Flow Detection Behind Casing and Formation Pressure Measurement

Aberdeen Formation Evaluation Seminar
20th Apr. 2016, Aberdeen, Scotland

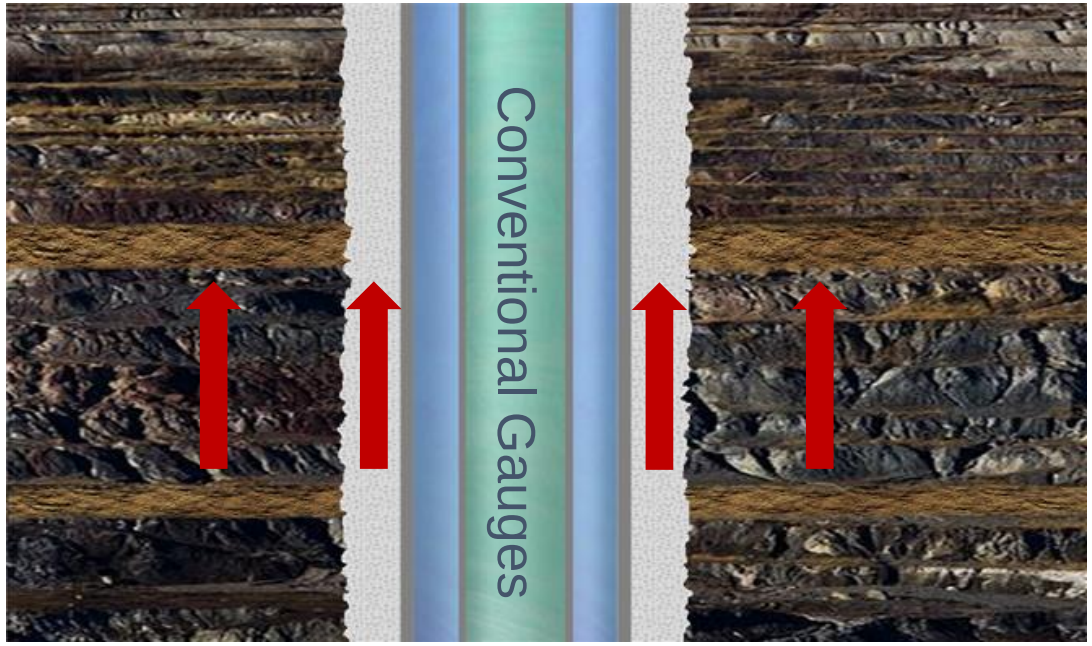
Mohammad Abshenas
TGT Oilfield Services UK

Agenda

- Spectral Noise Logging
- Flow Surveillance Behind Casing
- Formation Pressure in Multi-Layered Reservoirs
- Summary

Formation Pressure in Production Wells

- Formation Pressure in multi-layered reservoirs
  - Openhole Formation Testers
  - Downhole Gauges and PLTs
- Vertical Communication between reservoir units through Flow behind casings.



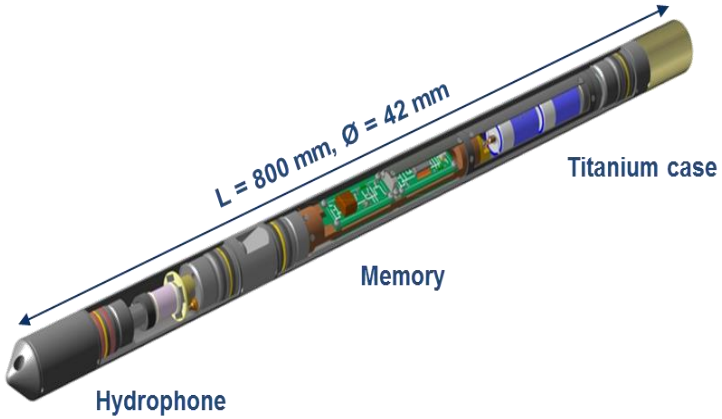
Formation pressure in reservoirs, and specially in multi-layered development fields is one of the most important parameters for production optimization and filed development plans. Traditionally the pressure of different layers is measured using wireline formation testers during Openhole phase but when in comes to production phase it is not as easy anymore. ***Downhole pressure gauges and PLTs only measure an equilibrium pressure or average pressure of multiple layers.***

Cross flows and communication behind casing can make matters much more complex. (picture) as you see all of our measurements will be done inside the wellbore but quite often a lot is happening behind the casing.

Spectral Noise Logging methodology addresses this issue.

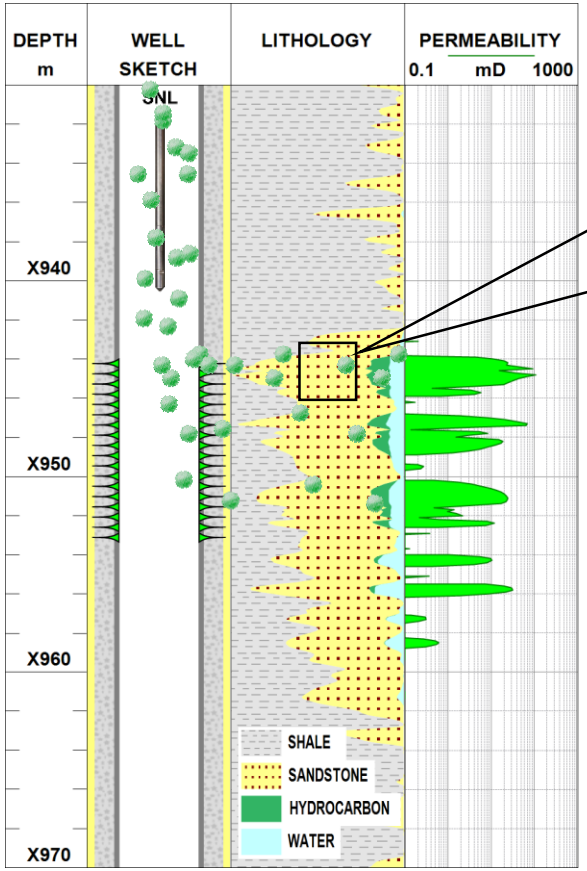
Spectral Noise Logging

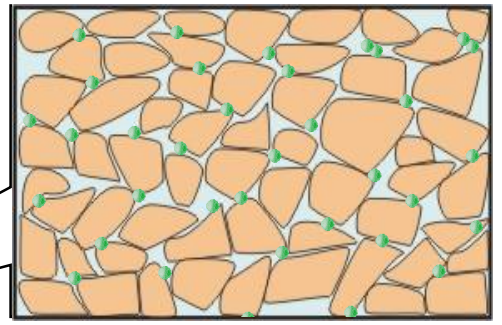
- Downhole Logging Tool
- Records high resolution noise
- Two measureable parameters: ***Frequency*** and ***Intensity***
- Provides information on reservoir flow ***behind multiple barriers***

