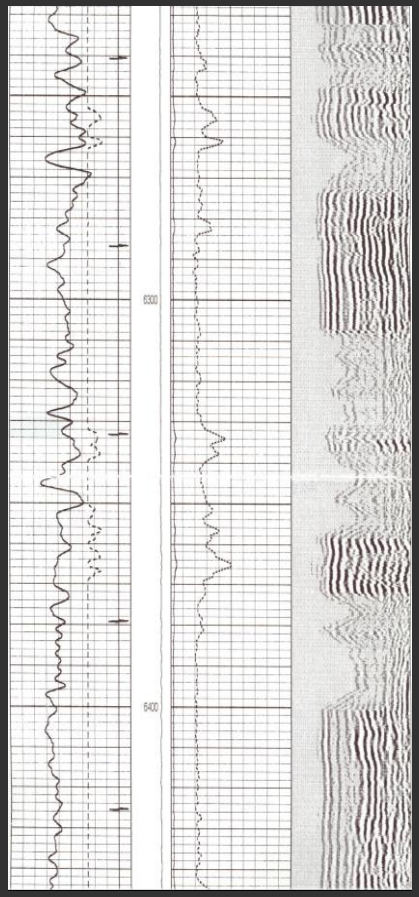
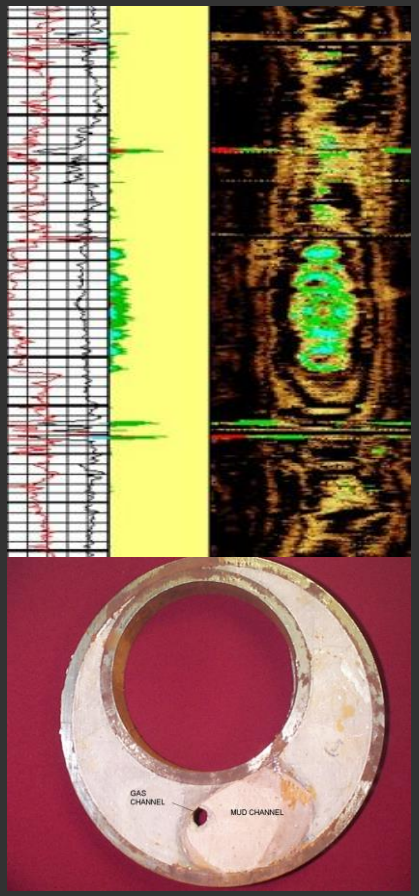
CEMENTING TO PREVENT CASING FAILURE

Kirk Harris
ThoroughBond LLC
JANUARY 2021

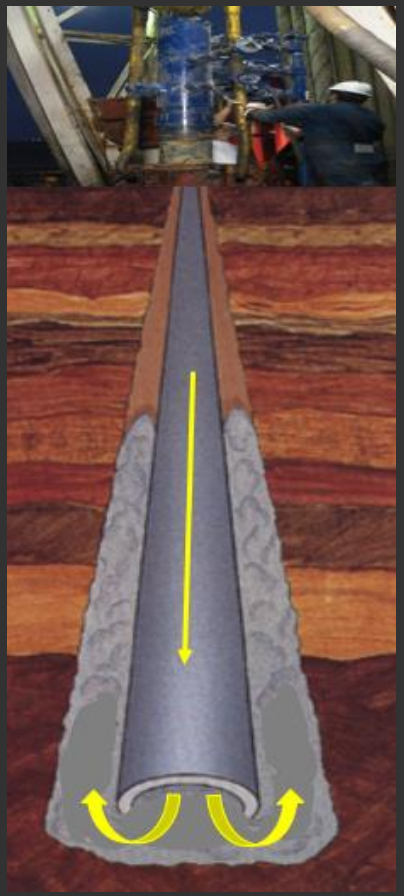
Agenda



Bonding Cement
To Protect Casing

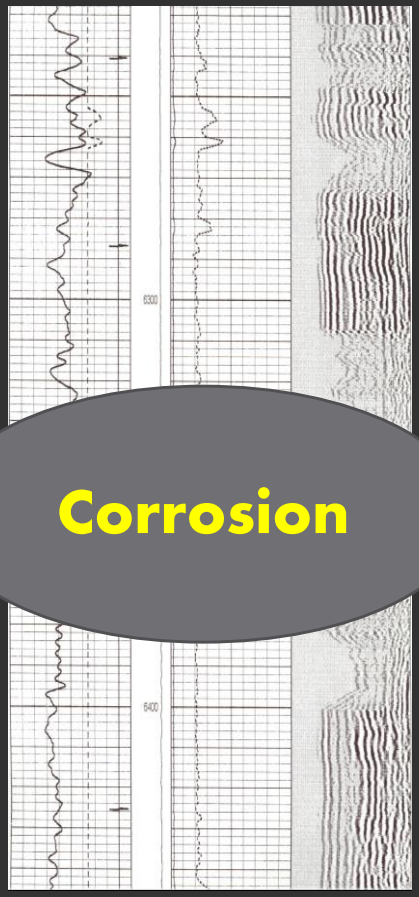


Displacing Mud
To Protect Casing



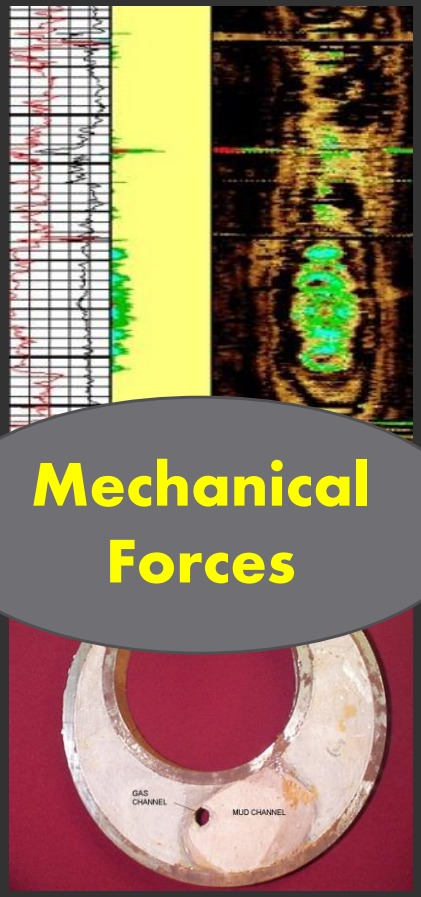
Lifting Cement
to Protect Casing

Agenda



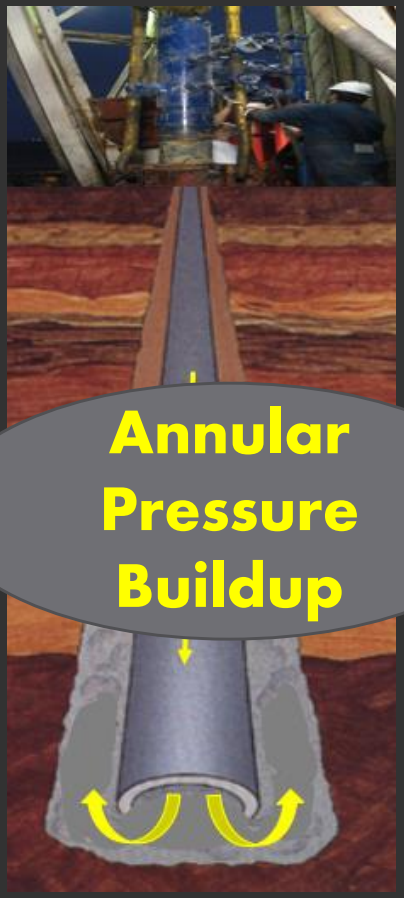
Corrosion

Bonding Cement
To Protect Casing



Mechanical Forces

Displacing Mud
To Protect Casing



Annular Pressure Buildup

Lifting Cement
to Protect Casing

Cementing Quiz

1. The three legs of the well integrity stool are:

   - Casing Design
   - Material(s) Selection
   - ?

Cementing Quiz

1. The three legs of the well integrity stool are:

   - Casing Design
   - Material(s) Selection
   - **Cementing**

Cementing Quiz

2. What are the three main reasons we cement wells ?

Cementing Quiz

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   - **Zonal Isolation**

Cementing Quiz

2. What are the three main reasons we cement wells ?

- **Zonal Isolation**
- **Protect the Casing**

Cementing Quiz

2. What are the three main reasons we cement wells ?

- **Zonal Isolation**
- **Protect the Casing**
- **Support the Casing**

Protect the Casing from Corrosion

Cementing Quiz

3. Does cement corrode ?

Cementing Quiz

3. Does cement corrode ?

- **Yes**

Cementing Quiz

3. Does cement corrode ?

- **Yes**
- **And No**

Cementing Quiz

4. What cementing “best practice” do we often “not practice”?

Cementing Quiz

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   - **Centralization**

Cementing Quiz

4. What cementing “best practice” do we often “not practice”?

- **Centralization**
- **Pipe Movement**

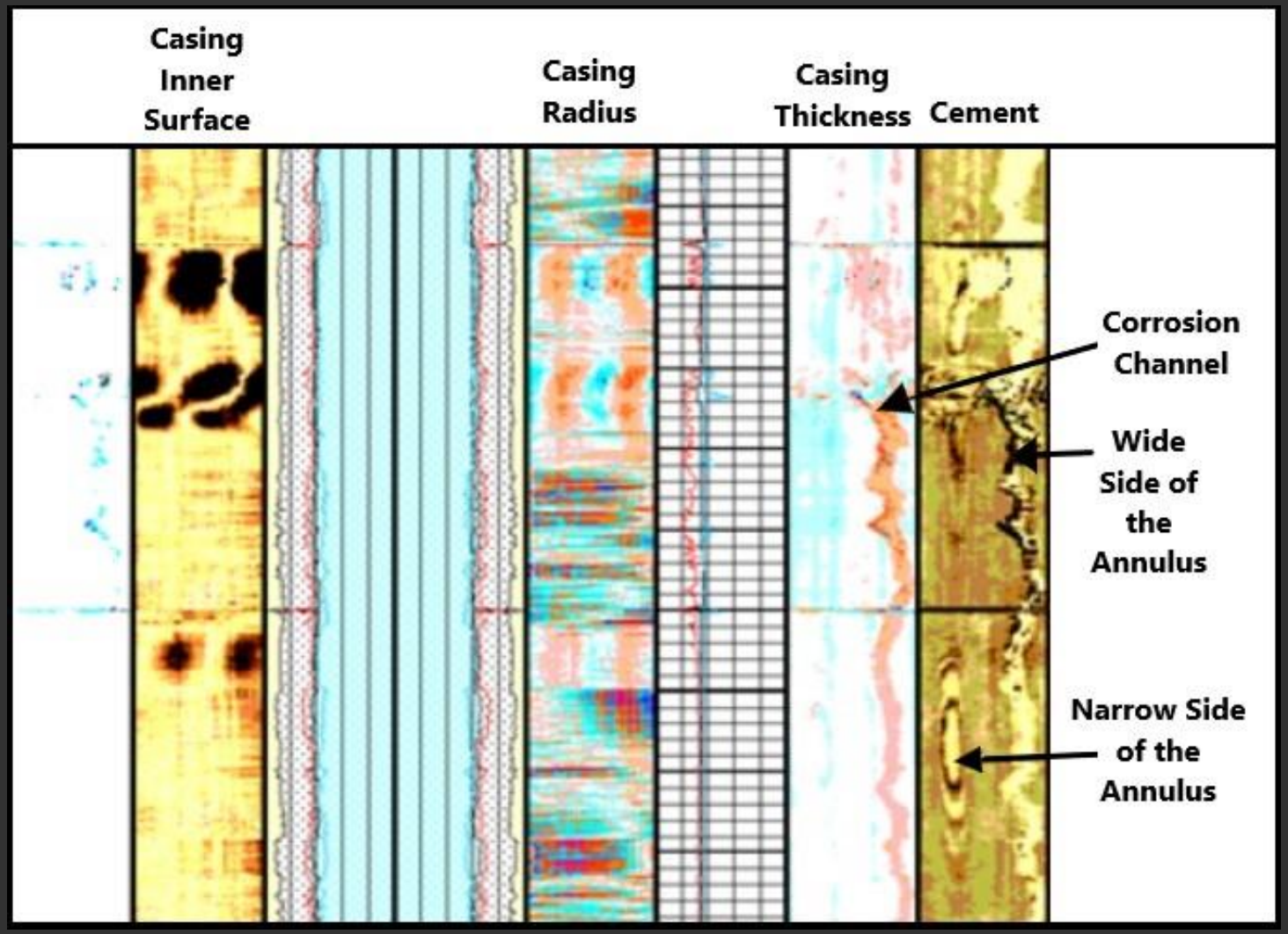
Cementing Quiz

4. What cementing “best practice” do we often “not practice”?

- **Centralization**
- **Pipe Movement**
- **Enhanced Bond**

Bonding Cement to Combat Corrosion

Casing Failure by Corrosion



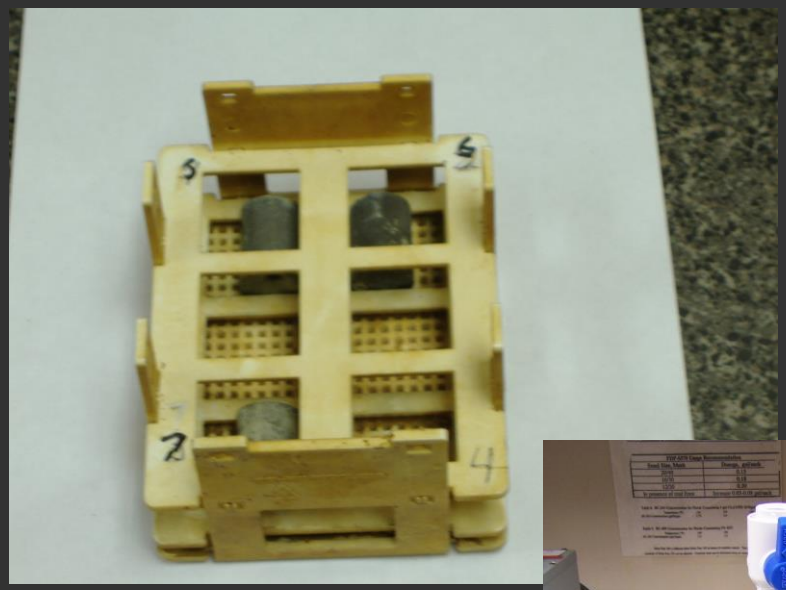
Cement Corrosion Requires…

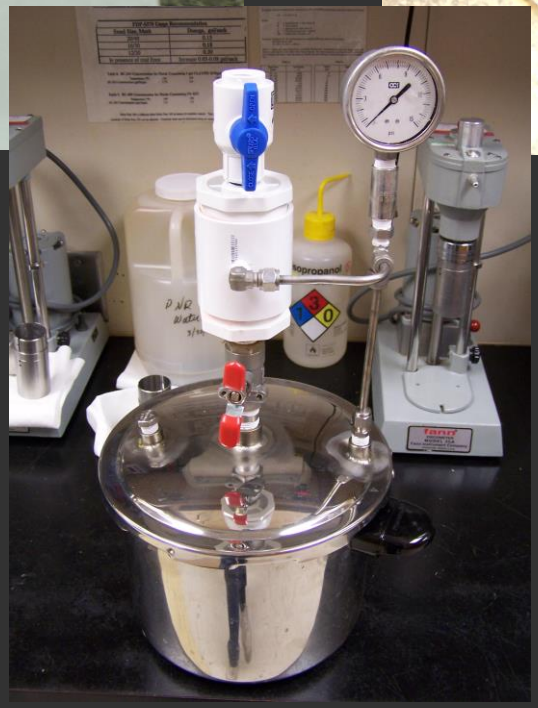
1. Acid Solubility
2. Exposure to the “Acid”
3. Transport of Residue

