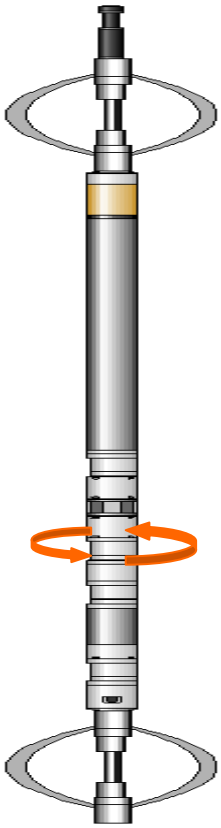
BOREAL E-line

Cement Bond Log Quick Reference



Upper Bow Spring Centralizer

Collar Locator

Gamma Ray & Telemetry

Transmitter

2ft Radial Receivers (8 or 6)

3ft Receiver

5ft Receiver

Lower Bow Spring Centralizer

CBL: Cement Bond Log (GR-CCL, 3' & 5' Receivers)
RBL: Radial Bond Log (CBL + 2' Radial Receivers)

Factors Influencing Amplitude Measurements

1. Tool not centralized
   Reduces amplitude, cement appears better than in actuality
2. Insufficient cementing curing time
   Higher amplitude than real may result a pessimistic interp
3. Gas bubbles in borehole fluid
   Will decrease acoustic signal
4. Gas bubbles in annulus or void space in cement sheath
   Causes amplitudes to read higher than actual free pipe signal
5. Changes in pipe thickness
   Will cause different min/max amplitude values
6. Light weight cement
   Higher amplitude
7. Micro-annulus
   Increases amplitudes
8. Fast formation
   Questionable amplitude can appear quite high, may looks like partial bond. First arrival on VDL is faster due to Carbonate rock
9. Bonded to pipe, not to formation
   Low pipe amplitude but poor cement integrity
10. Cement sheath < 3/4" (2 cm)
    Will increase amplitude.

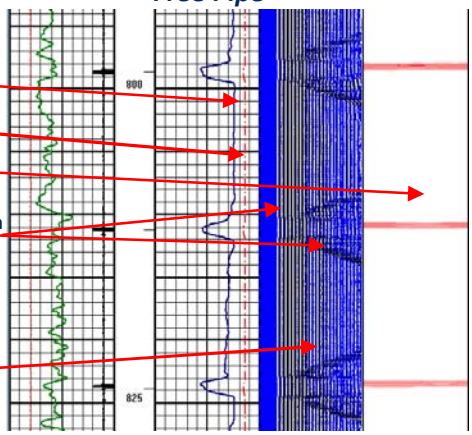
Free Pipe

No bond to pipe

- High consistent 3' amplitude
- 3' TOA tracks casing arrivals
- High radial amplitudes
- Pipe arrivals "train tracks" with "chevrons located in VDL"

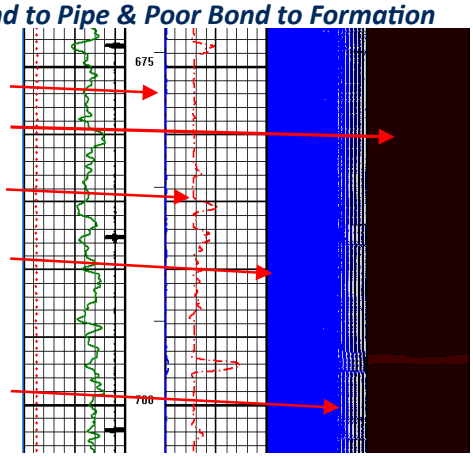
No bond to formation

- No formation waves in VDL



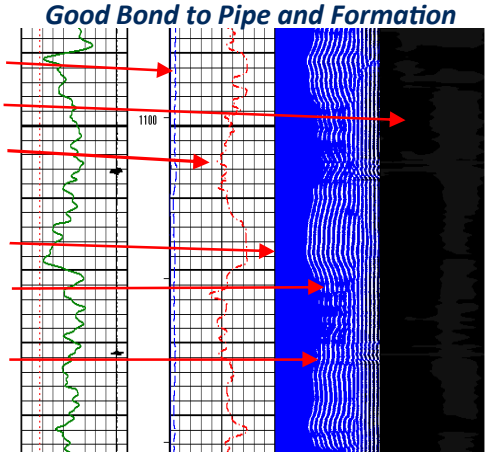
Good Bond to Pipe & Poor Bond to Formation