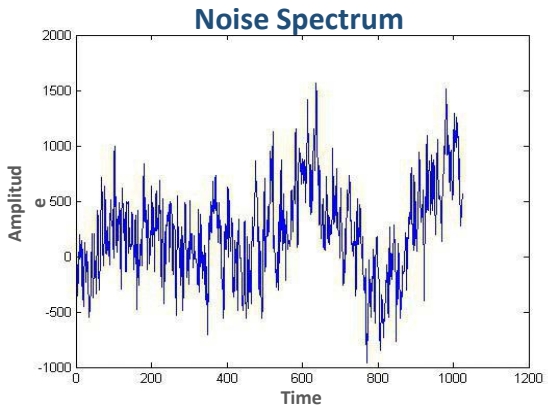


Spectral Noise Logging Tool	
Tool OD	1 11/16" (42mm)
Temp Rating	302 degF (150 C)
Press Rating	9,000 PSI (60 MPa)
Frequency Range	8-60,000 Hz
Dynamic Range	90 dB
Depth of Investigation	10-15 ft.
Sampling Rate	1 sec
Battery Life	67 hrs
H2S Resistance	Up to 25%

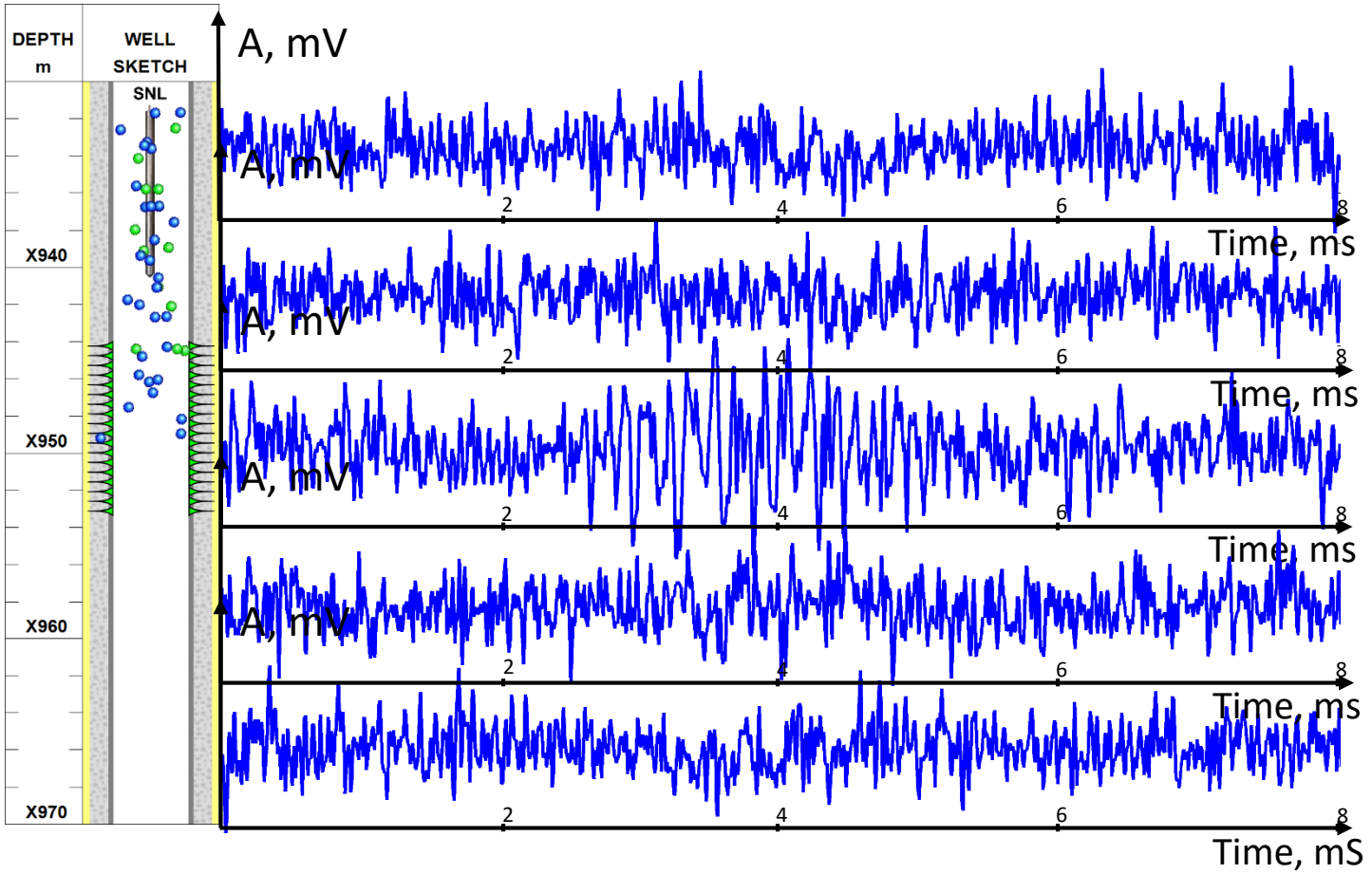
Spectral Noise Logging



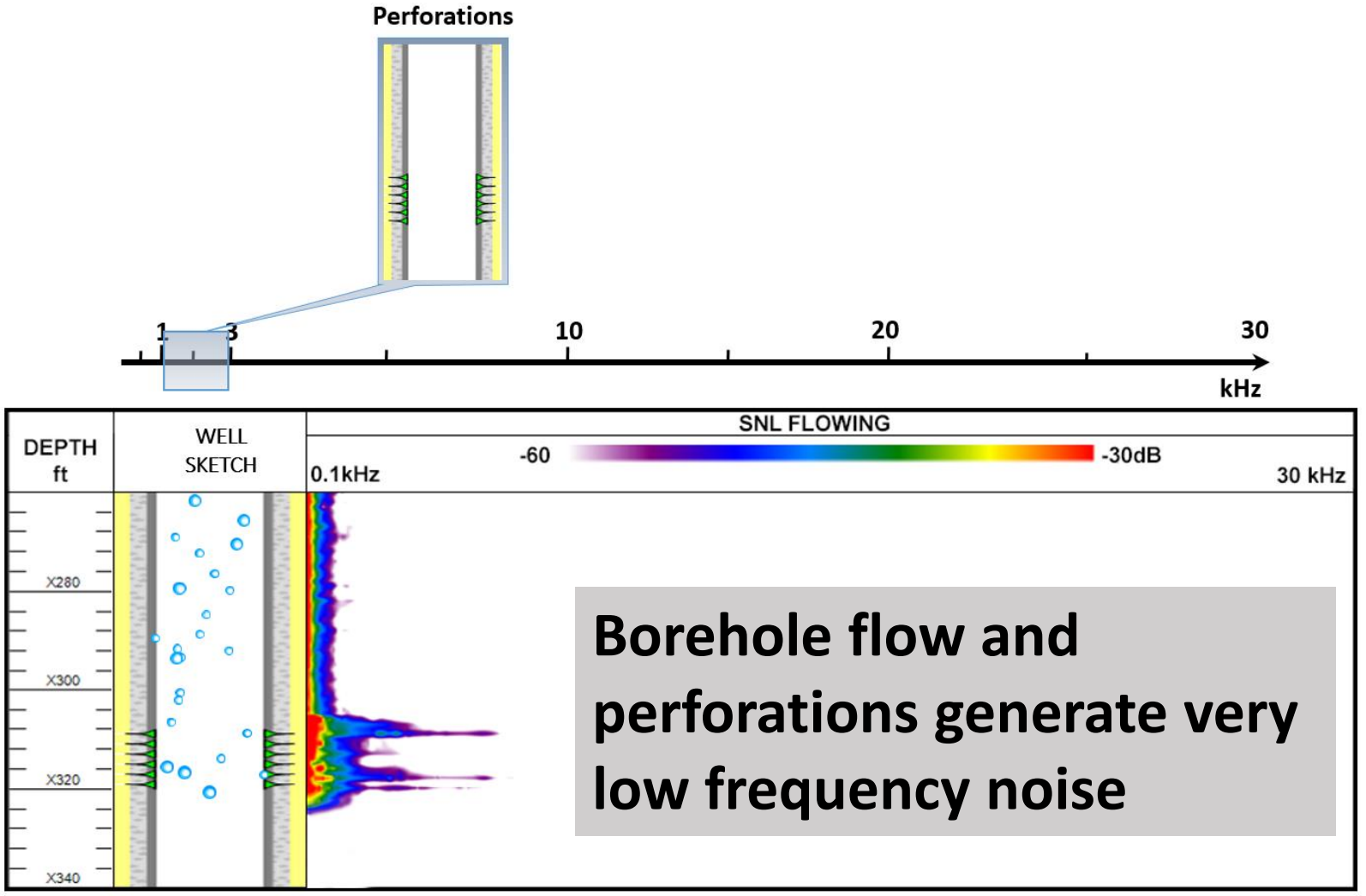




Spectral Noise Logging

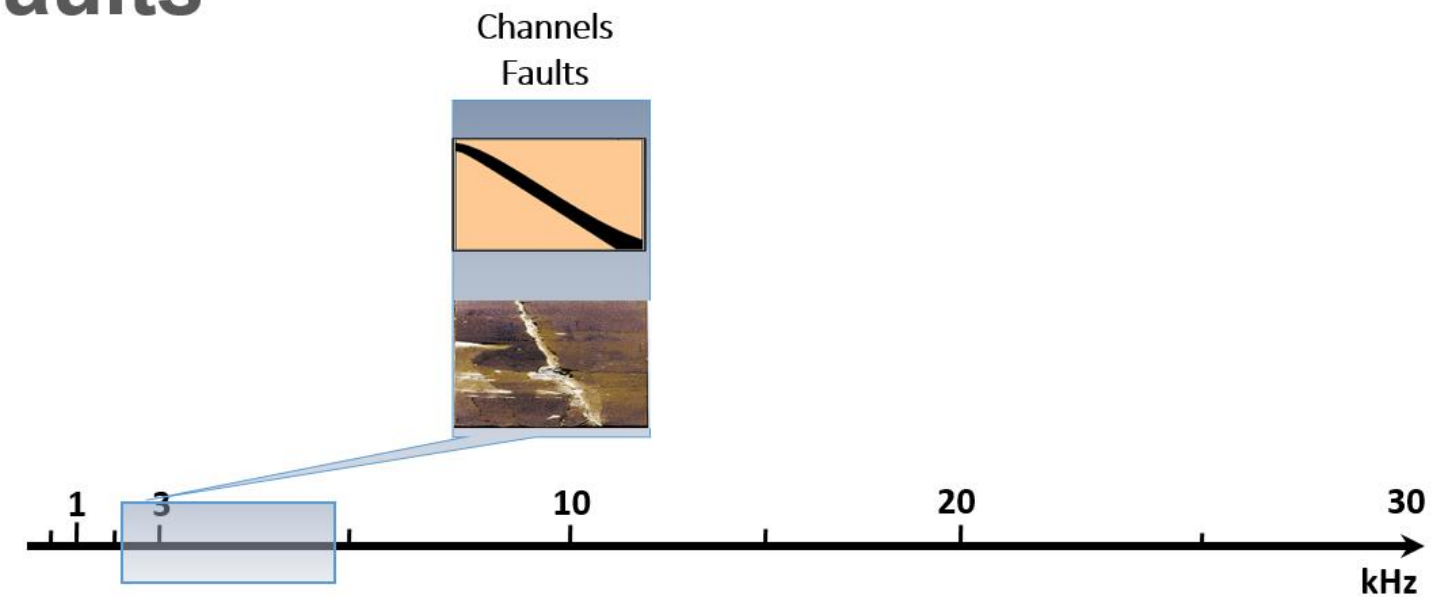


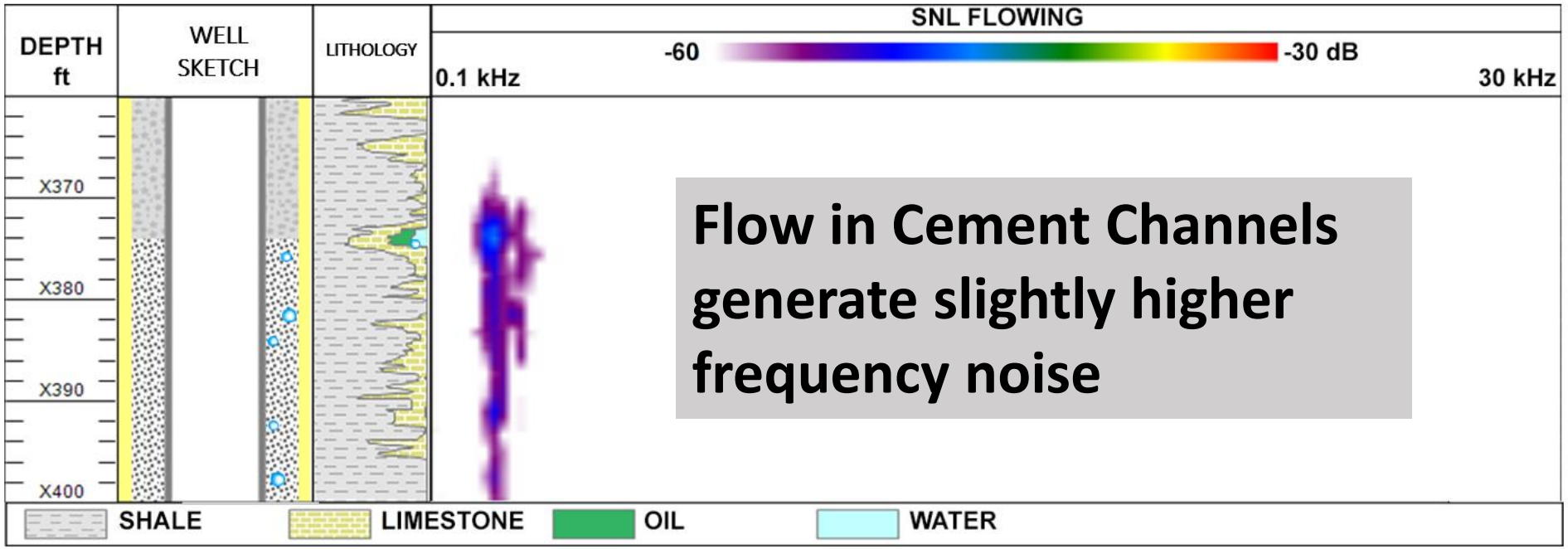
Borehole noise



Borehole flow and perforations generate very low frequency noise

Channels/Faults