Sulfuric Acid

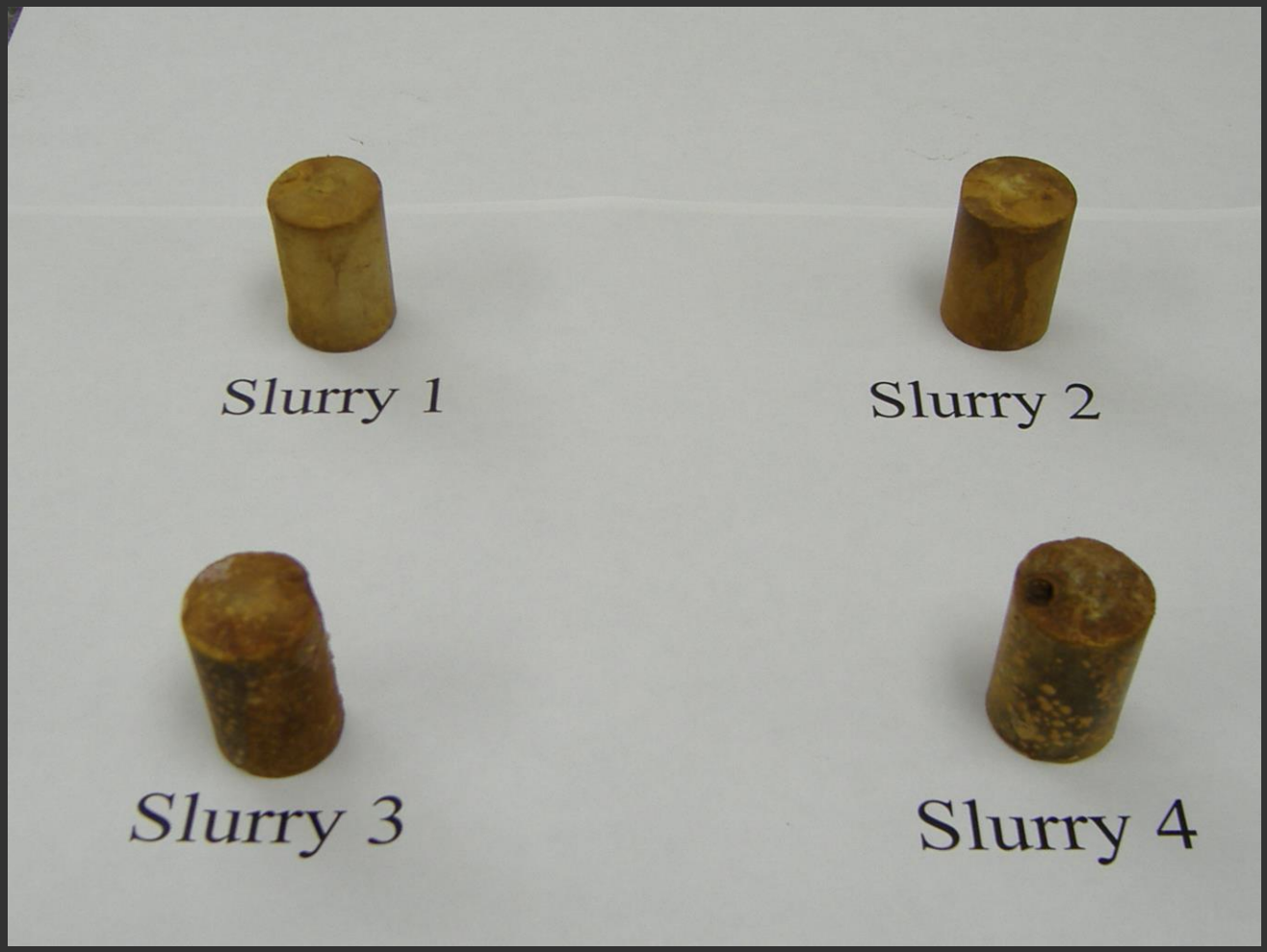
Sulfuric Acid

Carbonic Acid





Carbonic Acid



Carbonic Acid

$$Ca(OH)_2 + HCO_3 \rightarrow CaCO_3 + 2H_20$$

Cement + Carbonic Acid = Calcium Carbonate + Water

Formation of Calcite

Formation of Calcite

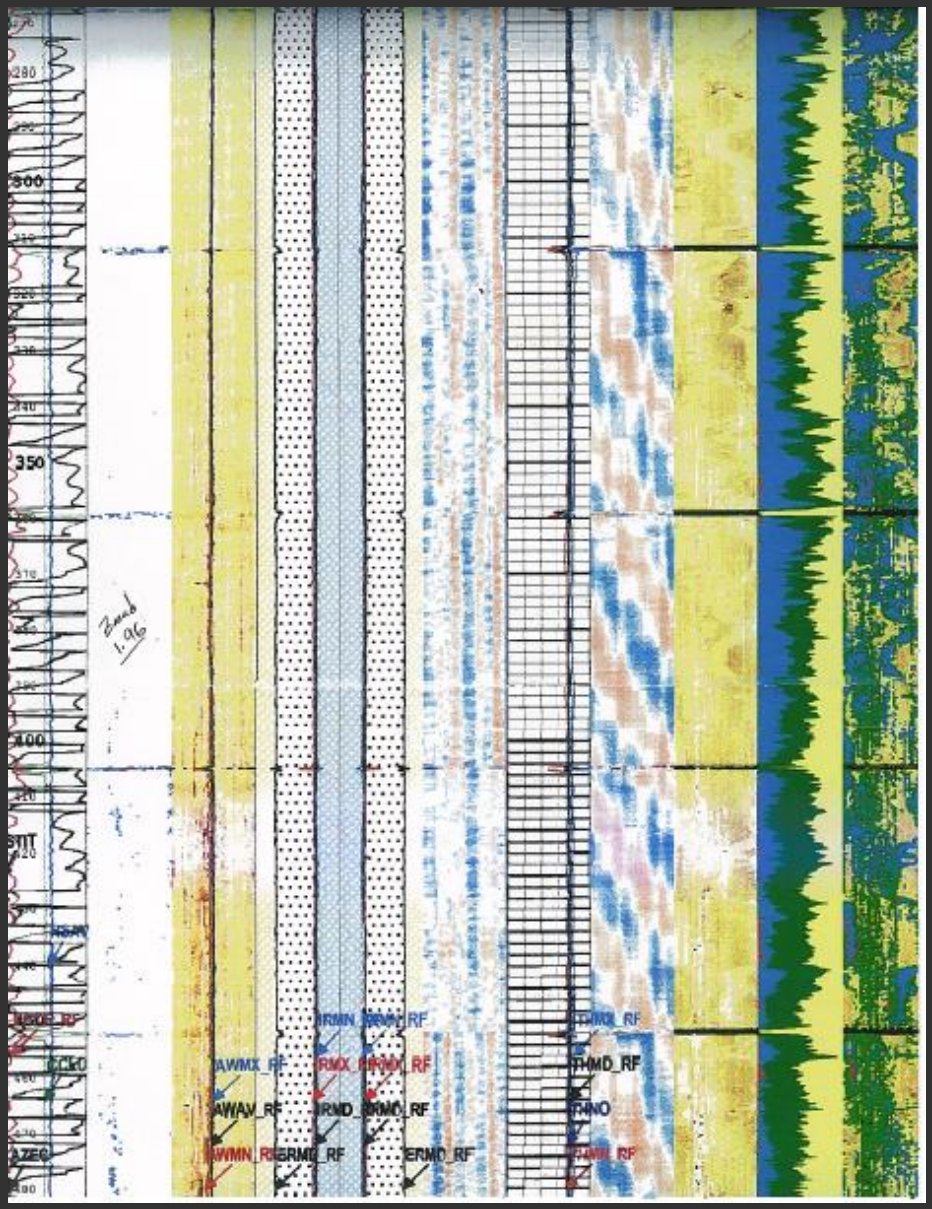
Increases Shear Bond

Acid Solubility

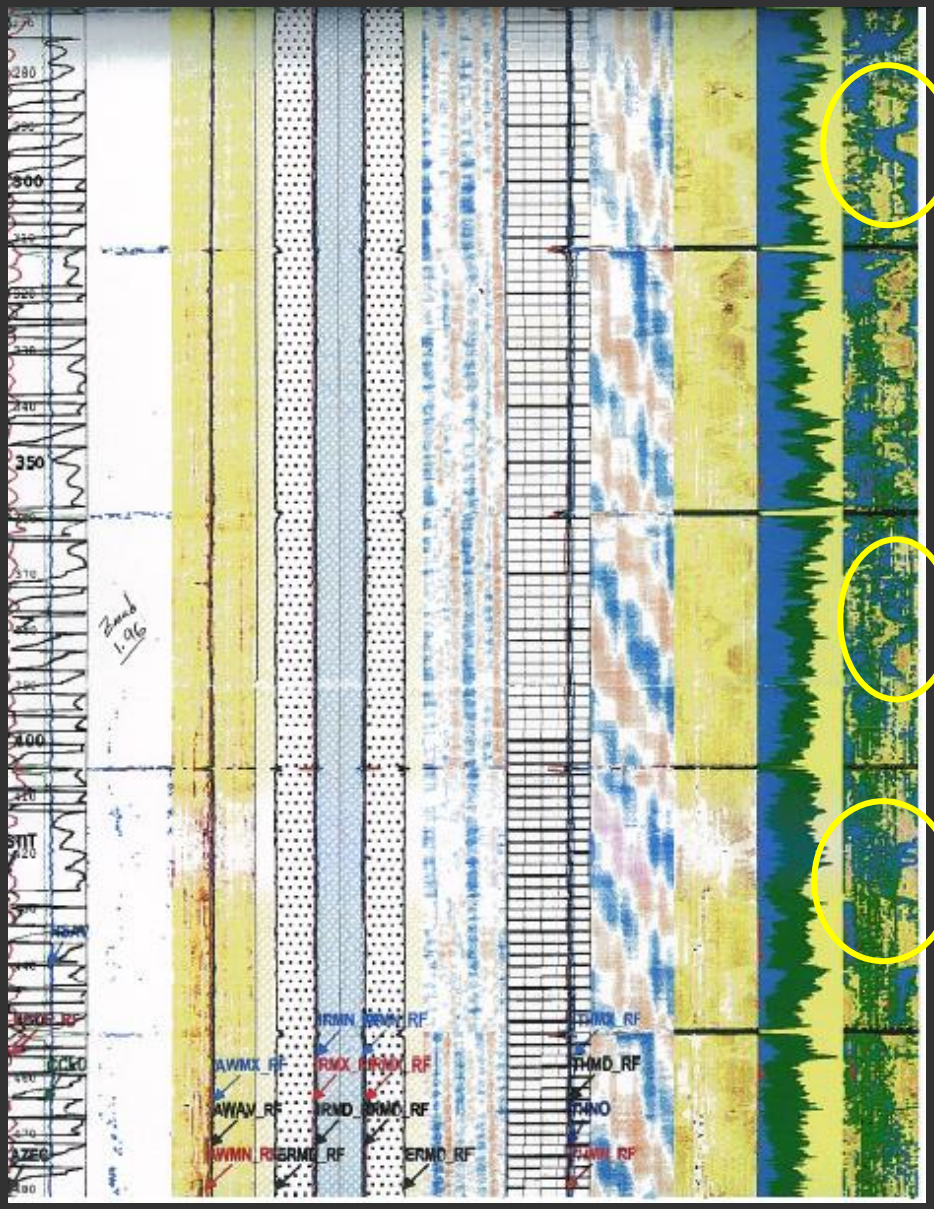
- Cement – 40 %
- Pozmix Slurries – 15 – 90 %
- Low Fluid Loss Slurries – 4 - 7 %
- Latex Slurries – 3 - 5 %
- Non-Portland– 0 – 1 %

