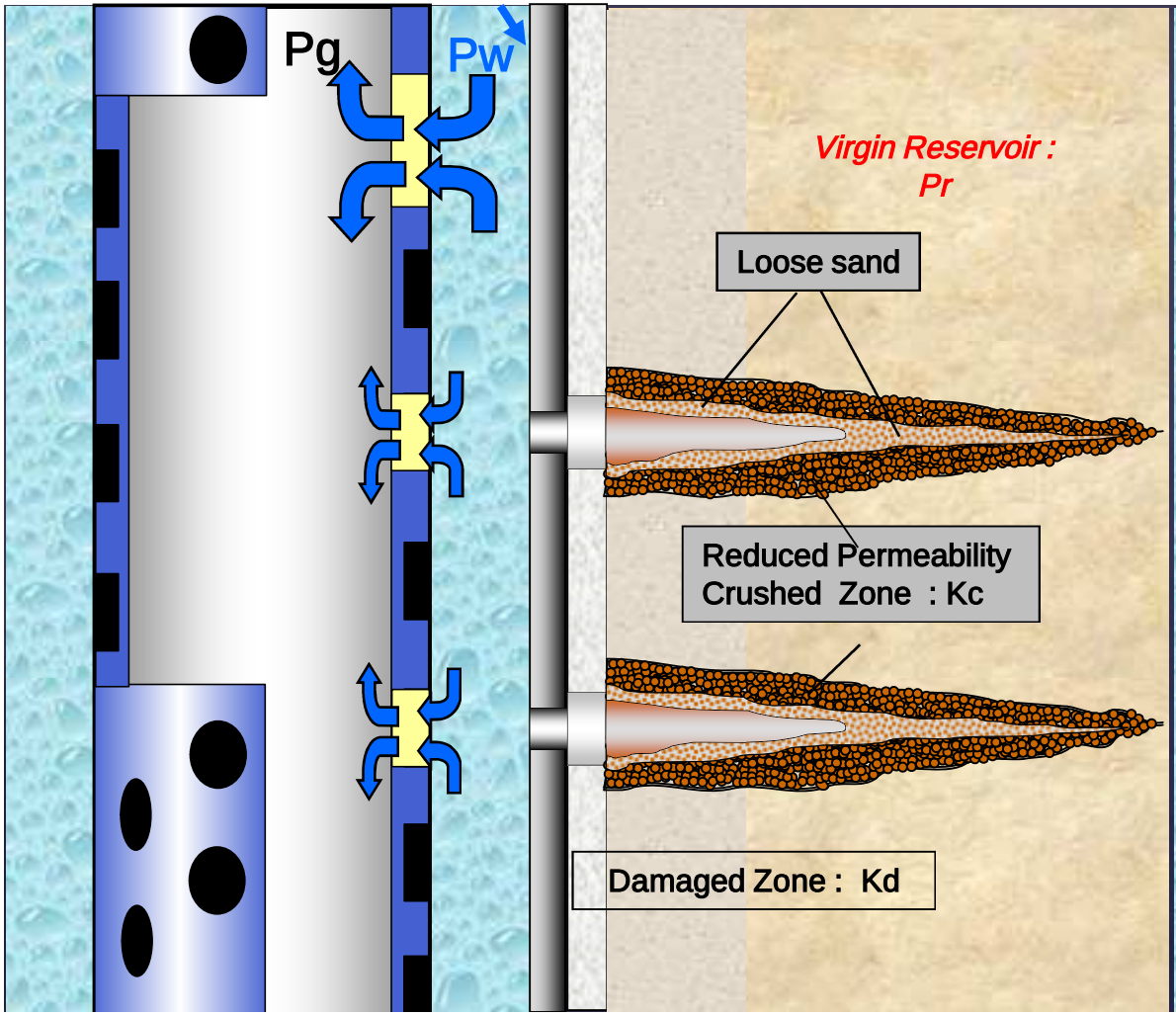
Perforation & DUB Timescale

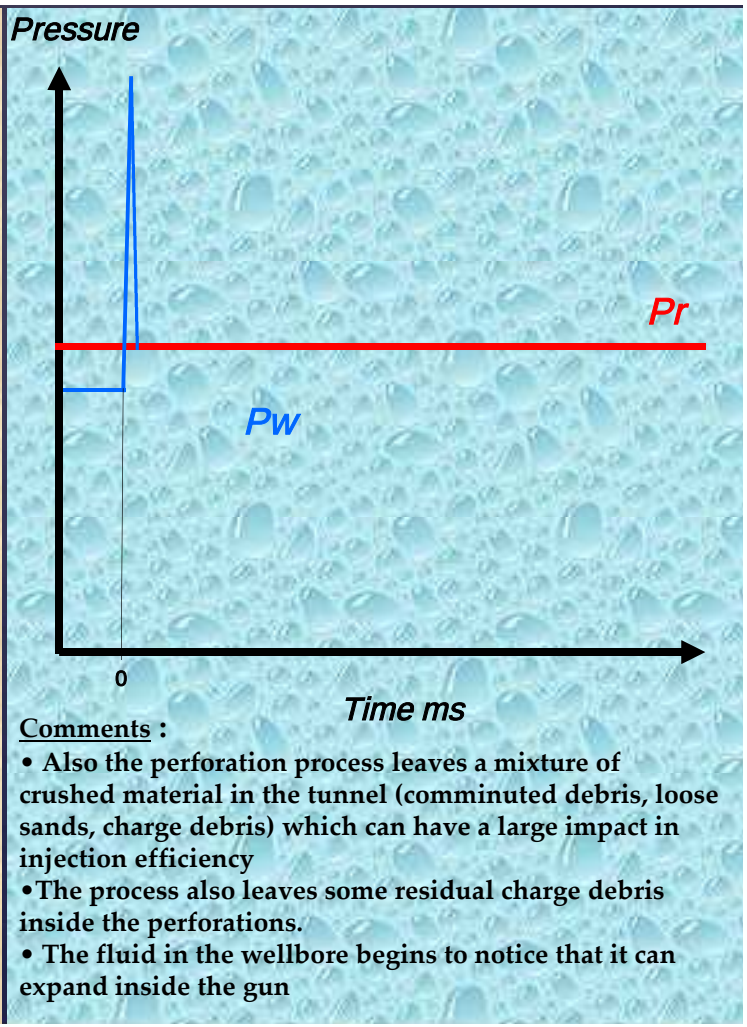
5 : Wellbore fluid rushes in gun

Shape Charge Detonation
Gun Pressure : **Pg**
Pw > Pg

Perforation Tunnel
&
Reservoir Pressure : Pr

DUB Condition : NO
Pr < Pw > Pg





Comments :

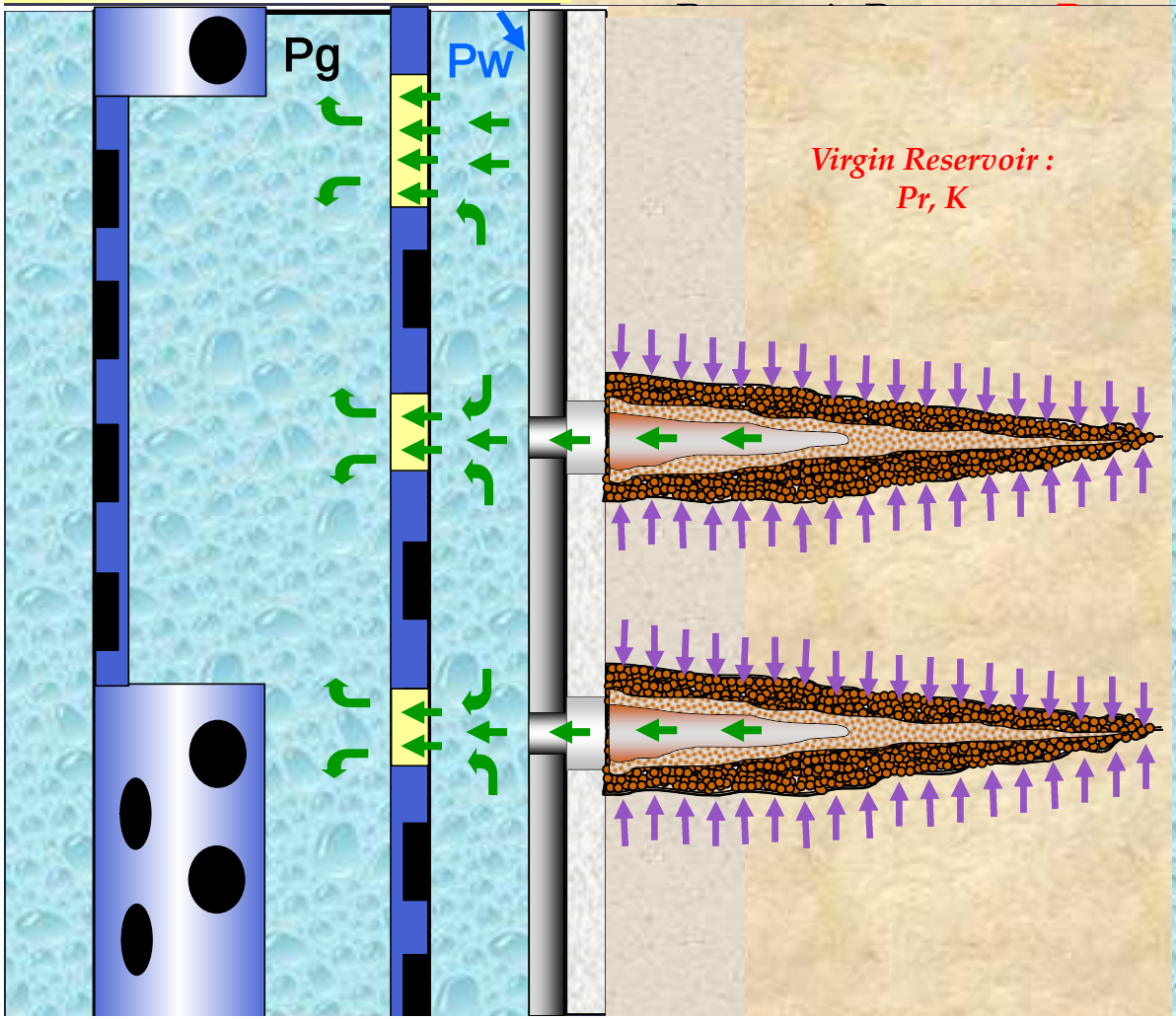
- Also the perforation process leaves a mixture of crushed material in the tunnel (comminuted debris, loose sands, charge debris) which can have a large impact in injection efficiency
- The process also leaves some residual charge debris inside the perforations.
- The fluid in the wellbore begins to notice that it can expand inside the gun

