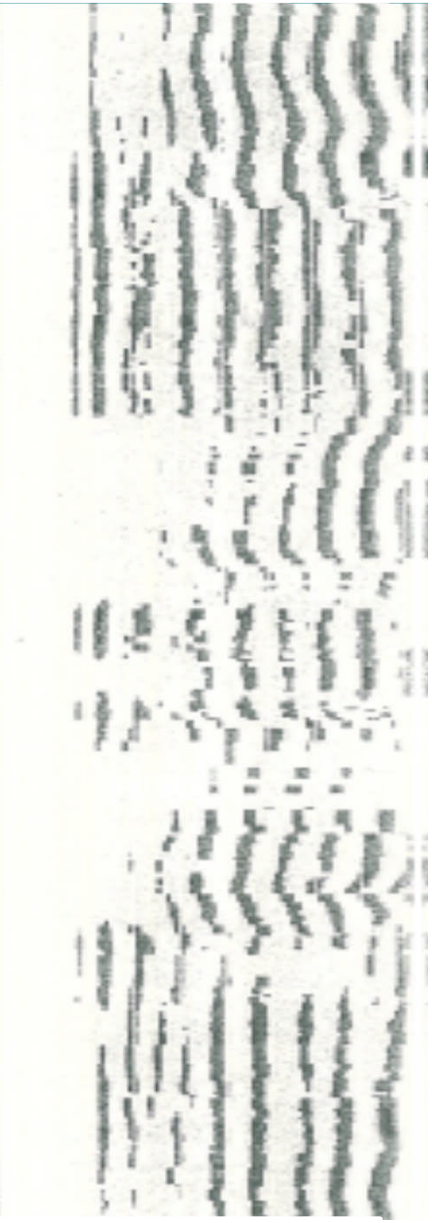
Bond Log Interpretation



Bond Log Interpretation

- Hang Log On Wall
- Quality Control Check (1)
- Observe (6)
- Investigate Shear Bond (3)
- Reason (2)
- Interpret

Hang Log On Wall


-COLOMBIA-
ELK HILLS
PERMIAN
HUGO
magnet
VINTAGE

Quality Control Check

Step 1 - Check Transit Time

Observe

Step 2 - Casing Ring

Step 3 - Formation Signals

Step 4 - Compare with the Pressure Pass

Step 5 - Find TOC

Step 6 - Observe it UP AND DOWN

Step 7 - Observe it SIDE TO SIDE

Shear Bond

Step 8 - Check Shear Bond - Casing

Step 9 - Check Shear Bond - Cement

Step 10 - Check Shear Bond - Post Job

Reason

Step 11 - Check for Formation Affects

Step 12 - Evaluate Cementing Operations

Interpret

- What has happened ?
- Why did it happen ?
- Should we squeeze ?
- How should we squeeze ?
- What do we change to make the next well better ?

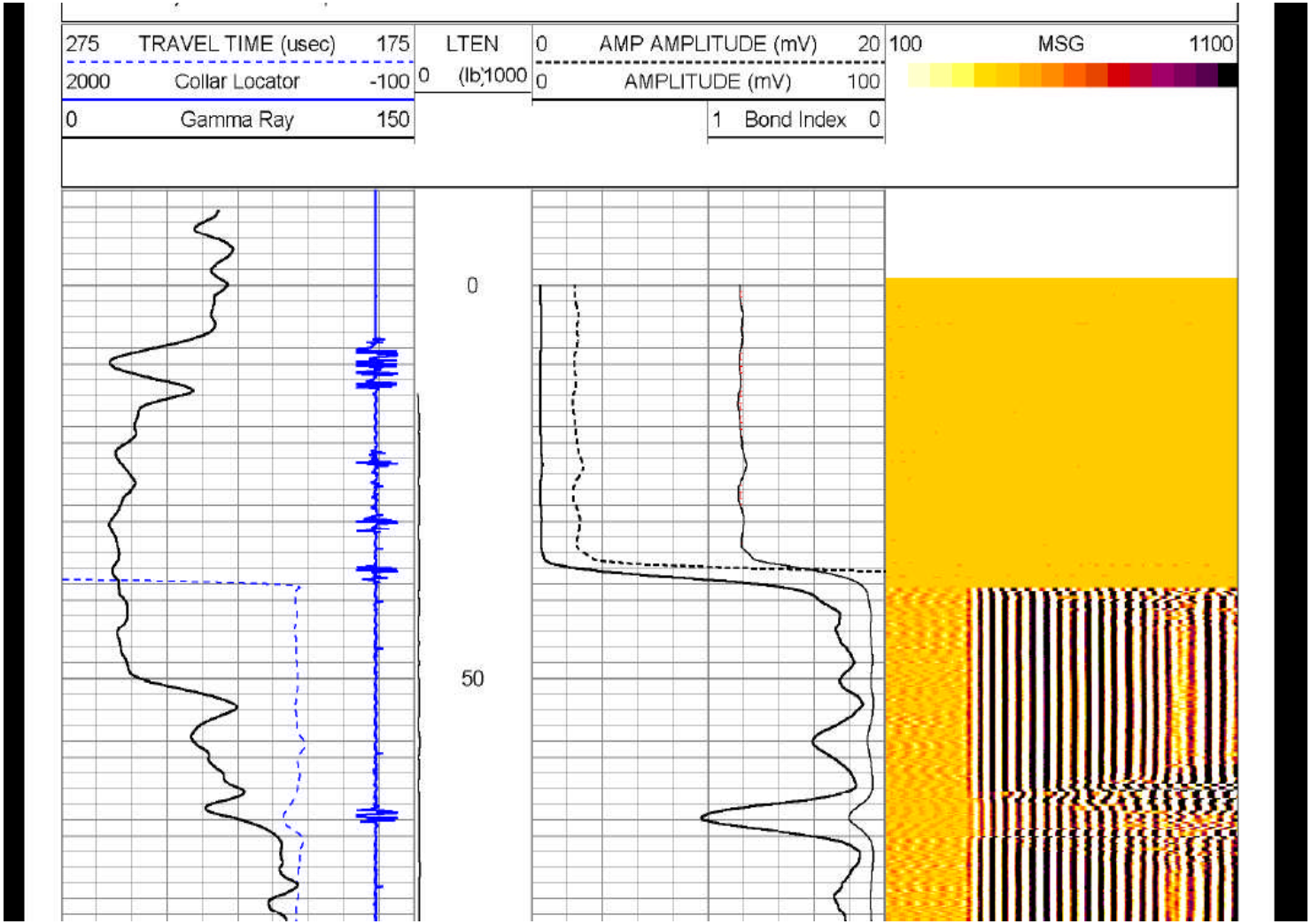
Quality Control


USLD REDRACK

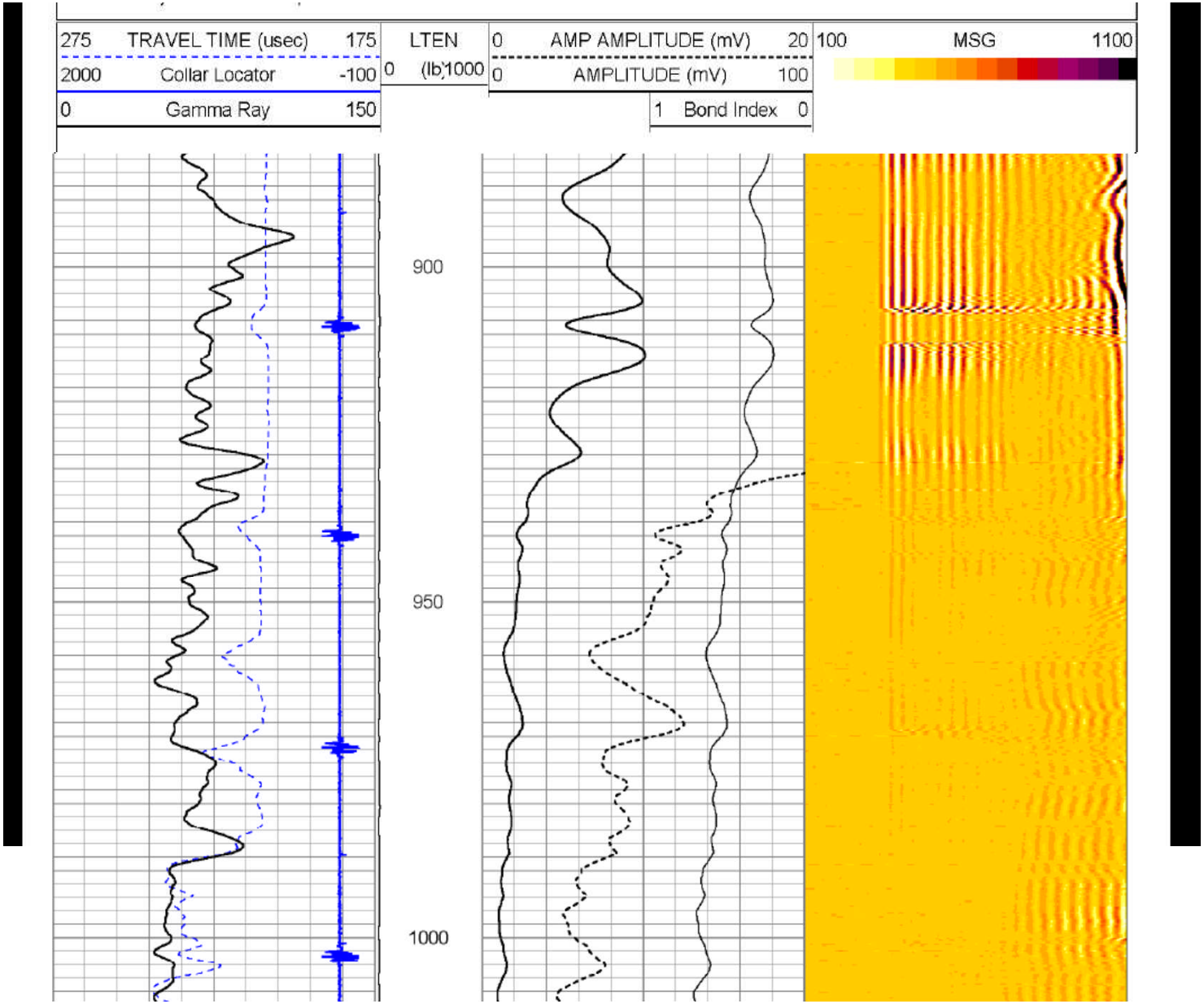
Step 1

- Check Transit Time
  - Is it Straight ?
  - Cycle Skip ?
  - Logging Tool Eccentricity

Check Transit Time



Check Transit Time

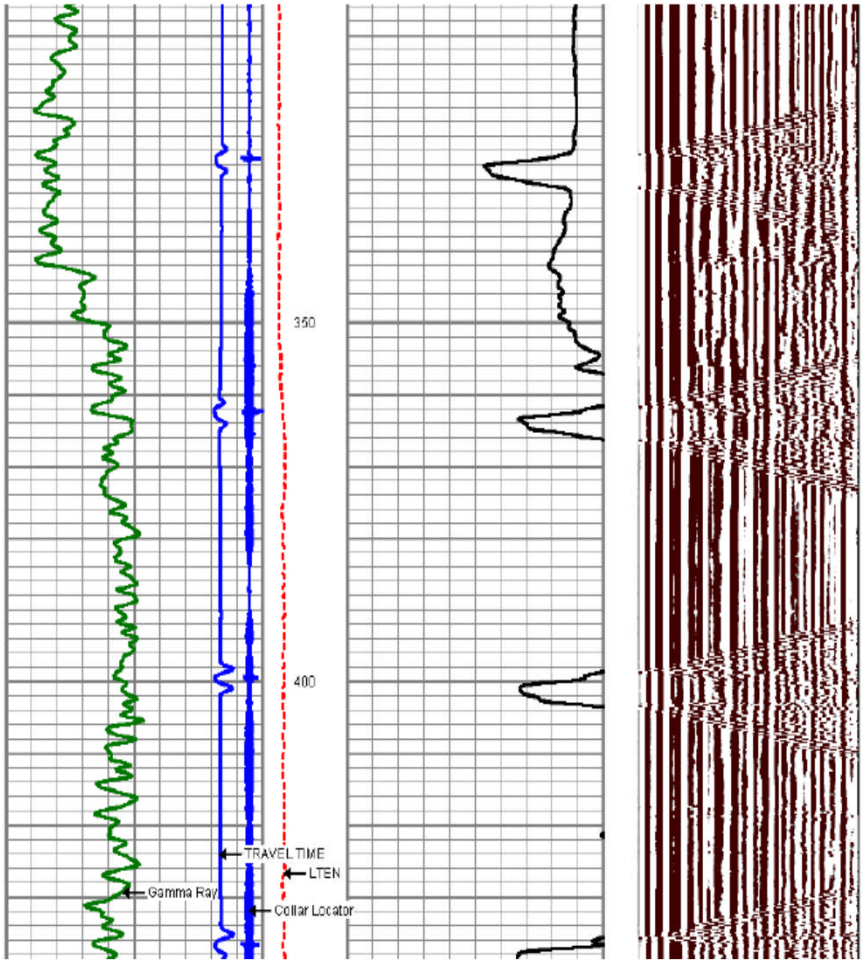


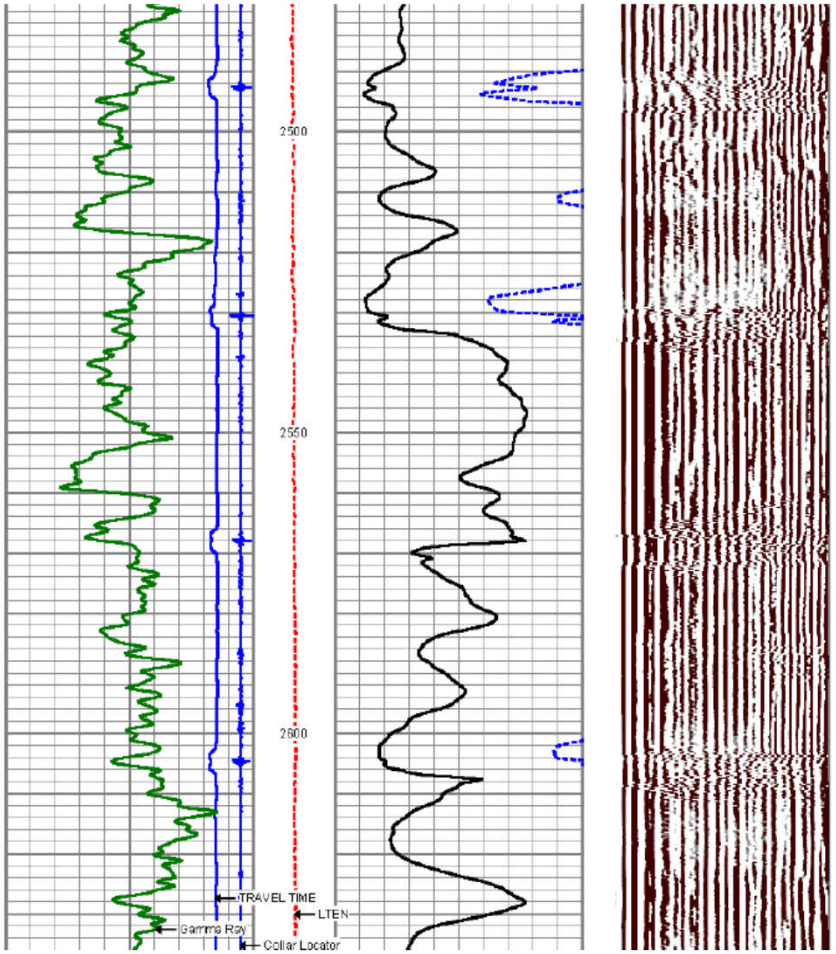
Observe

Step 2

- Check Pipe Ring
- Pipe Rings are *Usually* the First Arrival and are Represented by Very Straight Lines
- Observe Collar “Chevron Patterns”

Argentina

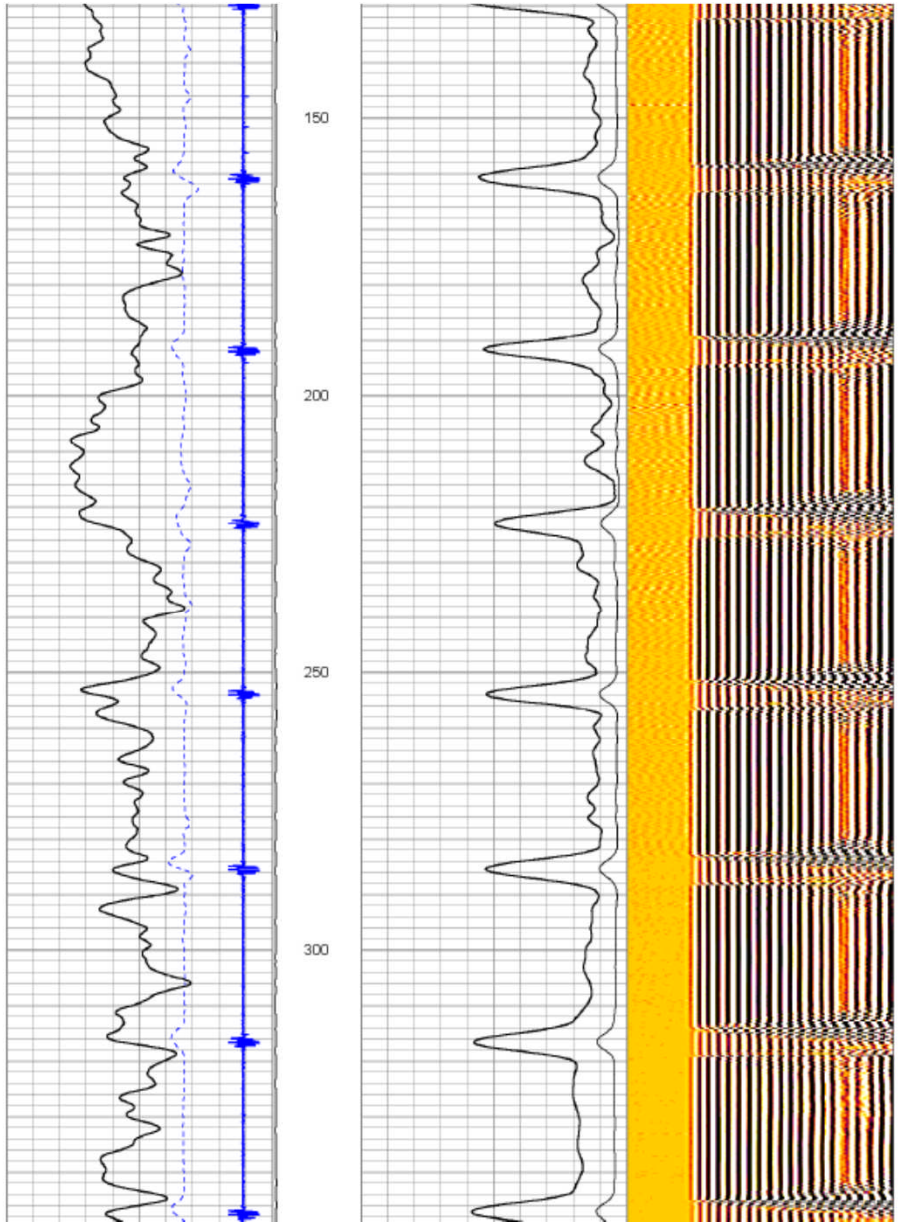

350
400
TRAVEL TIME
LTEN
Gamma Ray
Collar Locator


2500
2550
2600
TRAVEL TIME
LTEN
Gamma Ray
Collar Locator

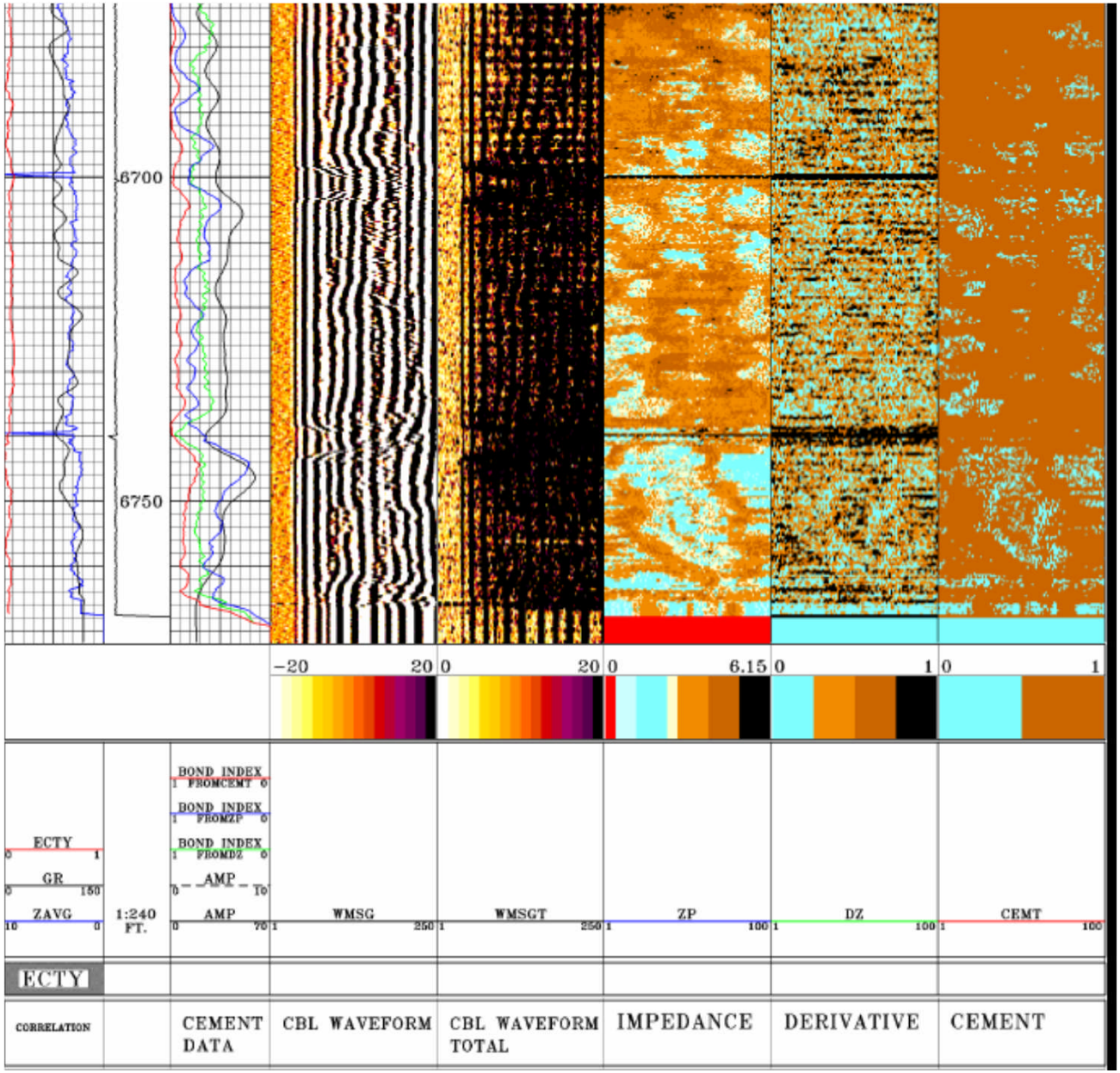
California

3 1/2 ”

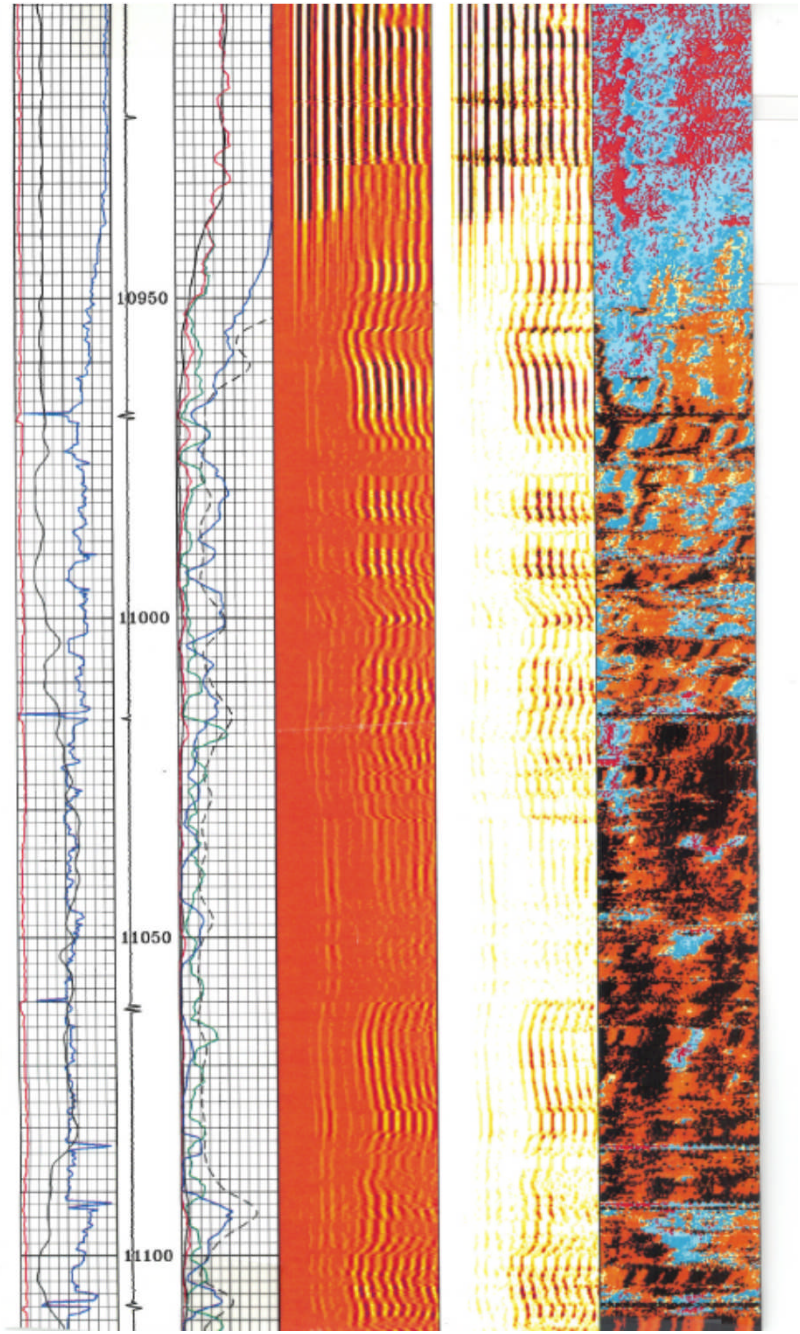
9.2 # casing



California


6700
6750
−20
20
0
20
0
6.15
0
1
0
1
ECTY
GR
ZAVG
1:240 FT.
BOND INDEX FROMCEMT
BOND INDEX FROMZP
BOND INDEX FROMDZ
AMP
AMP
WMSG
WMSGT
ZP
DZ
CEMT
ECTY
CORRELATION
CEMENT DATA
CBL WAVEFORM
CBL WAVEFORM TOTAL
IMPEDANCE
DERIVATIVE
CEMENT