Exposure

Exposure


280
300
350
400
AWMX_RF
AWAV_RF
AWMN_RF
RMX_RF
RMD_RF
ERMD_RF
THMX_RF
THMD_RF
THMO

Exposure


280
300
350
400
Band 1.96
AWMX_RF
AWAV_RF
AWMN_RF
RMX_RF
RMD_RF
RMN_RF
ERMD_RF
THMD_RF
THNO

Transport

Cementing Solutions for Corrosion

Use of Non-Portland Cement

- Pozzolans without gel
- Calcium Aluminate Cement

Lower Cement Permeability

Increase Shear Bond

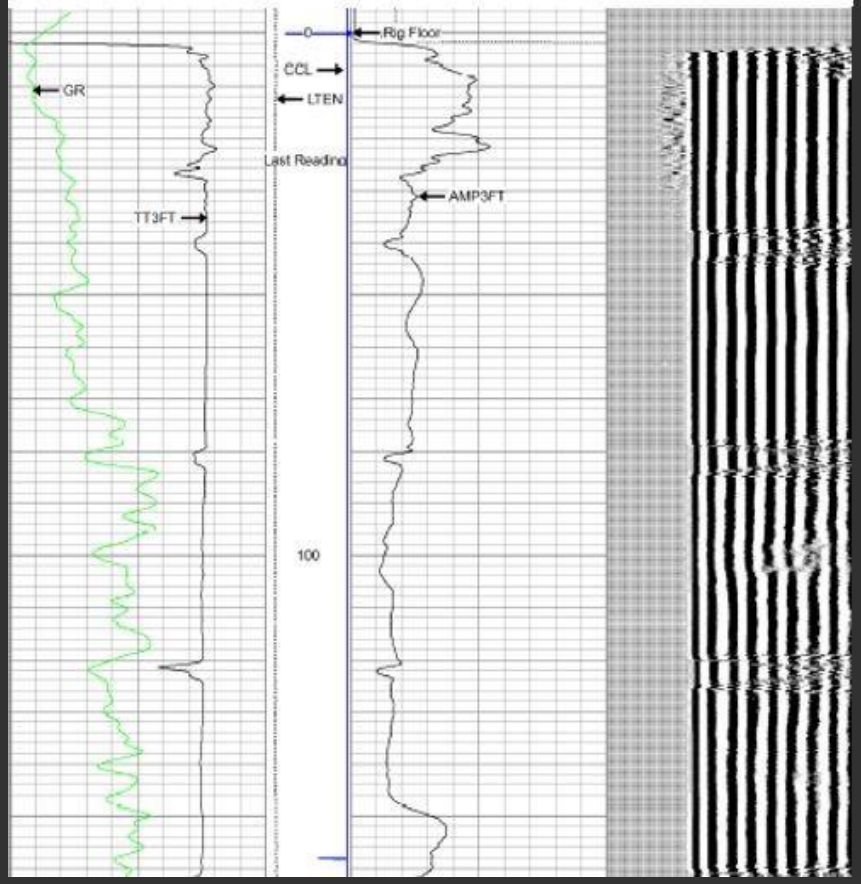
Cementing Solutions for Corrosion

Increase Shear Bond

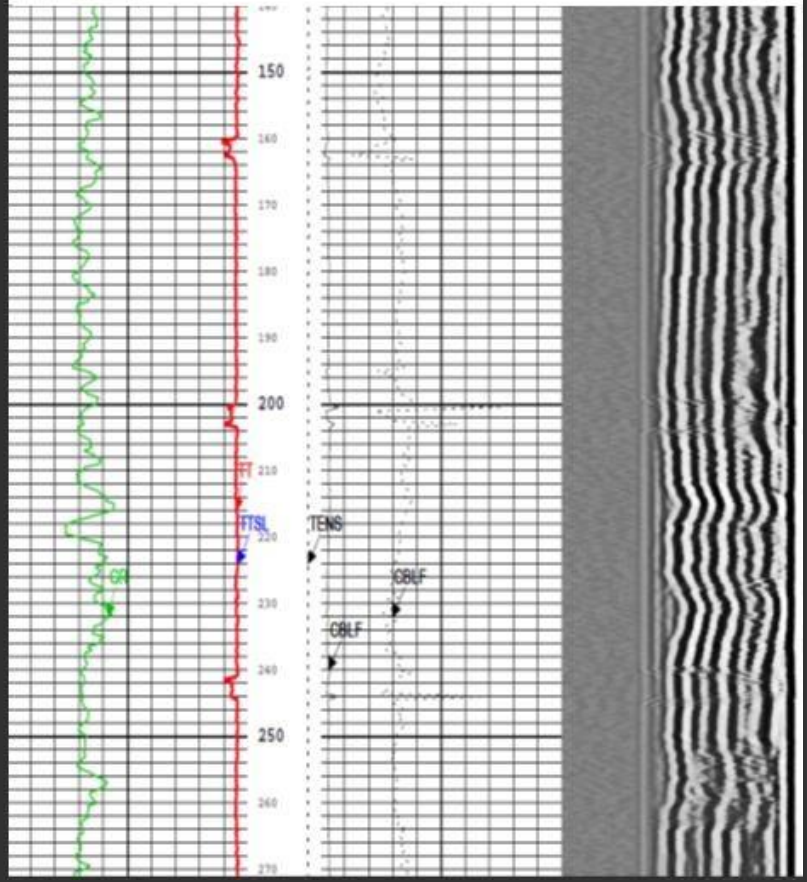
- Sand Blast Casing
- Fast Setting Cement
- High Shear Bond Cement
  - *0.3 – 1.2 % Expansion*
- Avoid Thin Cement Sheaths
- Displace with Light Fluids

Increasing Shear Bond

Normal



High Shear Bond



13 3/8” Casings

CO_2 Papers

Effective Zonal Isolation for CO_2 Sequestration Wells - Sweatman et al

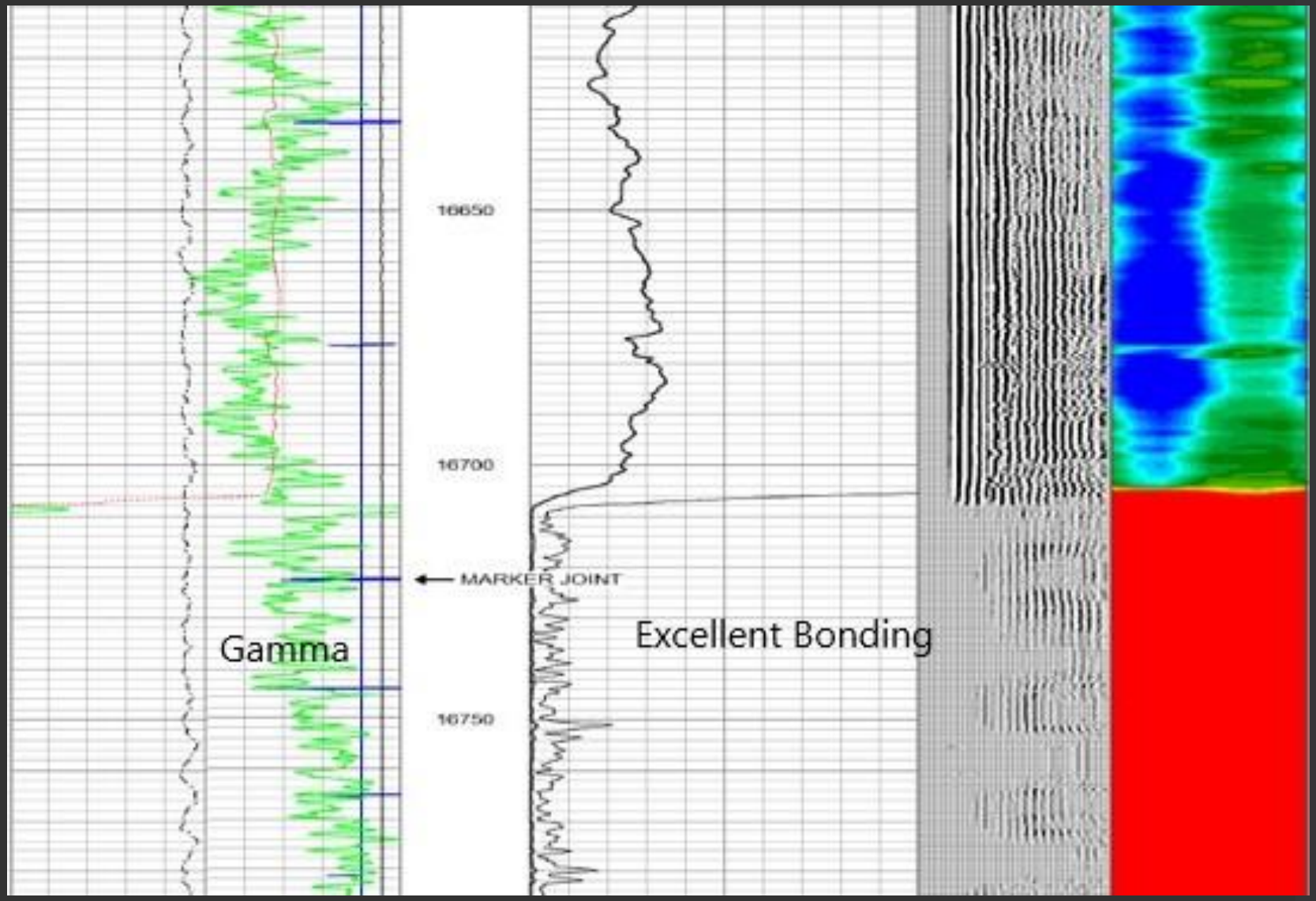
Effects of Supercritical Carbon Dioxide on Well Cements - Onan

Shear Bond Strength of Oil Well Cement in Carbonic Acid Environment – Hwang et al

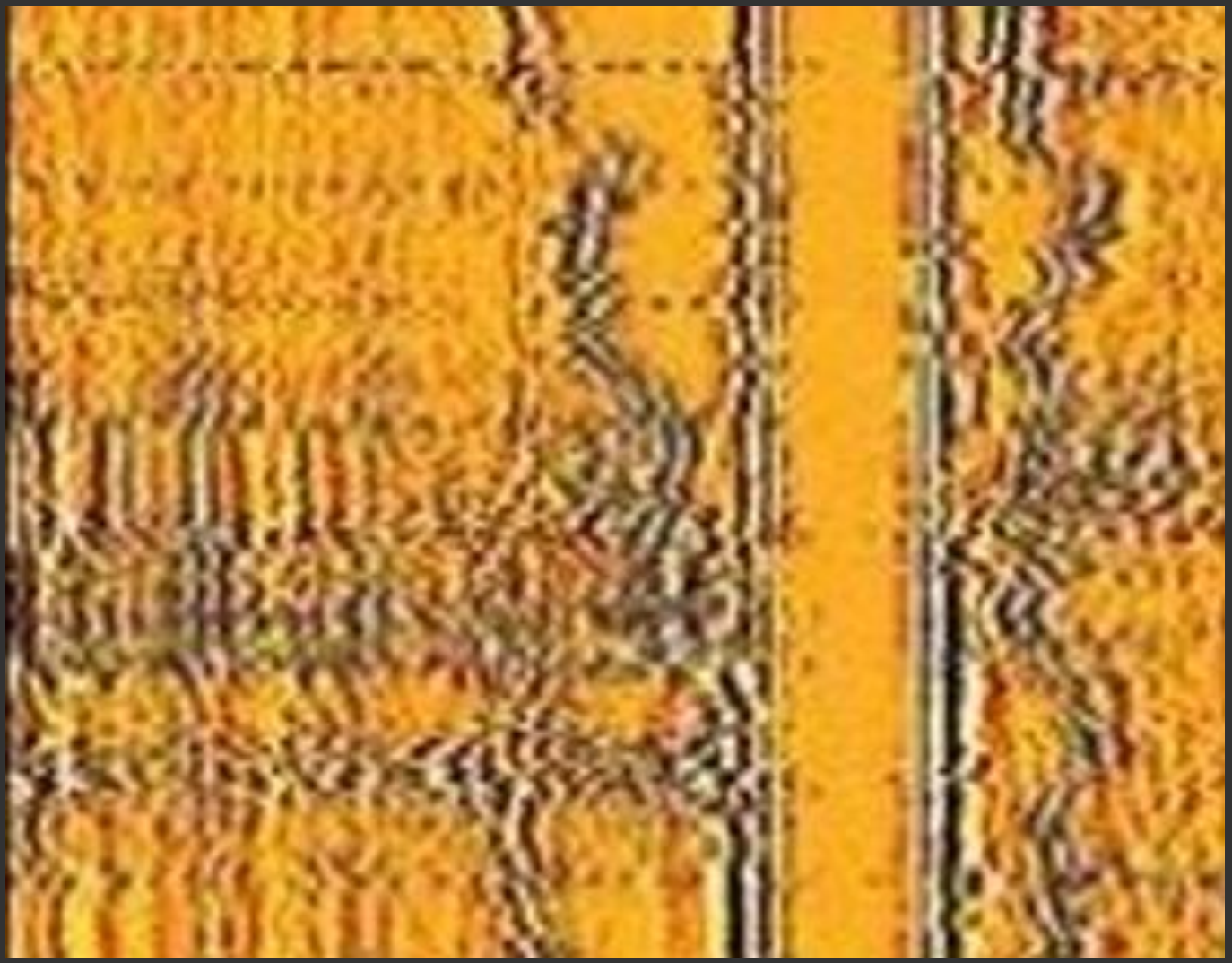
Displacing Mud to Combat Mechanical Forces

- Formation Creep
- Formation Subsidence
- Temperature-Induced Stresses
- Drilling Operations – Casing Wear