Perforation & DUB Timescale

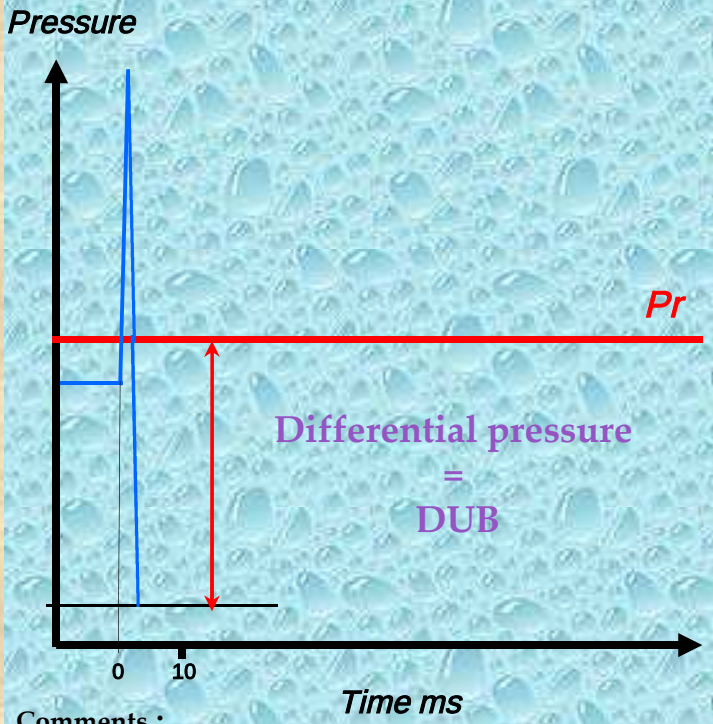
6 : Dynamic UB occurs

Shape Charge Detonation
Gun Pressure : **Pg**
Pw > Pg

Perforation Tunnel
&



DUB Condition : **YES**
Pr > Pw > Pg



Comments :

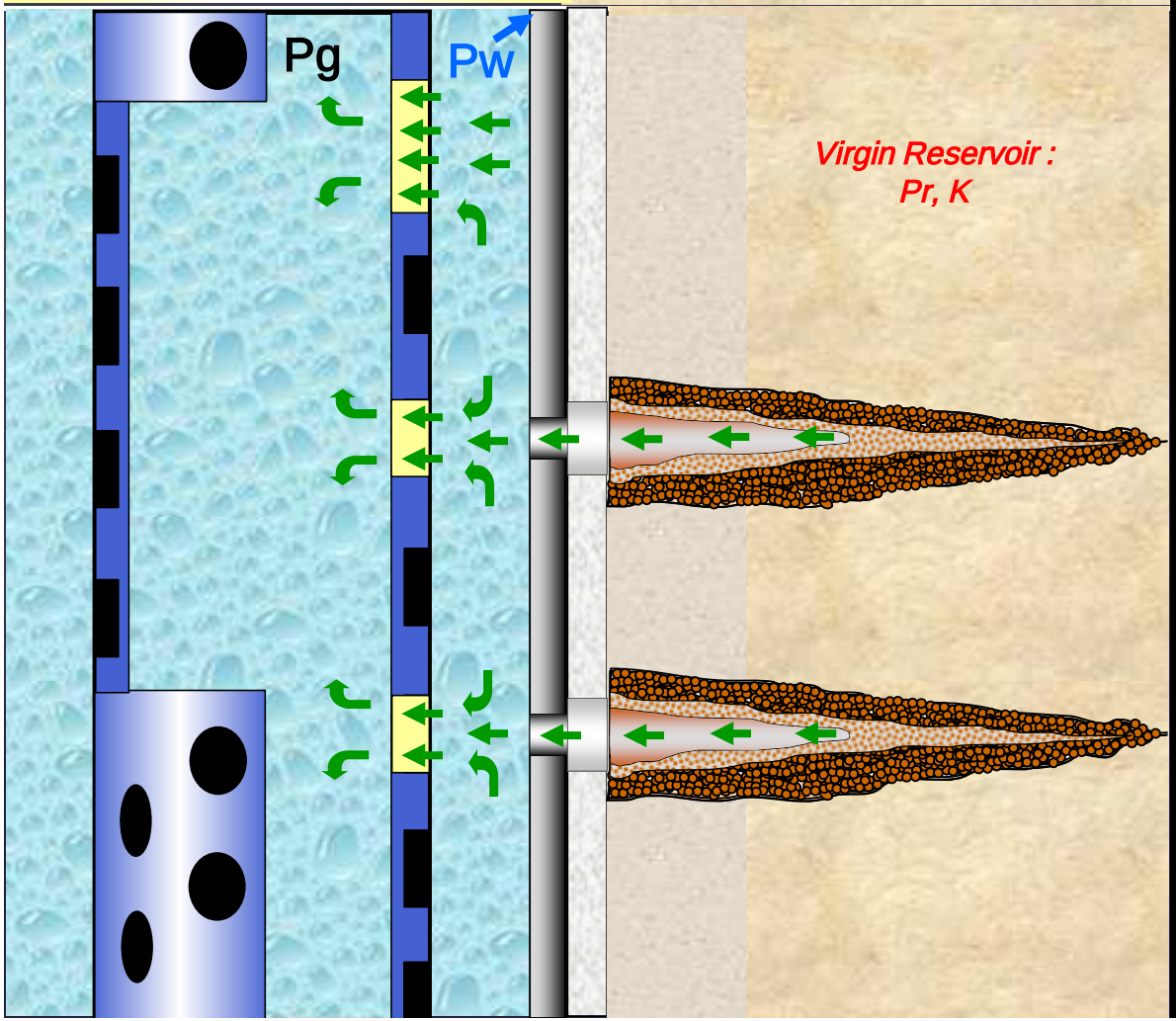
- **Tensile failure is caused by exposure to the high differential pressure between reservoir and wellbore. When the peak strength of the flow exceeds the strength of the rock damaged by perforating, tensile failure will cause the weakened rock to be removed**