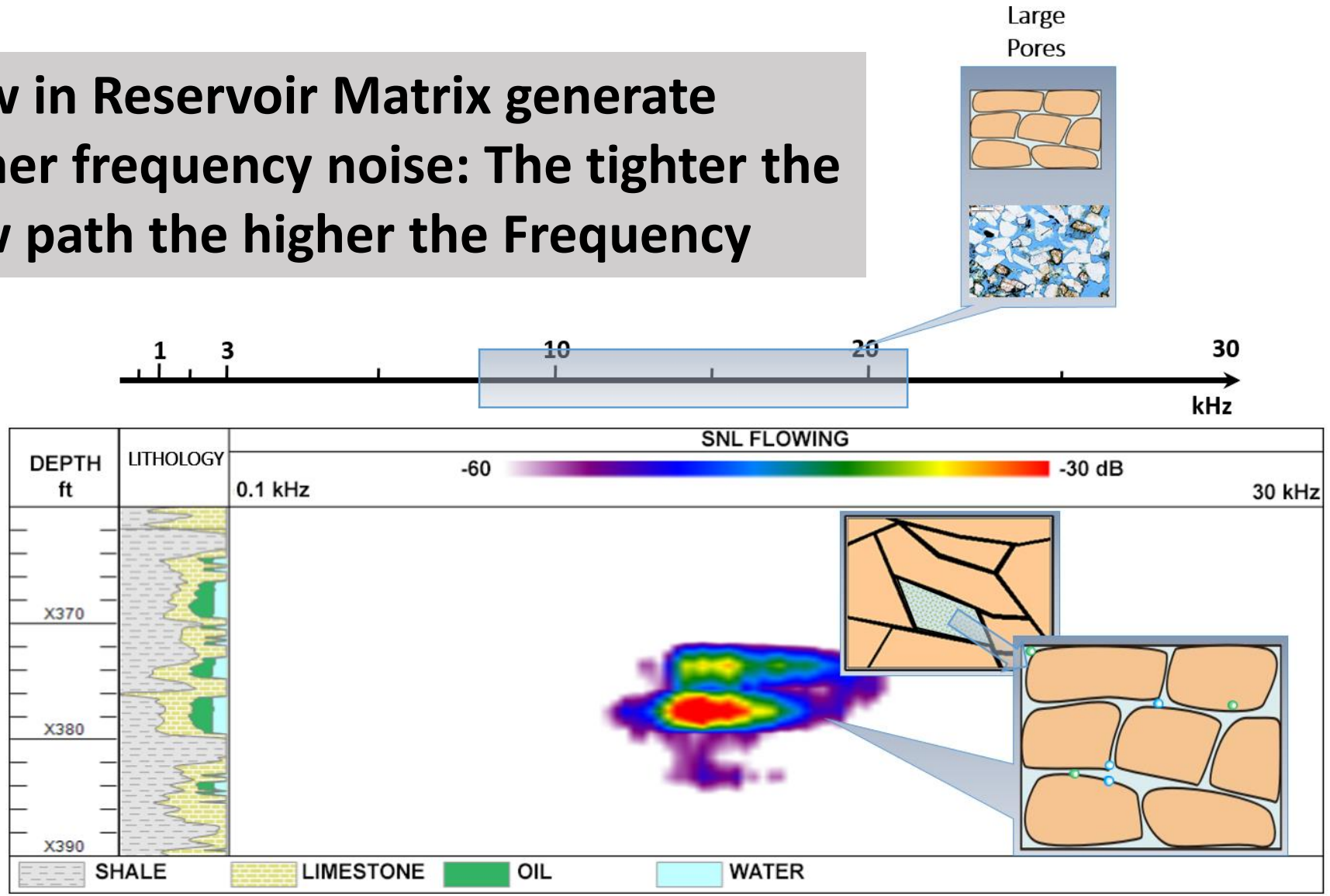




Flow in Cement Channels generate slightly higher frequency noise

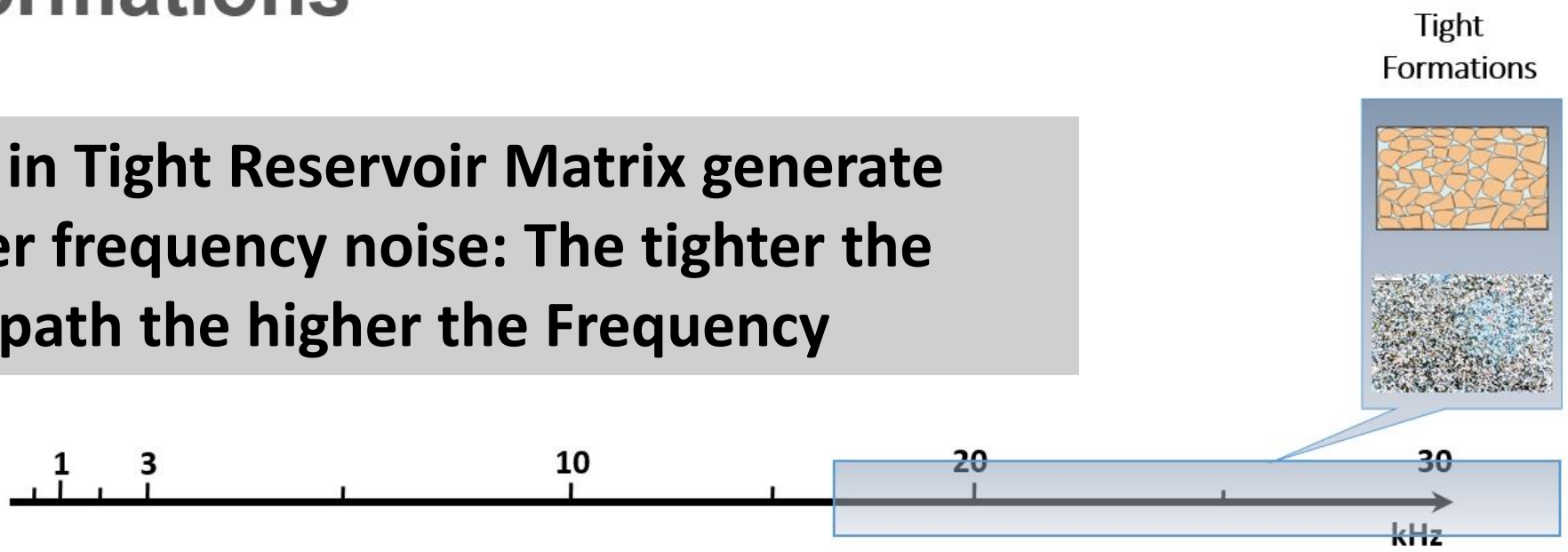
Matrix flow

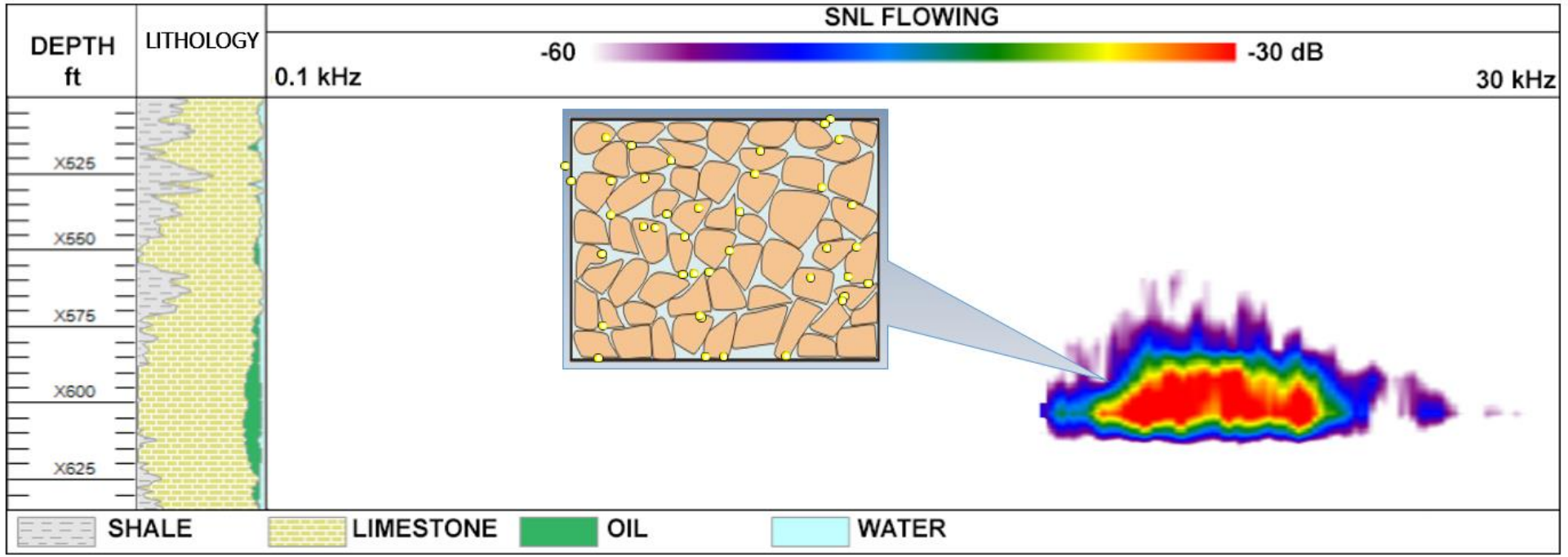
Flow in Reservoir Matrix generate higher frequency noise: The tighter the flow path the higher the Frequency