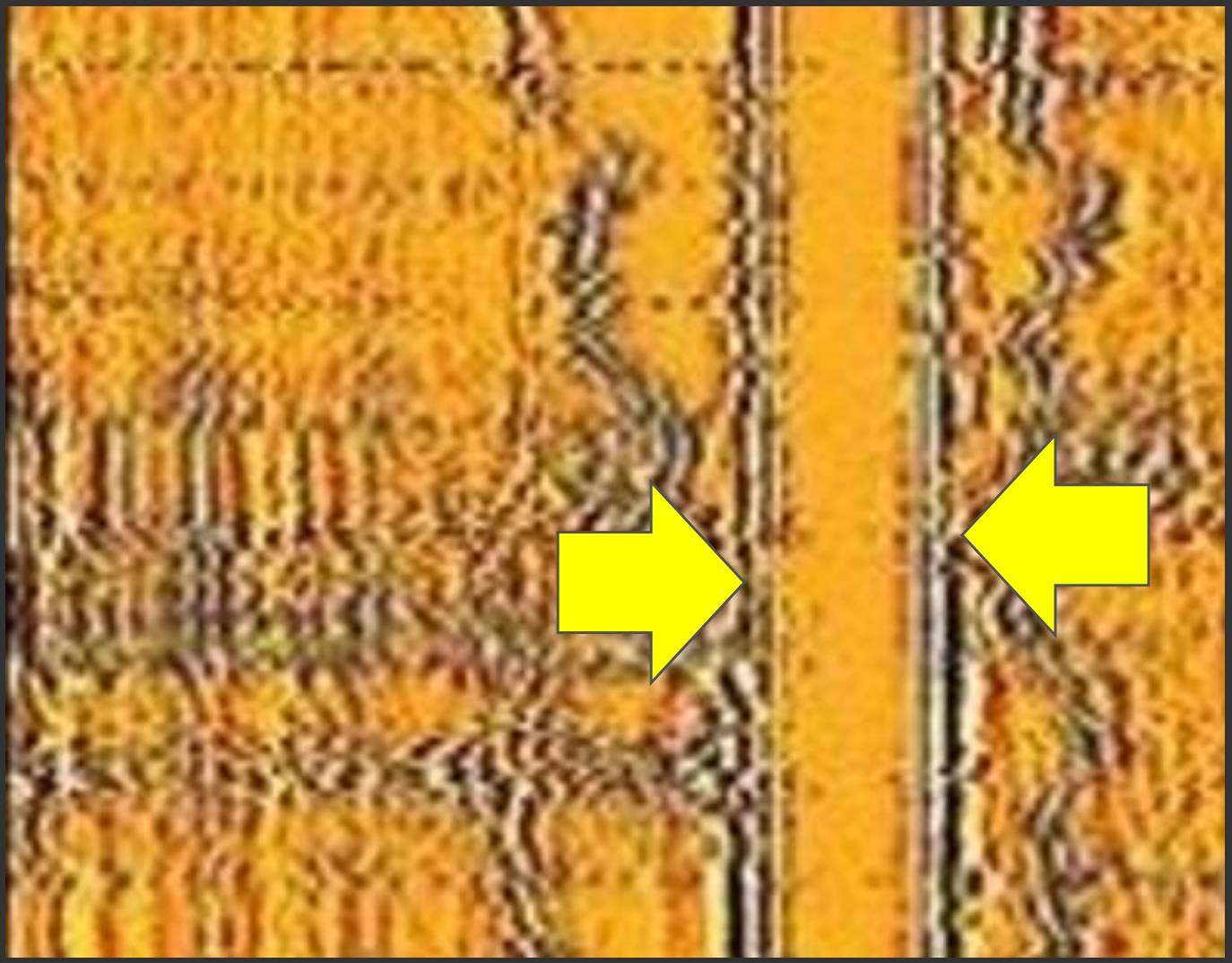
Formation Creep



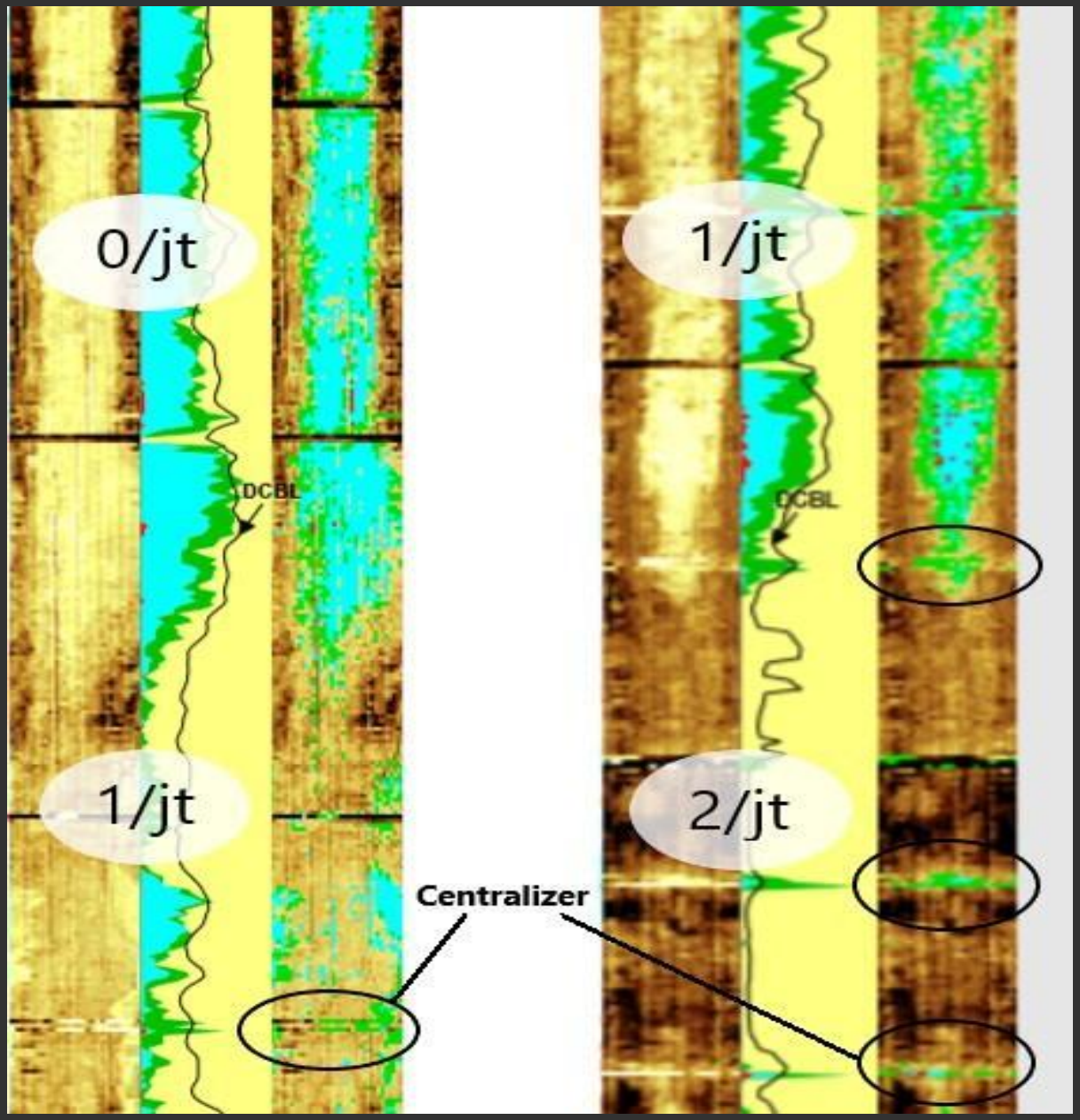
Formation Creep



Formation Creep

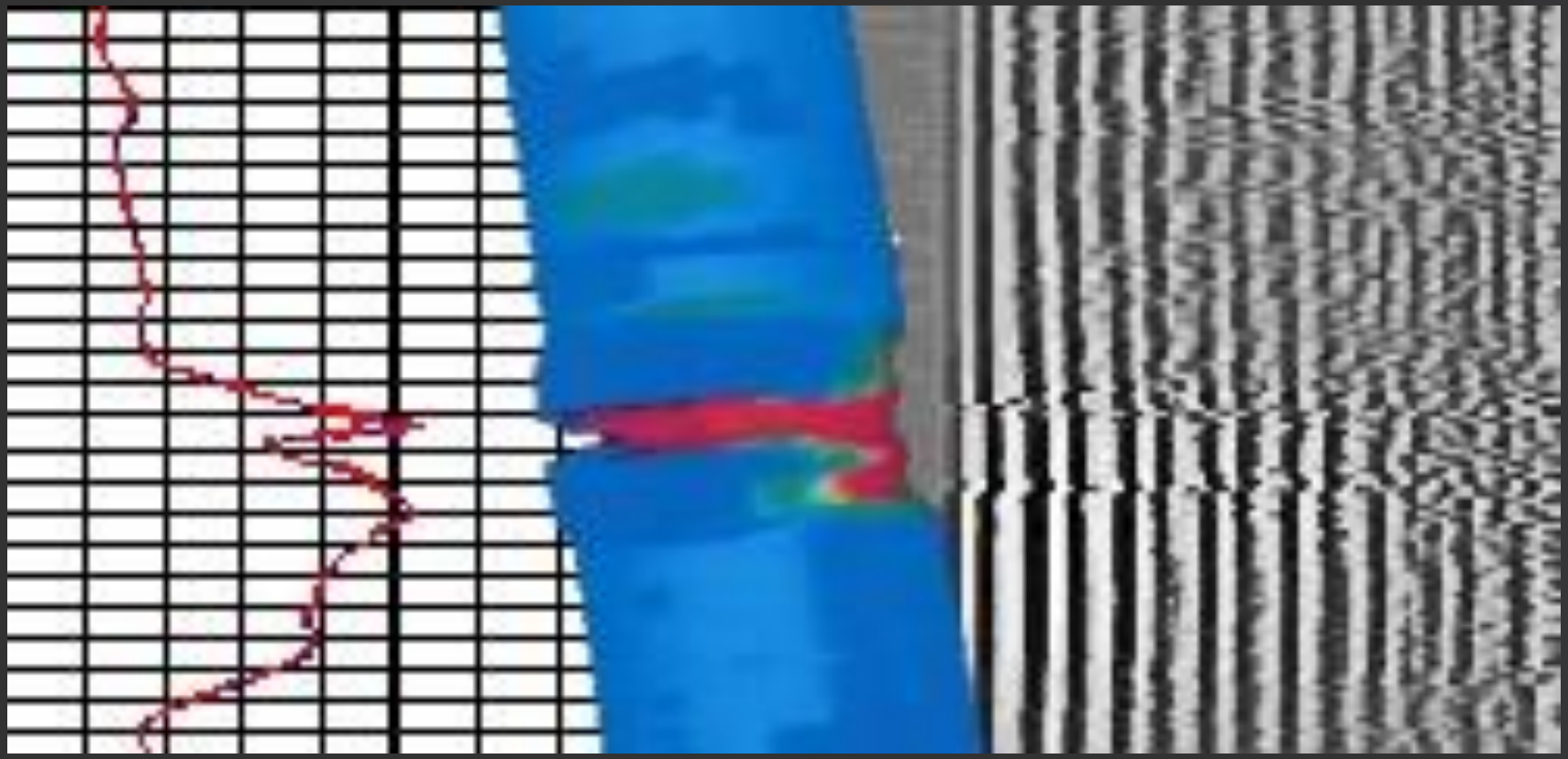


Displacing Mud

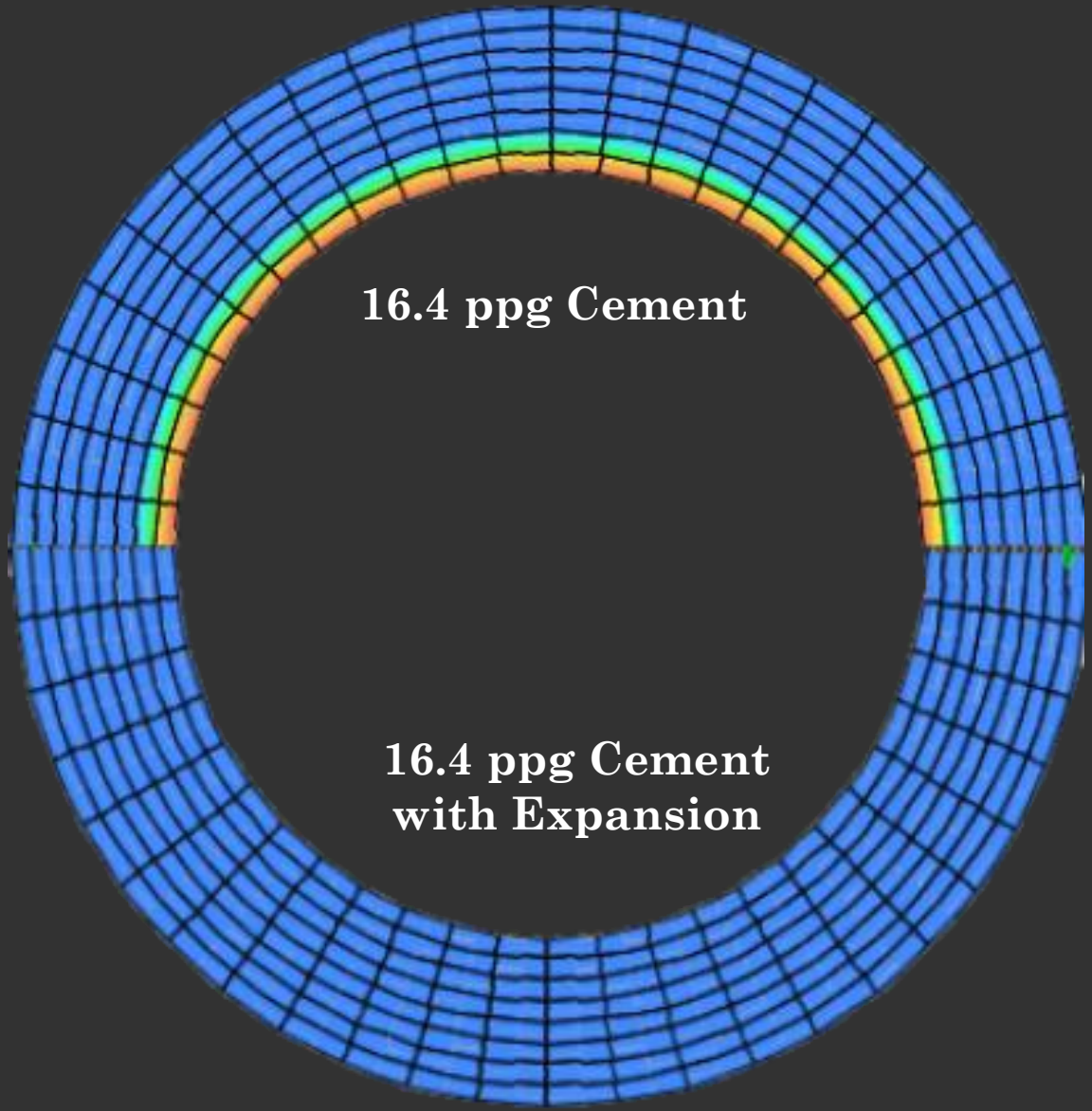


Casing Failure

Poor Mud Displacement



Stress Analysis – Cement Bond



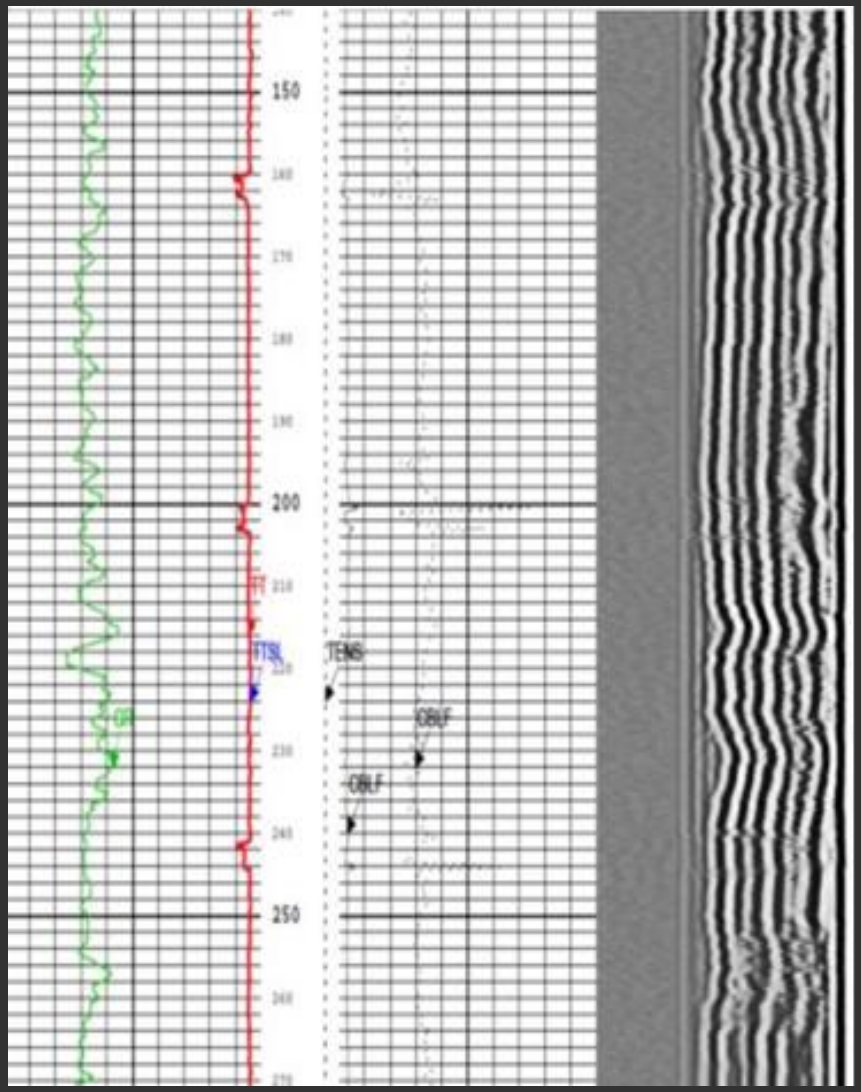
Cementing Mechanical Stresses

- Resilient Cement
  - Low Modulus of Elasticity
  - High and Early Strength
- Expansion – High Shear Bond
- For Salt Flows, KCL replacing Salt
- Uniform Cement Sheath
- Heavyweight Casing