- Low 3' amplitude
- Low radial amplitudes
- Late inconsistent 3' travel time (can be off scale)
- No pipe arrivals in VDL
- Only mud waves , little to no formation arrivals in VDL



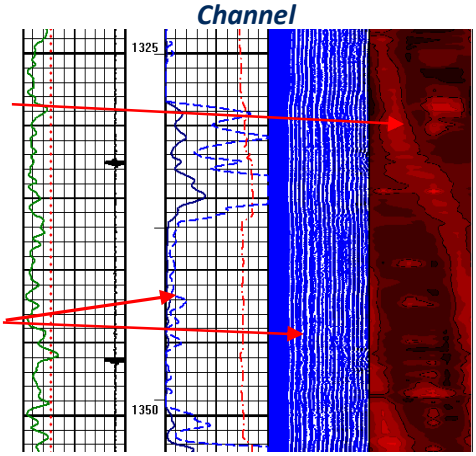
Good Bond to Pipe and Formation

- Low 3' amplitude
- Low radial amplitudes
- Late inconsistent travel time tracks lithology
- No pipe arrivals in VDL
- Good formation waves in VDL follows lithology
- Collars not clearly visible in VDL



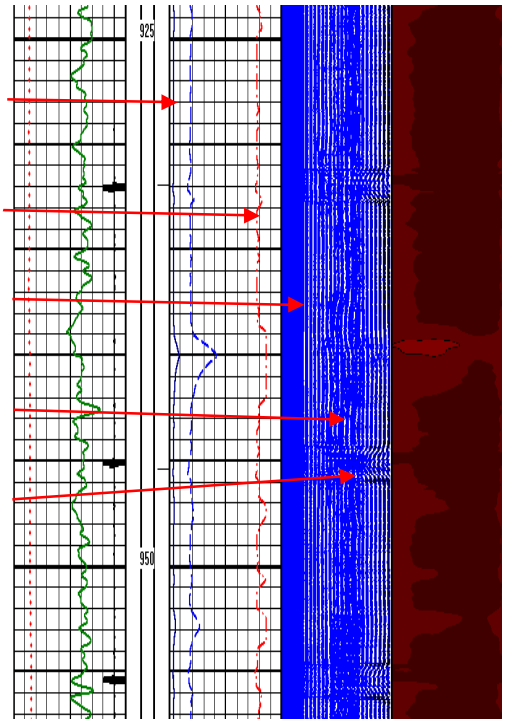
Channel

- Mapping of 2' radial readings identify channel
- Channel may appear as spiral due to tool rotation
- Channel may not be identi-fied from 3' amplitude or VDL



BOREAL E-line — Cement Bond Log Quick Reference

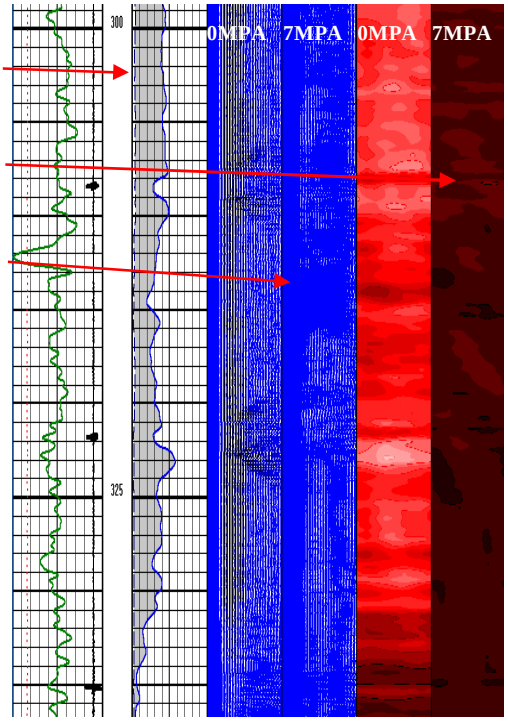
Light Weight Cement



- Higher "flat-line" of new 100% bond 3' amplitude (up to +/-10 mv)
- Travel time (TOA) is flat and tracks casing arrivals
- Pipe signals not fully attenuated and shown in VDL
- Formation waves weak or not present
- No Chevrons. "Straight" collars under good bond

Light Weight Cement has less compressive strength, doesn't fully attenuate pipe signal, so VDL and Travel Time will show pipe arrivals. A higher 100% bond baseline for Bond Index interpretation.