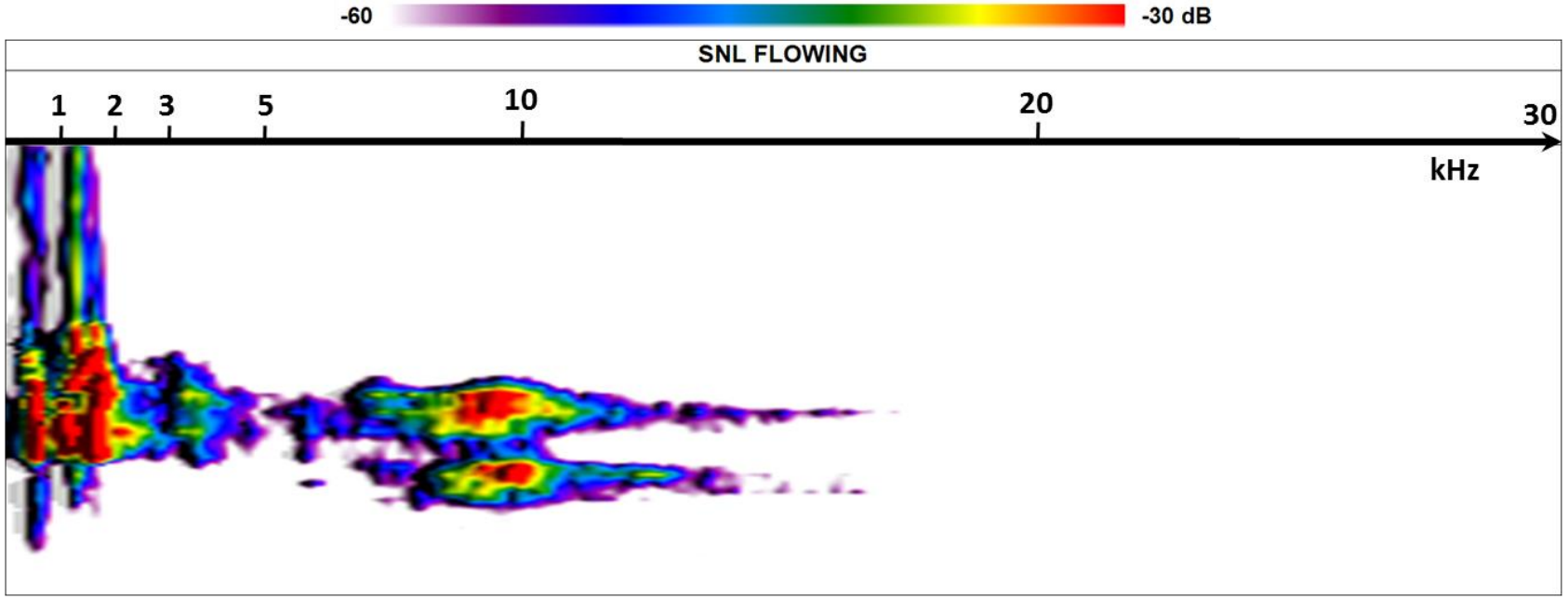
Tight formations

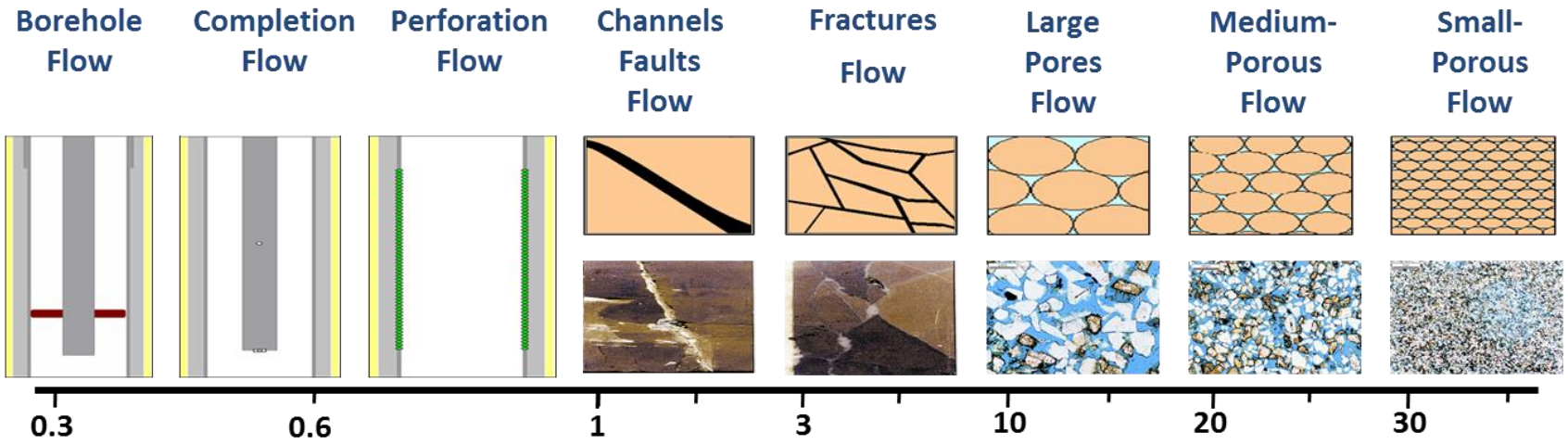
Flow in Tight Reservoir Matrix generate higher frequency noise: The tighter the flow path the higher the Frequency