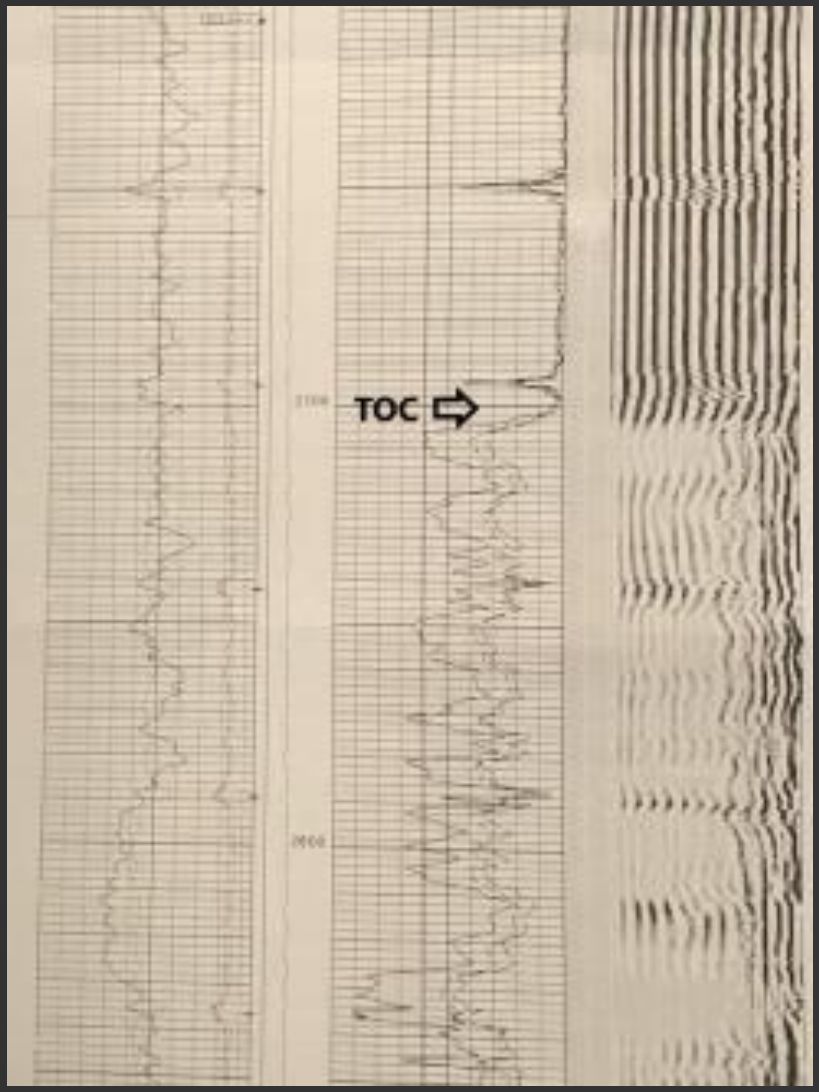
What is the greatest CEMENTING CHALLENGE in the world?


The greatest cementing challenge
in the world is
LOST CIRCULATION

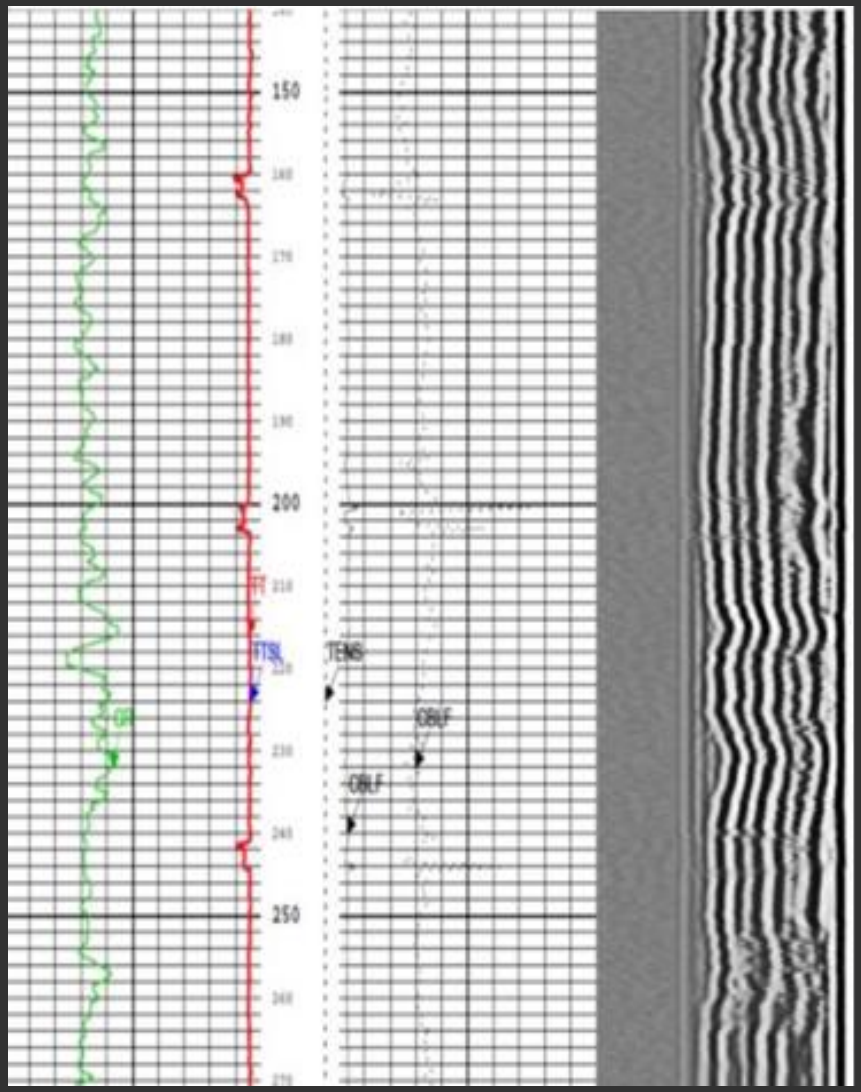
No Losses



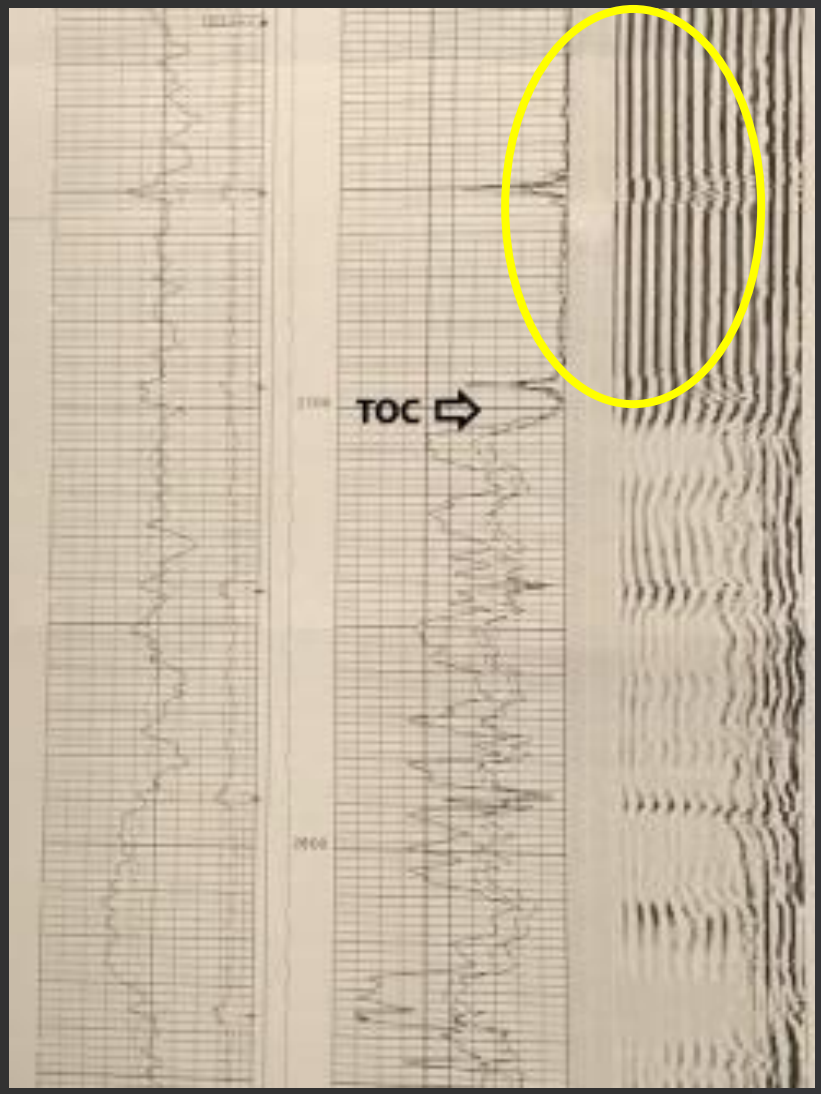
Full Losses



No Losses



Full Losses



Losses While Cementing

When cement is not present, the casing and casing connections are unprotected from…

- Corrosive Fluids

Losses While Cementing

When cement is not present, the casing and casing connections are unprotected from…

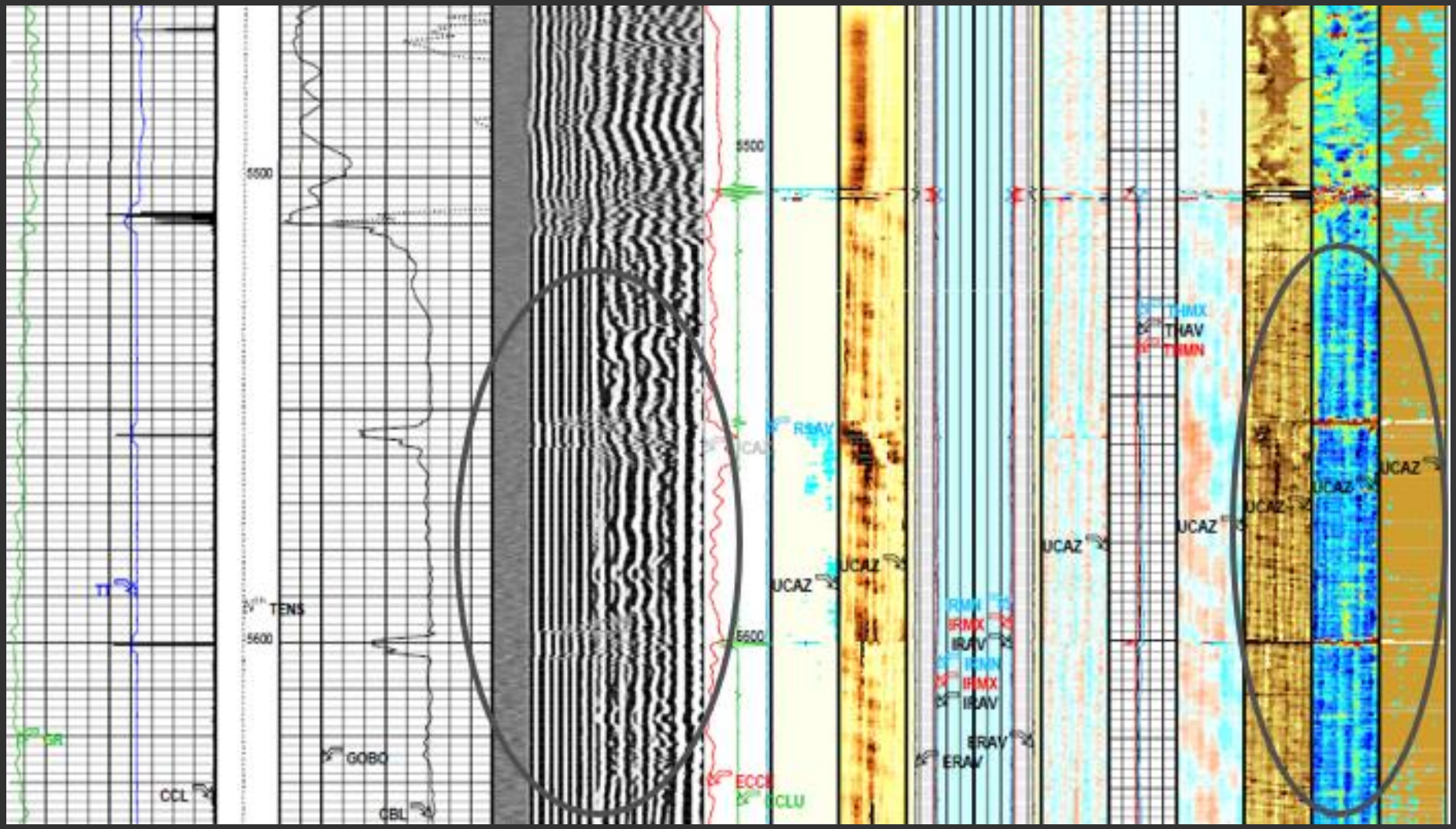
- Corrosive Fluids
- Mechanical Stresses