California



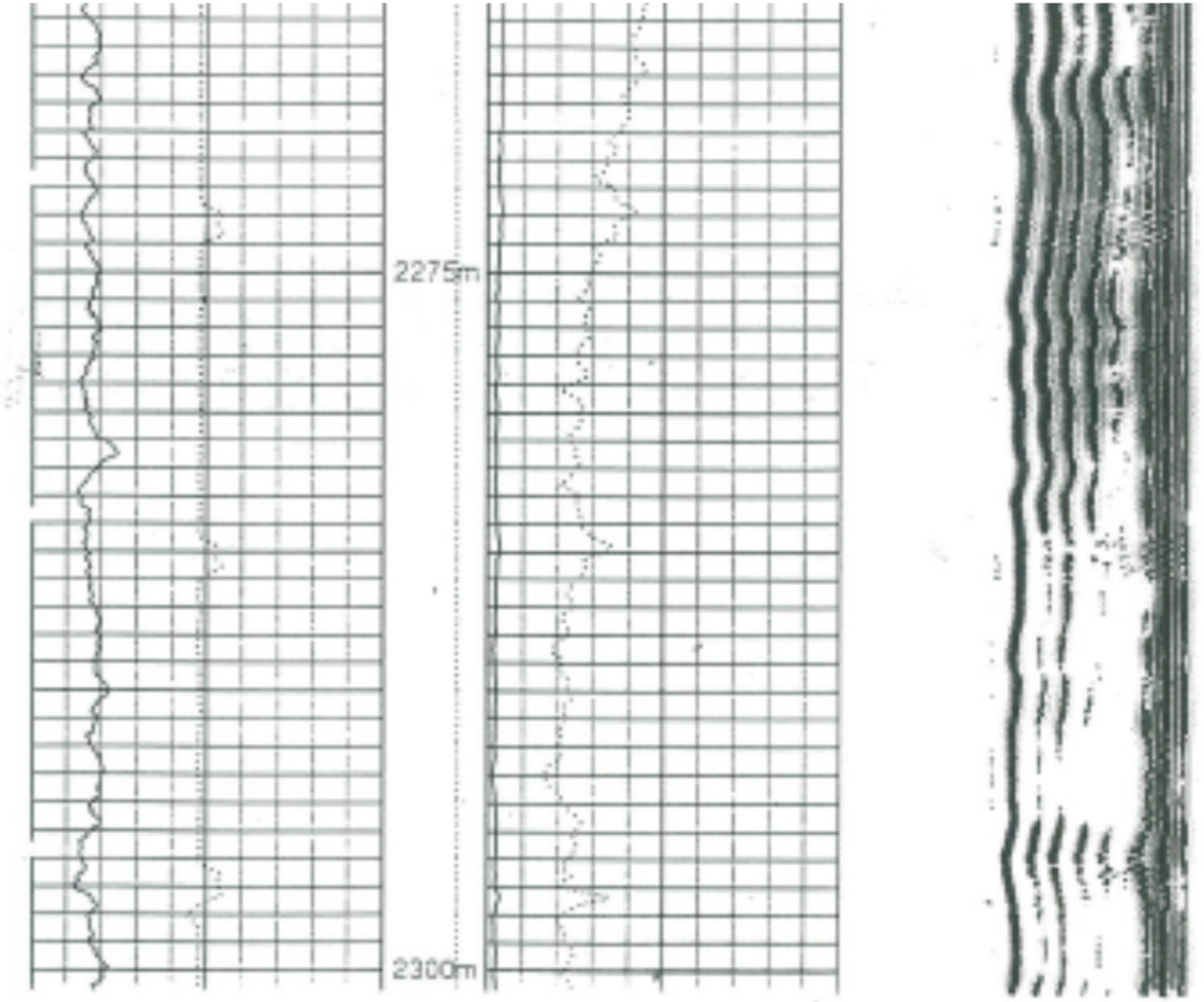
Step 3

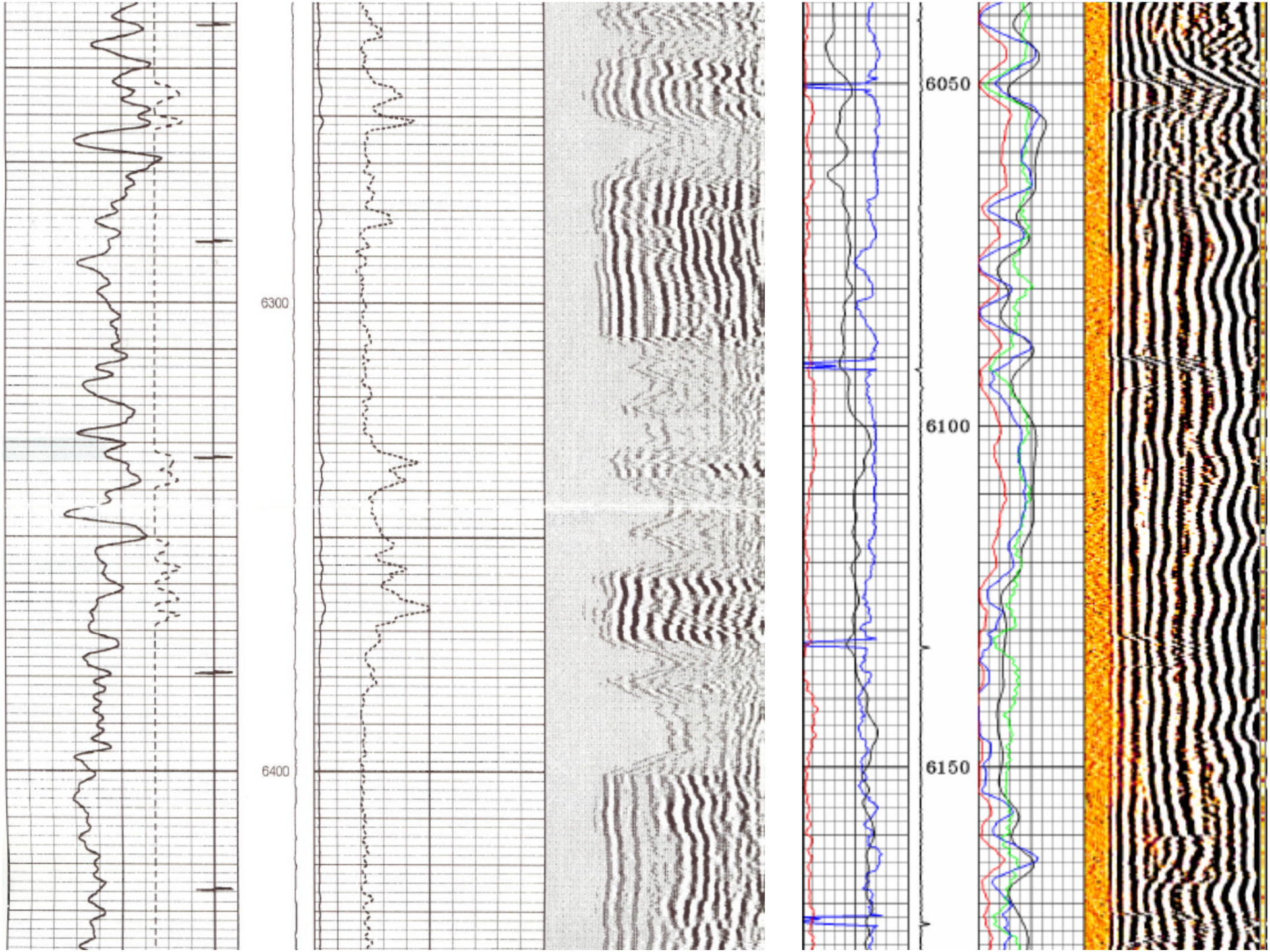
Find Formation Signals

Step 3

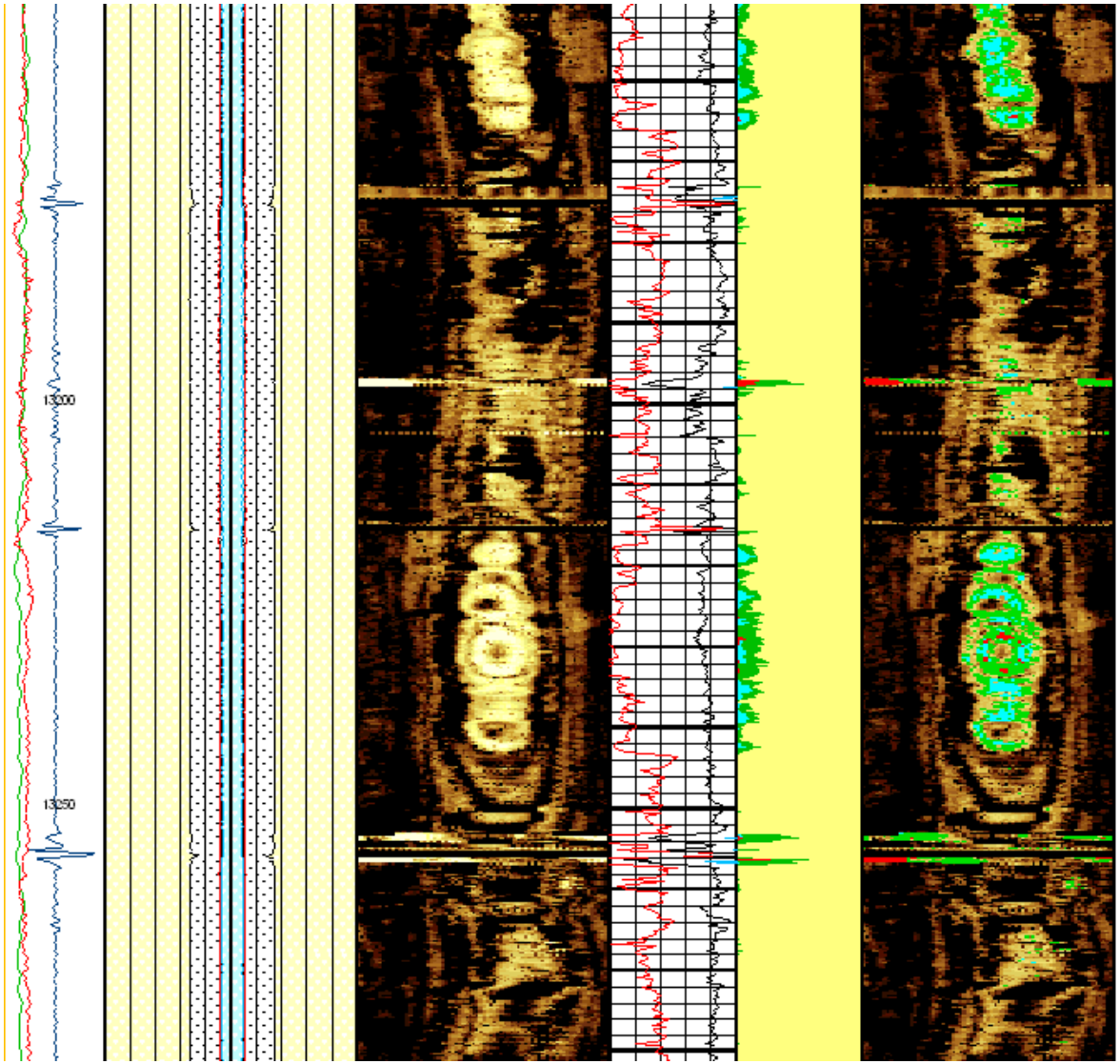
- Find Formation Signals
- If Formation Signals Are Apparent, We are Connected to the Formation (Hopefully By Cement)
- Formation Signals are Curvy & Squiggling…
- Wave Train Changes With the Formation Sonic Properties

Strong Formation Signals




6300
6400
6050
6100
6150

Qatar



Step 4

Make a Pressure Pass

Step 4

- Make a Pressure Pass - *Pressure Casing to 1000 - 1500 psi and make another pass (sometimes more is required)*

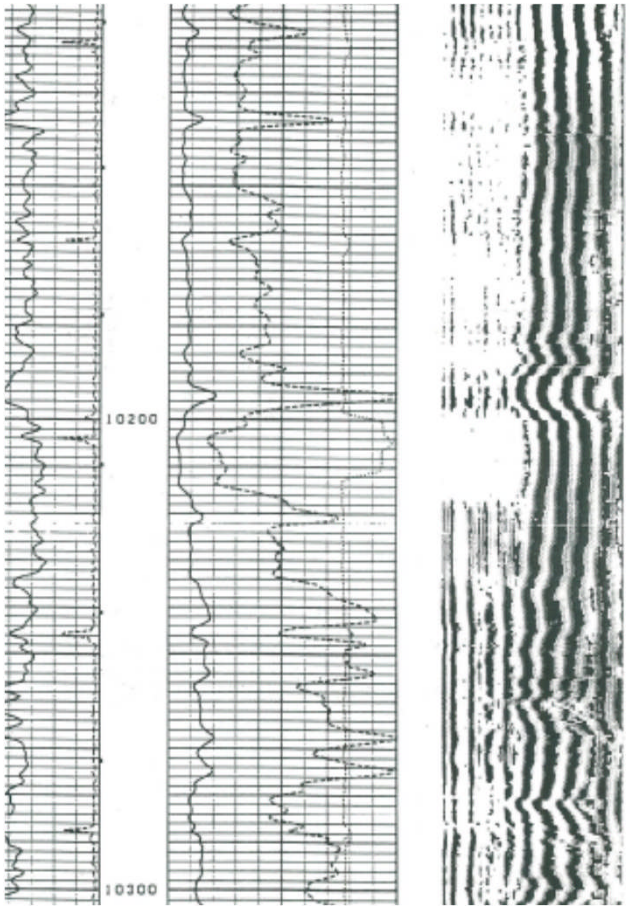
- If the log improves, then low shear bond exists

Bond Logging Best Practice

Run Bond Log @ 0 psi

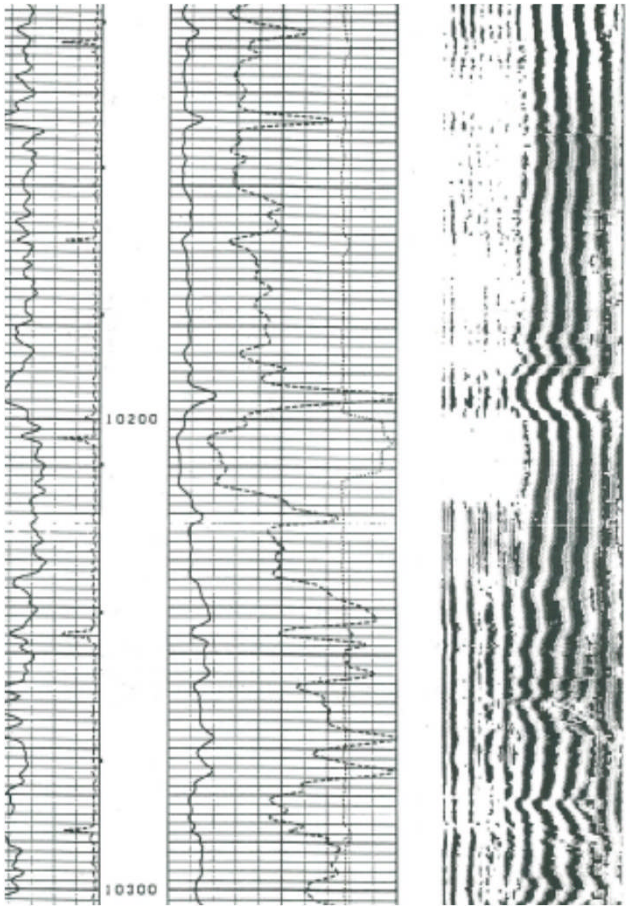
Repeat Pass @ 1000 – 1500 psi

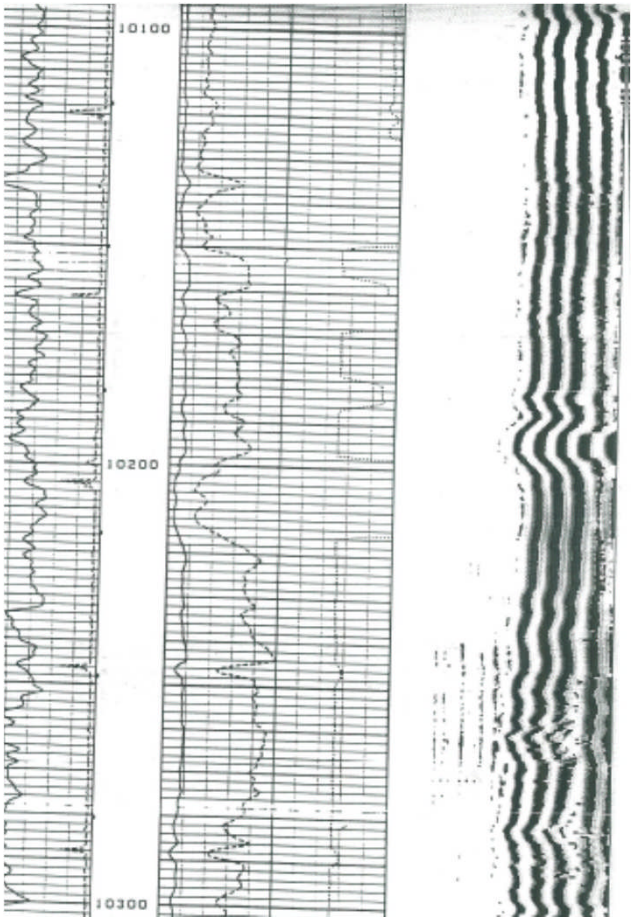
Pressure Pass



0 psi

Pressure Pass





0 psi

1000 psi

Step 5

Find Top-Of-Cement (TOC)

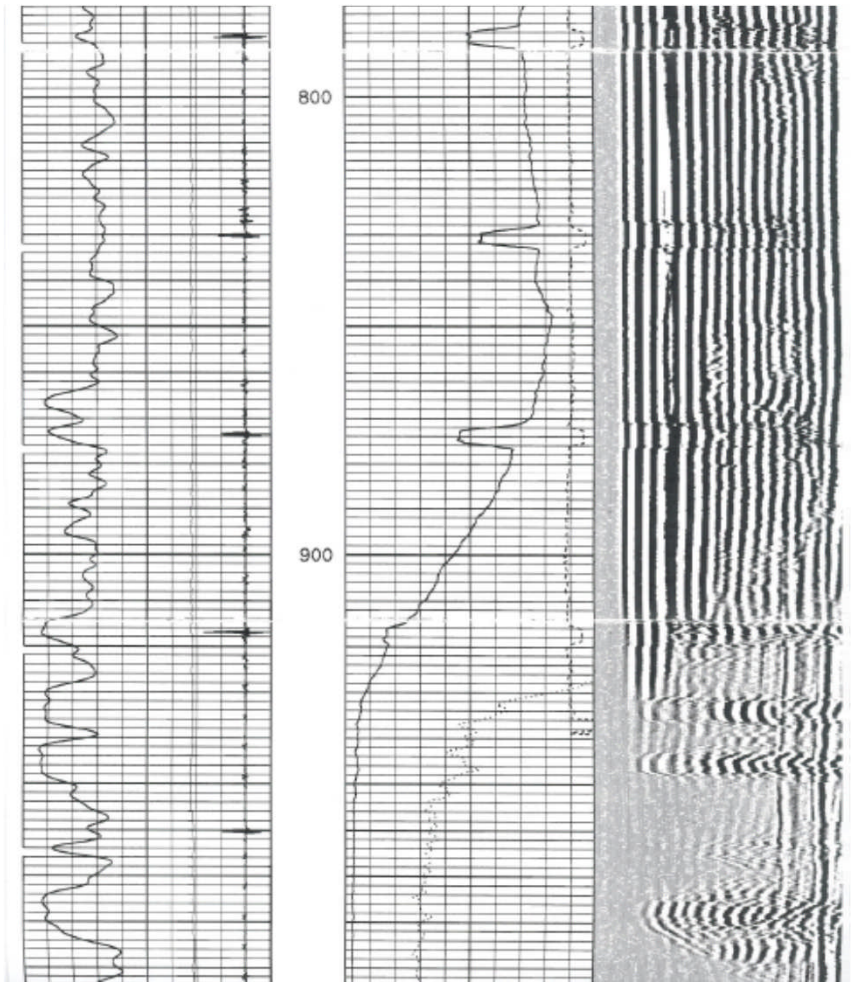
Step 5

Find Top-Of-Cement (TOC)

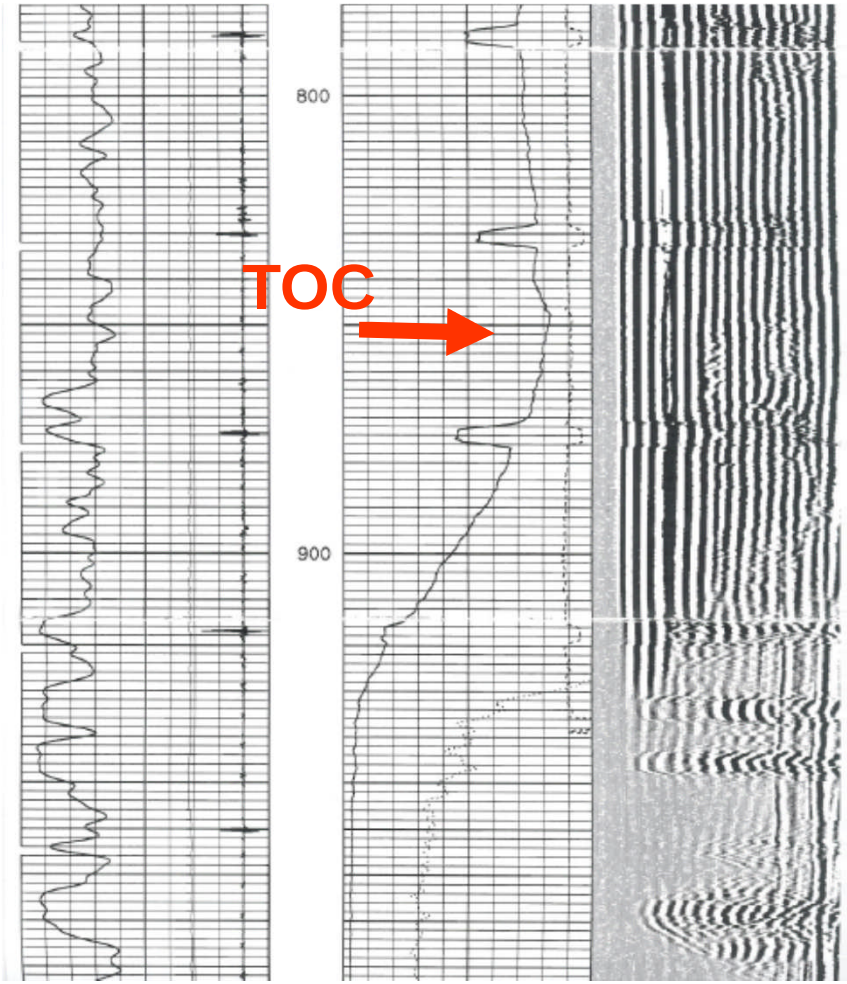
Step 5

- Find TOC
- Observe Free Pipe Reading
- Free Pipe Reading Can Be Compared to Other Parts of the Log For Interpretation

Top of Cement



Top of Cement



Observe

“A few observations and much reasoning lead to error; many observations and a little reasoning lead to truth.”

- Alex Carrel

Observe More

“Every man who observes vigilantly and resolves steadfastly grows unconsciously into genius.”