Spectral Noise - Analysis

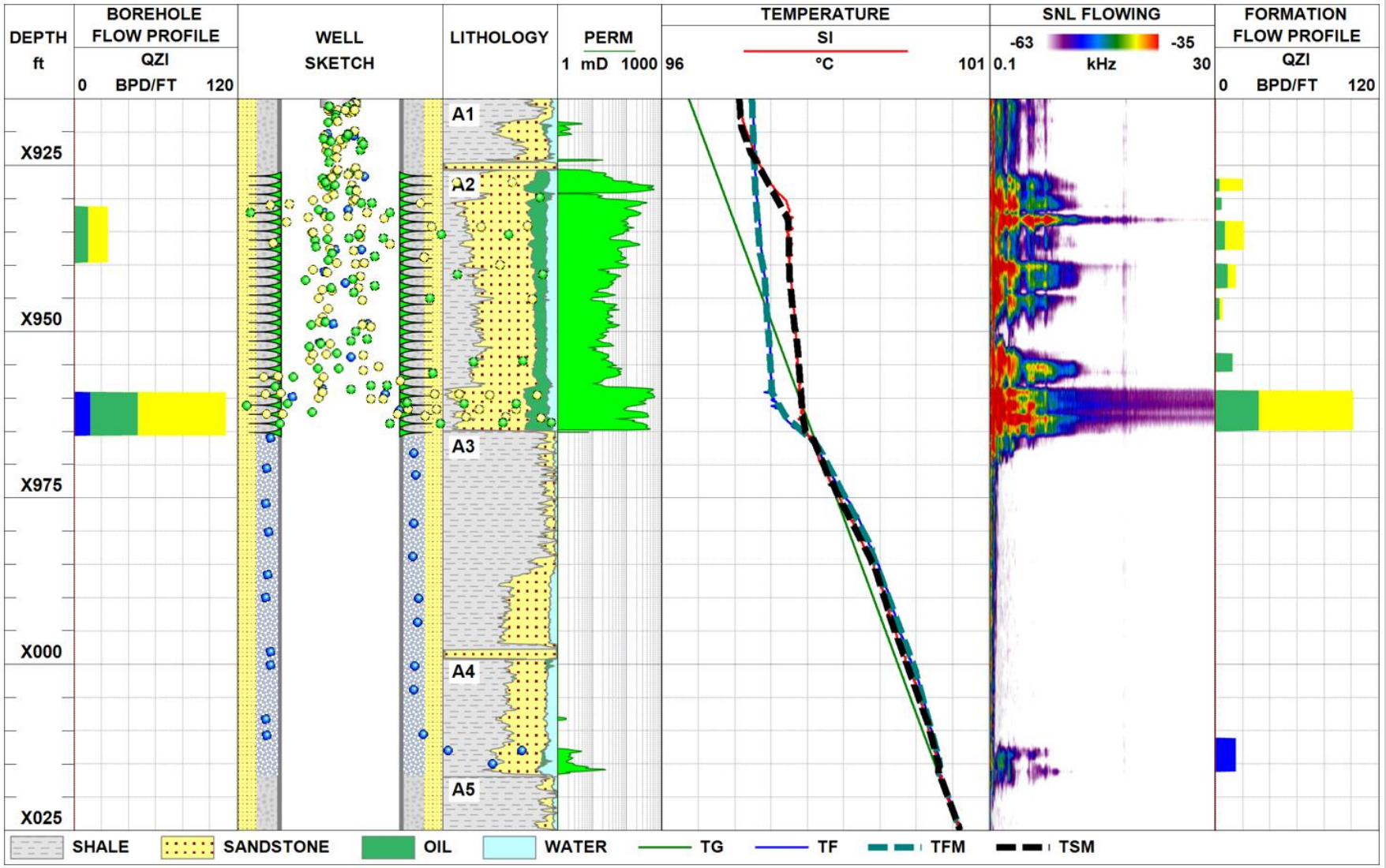




Spectral Noise Logging

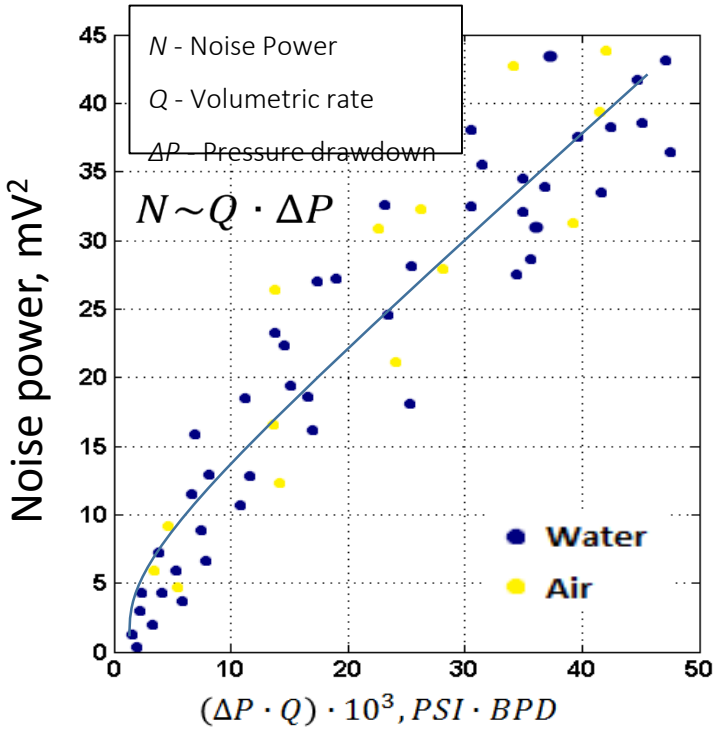
- Flow behind casings
- Formation Pressure
- Reservoir Properties such as Permeability, Formation Compressibility
- True Reservoir Height
- Leak Detection and annulus pressure investigation

Reservoir Flow Analysis



In this case study, PLT Spinner shows in flow of both water and hydrocarbon from the perforations