Perforation & DUB Timescale

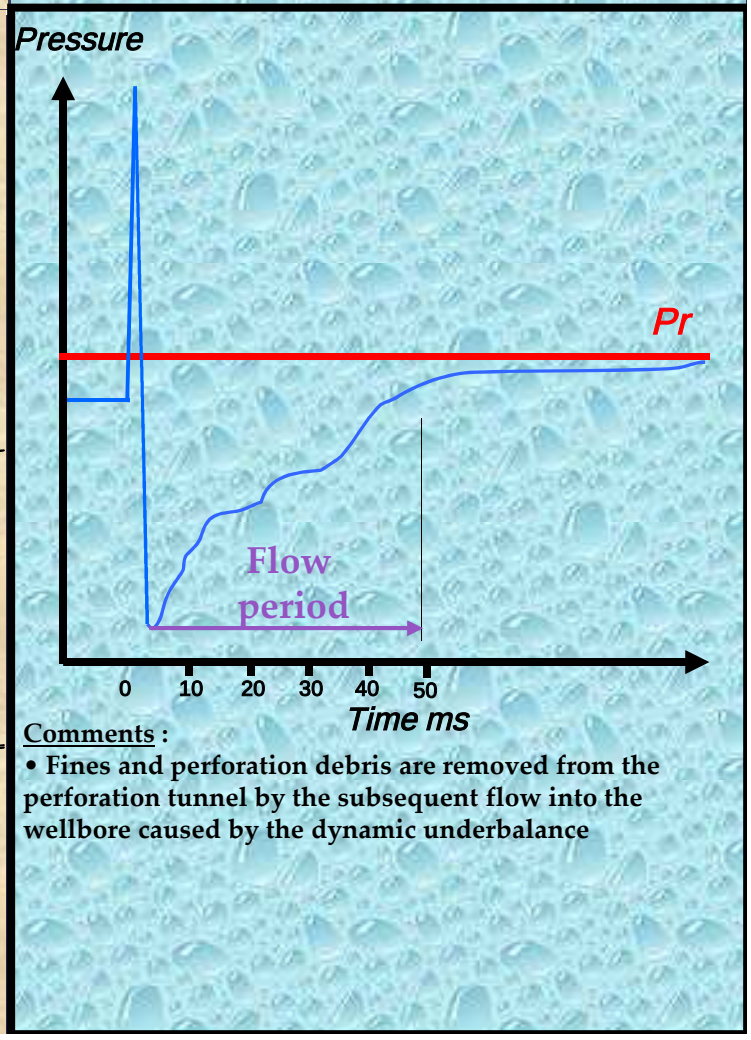
7 : Transport of failed material

Shape Charge Detonation
Gun Pressure : **Pg**
Pw = Pg

Perforation Tunnel
&
Reservoir Pressure : Pr



DUB Condition : YES
Pr > Pw



Comments :