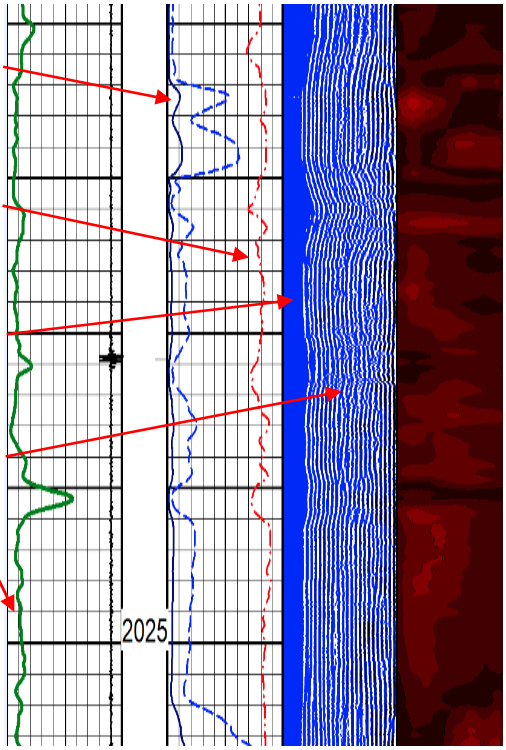
Micro Annulus



- Lower 3' amplitude under pressure
- Lower radial amplitudes under pressure
- Loss of pipe arrivals in VDL under pressure

Micro annulus is the small gap between the pipe and cement sheath. To test it, log the pipe under pressure to see reduction of 3' and radial amplitudes and improved VDL (compared to 0MPA). The presence of a micro annulus indicates cement present.

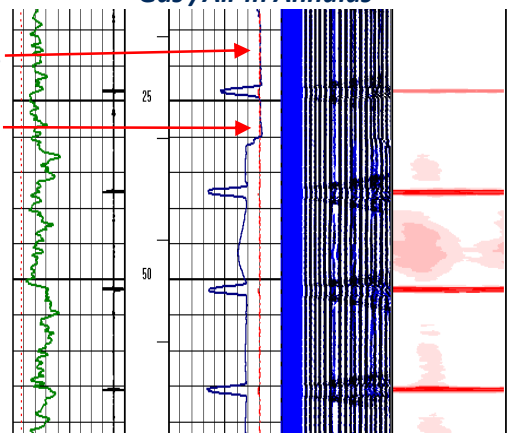
Fast Formation



- Amplitude can look like partial or poor bond
- Travel Time (TOA) earlier the pipe arrival time
- Earlier arrival time in VDL
- Wavy VDL no Chevrons
- Typically low GR indicating carbonate rock

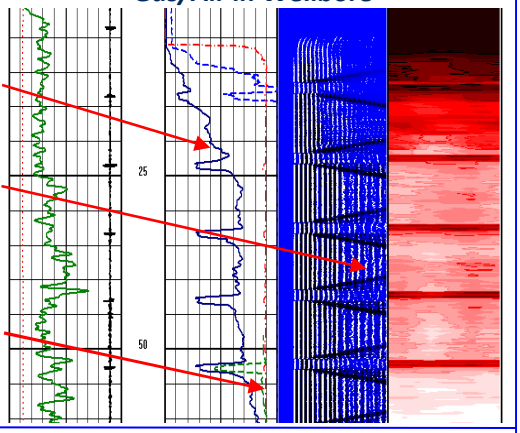
Formation arrivals appear like pipe signals. To identify Fast Formation look for earlier arrivals on Travel Time and VDL, wavy VDL without Chevrons.

Gas /Air in Annulus



- Higher 3' amplitude reads higher than actual free pipe signal
- Fluid level behind casing

Gas/Air in Wellbore



- Lower 3' amplitude and radial amplitudes
- "Broken" VDL due to inconsistent fluid
- Higher amplitude (and improved VDL) under pressure