at A2, but the Noise response reveals a channelling flow behind the casing from A4 which is the actual source of water.

Noise and Pressure: McKinley Equation



$$N \sim Q \cdot \left(P_{wf} - P_i\right)$$

$$Q \sim \left(P_{wf} - P_i\right)$$

$$N \sim f(\Delta P)$$

for liquids

$$N \sim \Delta P^2$$

for gases

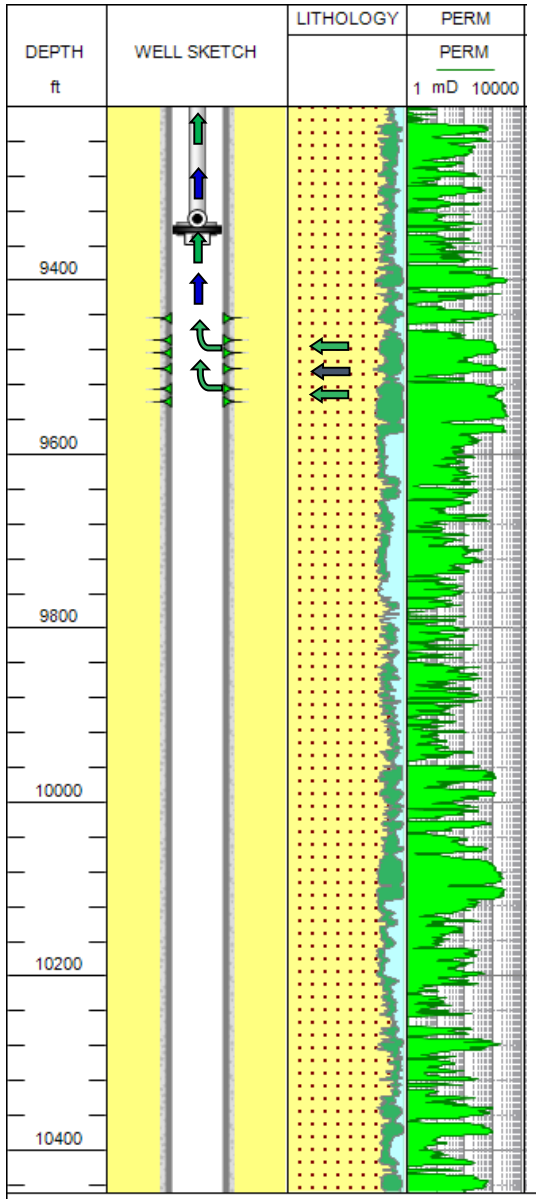
$$N \sim \Delta P^{3/2}$$

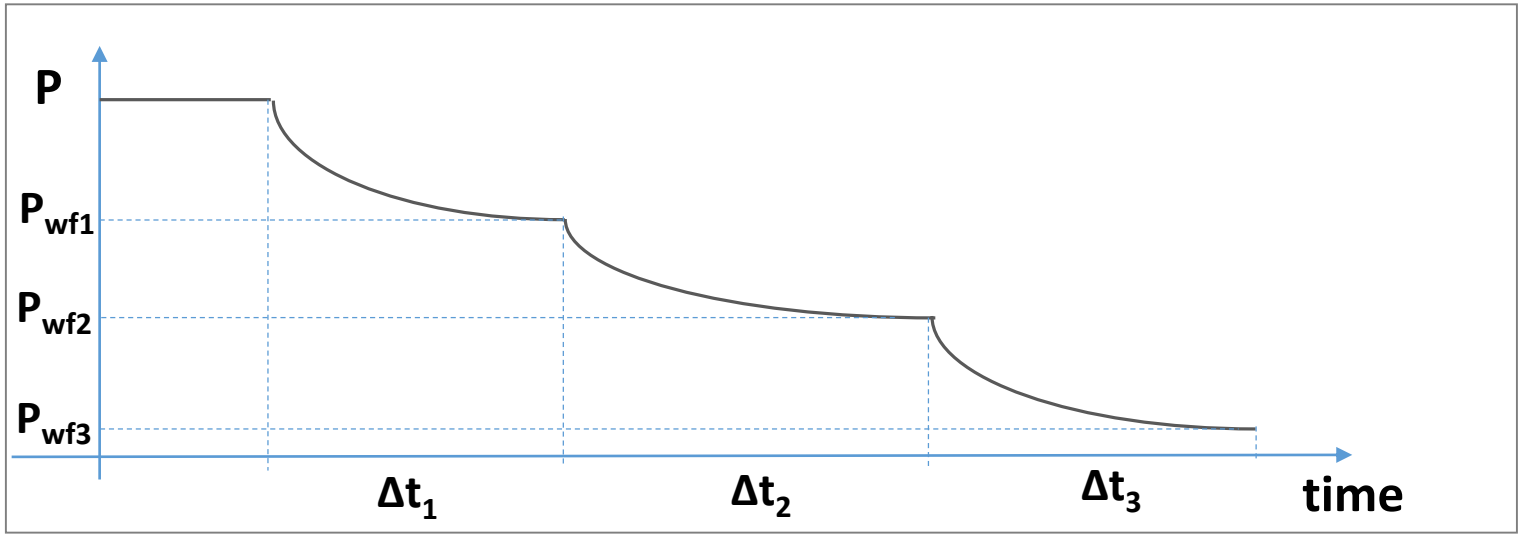
Multi-Rate: (for Liquids)