Losses While Cementing

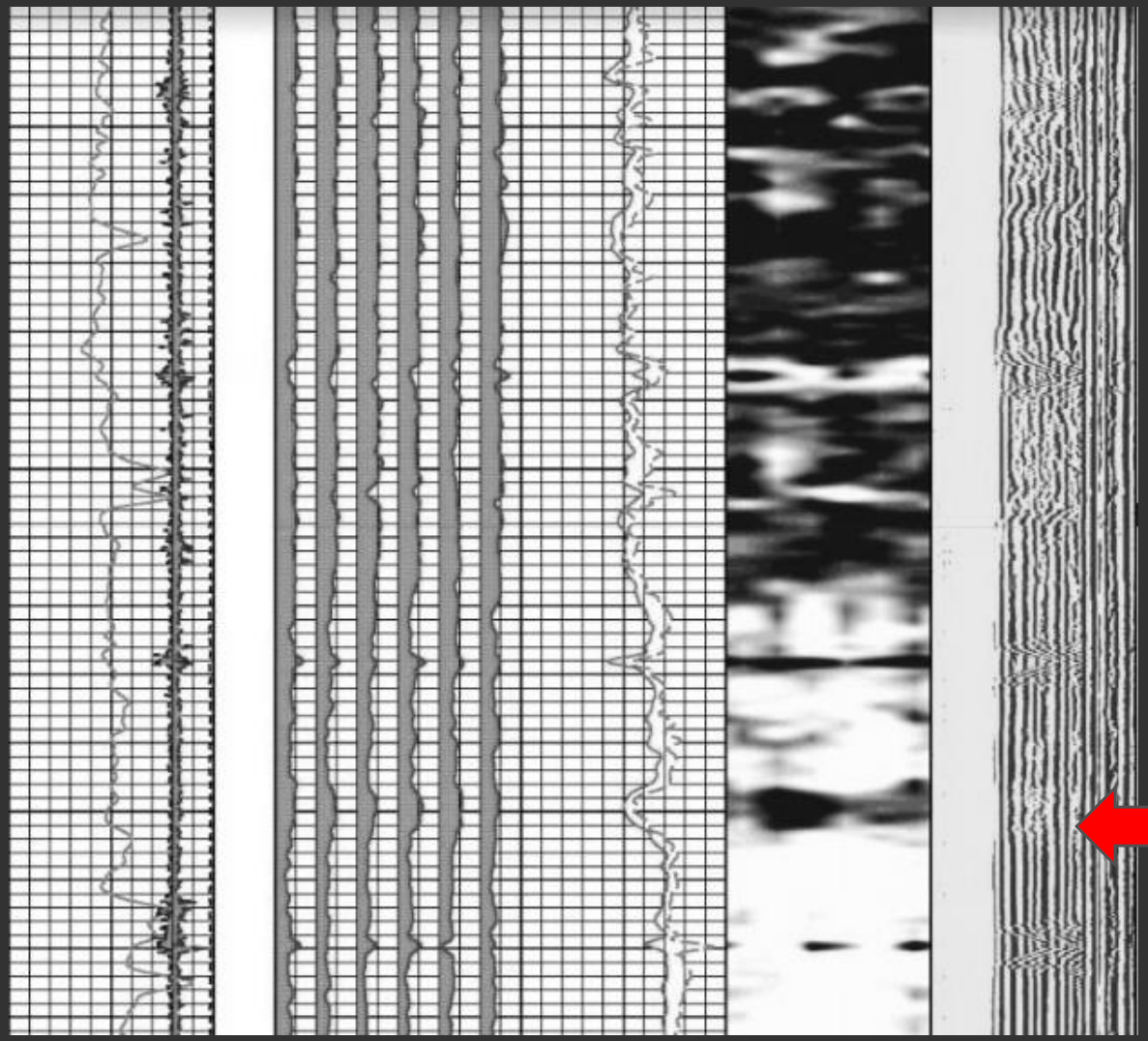
When cement is not present, the casing and casing connections are unprotected from…

- **Corrosive Fluids**
- **Mechanical Stresses**
- **Annular Pressure Buildup**

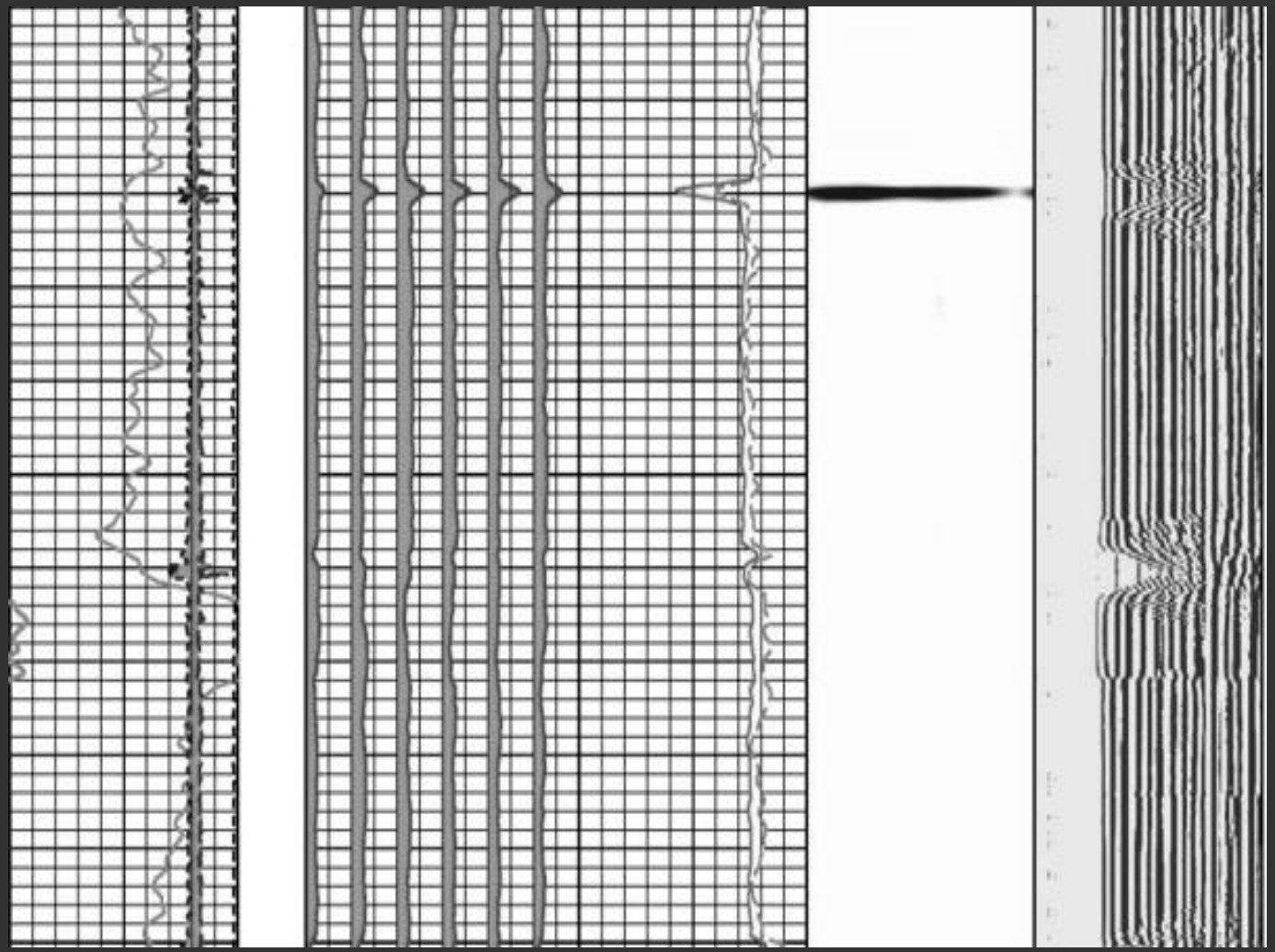
Losses and Corrosion



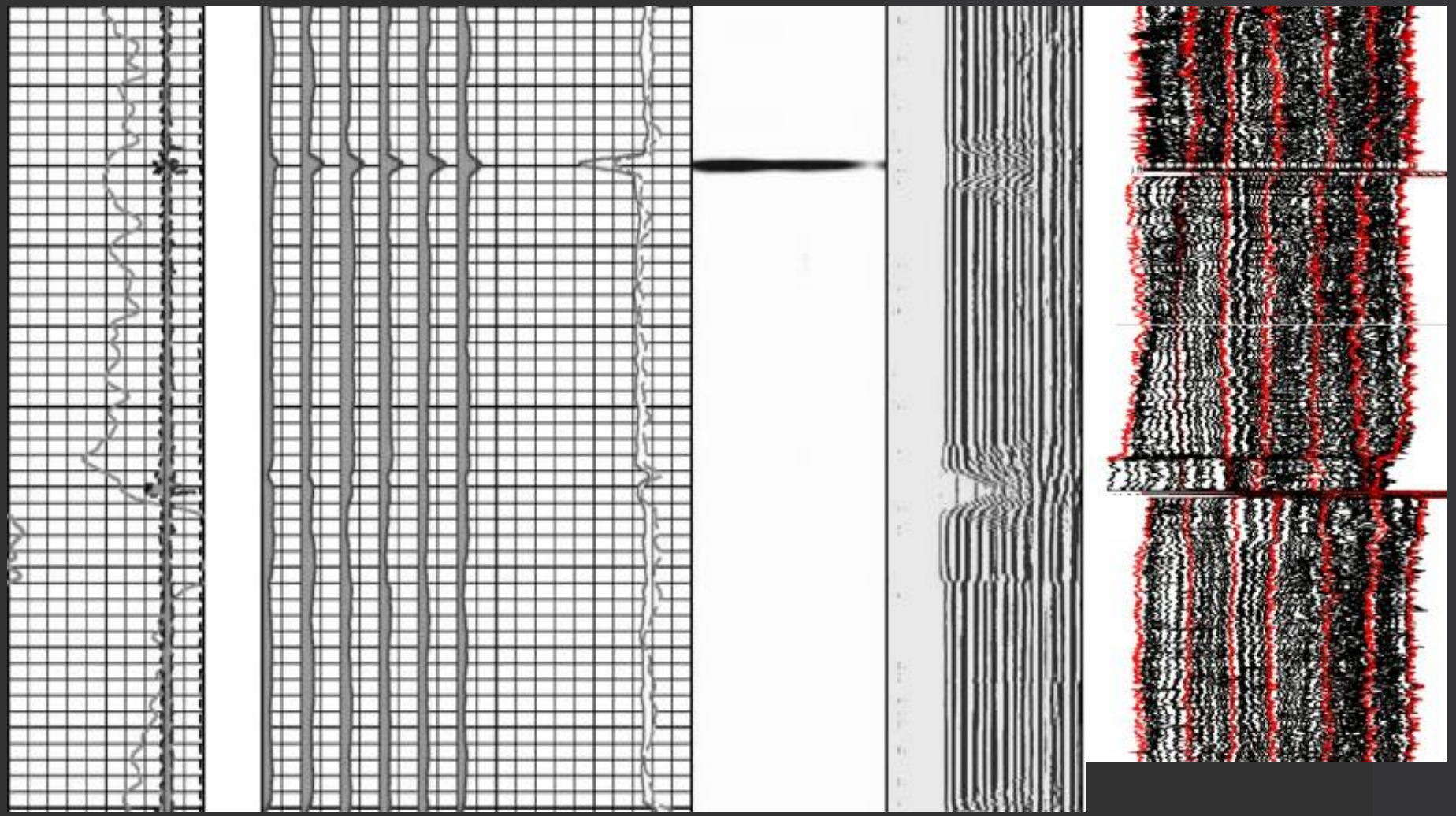
Losses and Casing Failure



Losses and Casing Failure



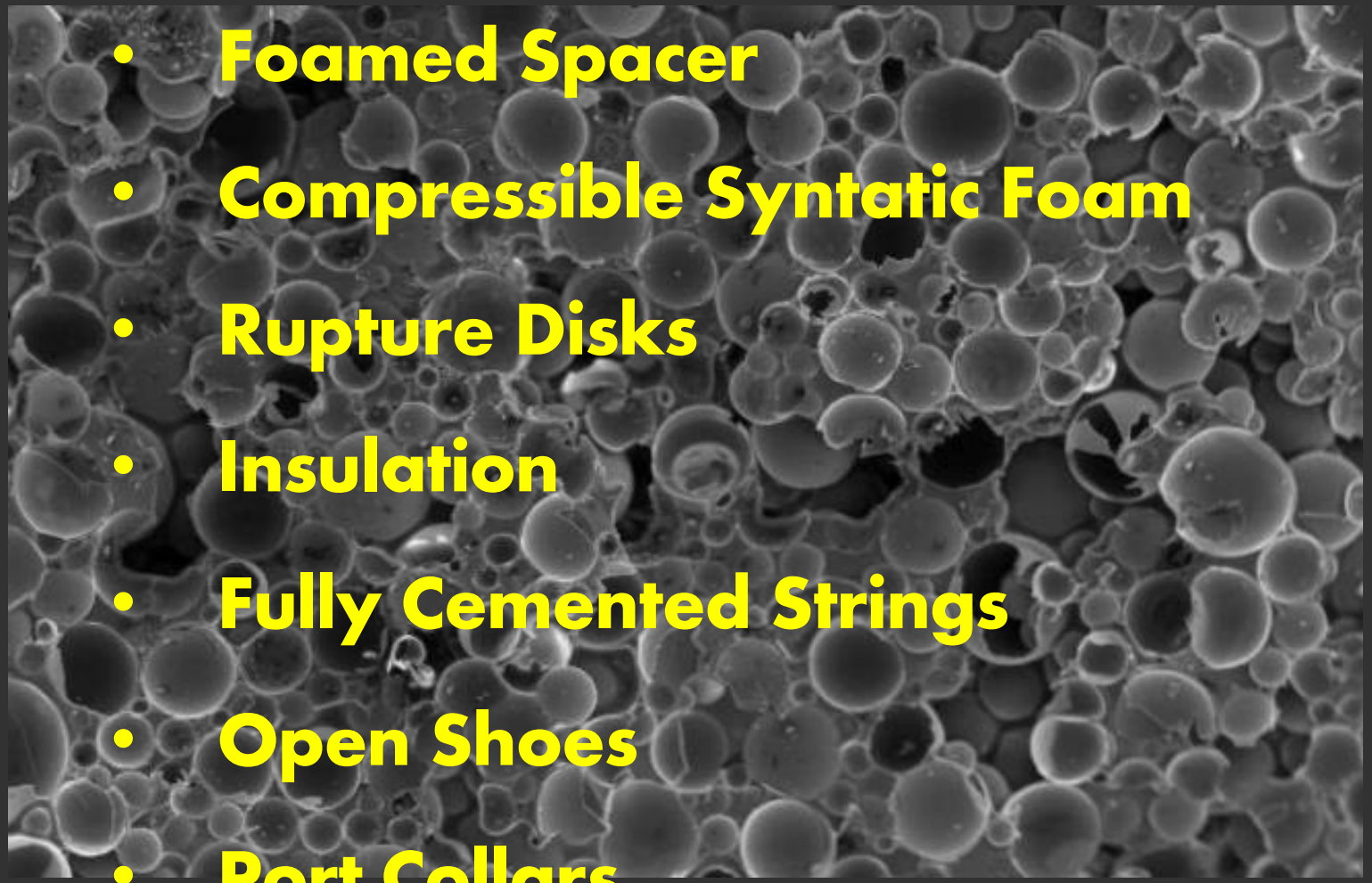
Losses and Casing Failure



Annular Pressure Buildup (APB)