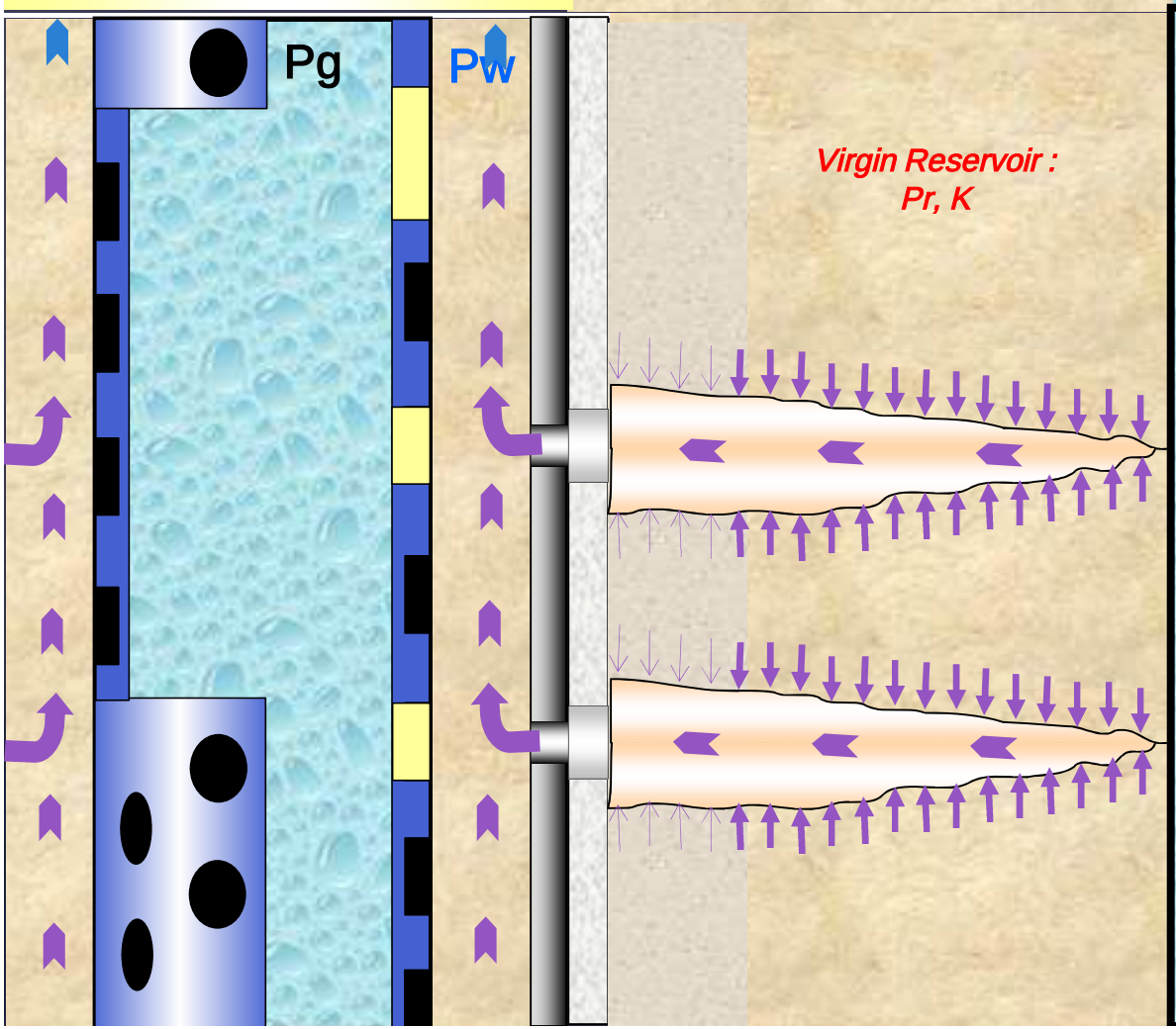
- Fines and perforation debris are removed from the perforation tunnel by the subsequent flow into the wellbore caused by the dynamic underbalance