- Edward G. Bulwer-Lytton


-COLOMBIA-
ELK HILLS
PERMIAN
HUGO
magnet
VINTAGE

Step 6

Observe the Log Vertically

Looking for Changes in the VDL

Step 7

Draw Horizontal Lines

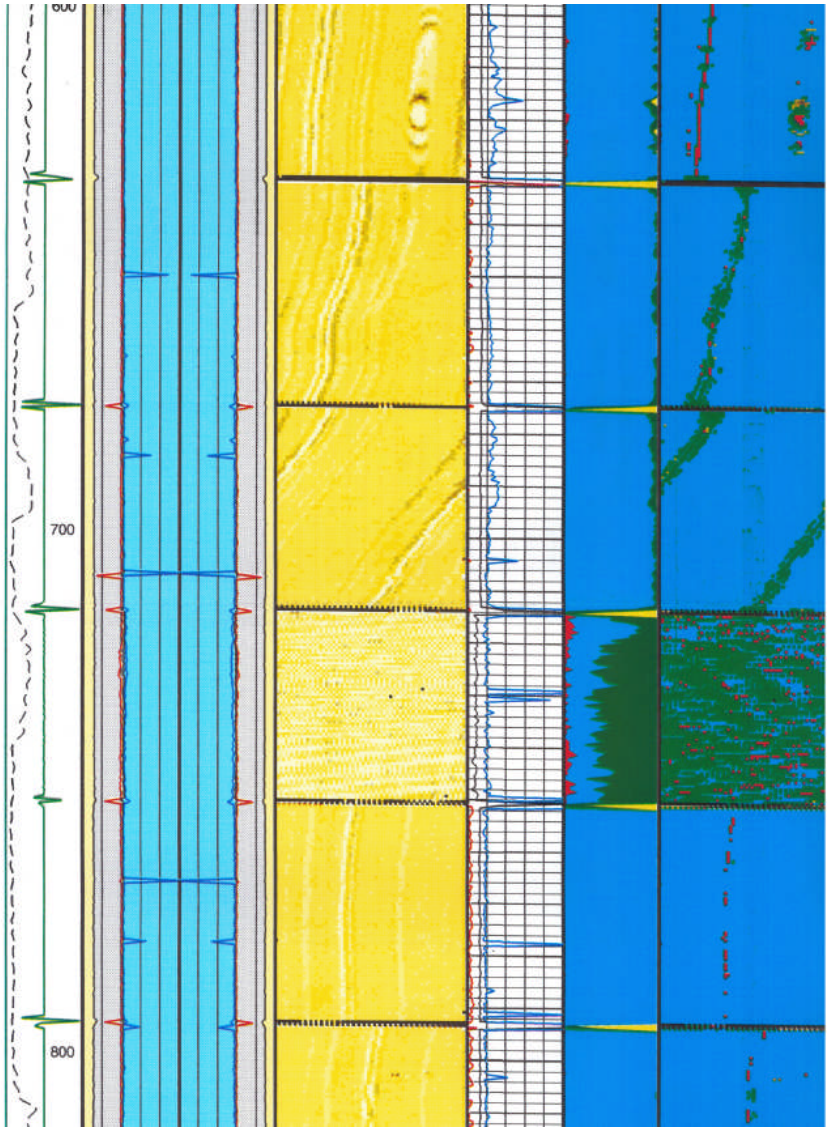
…Where you see those changes

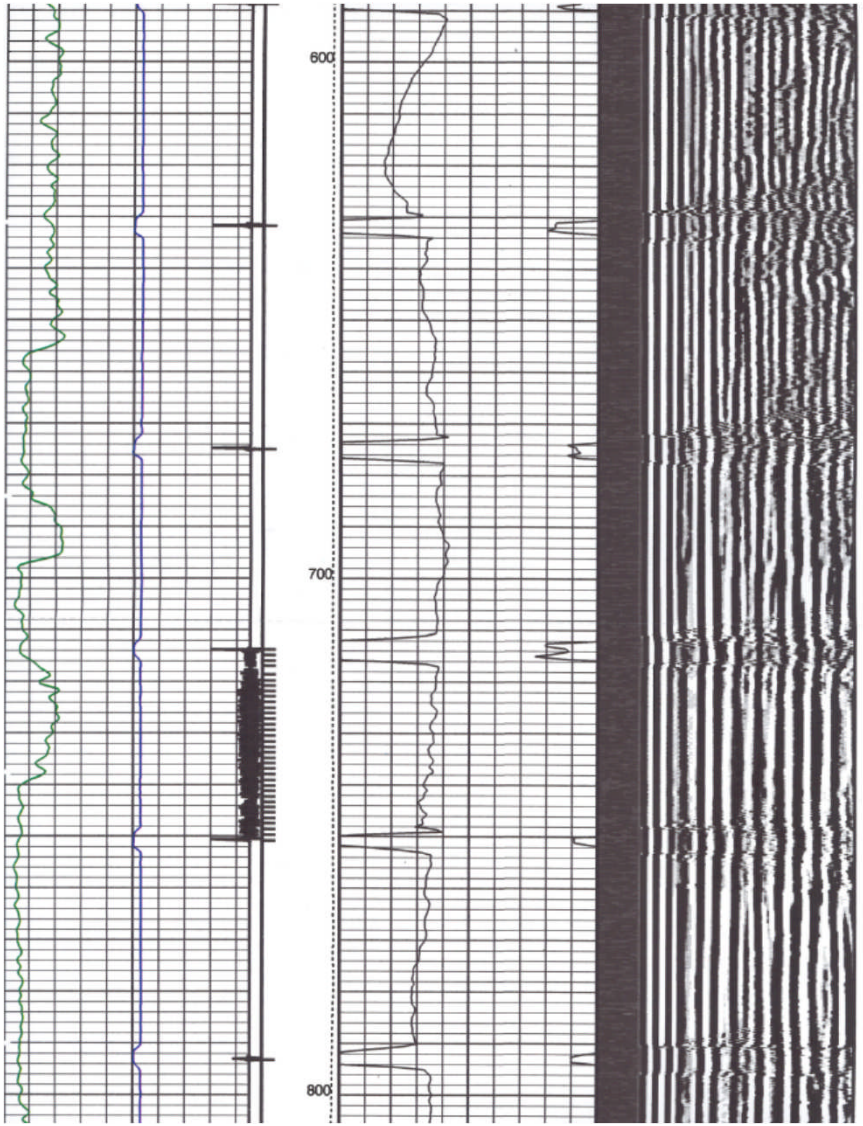
Step 7

Draw Horizontal Lines At Changes

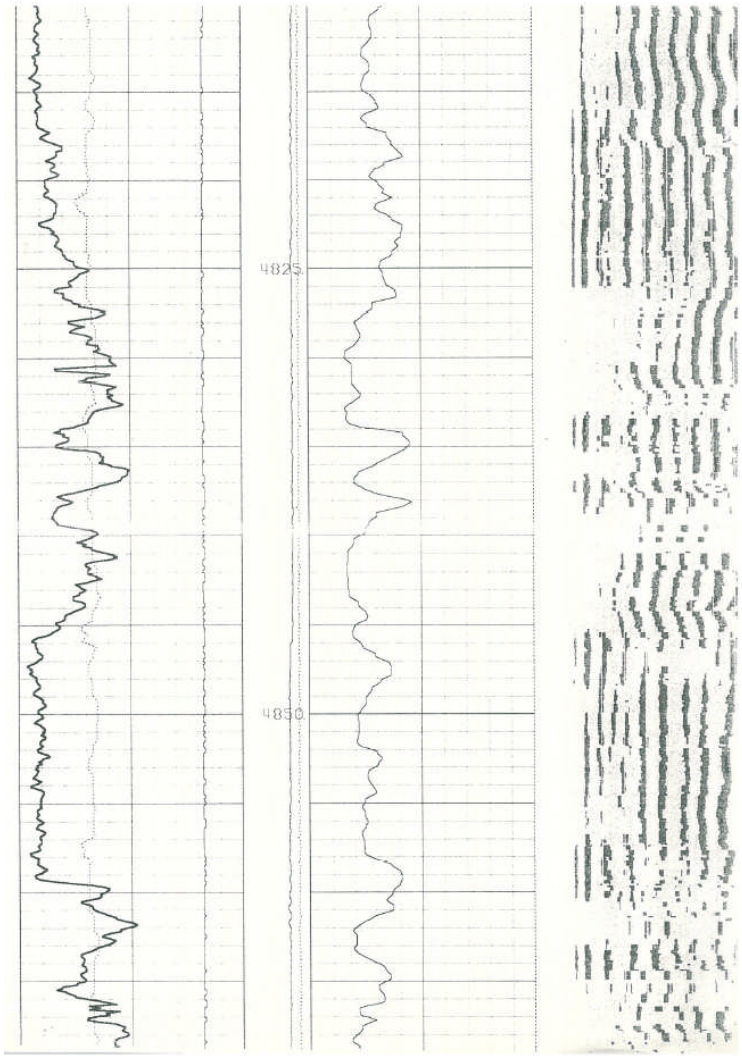
- Formation Changes
- At Casing Collars
- Centralizer Placement
- Do We Have More Than One Cement Type ?
- Start Solving the Mystery

Draw Horizontal Lines

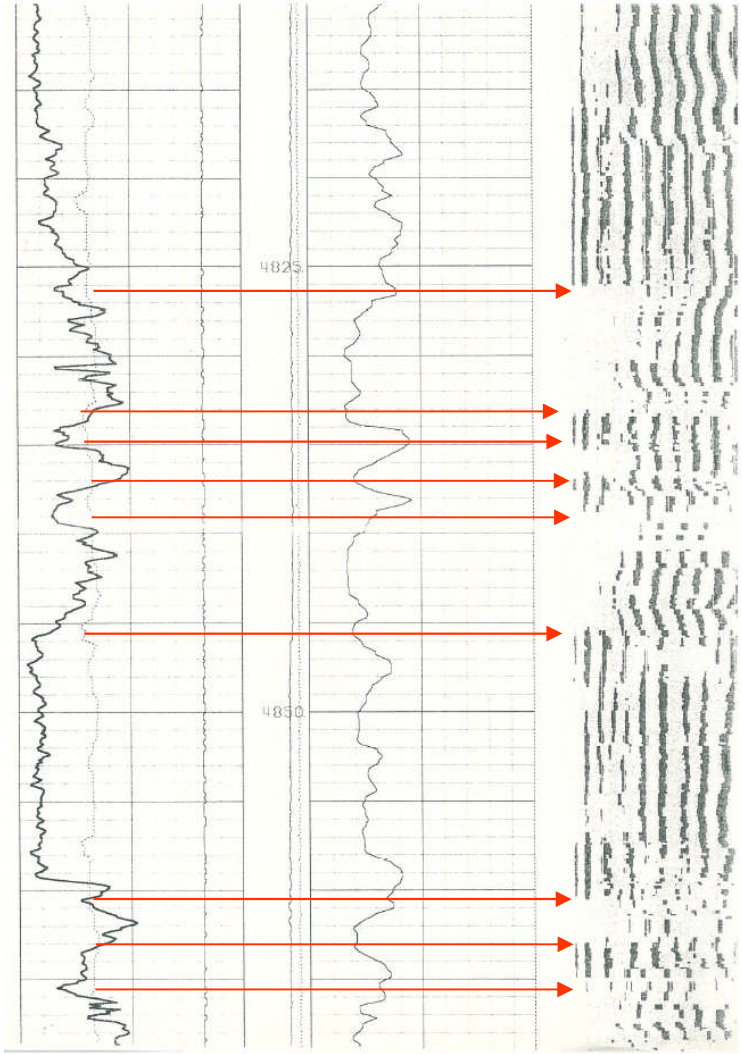




Draw Horizontal Lines



Draw Horizontal Lines



Shear Bond

Investigate Shear Bond

- Perhaps 80 % of all bond logs are affected by …
- LOW SHEAR BOND or Microannulus

Shear Bond

Shear Bond

Shear Bond = F/A

F = Force applied to casing to push casing out of cement sheath

A = Casing OD Surface Area along cemented length

Step 8

Investigate Shear Bond of the Casing

Investigate Shear Bond of the Casing

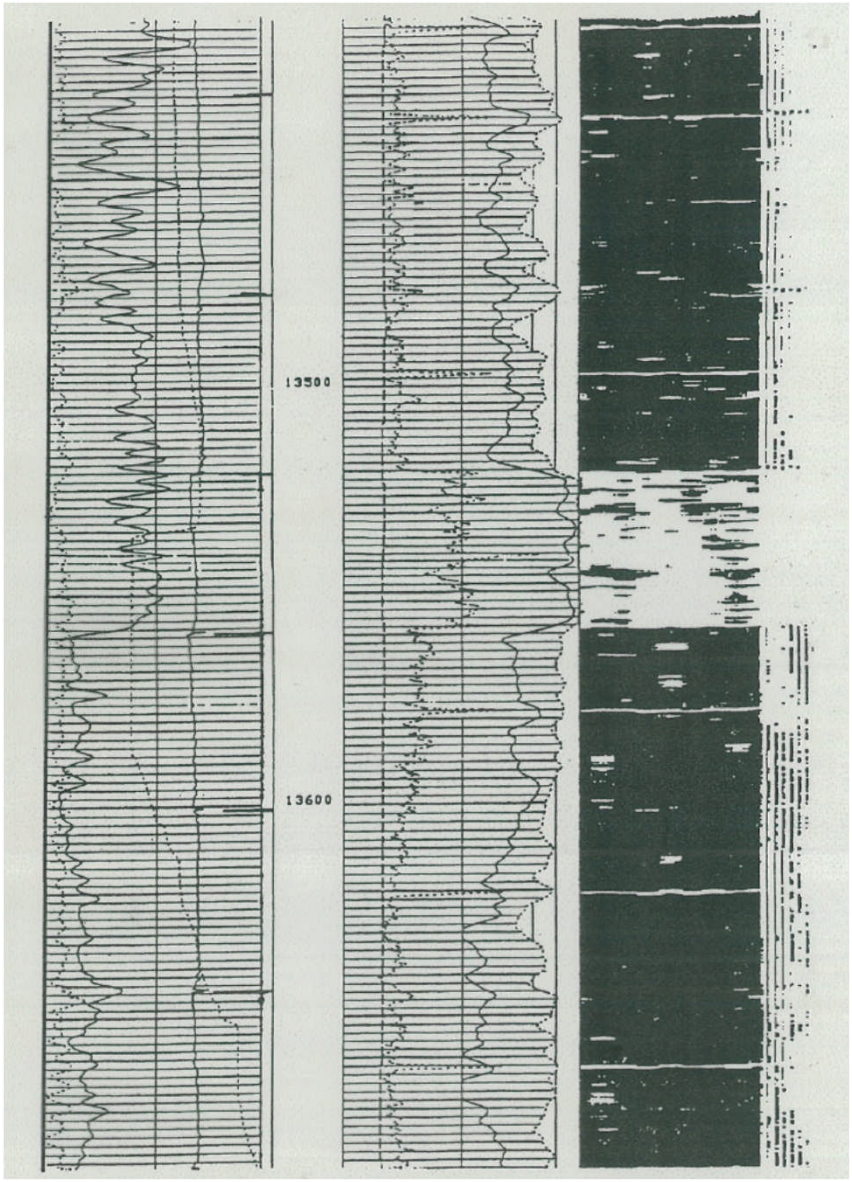
- Oil Based Mud – Casing Metal Must Be Water Wet
- What was the Casing Size & Weight?
  - Large Casings (> 9 5/8”) Exhibit High Amplitudes
  - Heavy Casing Rings More (Bigger Bell !)
- What was the condition of the casing ?
  - Sandblasted (Best Practice)
  - Old or New ?
  - Rusty ?

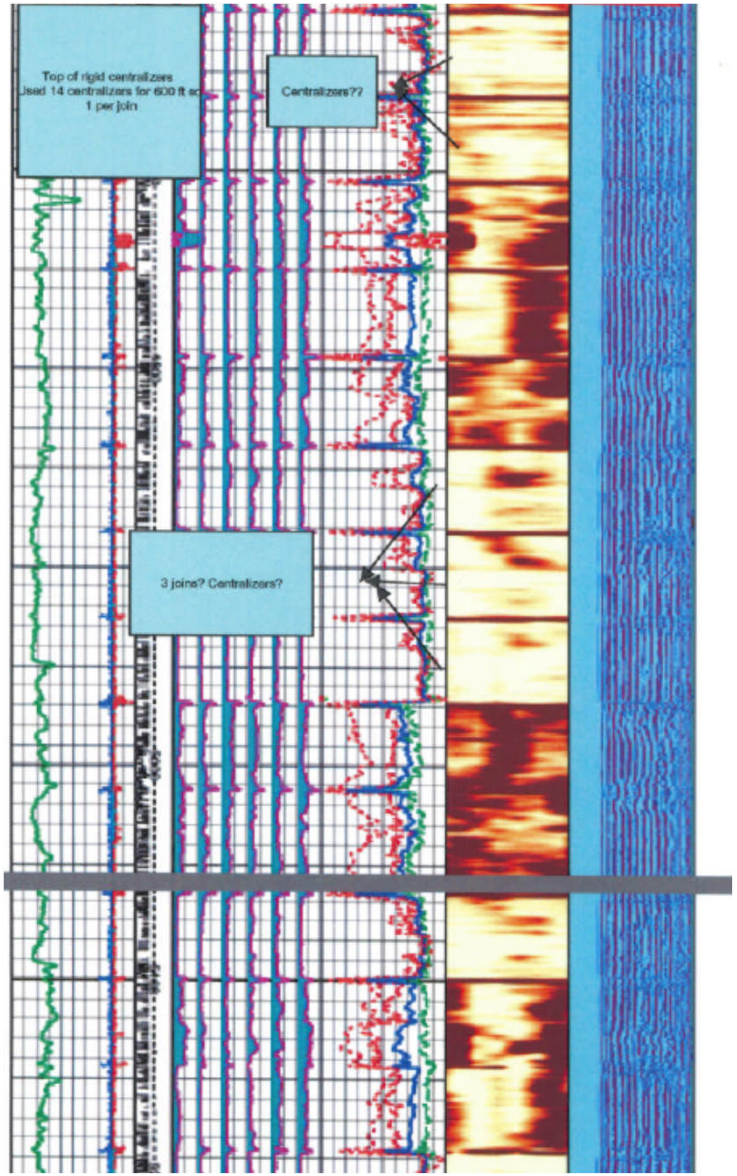
Shear Bond – Casing

Water Wetting the Casing

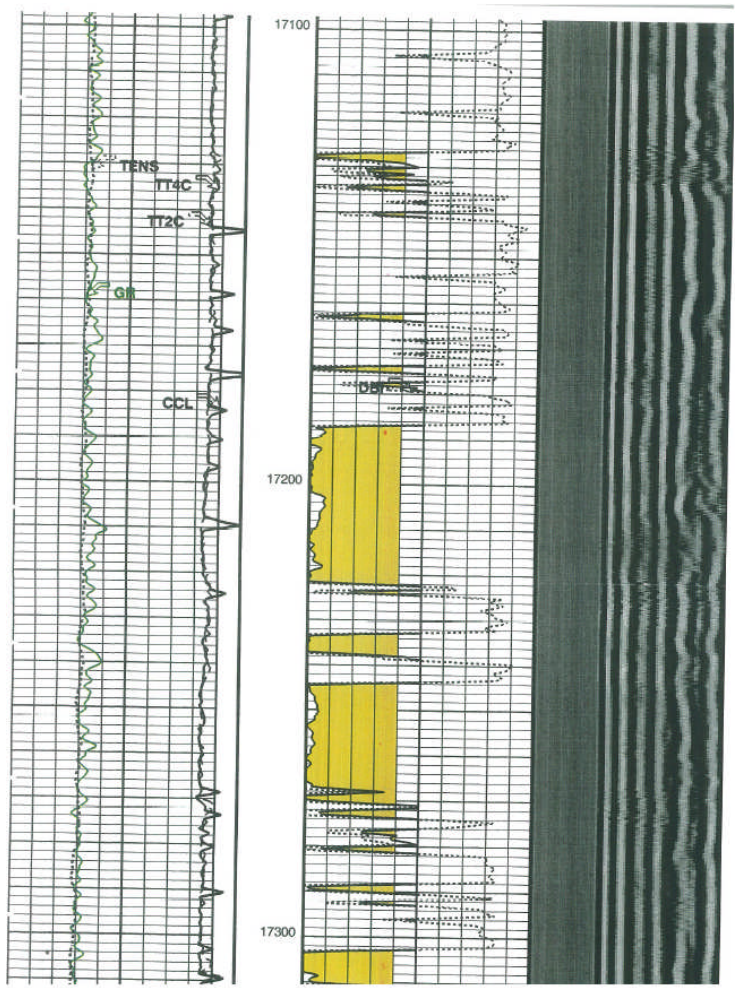
Shear Bond - Casing

Libya





Casing Size and Weight



11 ¾” Liner

Step 9

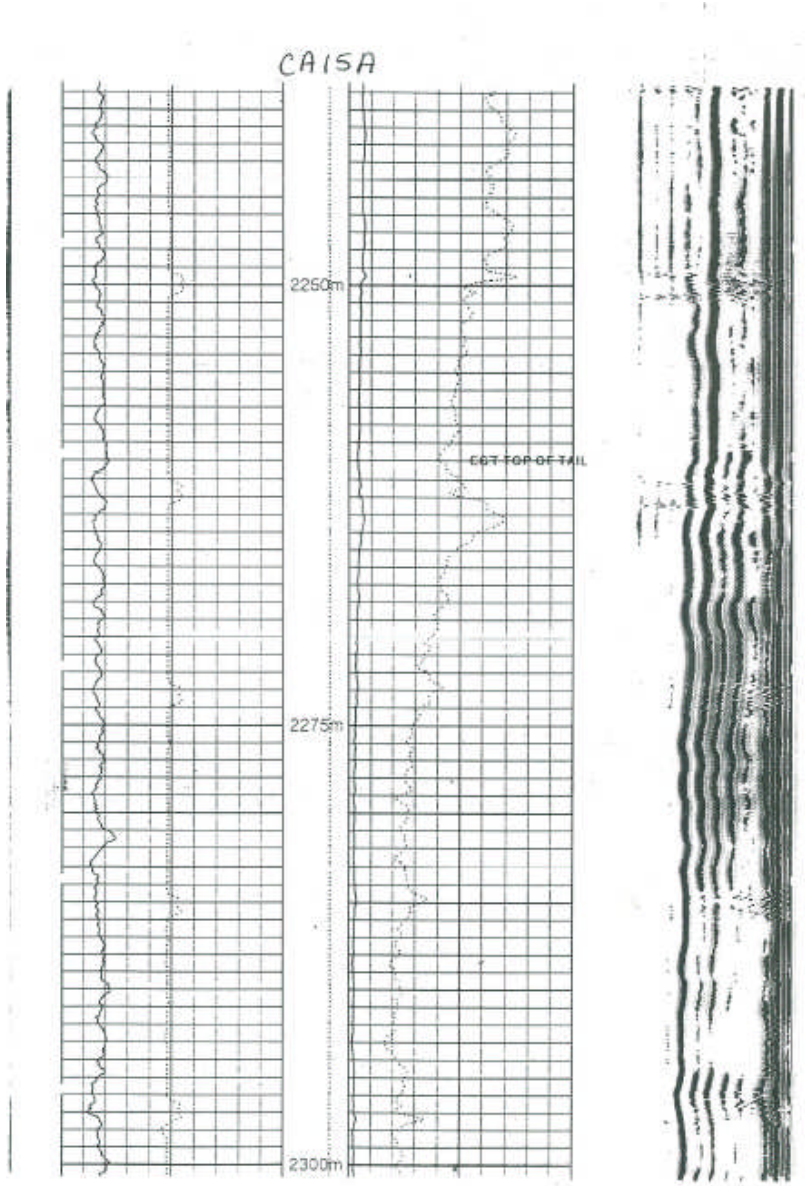
Investigate Shear Bond of the Cement

Step 9

Investigate Shear Bond - Cement

- Cement Density?
  - Conventional lightweight cements have high amplitudes
- Compressive Strength @ log time 1500 psi?
  - Strengths less than 1500 psi have high amplitudes
- Shear Bond?
  - Use an expansion additive to increase bonding
  - Surfactants
  - Dispersants

Shear Bond - Cement



Step 10

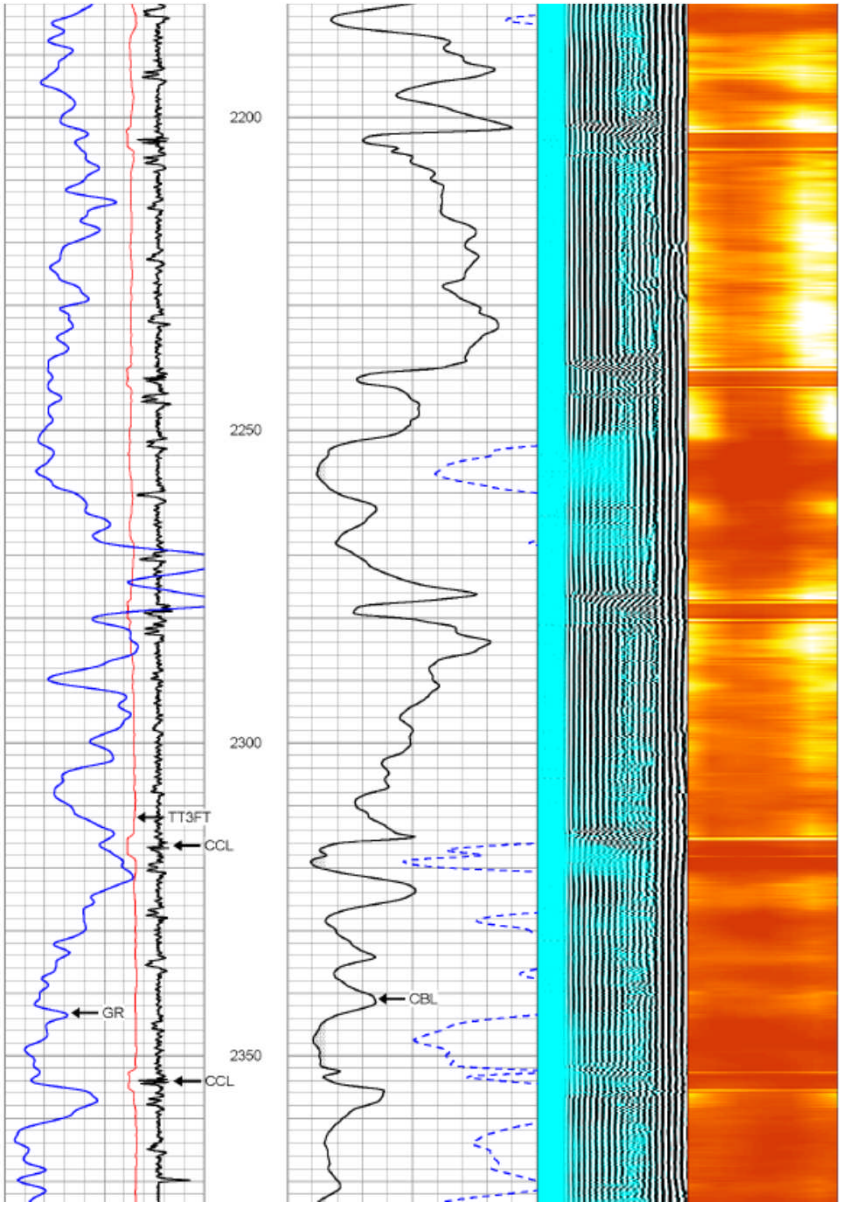
Investigate Shear Bond of Post Job Actions

Step 10

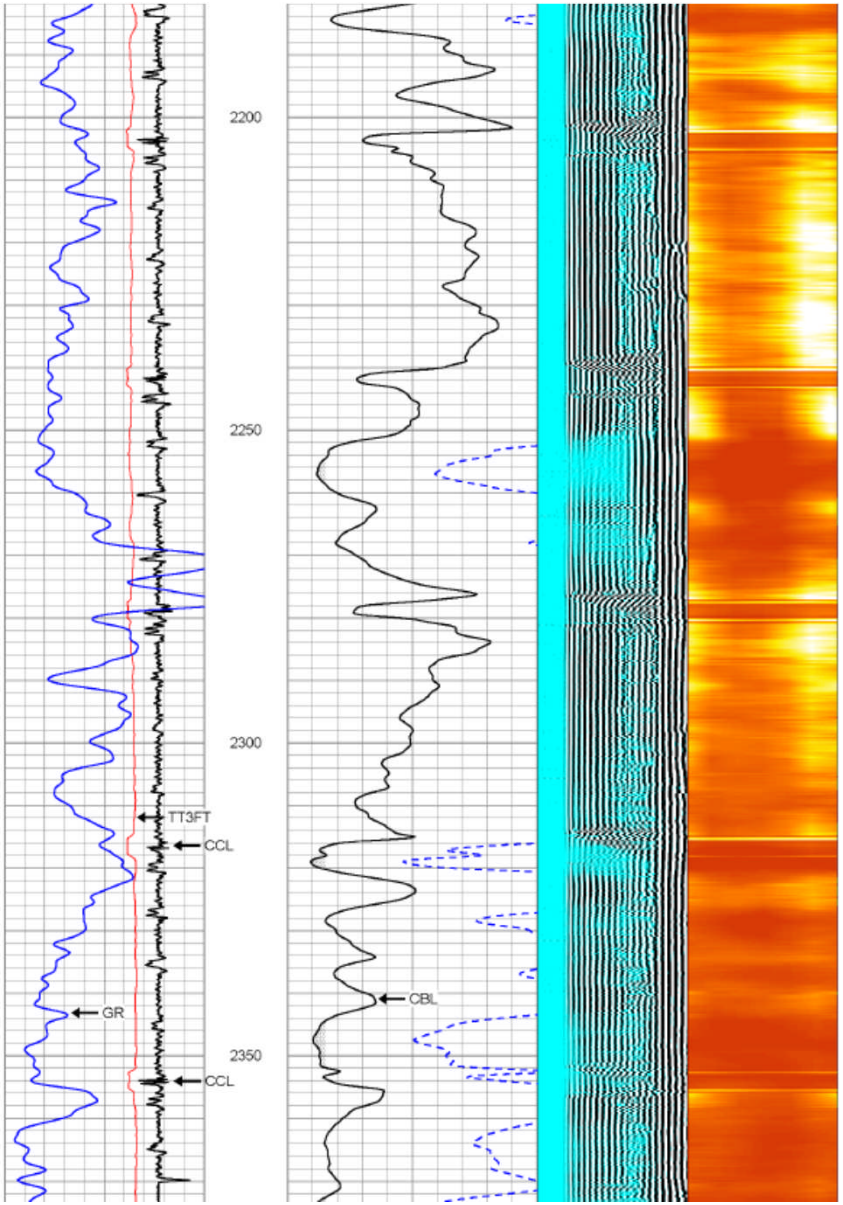
Shear Bond - Post Job

- Did we pressure test the casing before the bond log?
- When did we pull on the casing ?
- Displacement Fluids vs. Logging Fluids
- Did the Floats Hold ?