$$\frac{N_1}{N_2} = \frac{f(\Delta P)_1^2}{f(\Delta P)_2^2}; \quad \frac{N_2}{N_3} = \frac{f(\Delta P)_2^2}{f(\Delta P)_3^2}$$

McKinley Theory (1994): Noise Power is directly proportional to Q.ΔP Flow rate is also a function of ΔP, by using the ratios of Noise Power (N) the true formation pressure is determined.

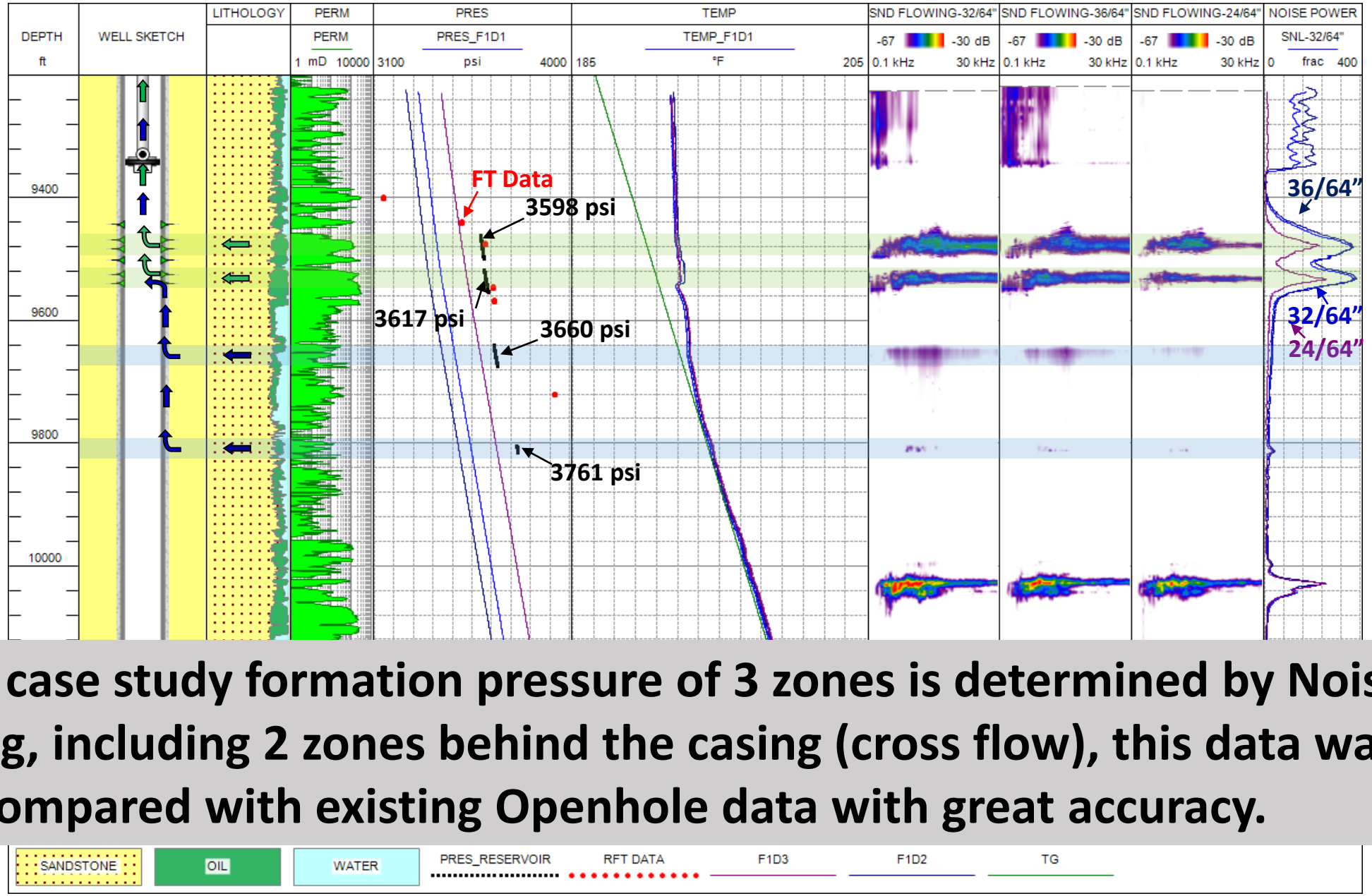
Reservoir Pressure (SPE-177620)





$$p(r,t) = p_e + \frac{QB}{4\pi\sigma}\left[Ei\left(-\frac{r^2}{4\chi t}\right) - 2S\right]; \quad \chi = \frac{k}{\mu\Phi c_t}; \quad \sigma = \frac{kh}{\mu}.$$

Reservoir Pressure (SPE-177620)



In this case study formation pressure of 3 zones is determined by Noise Logging, including 2 zones behind the casing (cross flow), this data was then compared with existing Openhole data with great accuracy.

Reservoir Pressure (SPE-177620)

Comparison of the results from SNL with Pressures from Open Hole Formation Tester

Comparison Table				
Top	Bottom	Formation pressure	Average values	OH FT
ft	ft	psi	psi	psi
9,461	9,500	3,588.3 – 3,607.7	3,598.0	3,611
9,518	9,555	3,607.8 – 3,626.2	3,617.0	3,648
9,641	9,675	3,651.8 – 3,668.8	3,660.3	Not tested
9,805	9,816	3,758.0 – 3,763.4	3,760.7	Not tested

Summary

- **Spectral Noise Logging**
- **Flow Surveillance behind barriers**
- **Formation Pressure**
- **Other Application:**
  - ✓ ***Reservoir Permeability, formation Compressibility***
  - ✓ ***Well Integrity – Leak Detection, Annulus Pressure Investigation***

TGT Oilfield Services UK LTD

WWW.tgtoil.com

KMD Building, Wellington Circle, Altens,
Aberdeen, AB12 3JG
Mohammad.Abshenas@tgtoil.com