Perforation & DUB Timescale

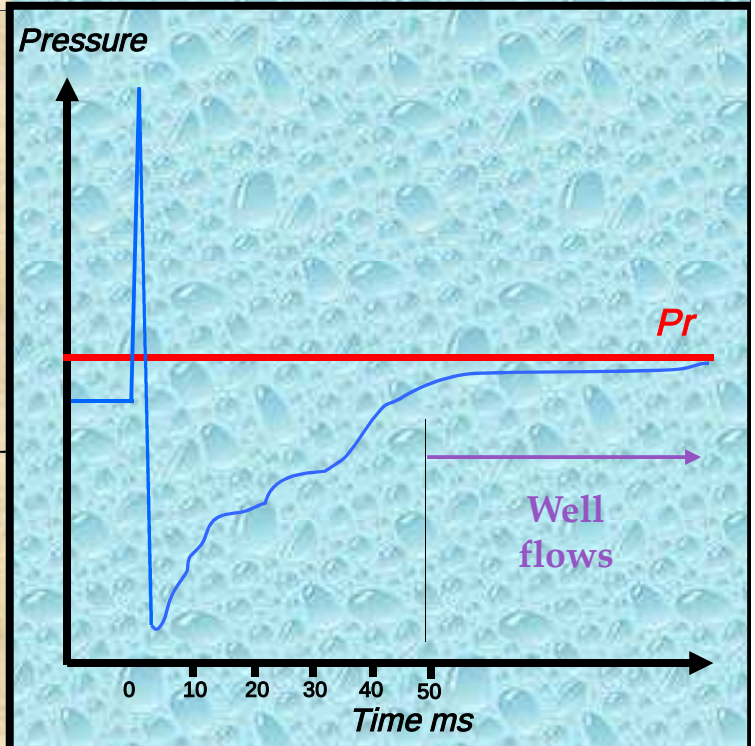
8 : Reservoir response

Shape Charge Detonation
Gun Pressure : **Pg**
Pw = Pg

Perforation Tunnel
&
Reservoir Pressure : Pr

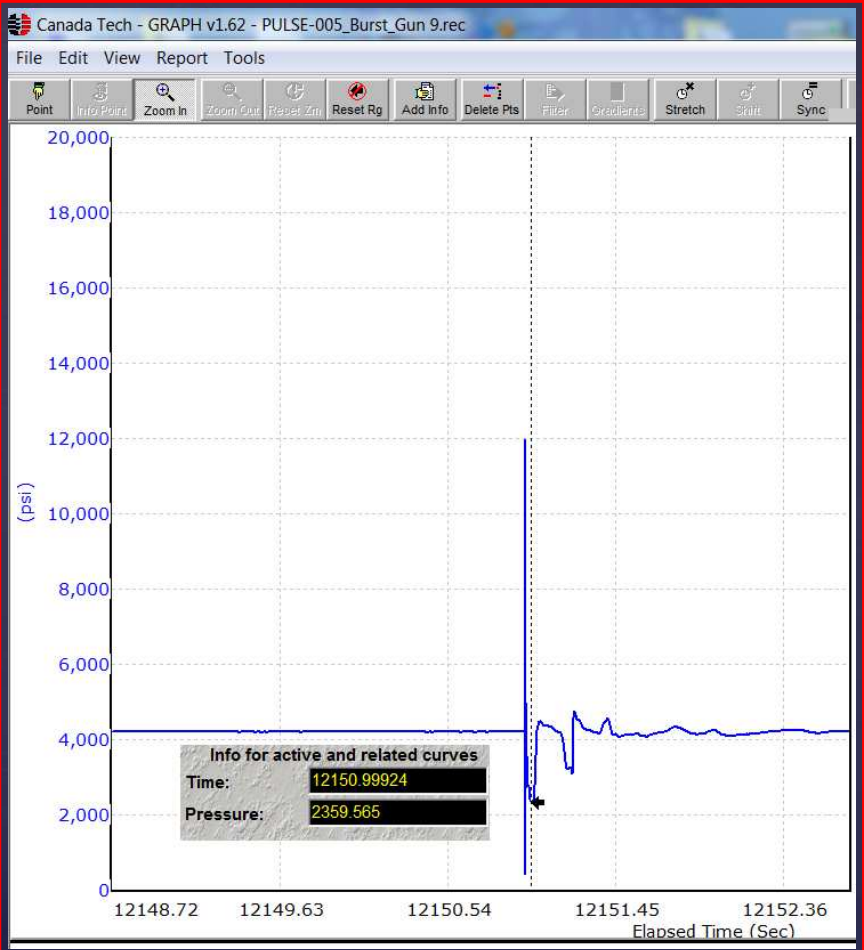


DUB Condition : NO
Pr > Pw

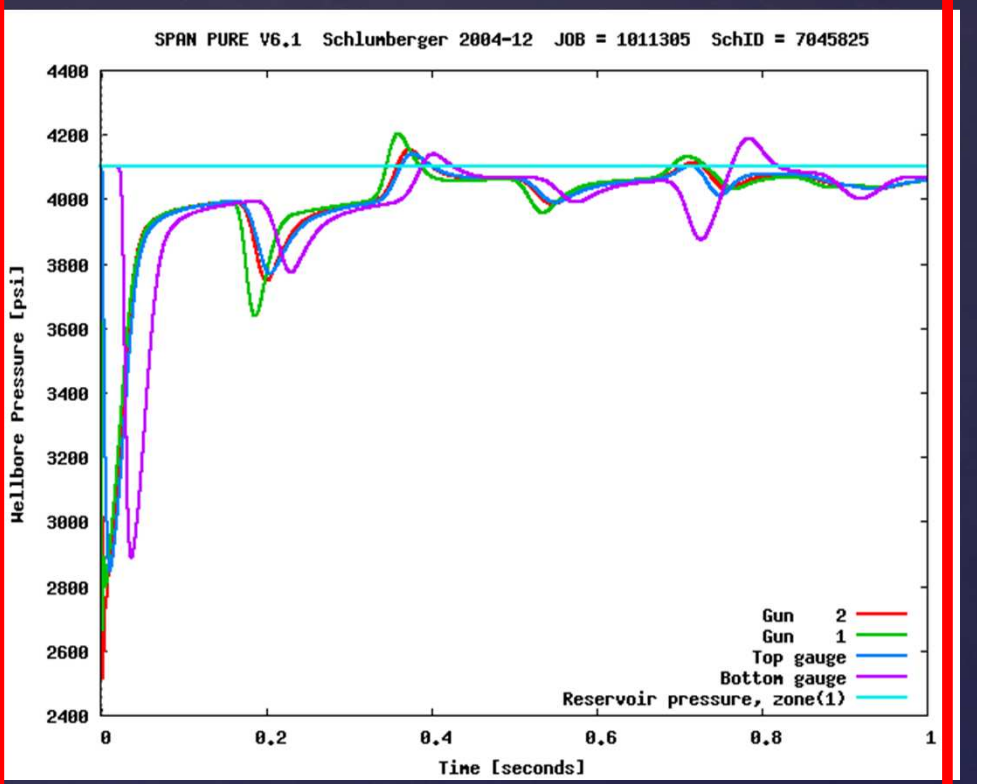


Comments :
- After perforating and DUB events ,perforation tunnels are free of damages .
- Reservoir is flowing with increased permeability around perforation tunnel and thus enhanced well productivity.