Colombia



Colombia
Float Equipment Failed



Reason

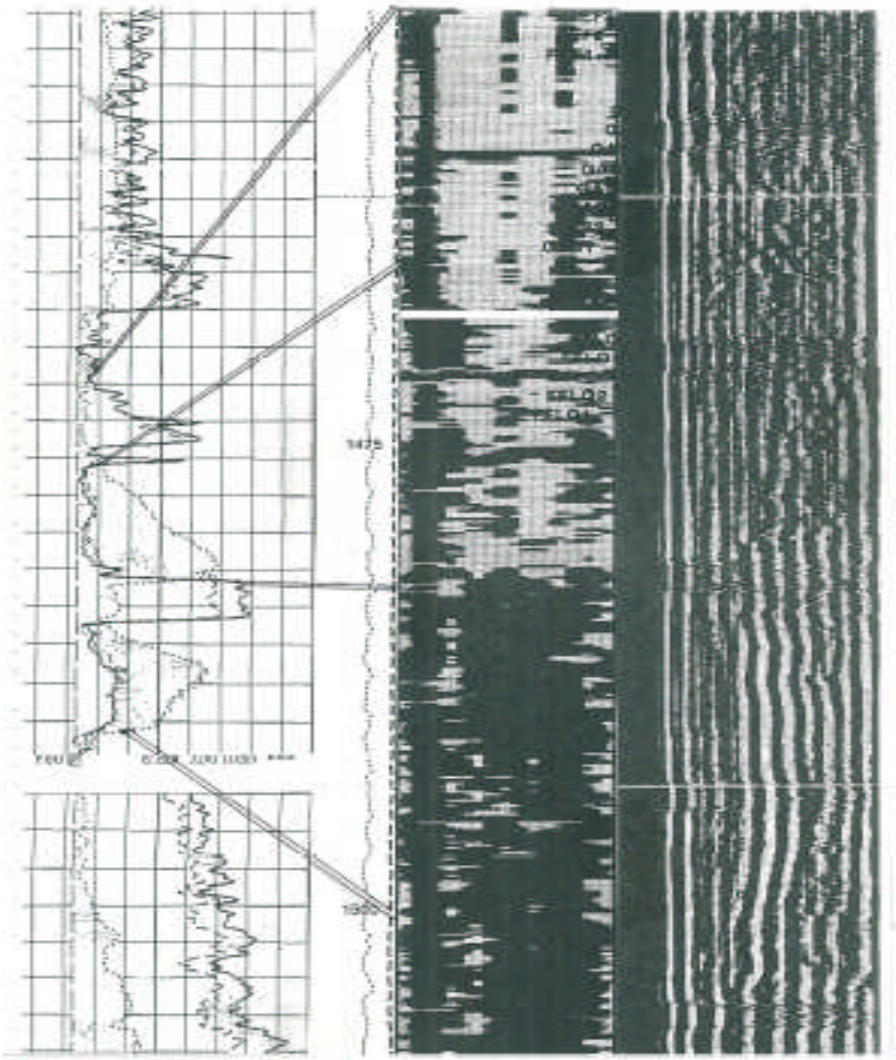
Step 11

Investigate Formation Affects

Step 11
Investigate Formation Affects

- Line up Gamma & Porosity Changes
  - Line up Sands & Shales
- Line up Between Pressured/Depleted Formations
- Line up across from water and hydrocarbon contacts
- Look at Lithology Column

Australia

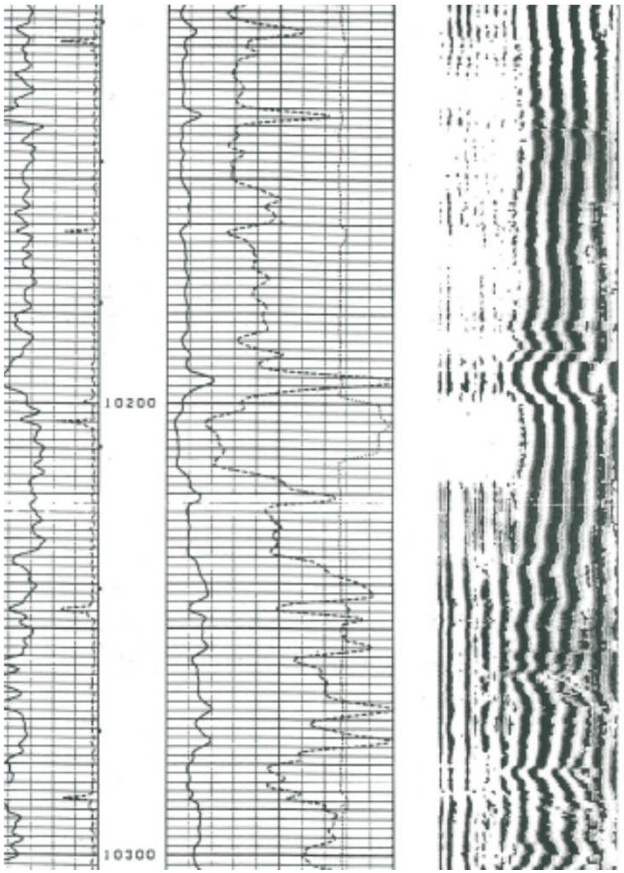


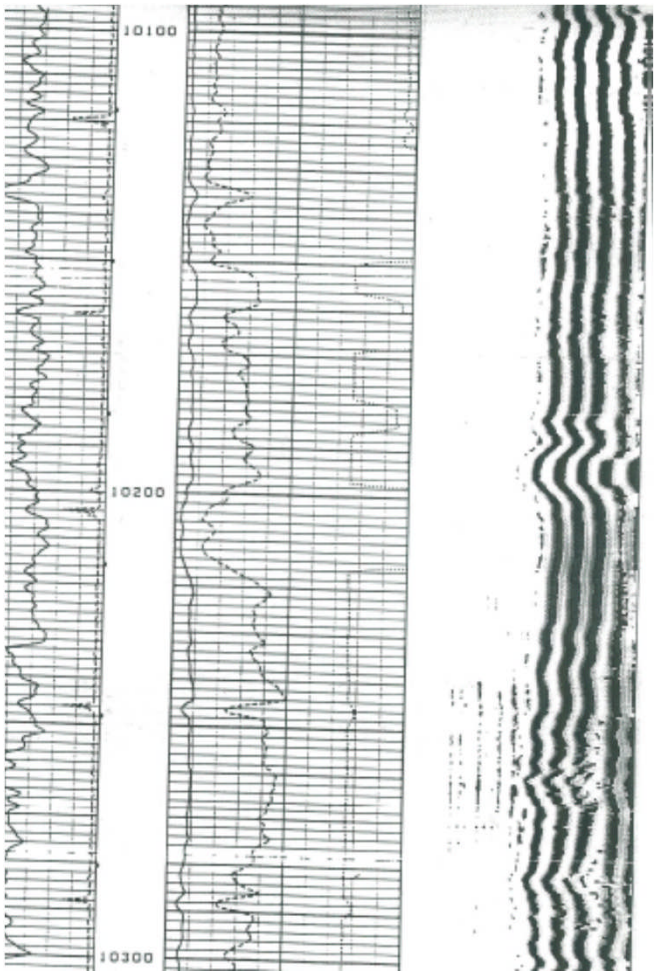
Washouts /

Hydrocarbons

Formation Effects

1000 psi applied while logging





Why does the formation affect the bond log so much ?

Physical Reasons

Sonic Reasons

Why does the formation affect us so much ?

Physical Reasons	Sonic Reasons
Filter Cake	Formation “Squeeze”
Formation Fluids	Fast Formation
Wash Out – Channeling	Thin Cement Sheath
Dehydration of the Cement	

Low Formation Impedance

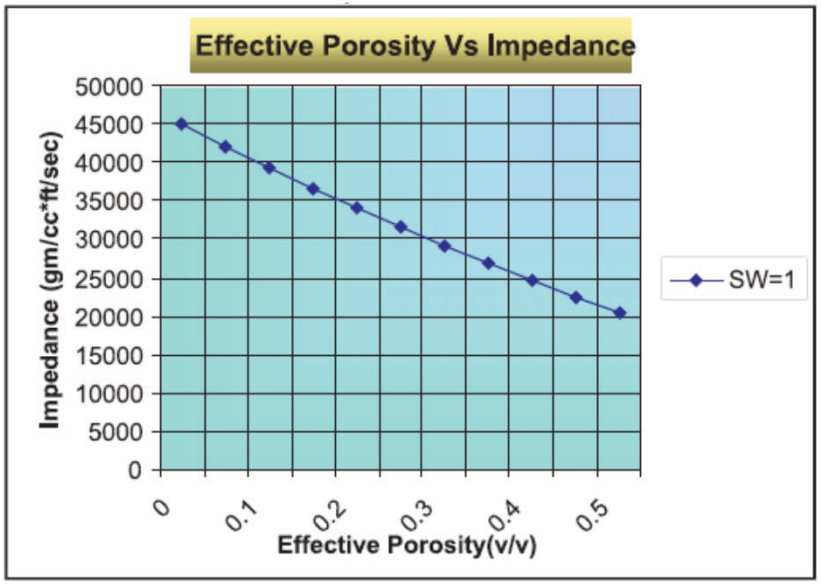
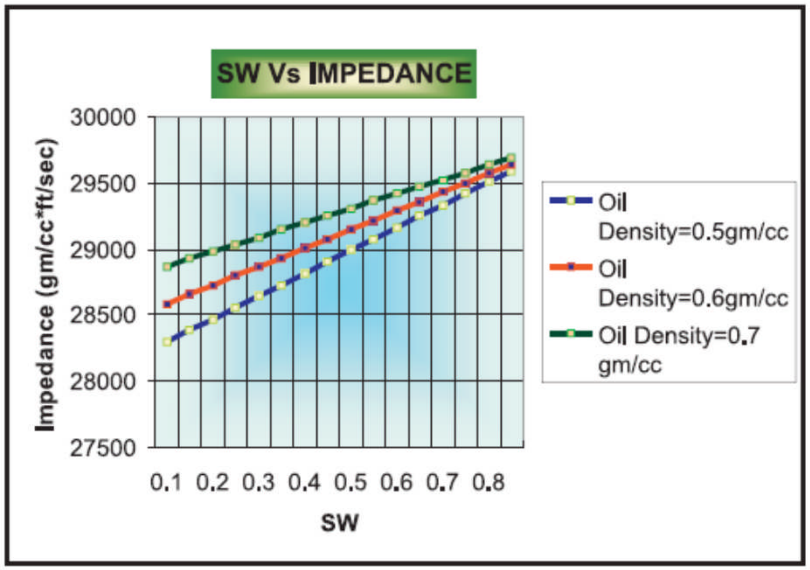


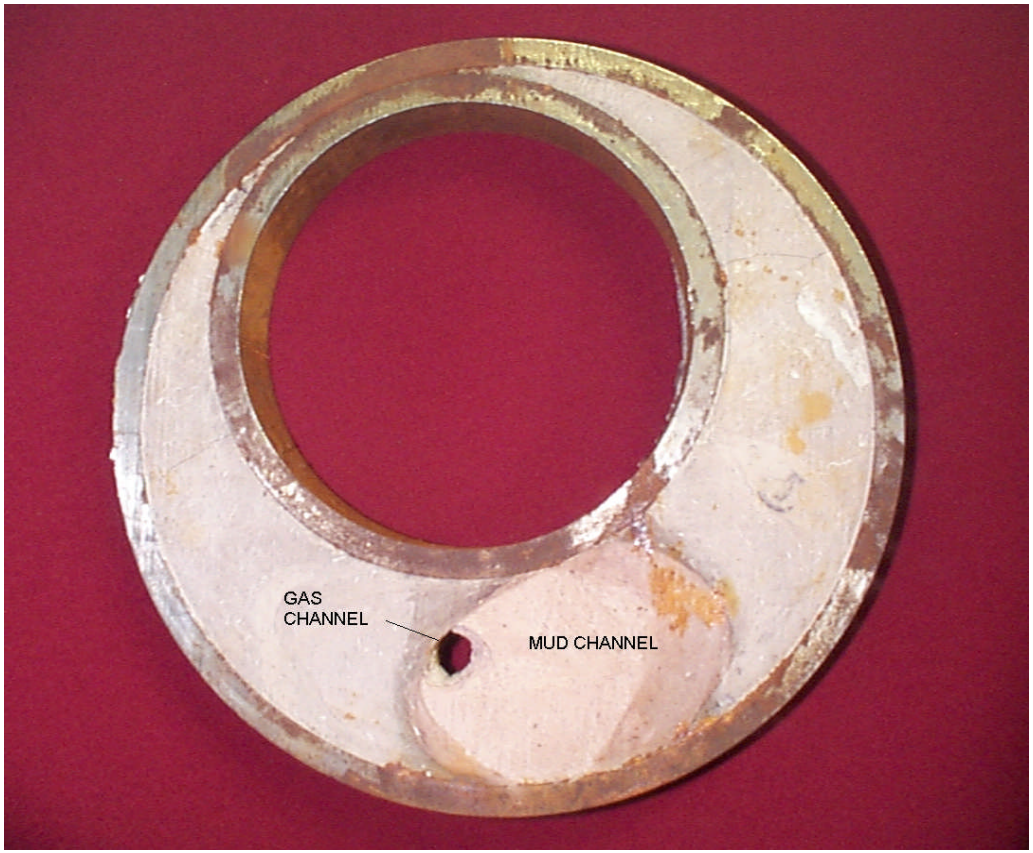
Fig. 1



Tiwary, et al.

Special Conditions

- Casing – in – Casing



Step 12

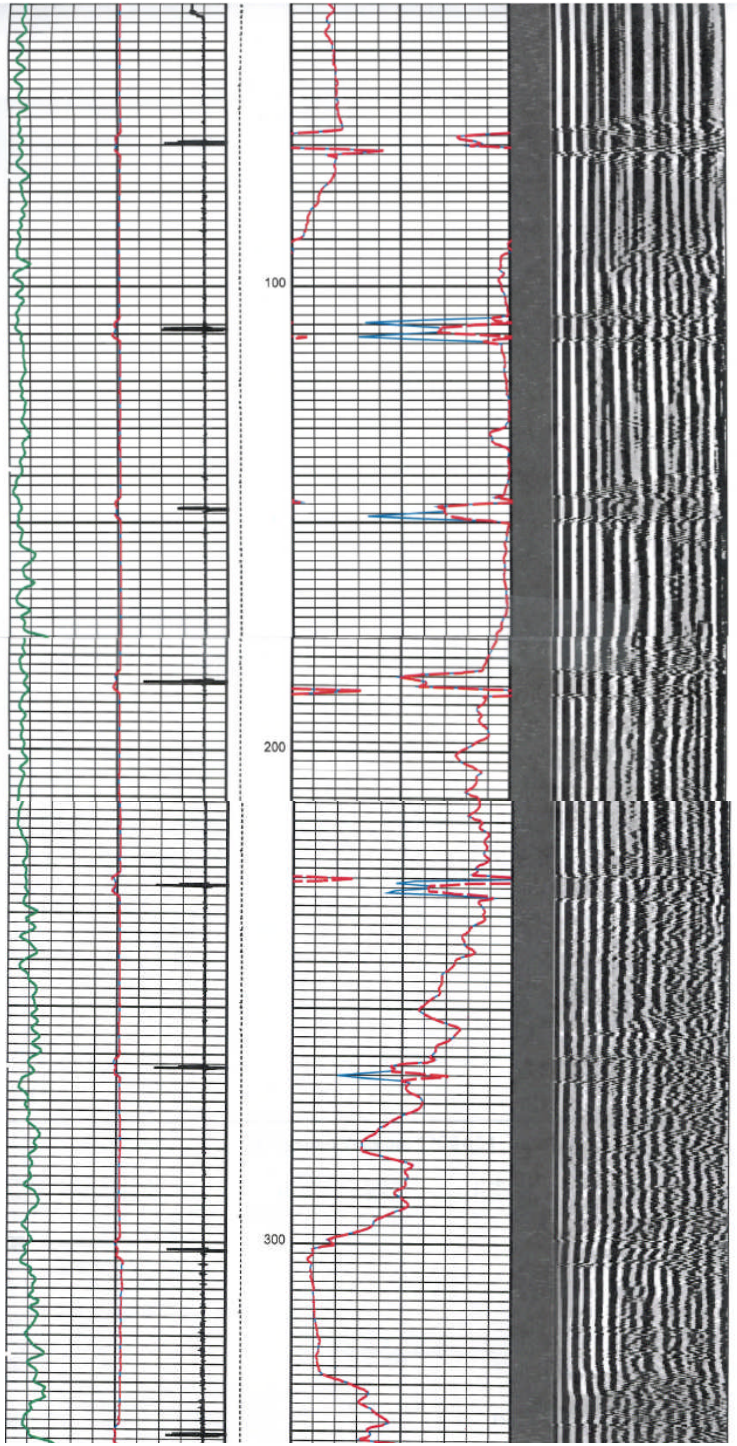
Investigate Cementing Practices

Step 12

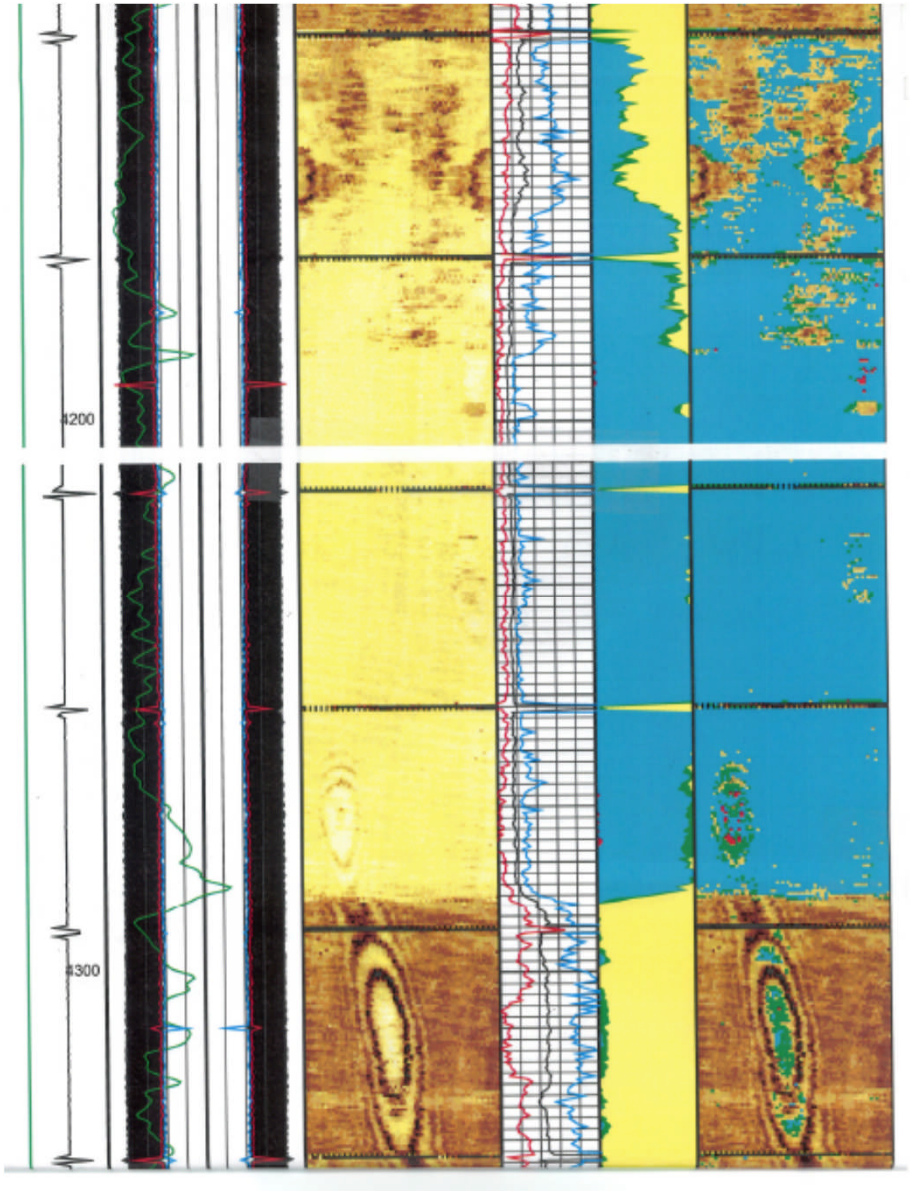
Investigate Cementing Practices

- Losses While Cementing
- Cement Returns
- Cement Volume
- Cement Type
- Cement Chart_Slurry Density_Mixing Problems
- Centralizer location
- Zones of Differential Pressure
- Flows After Cementing
- Floats Held
- Mud Type / Properties

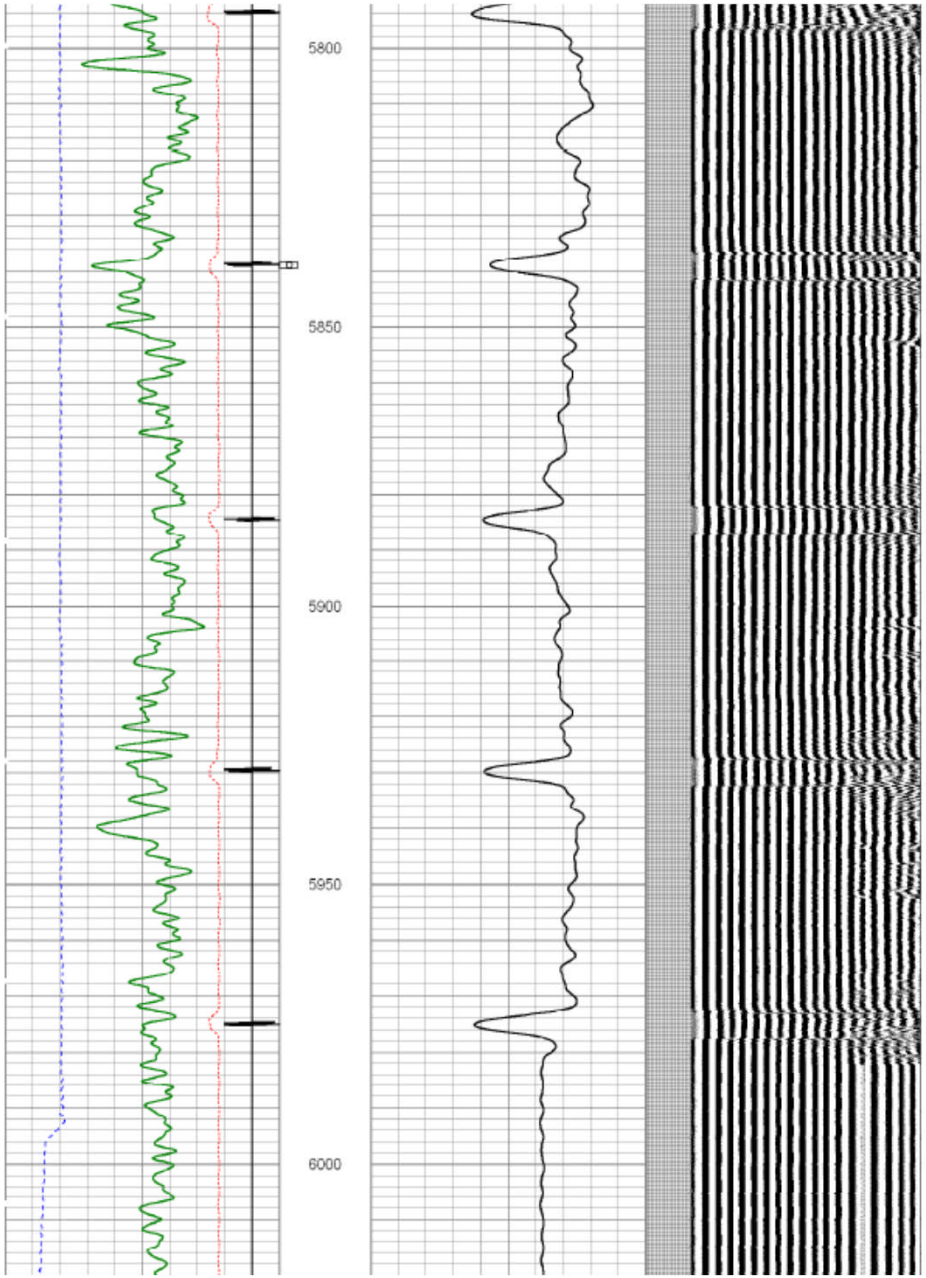
Fallback
in Middle East



Crossflow

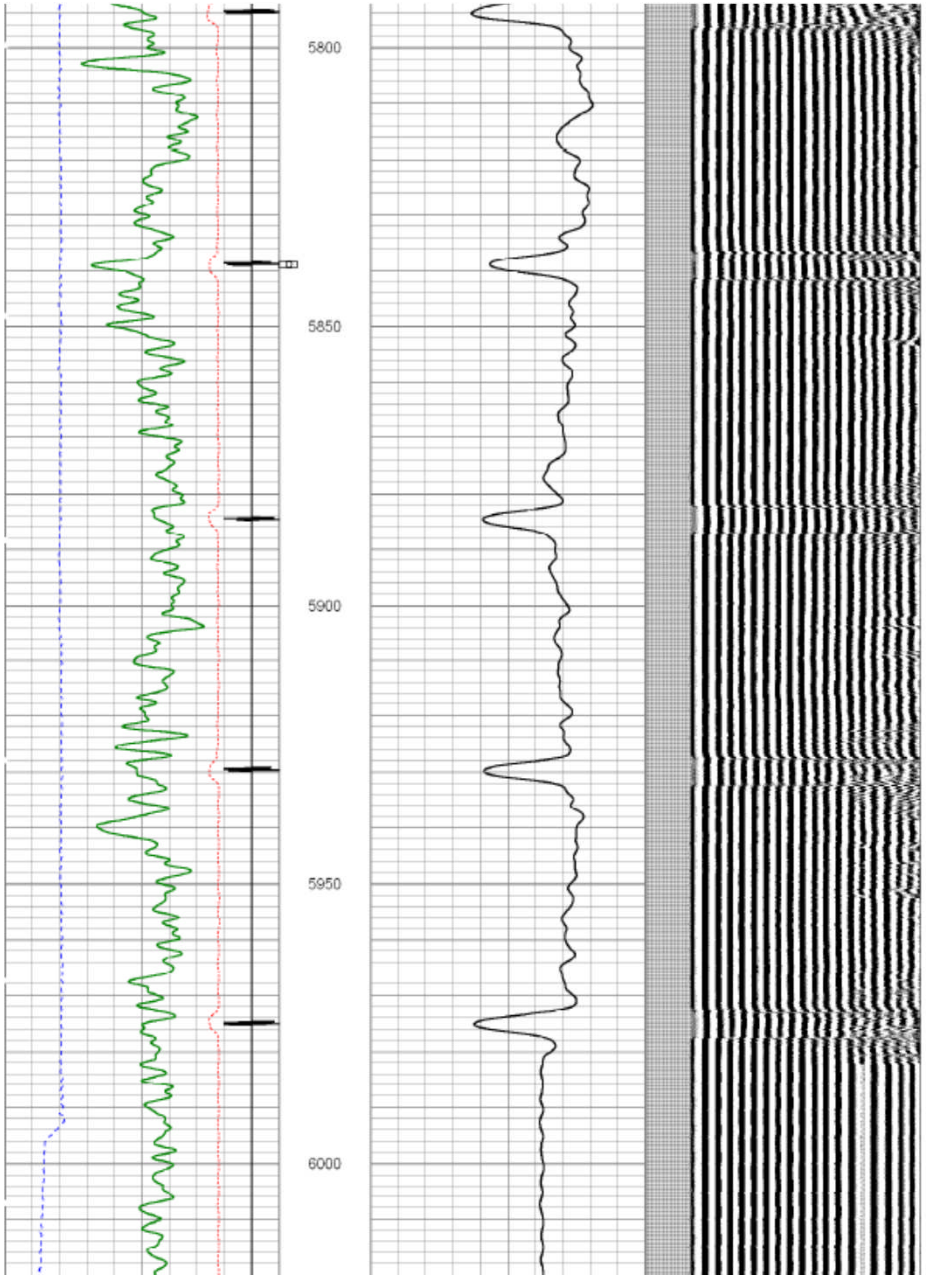


Interpretation



Bad or No Cement
from 5800-6000 ft

= OPINION



Weakly Bonded Cement from 5800-6000 ft due to the low shear bond of 11.5 ppg lt wt cement and new casing. Also a potential channel due to lack of centralizers (1 per 4 jts)

Do not squeeze.