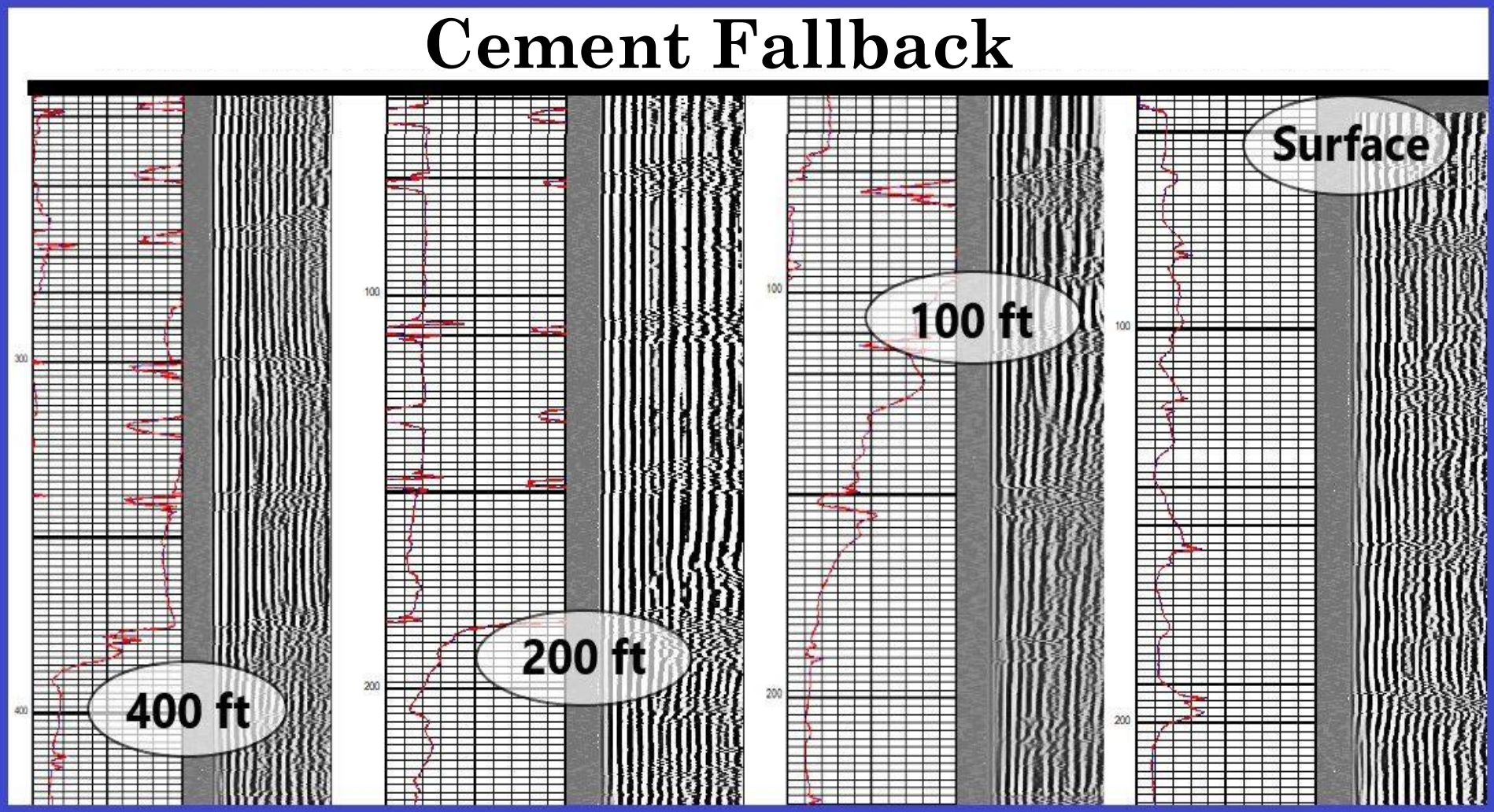
Pressure increase
in an annular void
(often casing x casing)
due to temperature rise

Annular Pressure Buildup (APB) Solutions



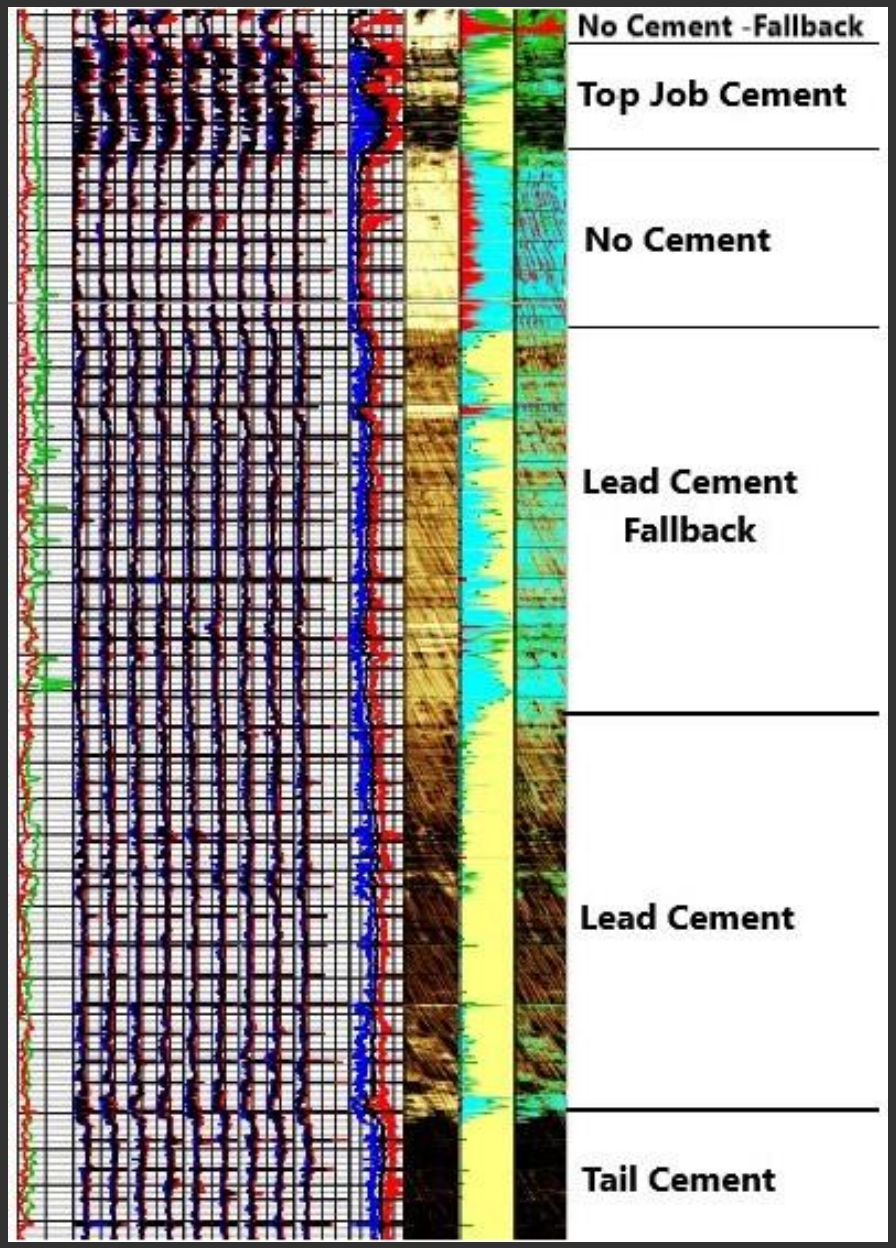
- Foamed Spacer
- Compressible Syntatic Foam
- Rupture Disks
- Insulation
- Fully Cemented Strings
- Open Shoes
- Port Collars