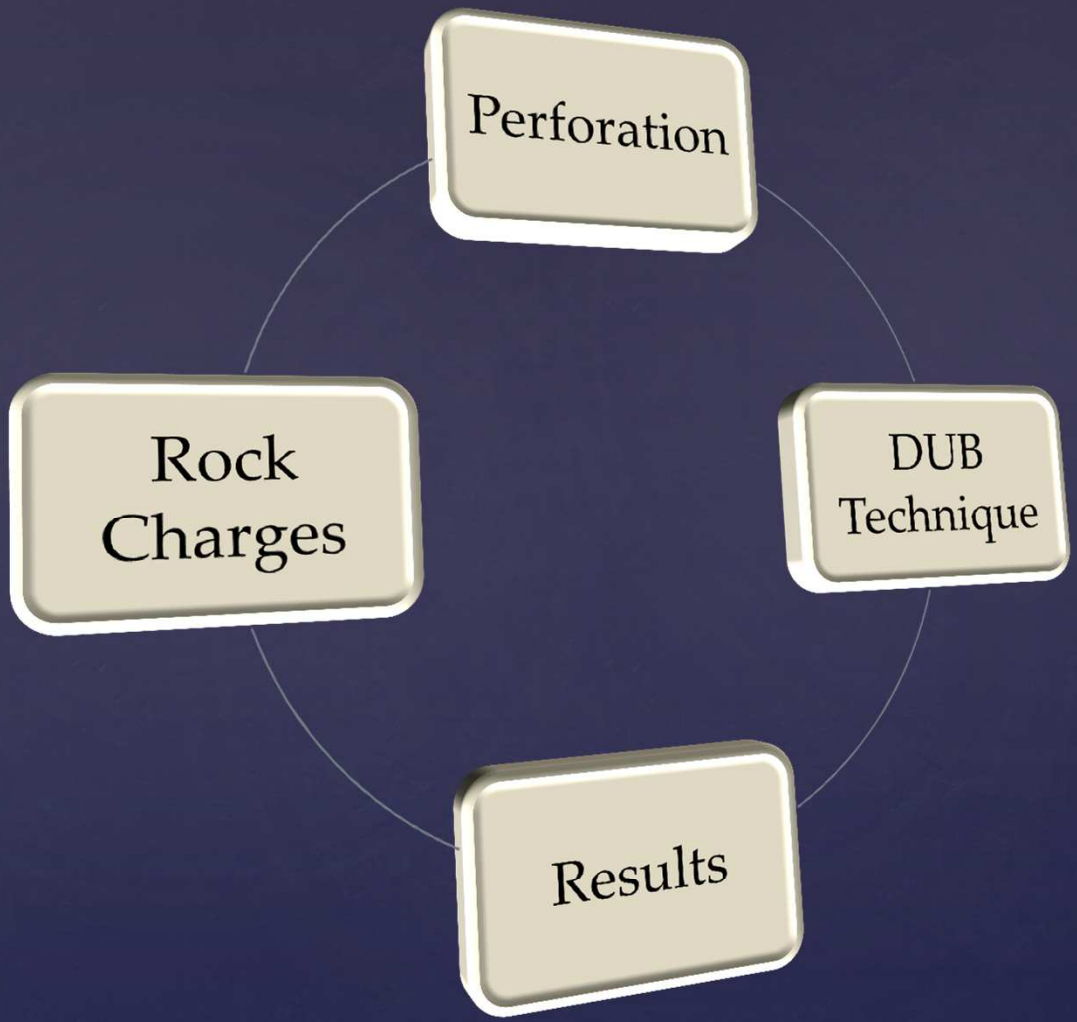
DUB environment



DUB pressure environment as measured using fast pressure gauge (Run # 9)



DUB pressure environment as predicted by the model during job design (Run # 9)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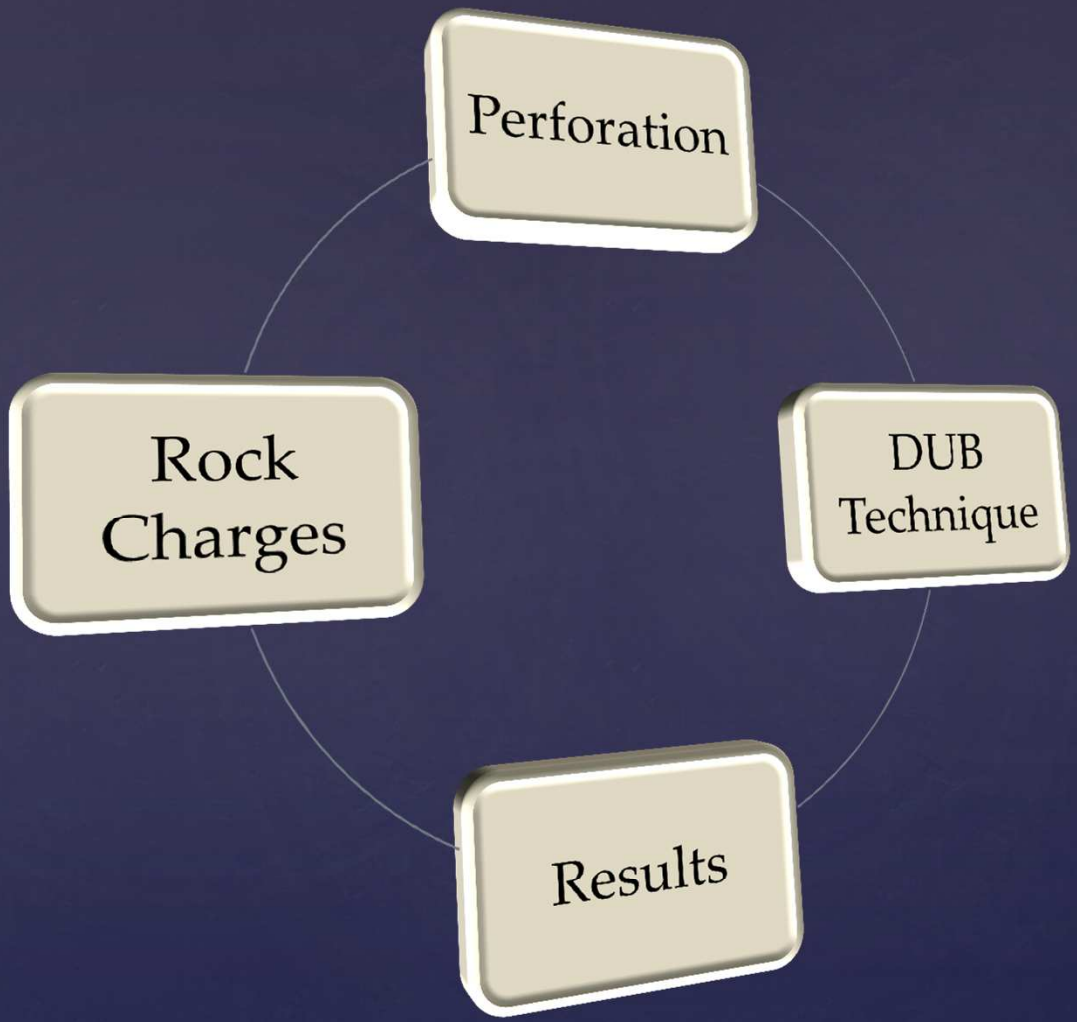
Rock Model Shaped Charges