= Interpretation

On next job, sandblast casing, use 11.5 ppg Tuned Light, and run 1 rigid centralizer per joint.

Recommendation to Squeeze

- Was there something noticeable in the job execution ?
- Do not squeeze off of a Bond Log…But use a Bond Log to Squeeze !
- How much zonal isolation do you need ?

12 Steps to Analyze a Bond Log

Hang Log on Wall

1. Check the Transit Time
2. Check Pipe Ring
3. Observe Formation Signals
4. Look @ Pressure Pass
5. Find TOC / Free Pipe
6. Observe Up and Down
7. Draw Horizontal Lines Side to Side
8. Check Shear Bond - Casing
9. Check Shear Bond - Cement
10. Check Shear Bond - Post Job
11. Think about Formation Effects
12. Evaluate Cementing Operations

Interpret

QUALITY CHECK

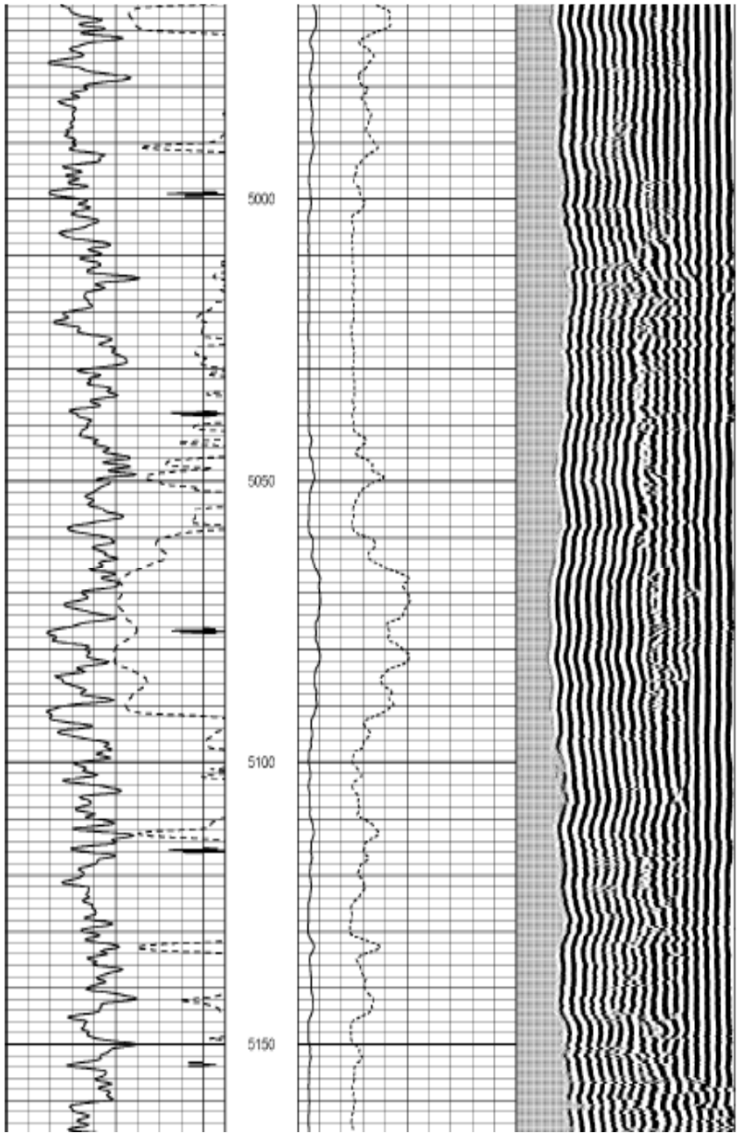
OBSERVE

SHEAR BOND

REASON

Seven Steps to An Excellent Bond Log

“Best Bond Log I’ve Ever Seen”



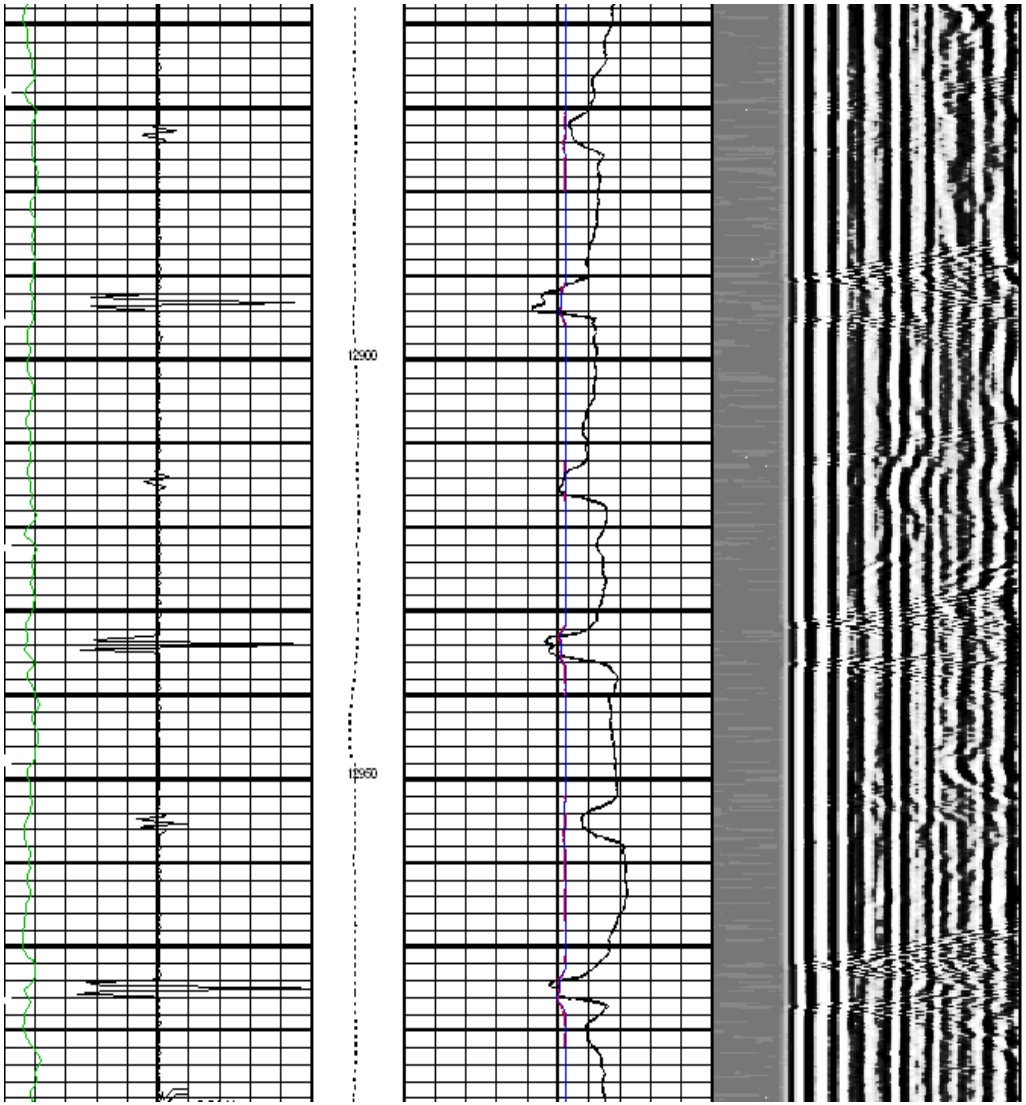
Seven Steps To An Excellent Bond Log

1. Sandblast the Casing
2. Centralize the Pipe
3. Expansive Cement Additive
4. High Compressive Strength Cement
5. Displace with a Low Density Fluid
6. Do Not Pressure Test Casing
7. Log with a Pressure Pass

Step # 1

Sandblast the Casing

Middle East



SPE 22063 Carpenter, et al

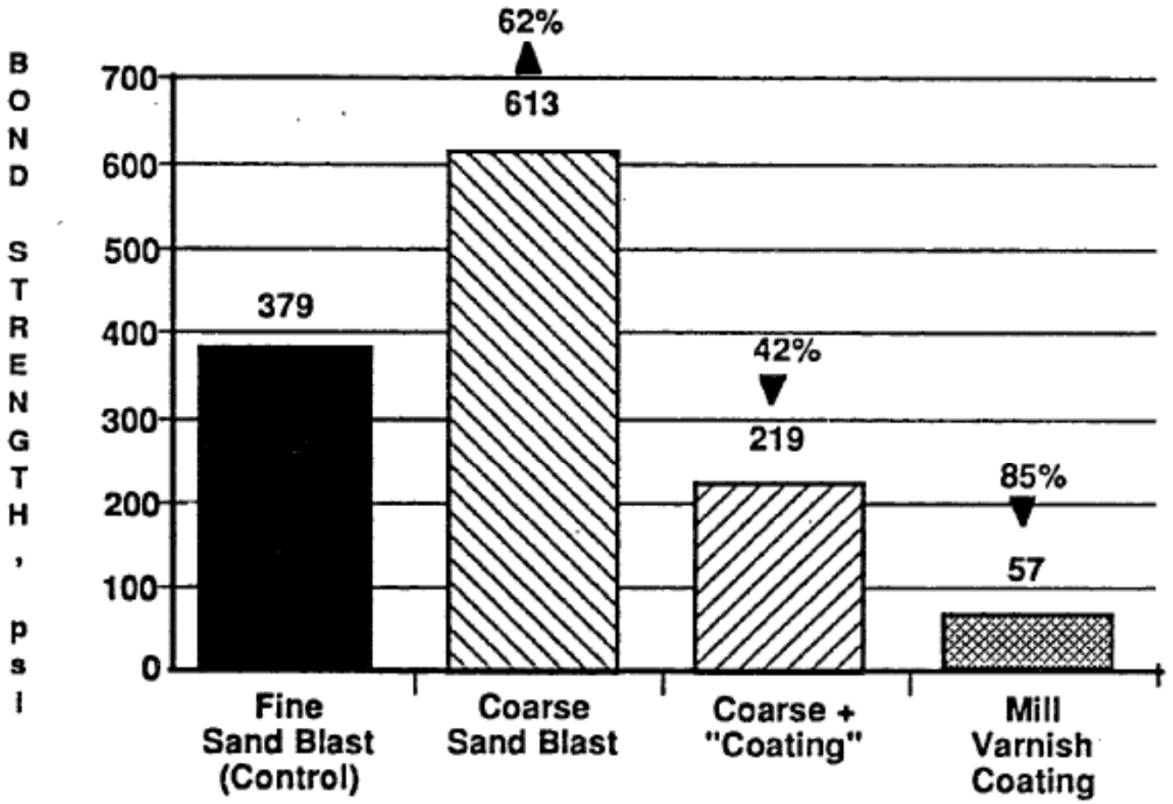
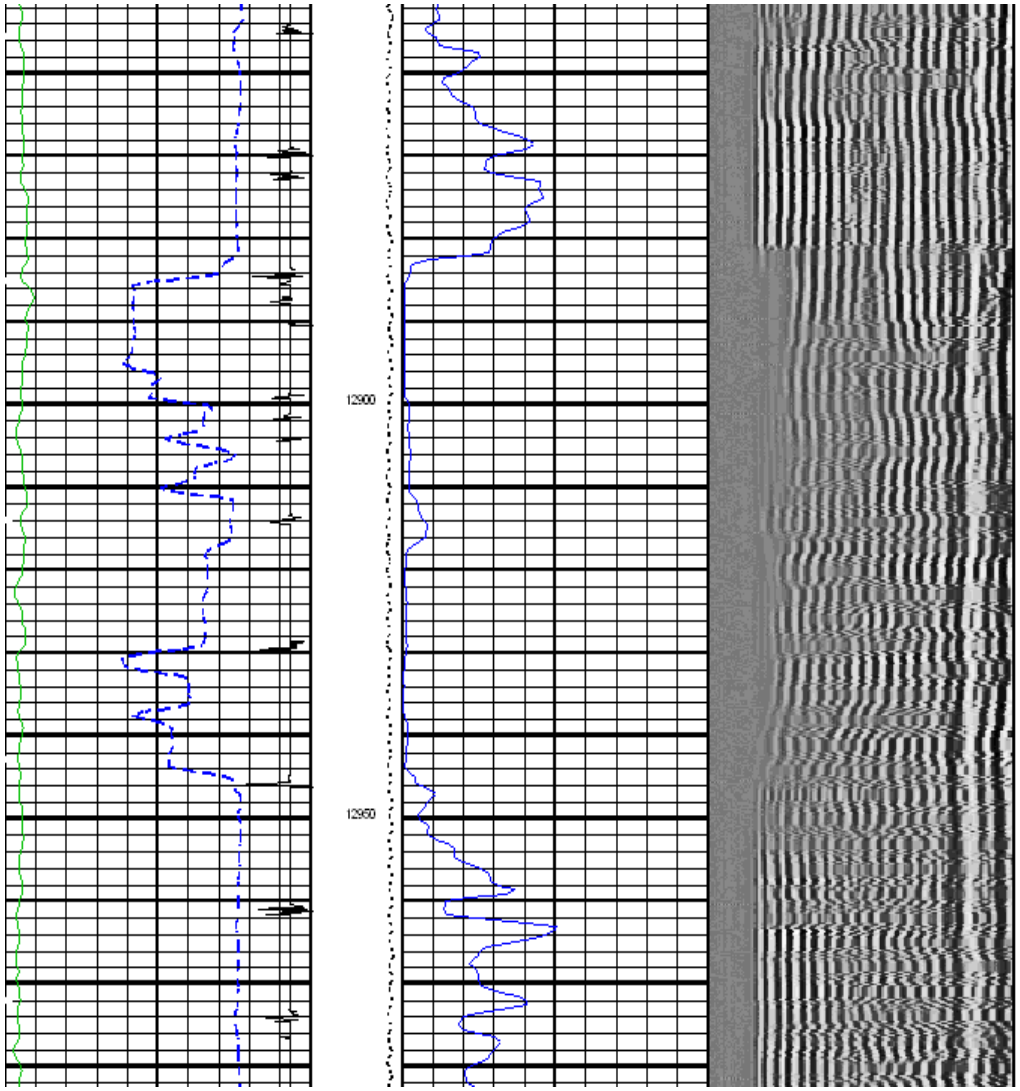


FIGURE 5. TWO DAY SHEAR BOND STRENGTH; CONVENTIONAL LFL CEMENT WITH VARIOUS CASING PREPARATIONS.