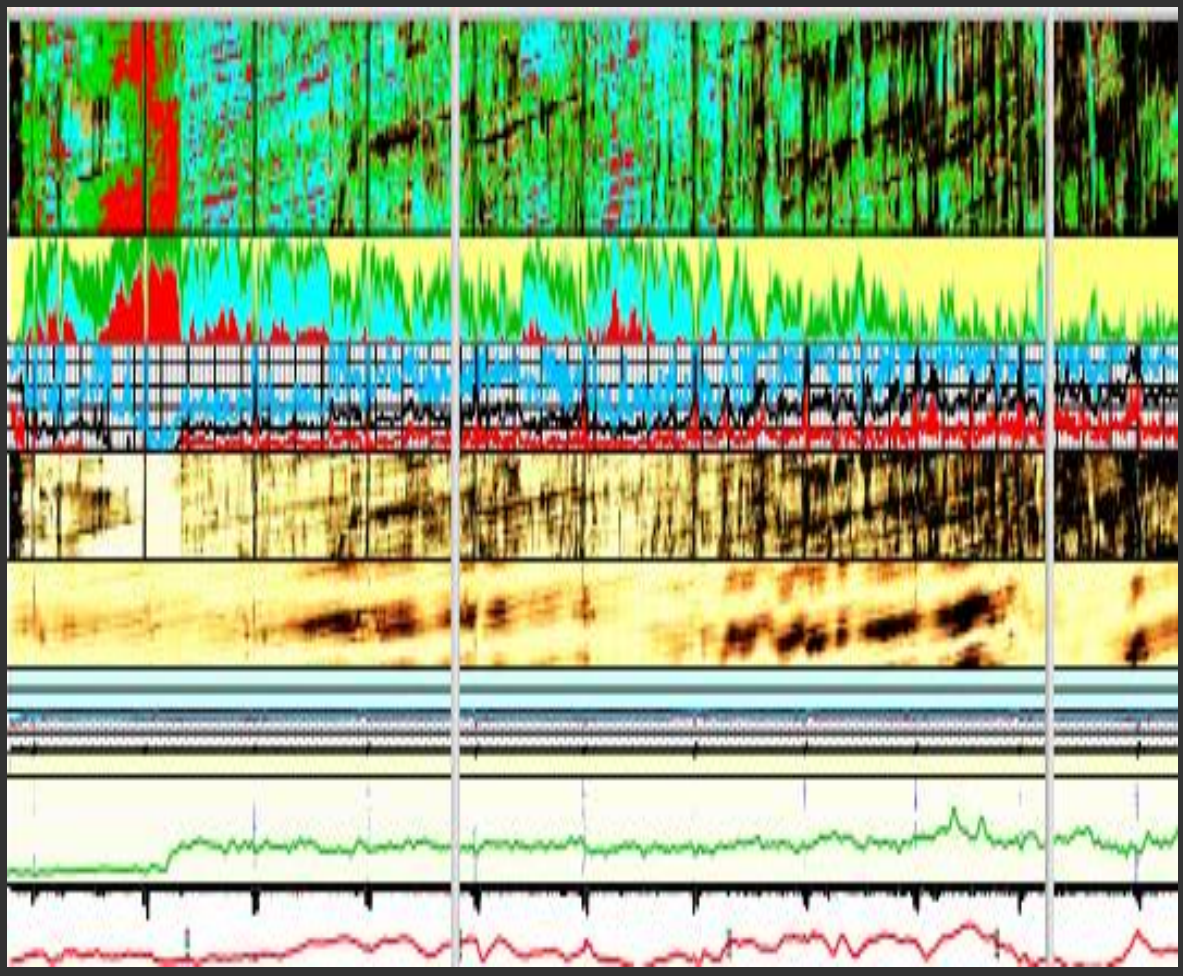
Losses and APB

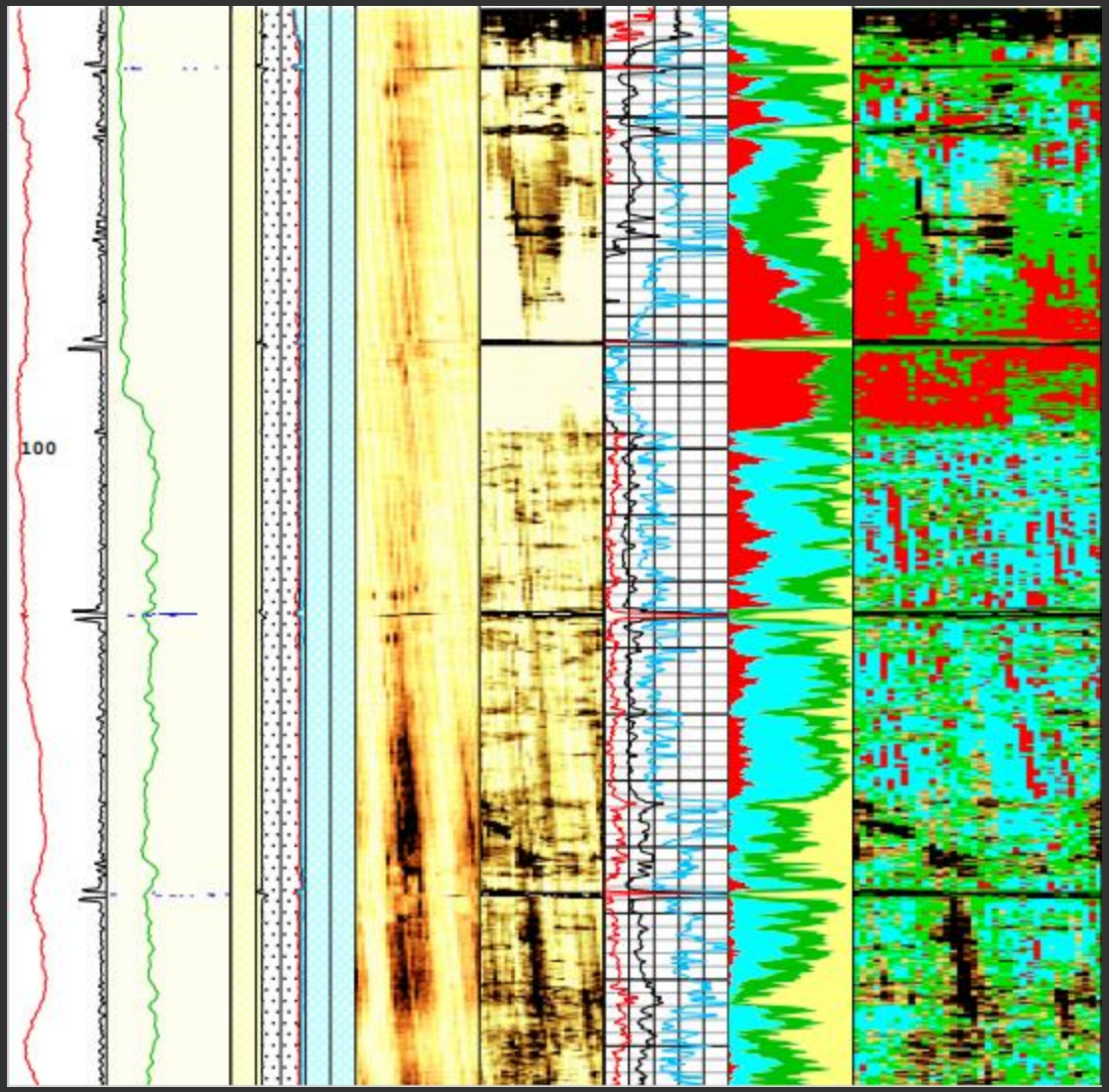


Cement Fallback

Losses – Fallback – Top Outs



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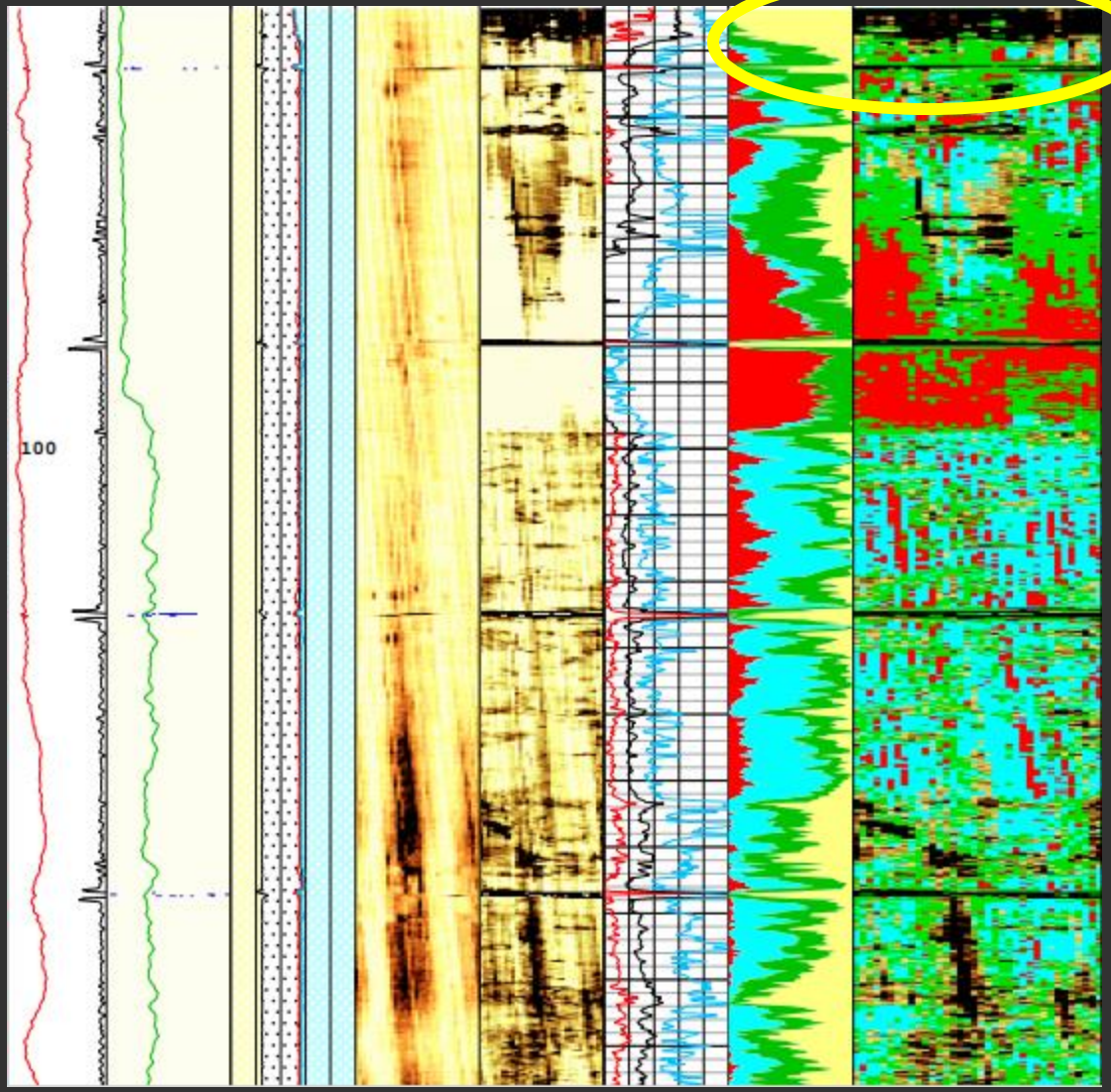
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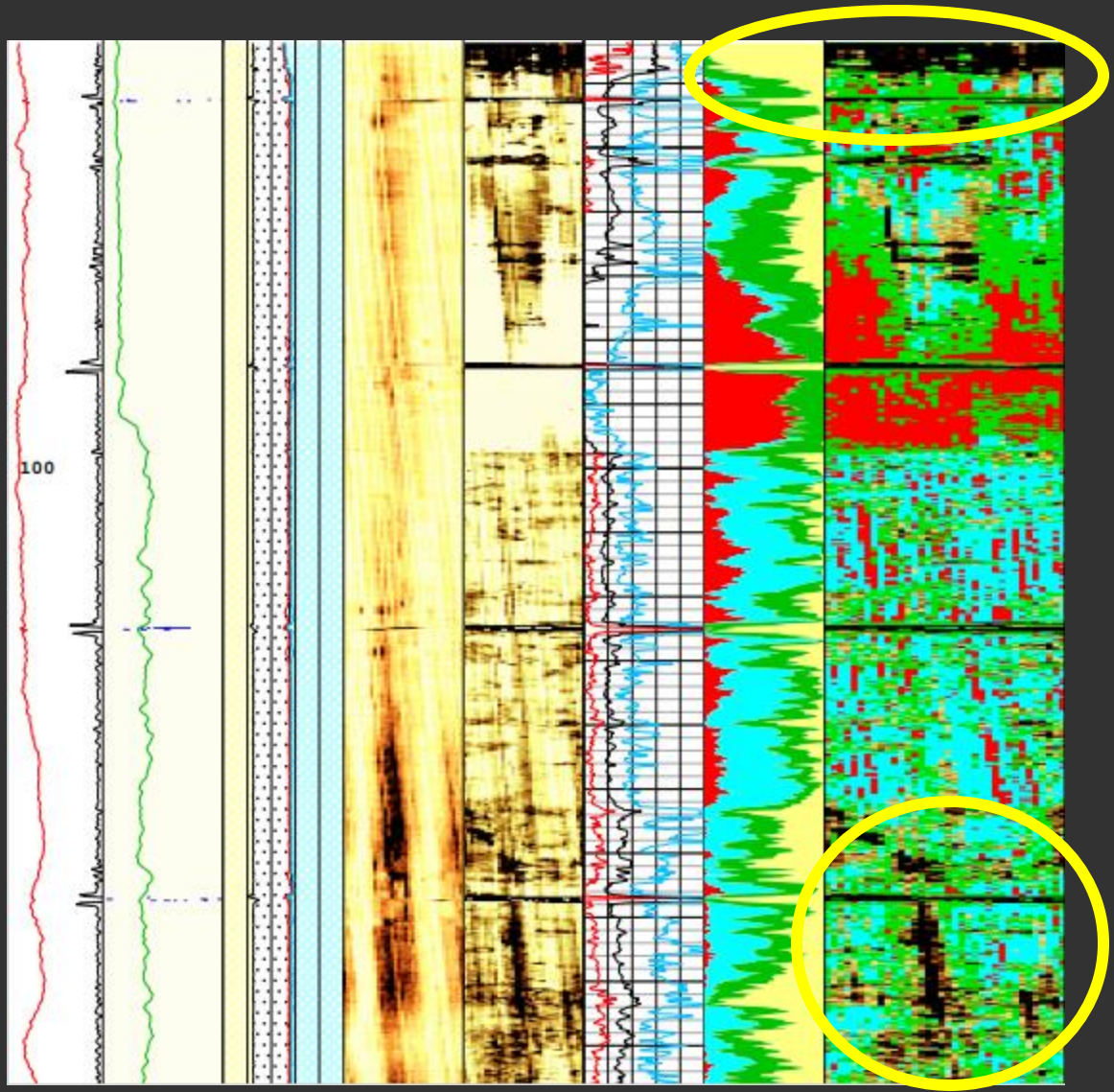
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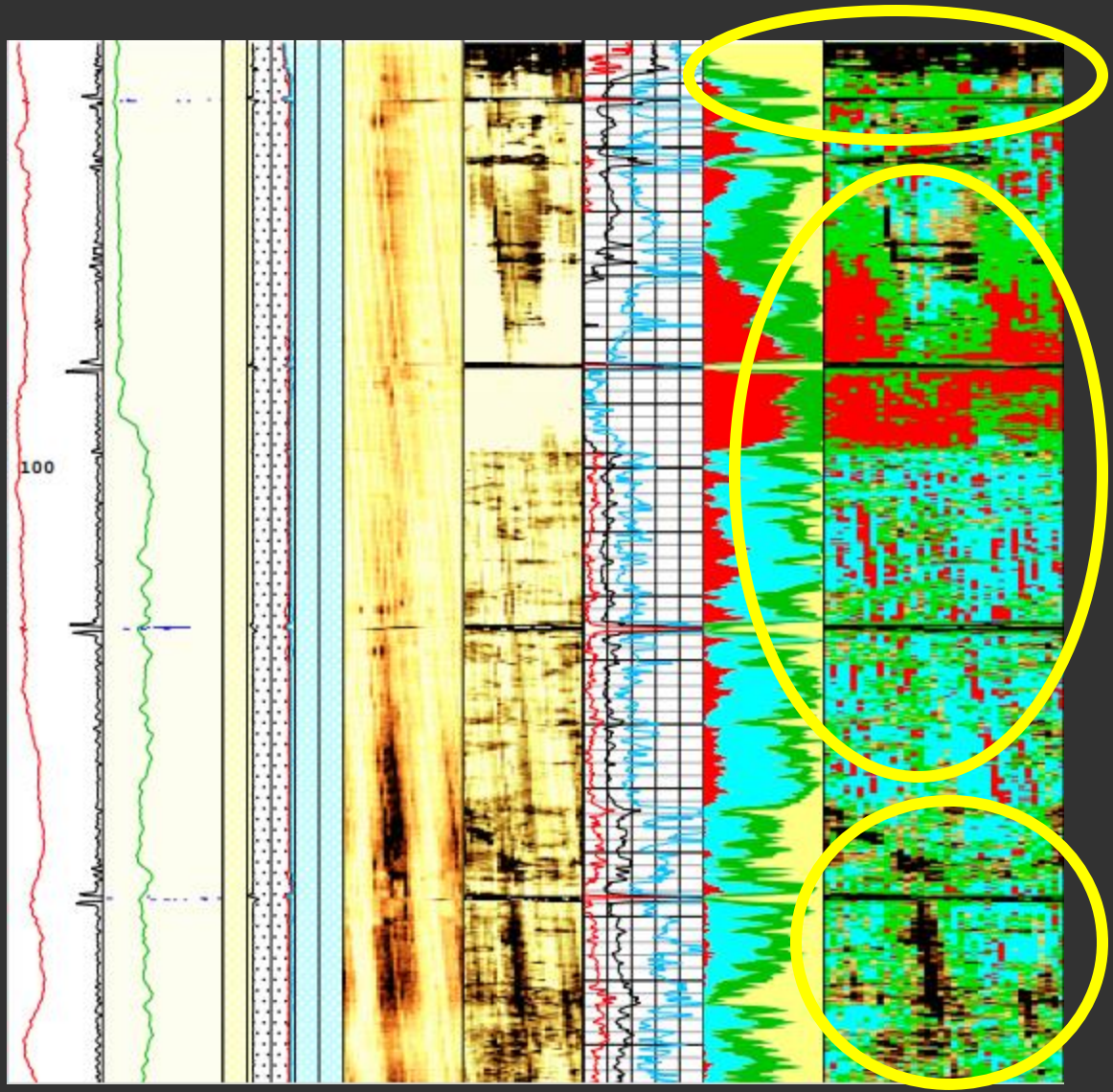
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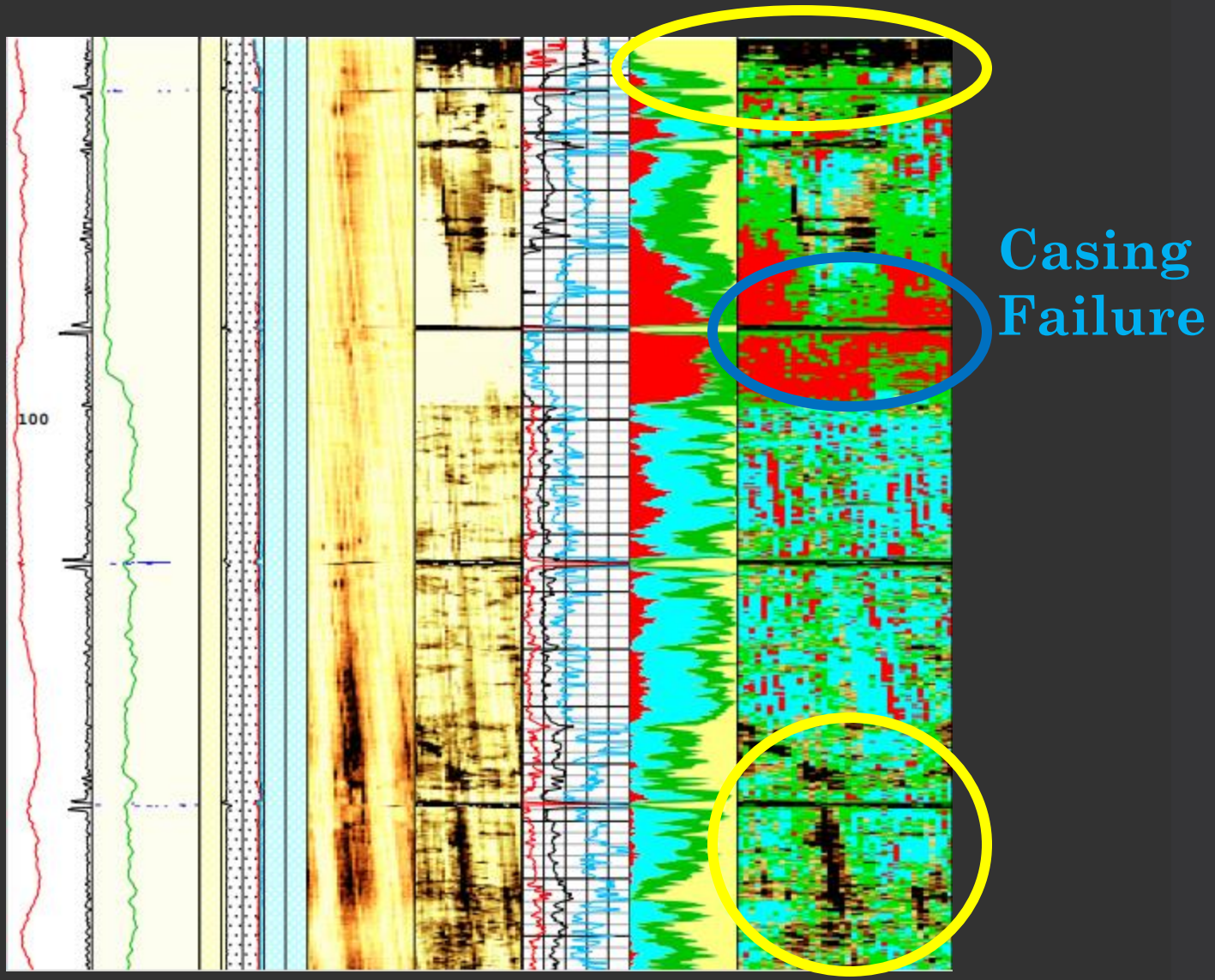
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Casing
Failure

Preventing Fallback

Solutions

- **Proven LCM Package in the Mud**
- **Cellophane Flakes instead of Fibers**
- **No Cement Baskets !**
- **Do Not Bullhead in HT Wells**

Summary

- Three common mechanisms of casing failure include corrosion, mechanical stresses, and annular pressure buildup.
- To help prevent premature casing failure, the CEMENTING KEYS are basic:
  - **BOND** - High shear bond between casing and cement
  - **CENTRALIZATION** - Ample cement sheath around the entire casing
  - **NO VOIDS** – Prevent lost circulation and fallback
  - **THE RIGHT CEMENT** – Strong, resilient, corrosion-resistant, and expansive.