Changing the standards by building the perforating models on actual rock lab tests instead of normal concrete block
Several lab tests showed:

- 27% increase in stressed-sandstone penetration
- 33% increase in stressed-limestone penetration
- 50% more formation contact for more effective stimulation treatments and increased drainage contact for greater productivity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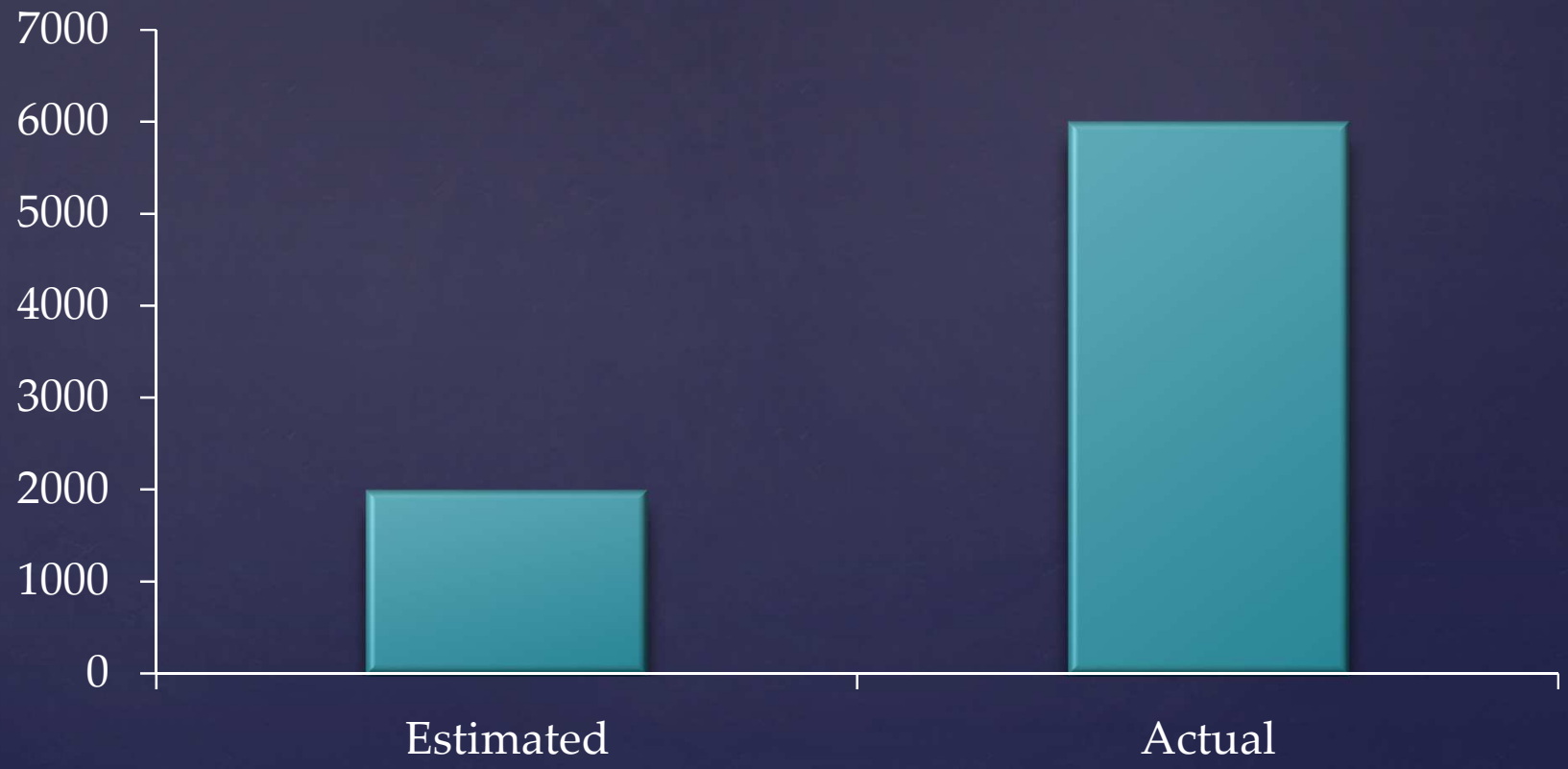
Job Results



Thank You