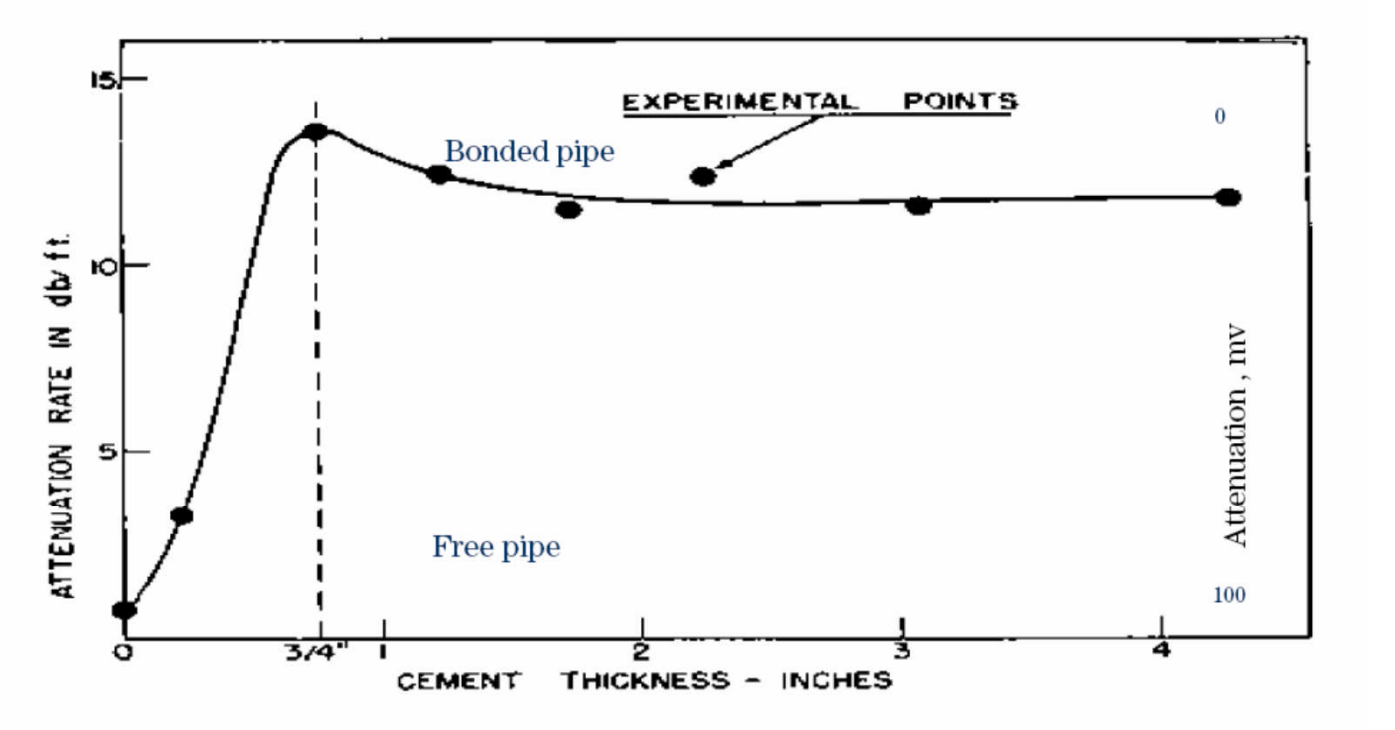
Middle East



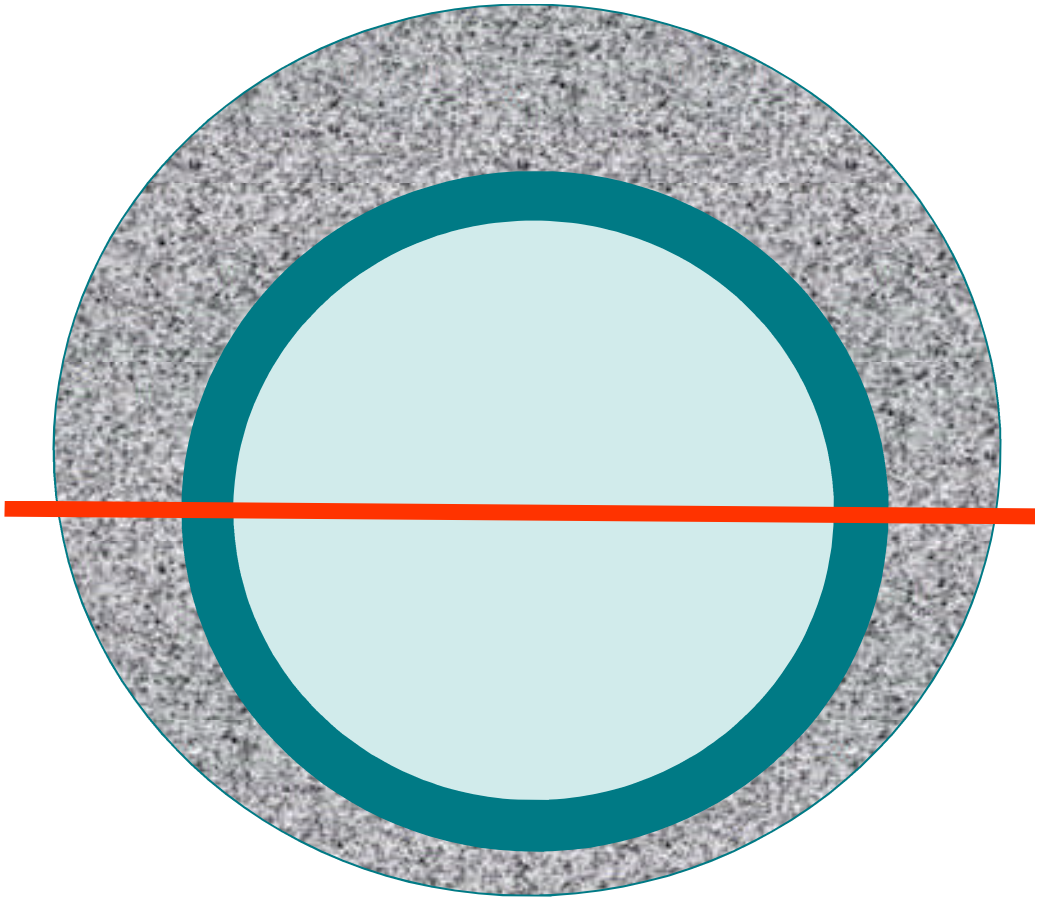
Step # 2

Centralize the Pipe

Effect of Cement Thickness on Cement Bond Curve



Centralizers

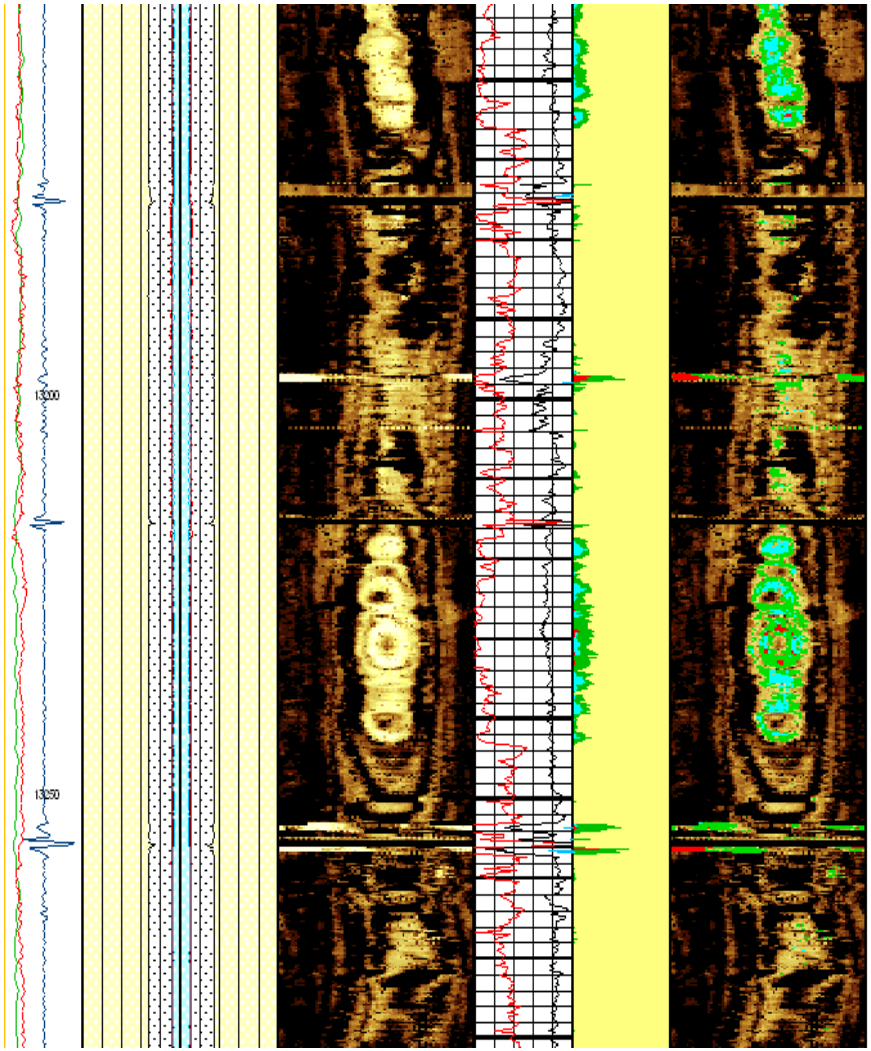


Centralize the Pipe

- Rigid in Open Hole
- Spacing Program

- 1 per jt- vertical
- 2 per jt - deviated

Middle East



Step # 3

Expansive Cement Additive

Expansion

SPE 22063 – Carpenter, et al

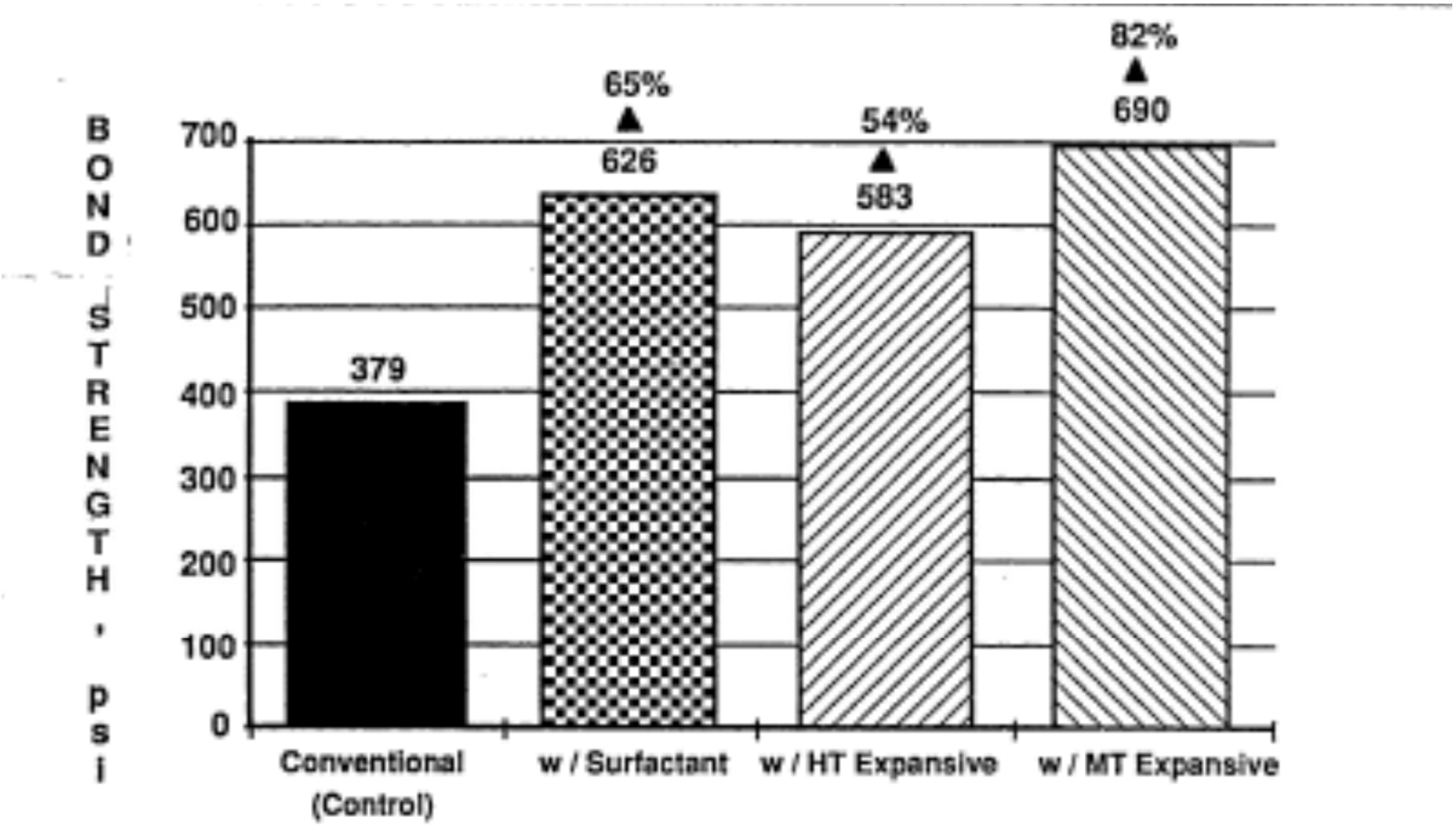
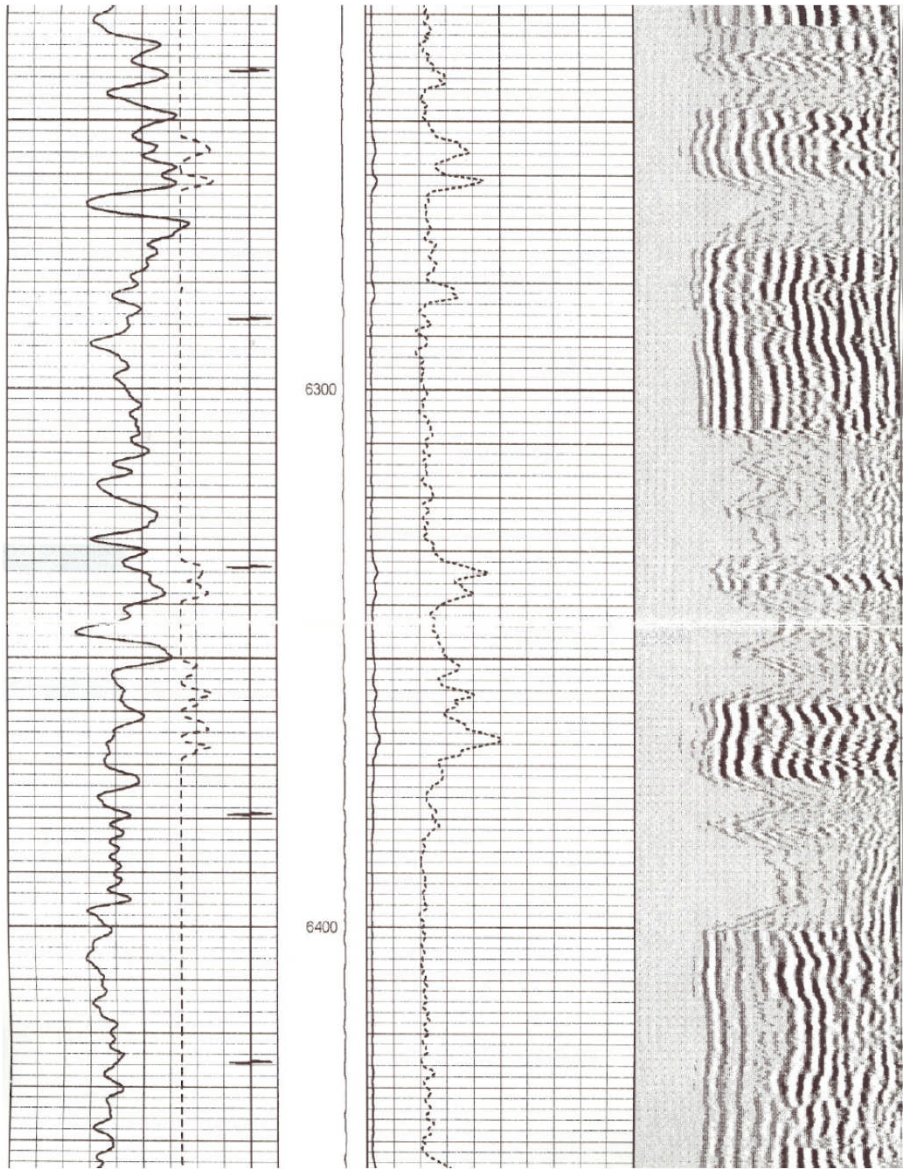


FIGURE 6. TWO DAY SHEAR BOND STRENGTH; CONVENTIONAL LFL CEMENTS WITH VARIOUS ADMIXES.

Colorado USA

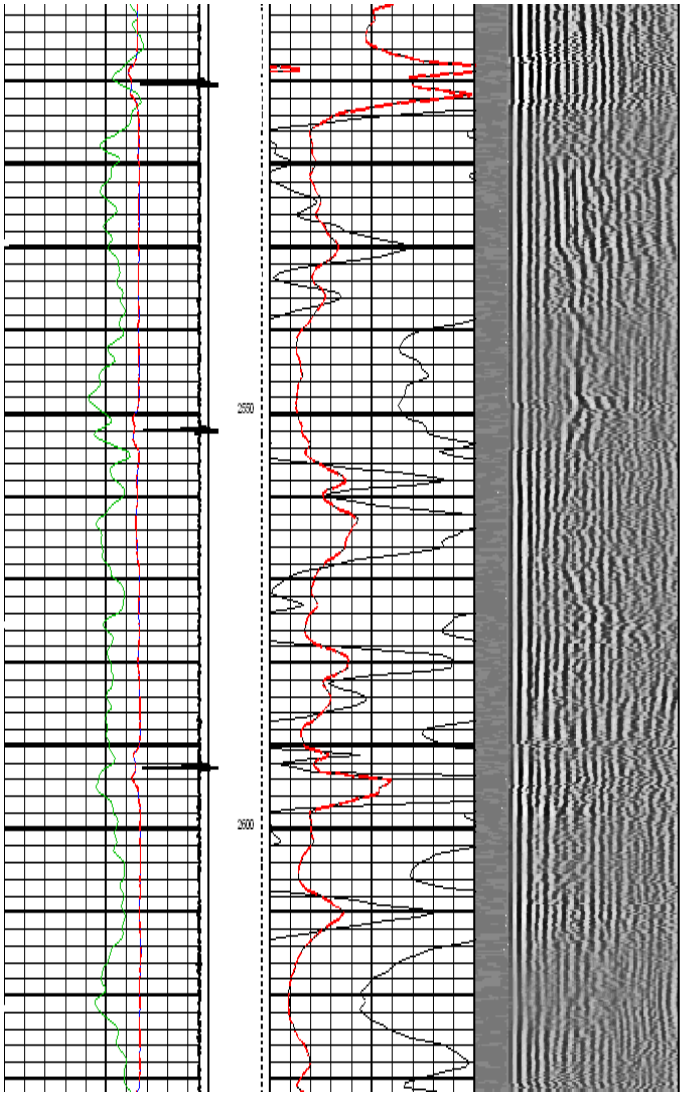


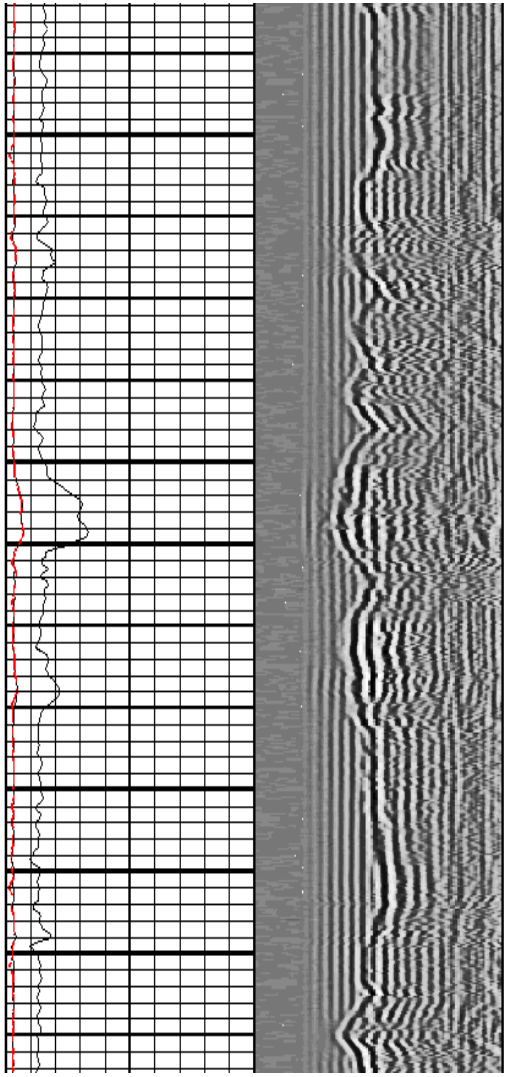
THUMS BJ’s Lead and Tail BA-61

Step # 4

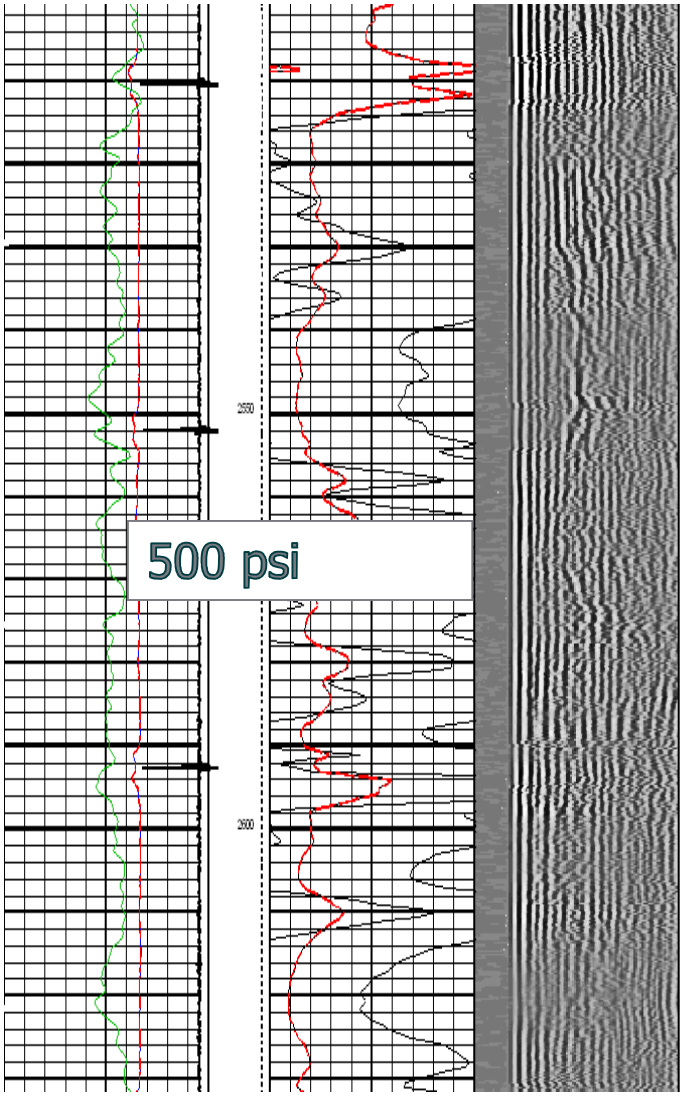
High Compressive Strength Cement

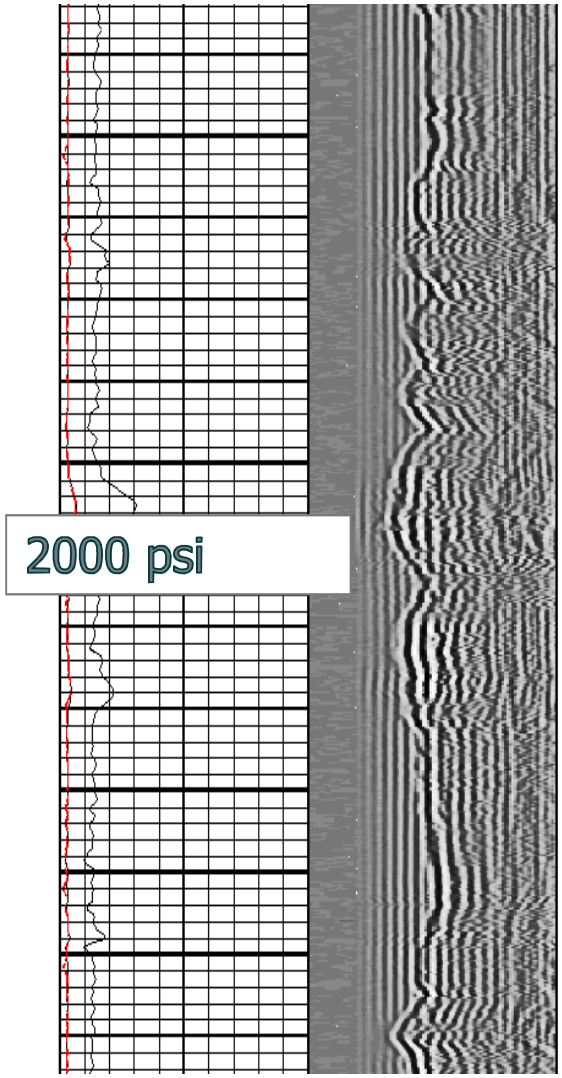
Colombia



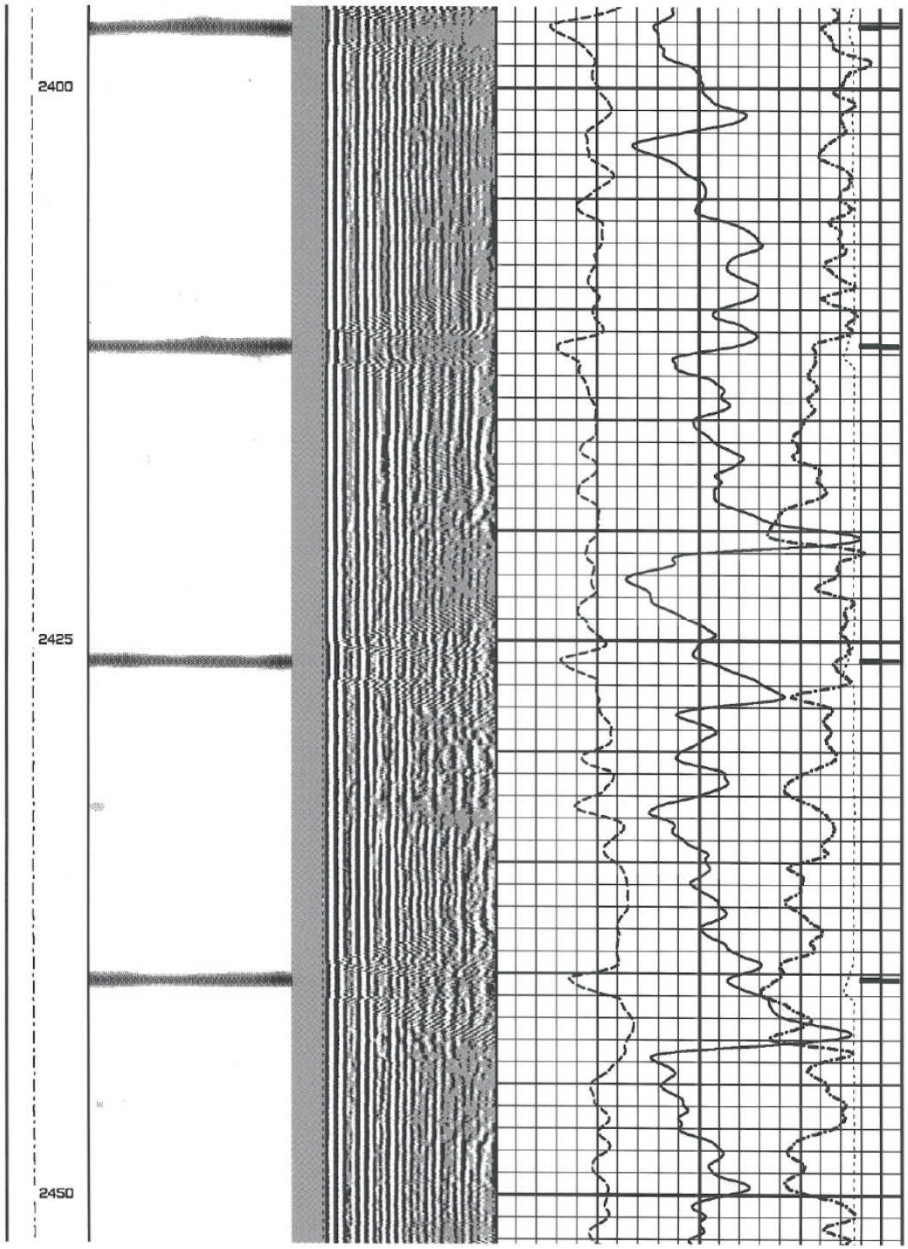


Colombia





Argentina



High Compressive Strength – Curing Time

SPE 22063

R.B. CARPENTER, J.L. BRADY, C.G. BLOUNT 9

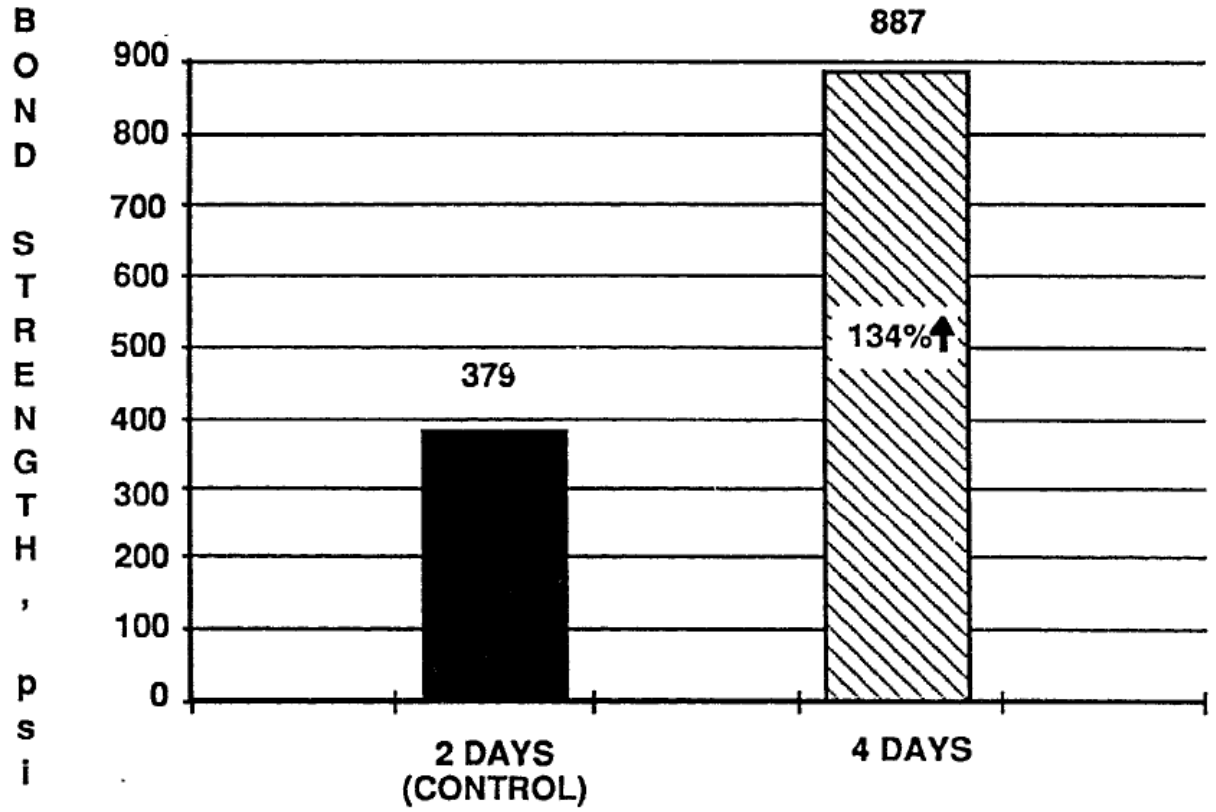
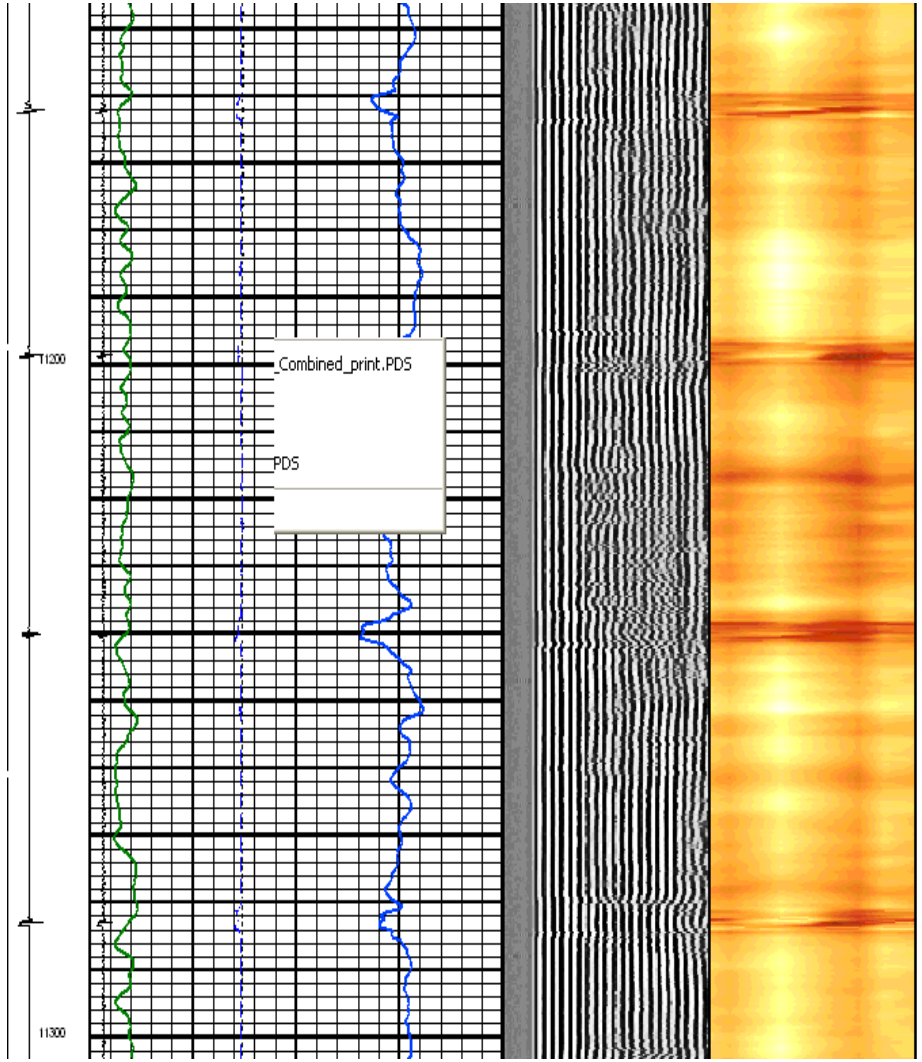


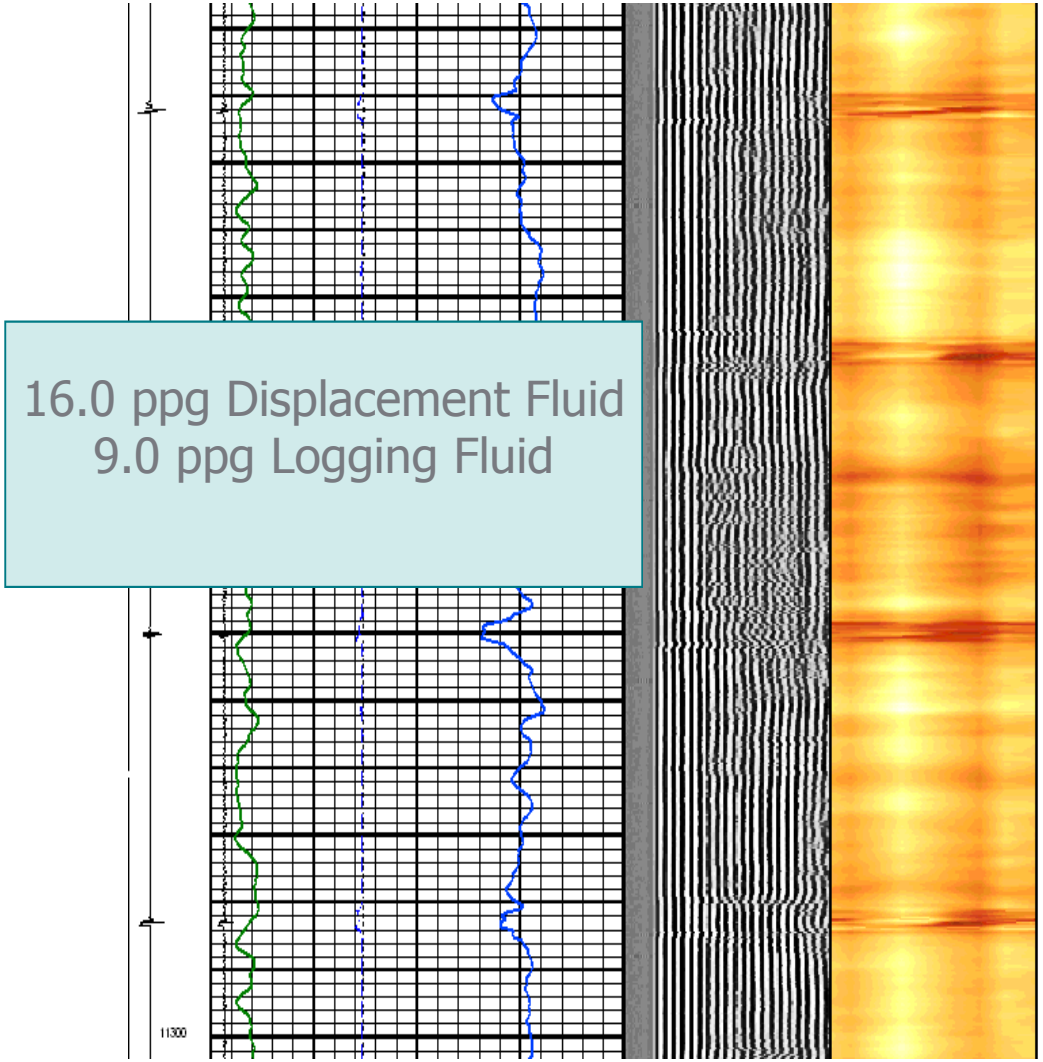
FIGURE 4. SHEAR BOND STRENGTH - TWO VS. FOUR DAY CONVENTIONAL LOW FLUID LOSS (LFL) CEMENT.

Displacement Fluid

West Texas



West Texas



Step # 6

Do Not Pressure Test Casing Before Running Bond Log

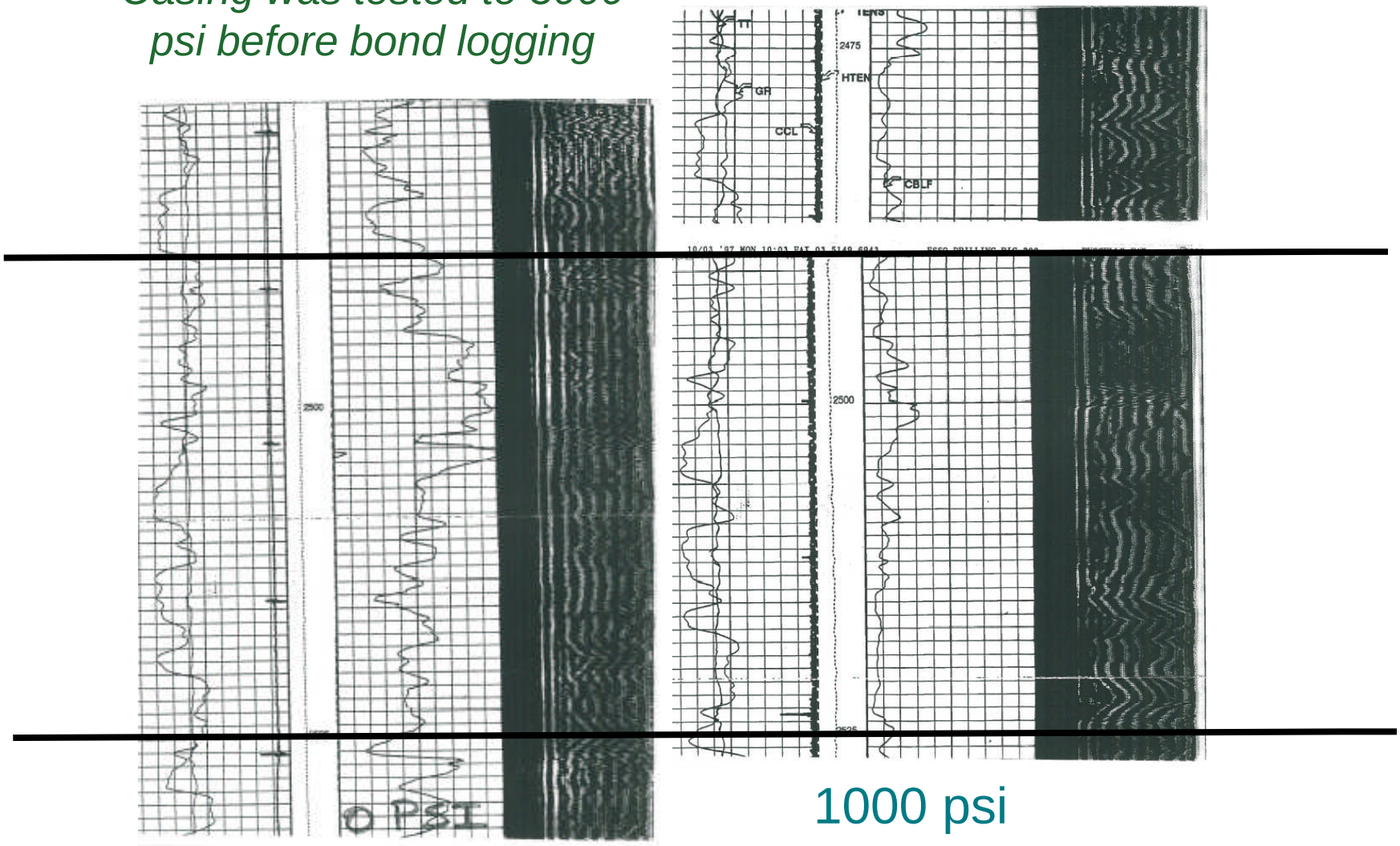
Pressure Testing Casing

- Do Not Pressure Test Casing Before Running a Bond Log

- Pressure Testing Casing After Bumping Plug – while Cement is still liquid – is a Best Practice
  - Hold Pressure for 10 minutes

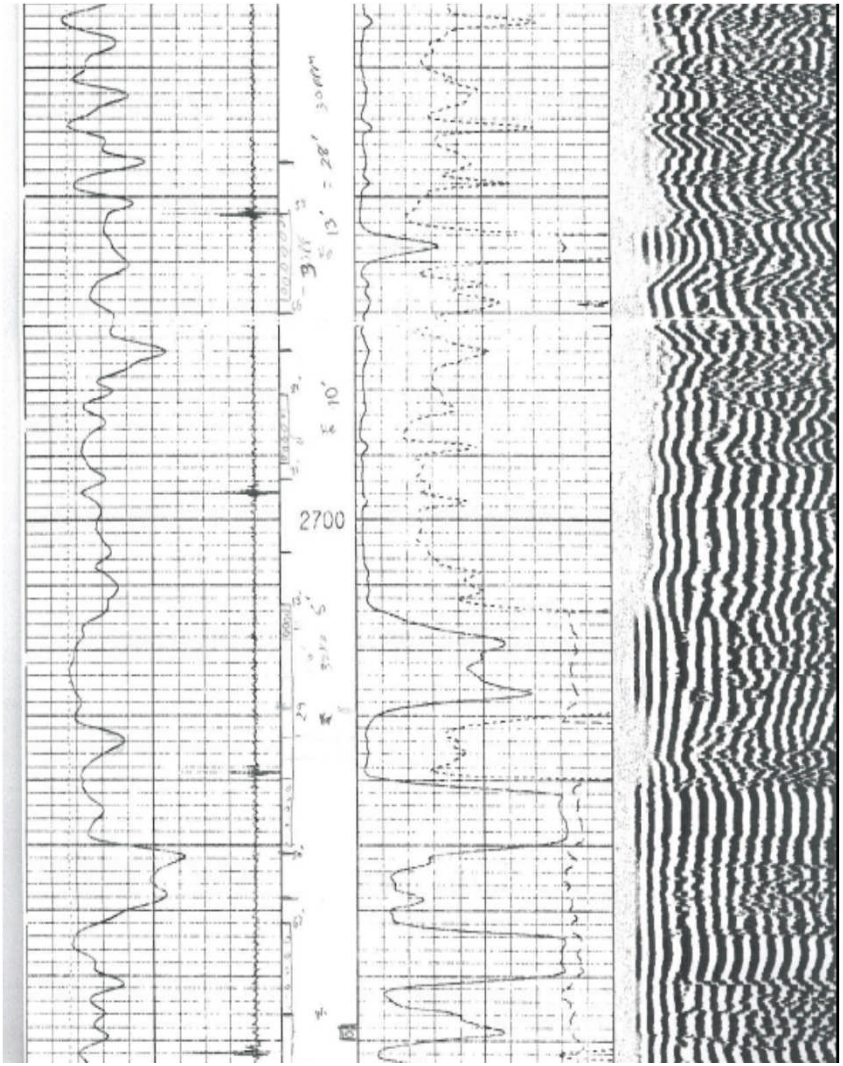
Australia

Casing was tested to 3000 psi before bond logging

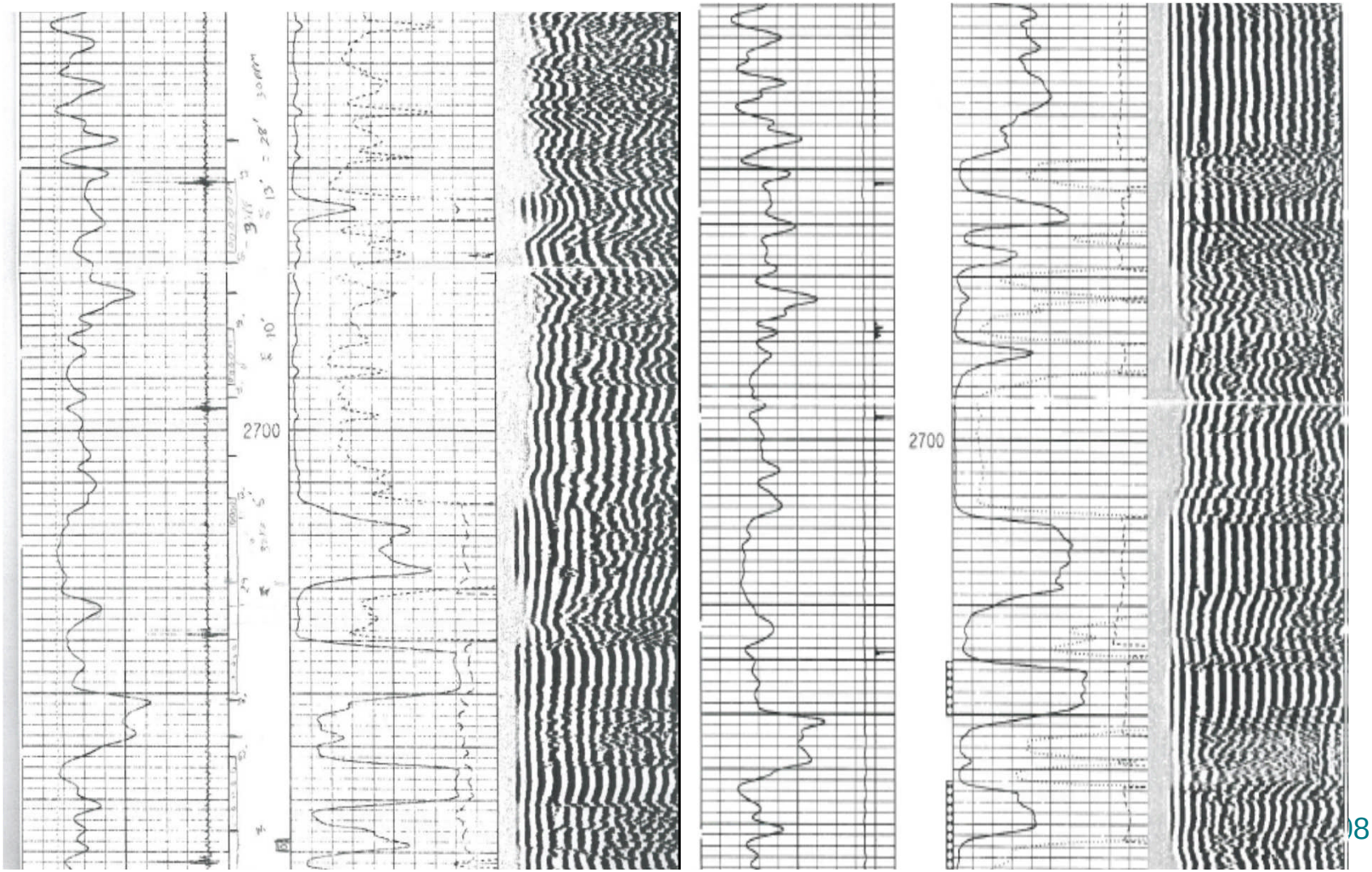


1000 psi

Kansas USA

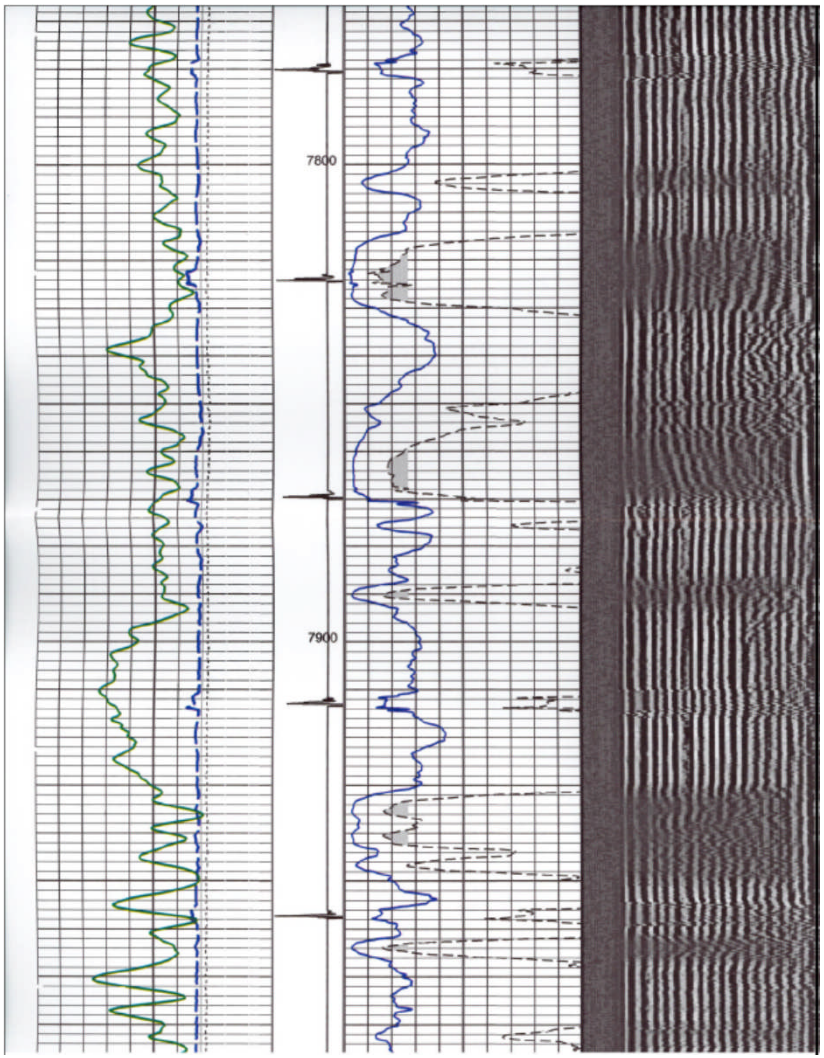


Kansas USA



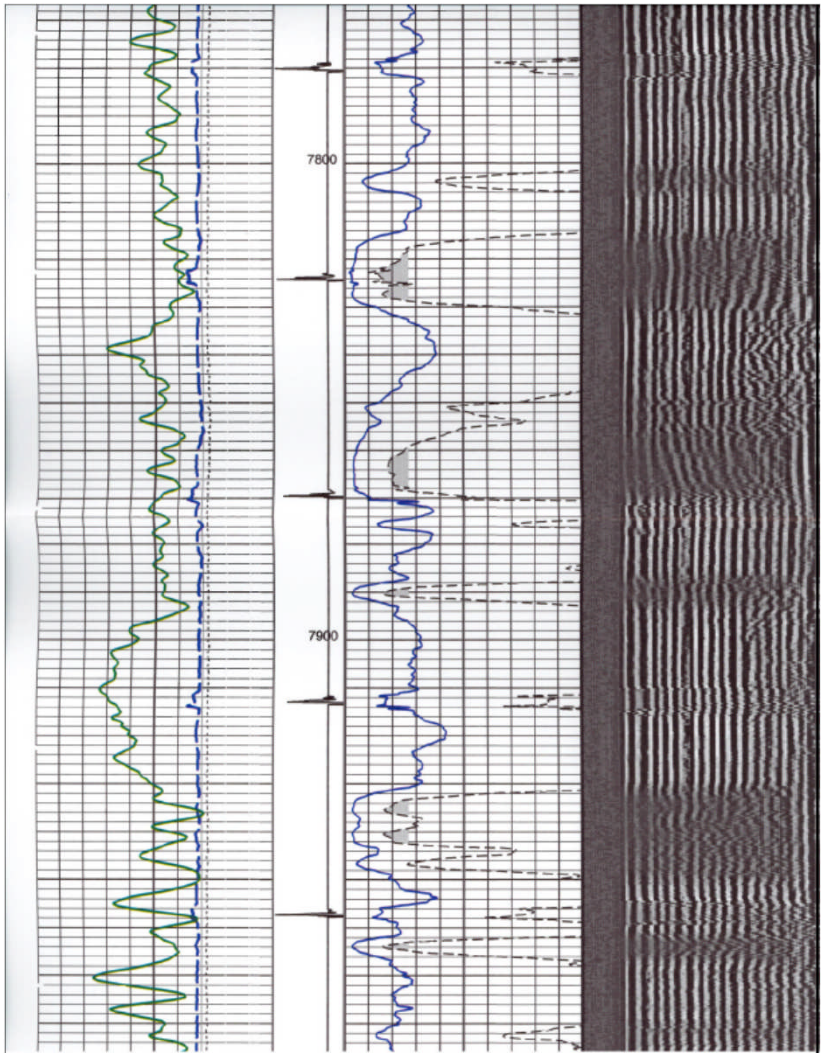
Log with a Pressure Pass

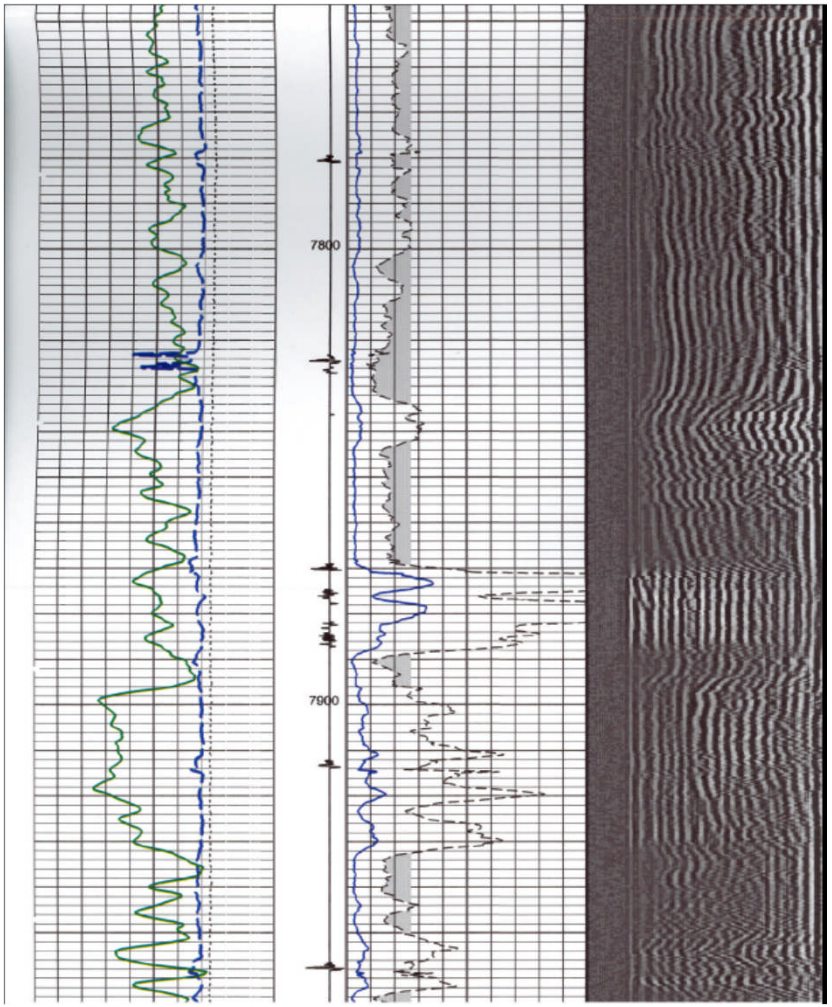
Texas



Log run with 0 psi

Texas





Pressure Pass @ 1000 psi

Seven Steps To An Excellent Bond Log

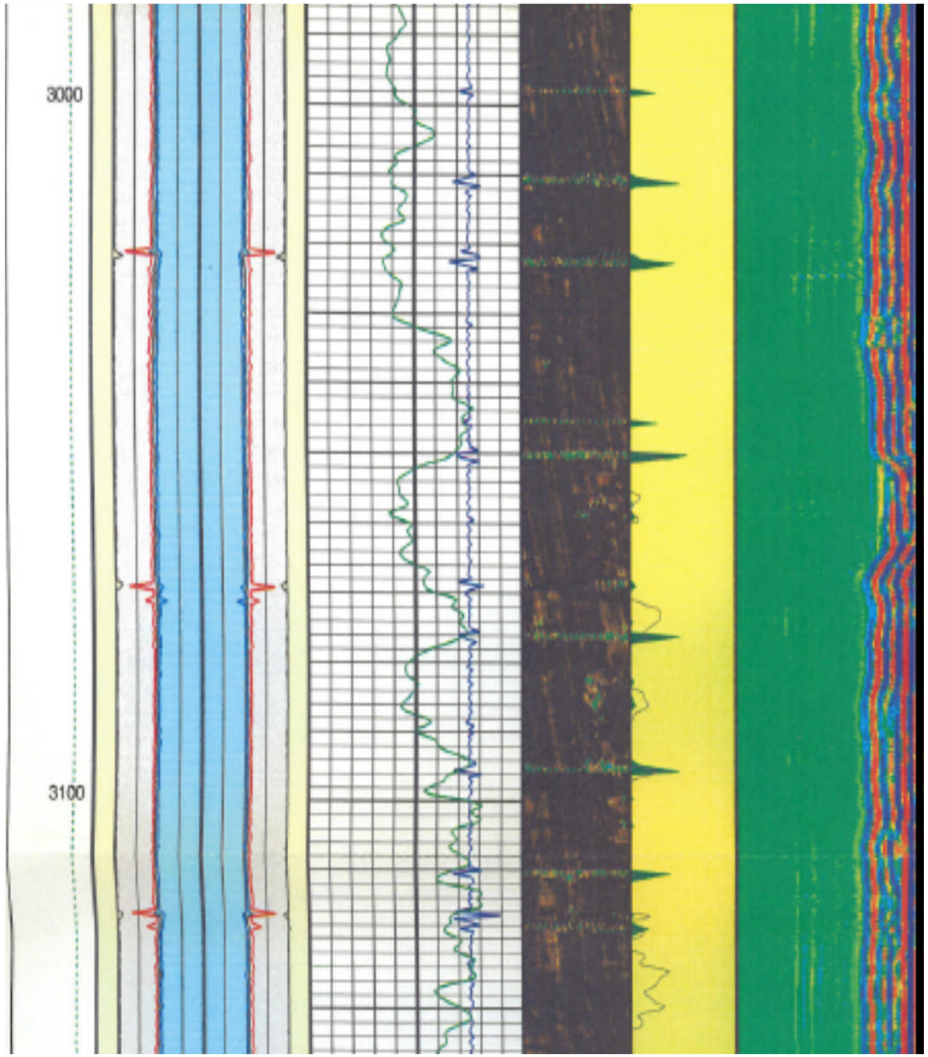
1. Sandblast the Casing
2. Centralize the Pipe
3. Expansive Cement Additive
4. High Compressive Strength Cement
5. Displace with a Low Density Fluid
6. Do Not Pressure Test Casing
7. Log with a Pressure Pass

Additional Tips

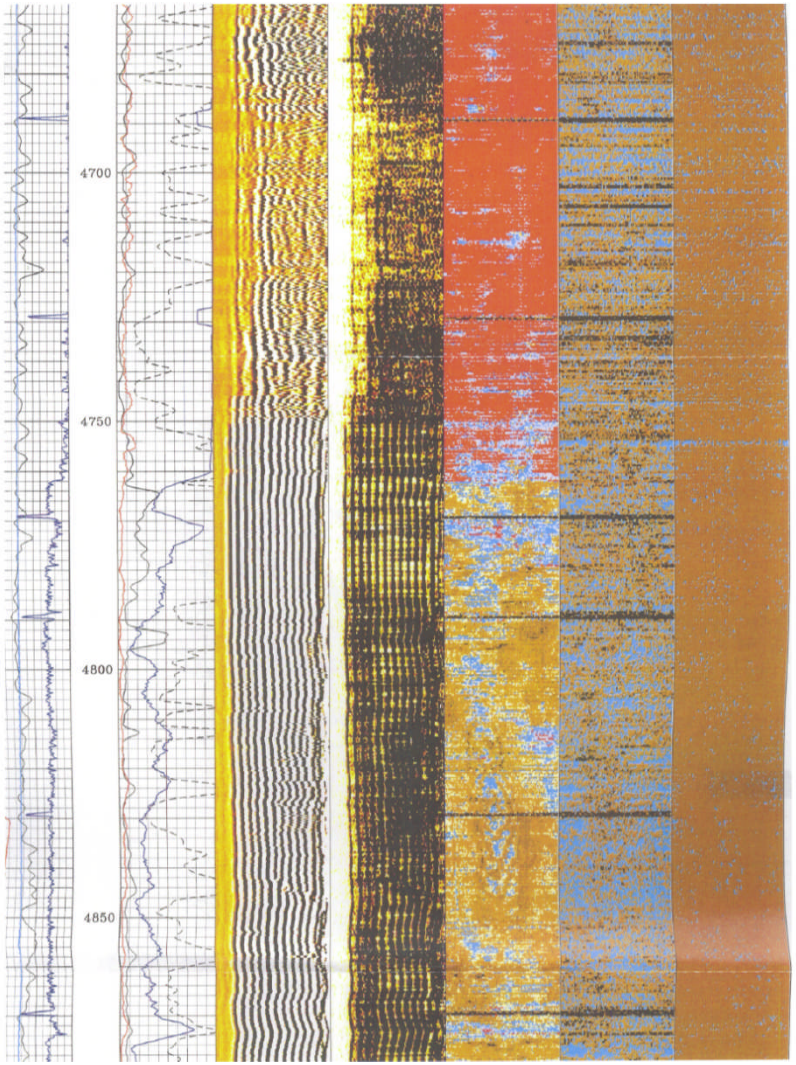
Tip # 1

Run Combination Log
CBL and Ultrasonic

California



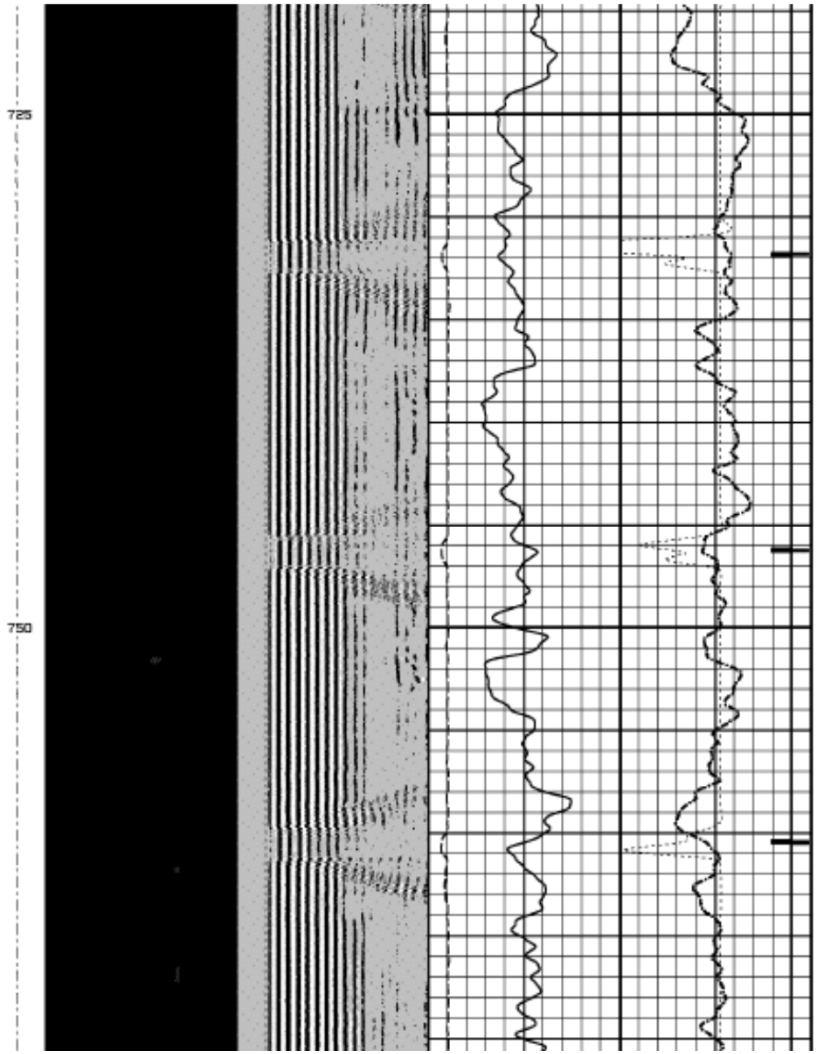
Texas



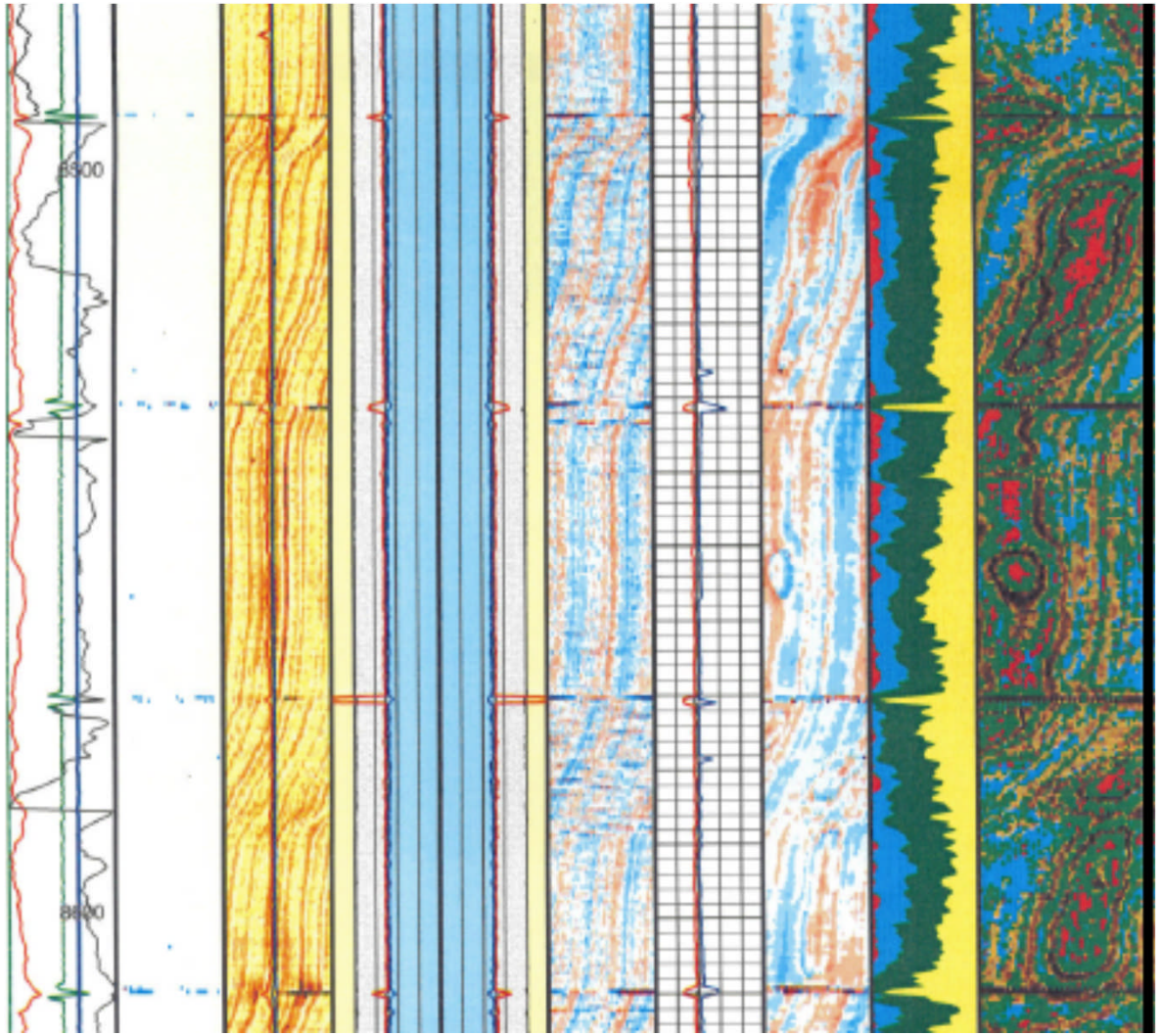
Tip # 2

Observe
Free Pipe Readings

Argentina

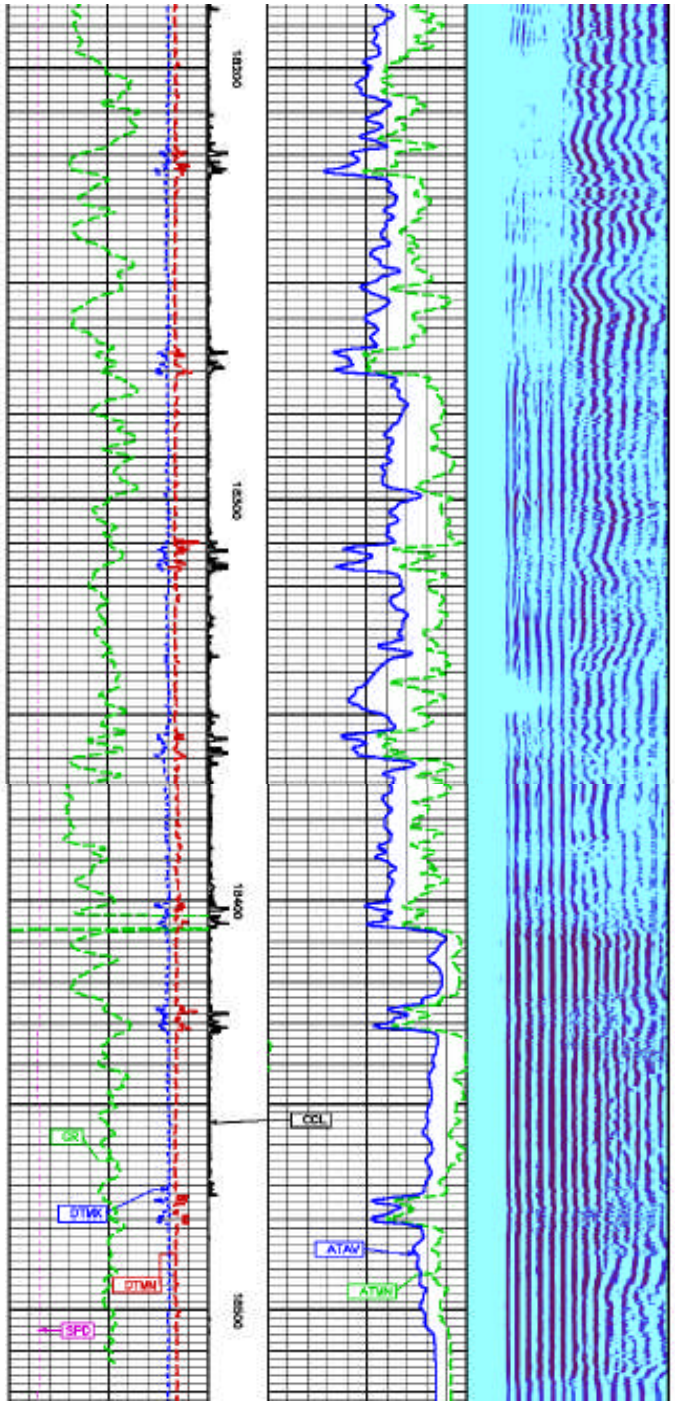


California



Tip # 3

Displace Theoretical
+ ½ Shoe Track Volume



Poor Cement from
Overdisplacement

Tip # 4

Coatings for Casing

Bond Coat

Tip # 5

Do Not Squeeze

Do Not Squeeze

“Do not squeeze solely because of a bad bond log !”

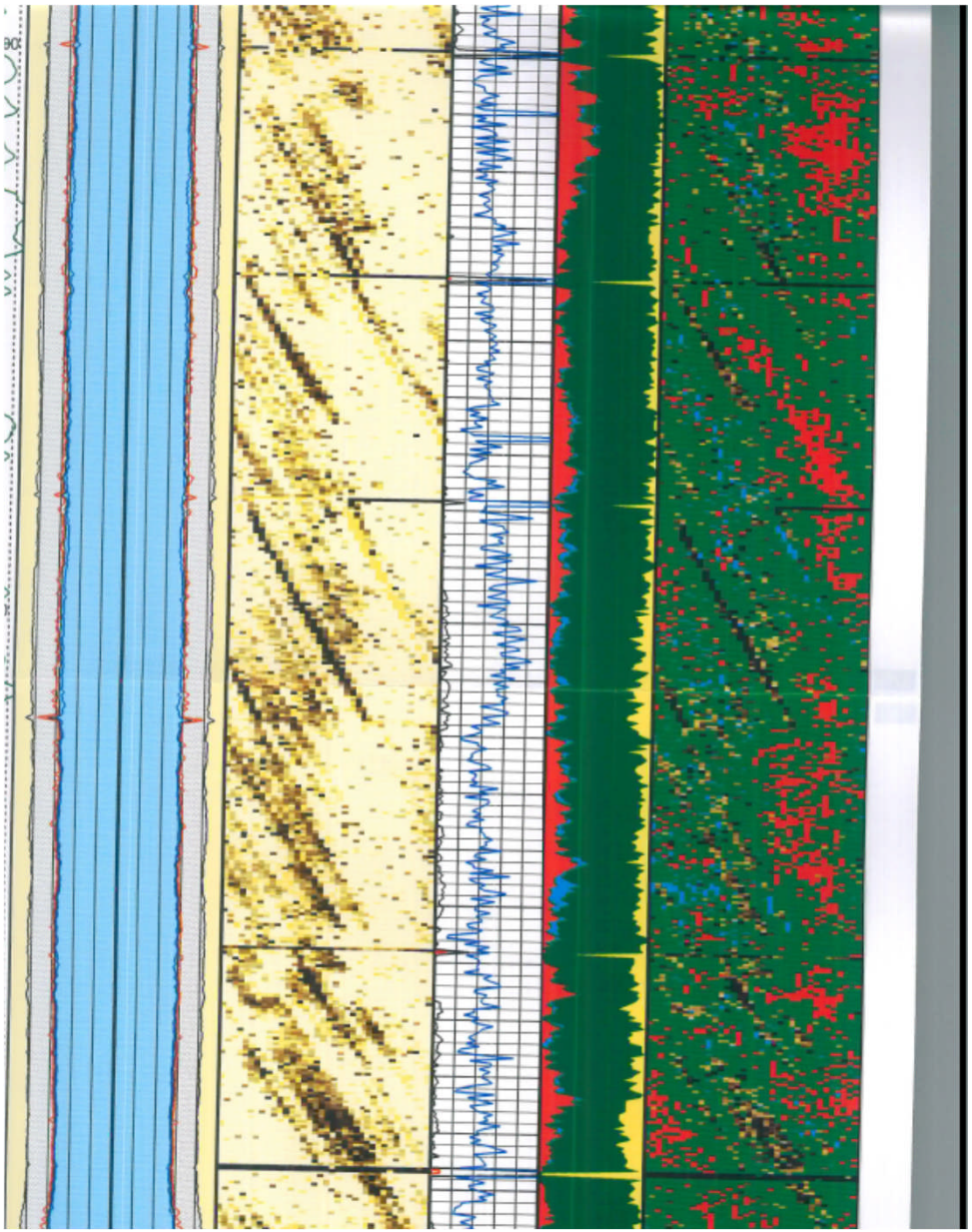
instead ….

“Use the bond log when you have to squeeze”

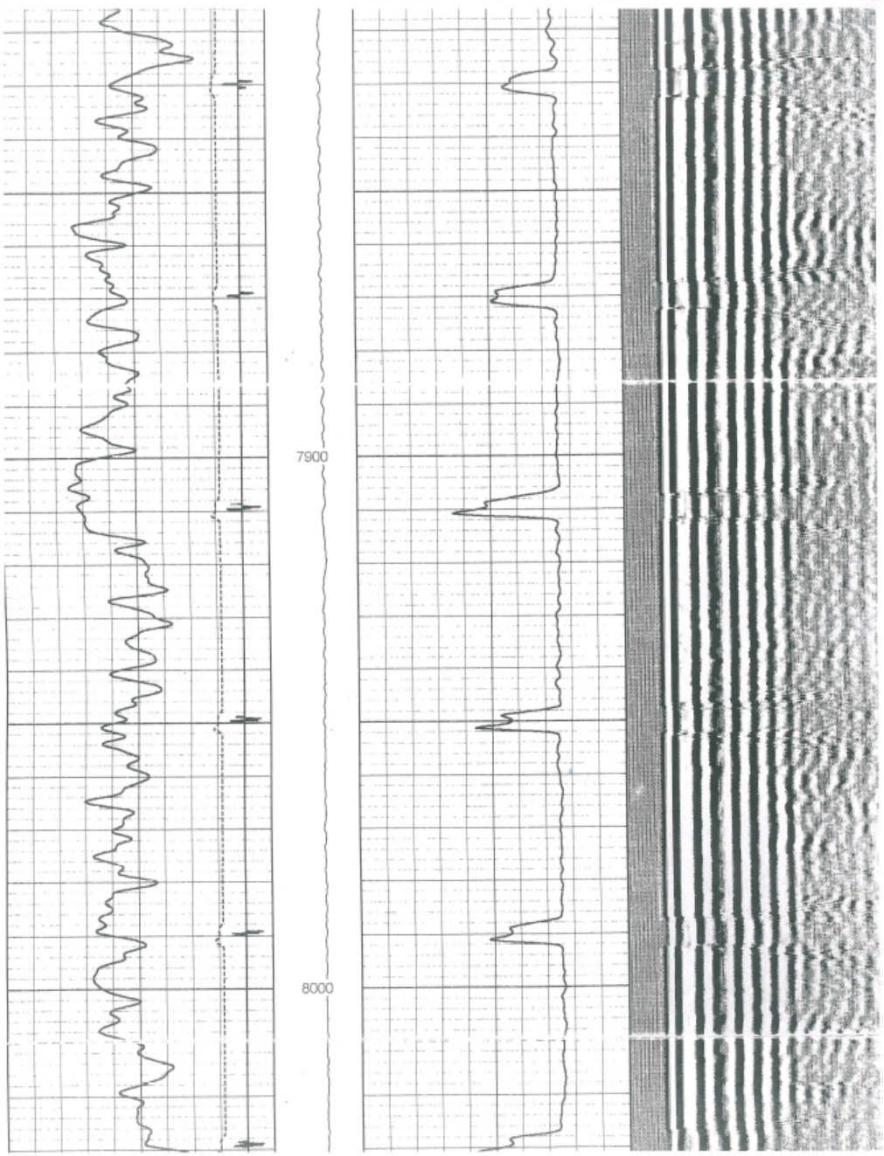
You Should Squeeze When You Have a Bad Bond Log PLUS

- Cementing Knowledge
  - Major losses occurred during cementing
  - The plug did not bump
  - Casing was stuck
  - Mud properties were not optimum
  - The well flowed after cementing
  - Cement slurry did not mix and pump as expected
  - Cement lift pressures while displacing were not observed
  - High Differential Pressures Between Zones of Interest

Colorado



Colorado



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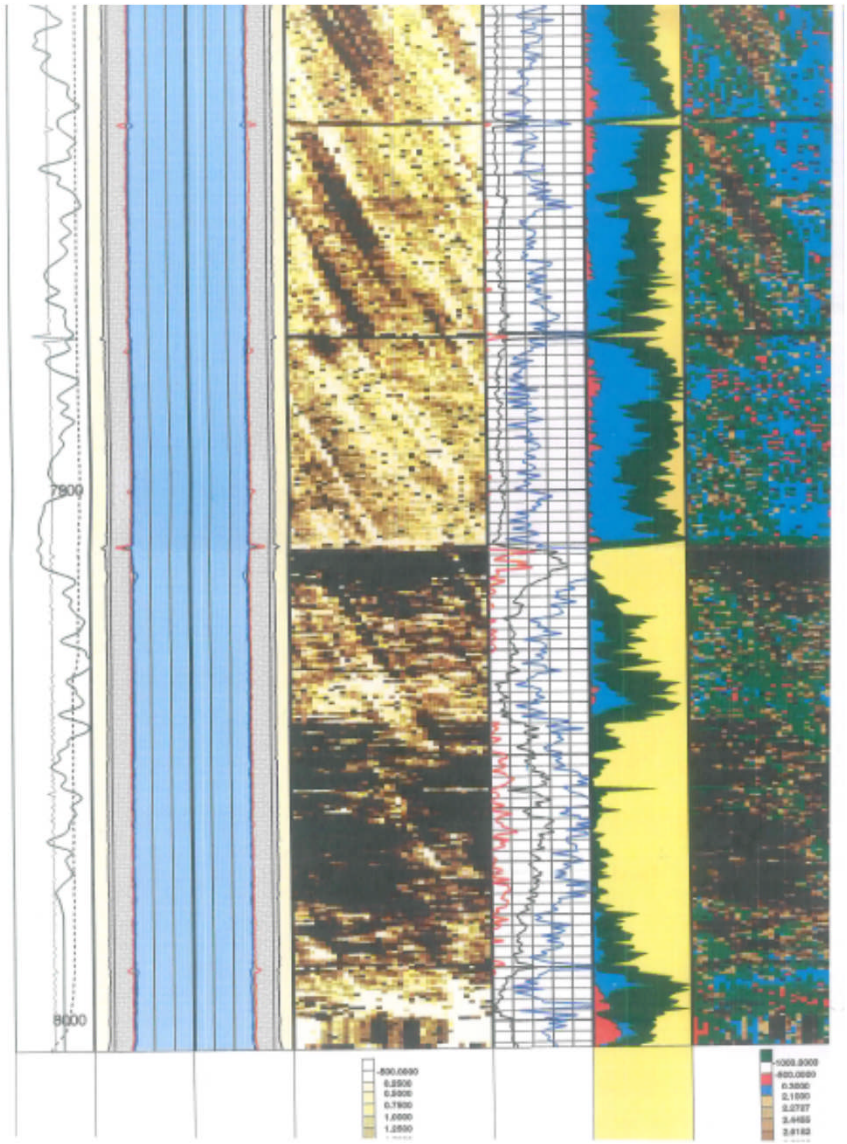
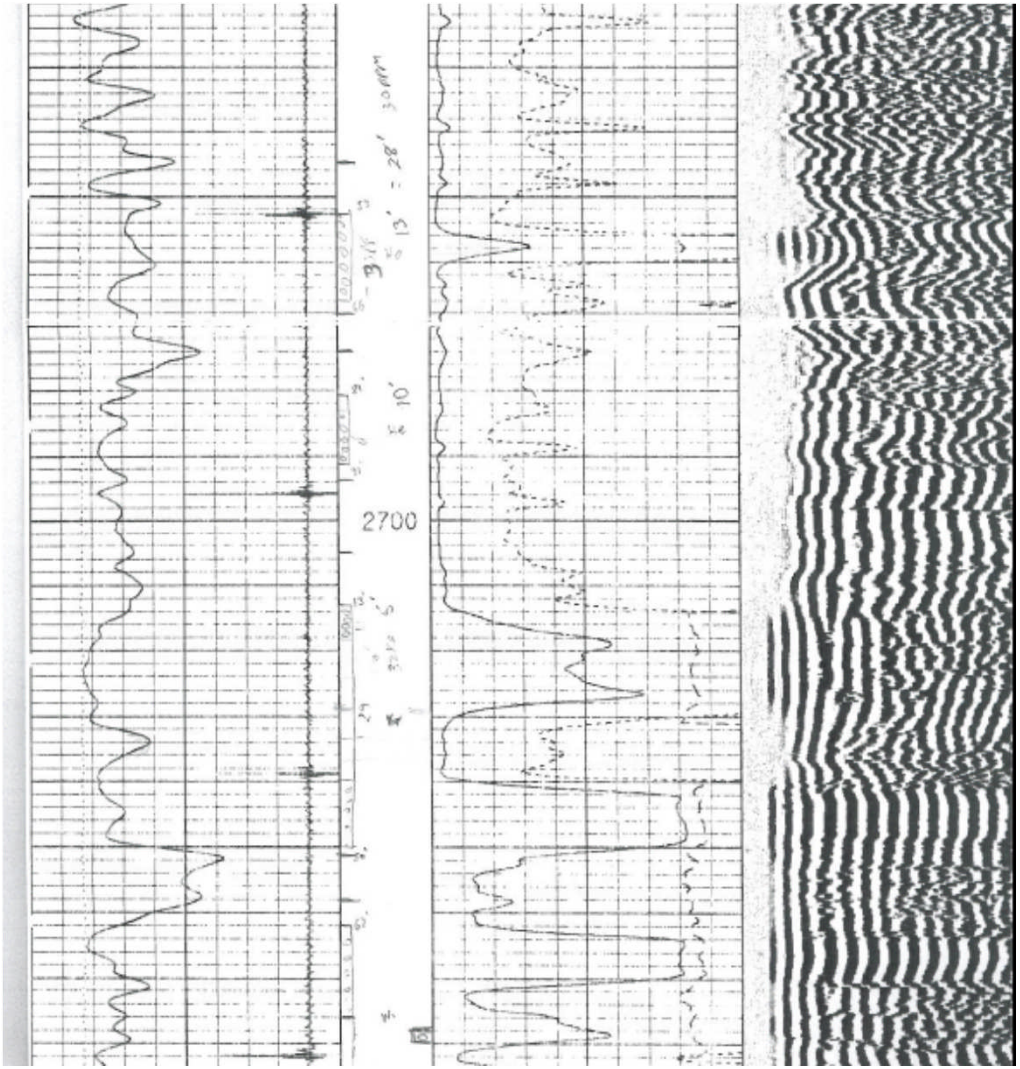


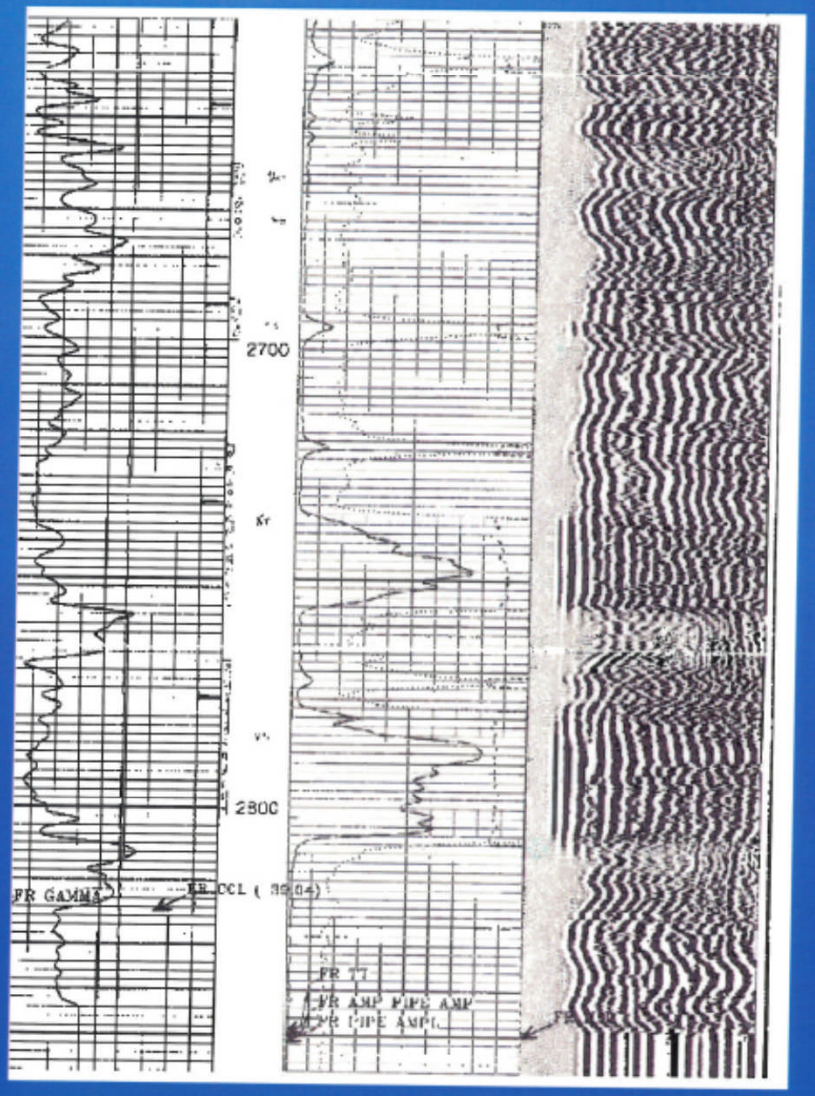
Kansas

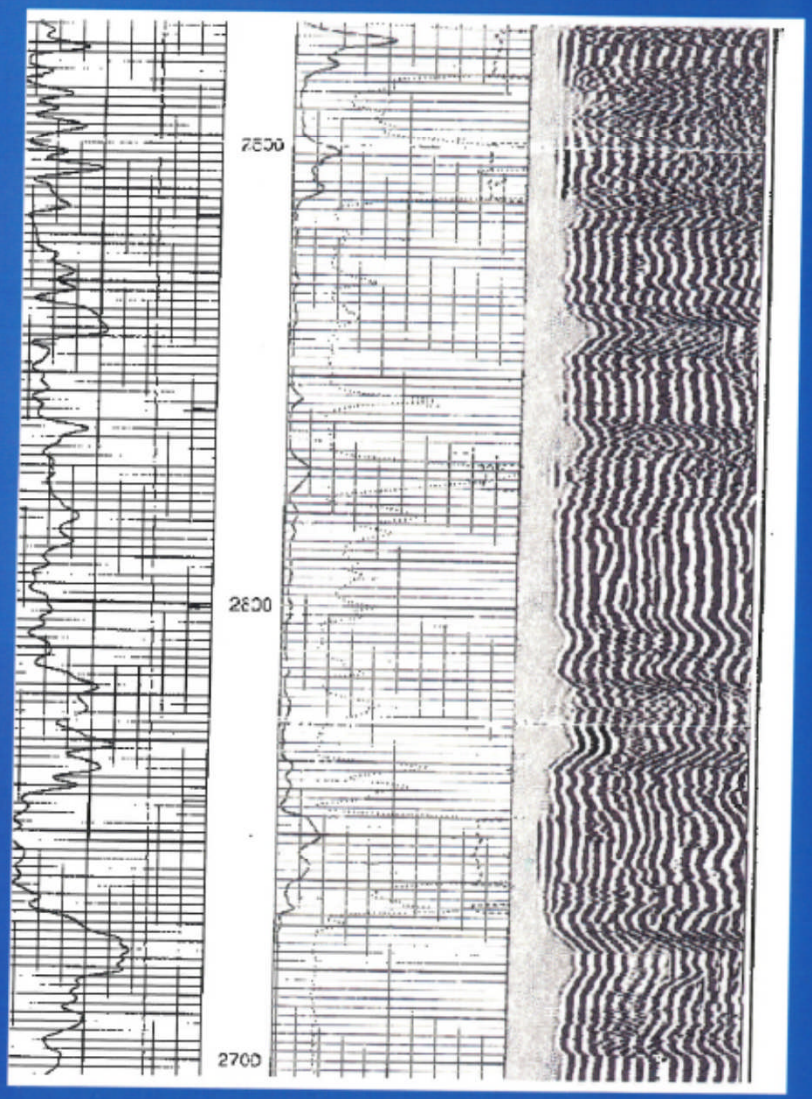


Kansas

Cement Bond Logs

Old cement blend





Improved cement blend

California