Long Term Well Integrity

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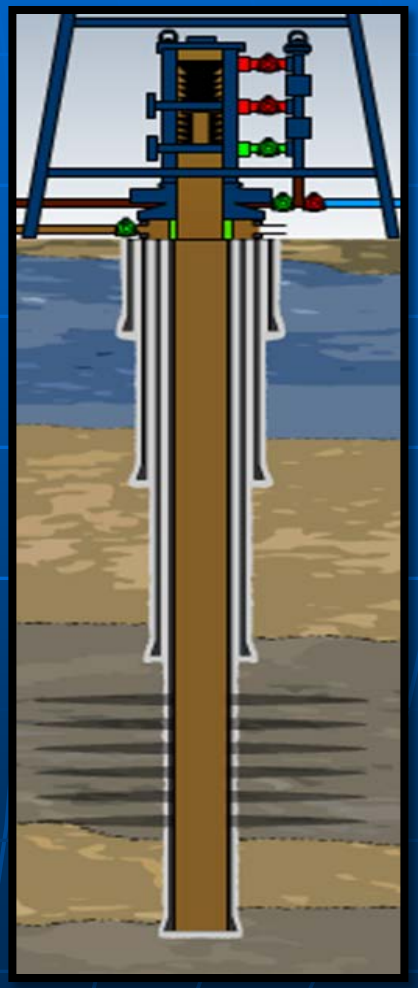
Society of Petroleum Engineers

Agenda

1. **Objectives of Well Cementing**
2. **Threats to compromise Cement Integrity**
   a) Pressure and Temperature fluctuations
   b) Corrosive Fluids
   c) HPHT environments
3. **Solutions**
4. **Case Histories in Hungary**

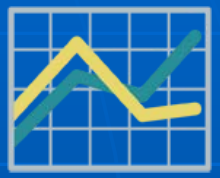
Objectives of Well Cementing

- **Zonal Isolation**
- **Support for casing strings**
- **Protection of casing**
- **Protection of borehole**



Threats to Cement Integrity

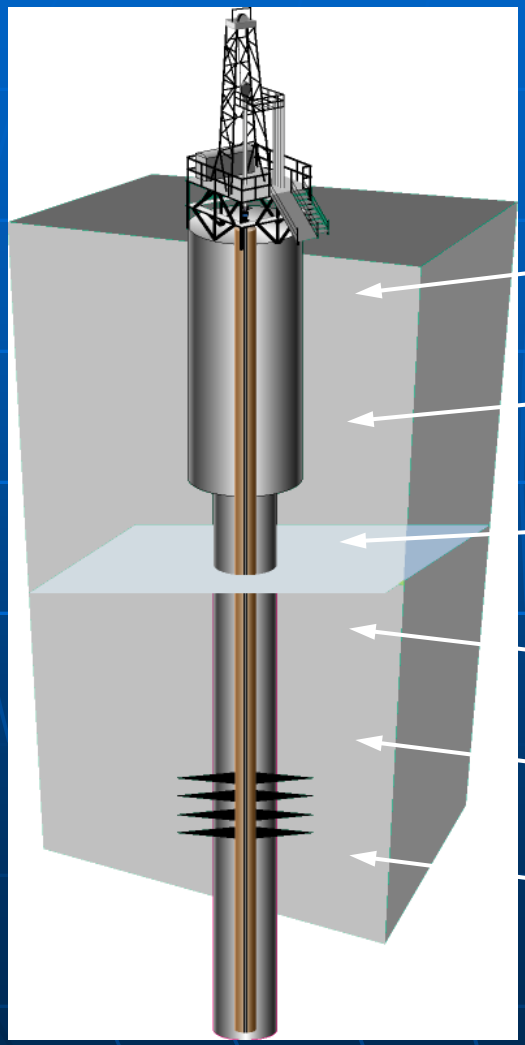
- **Pressure / Temperature fluctuations**



- **Corrosive fluids** (e.g. CO_2, H_2S)

- **HPHT environment**

Pressure and Temperature Fluctuations



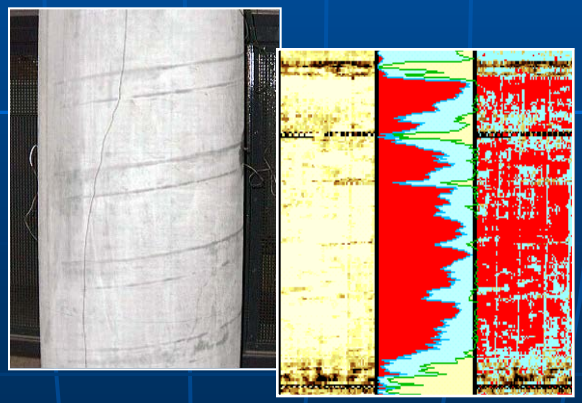
- Gas injection
- Temperature changes in upper casings during production
- Pressure changes: drilling, production
- Permanent well abandonment
- Formation changes/tectonic activity
- Well completion/perforation/stimulation

Concerns

Pressure and temperature changes during:

- Drilling
- Production
- Stimulation

Sustained Casing Pressure



Micro annulus; Cement cracks

Well completion/stimulation

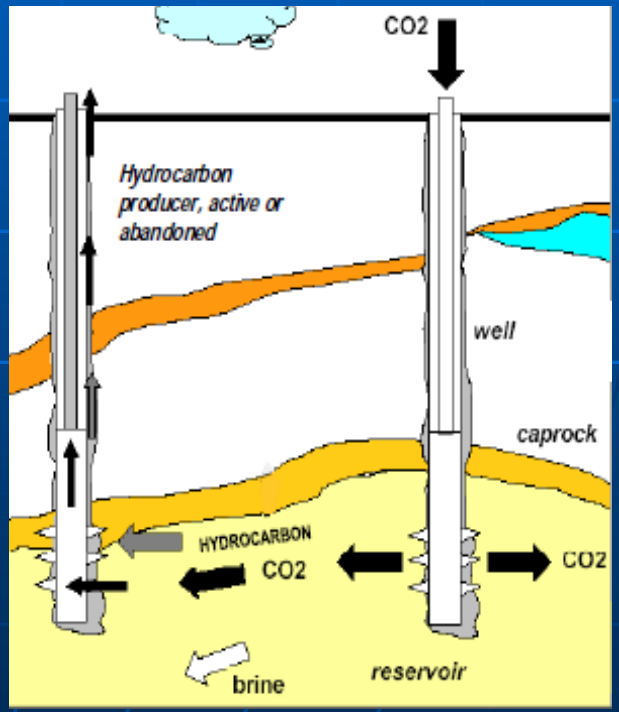
Corrosive Fluids

When ?

- Immediately after contact with fluid

Where ?

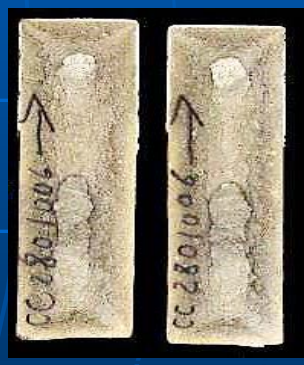
- CO_2 and H_2S environment
- CO_2 storage wells
- EOR CO_2 injector wells



Degradation of Portland Cement

- Degradation in CO2 environment:
  - Step 1 - Carbonic acid diffusion
  - Step 2 - Dissolution/Carbonation
  - Step 3 - Leaching
- Corrosion of casing
- Gas inflow

1 week

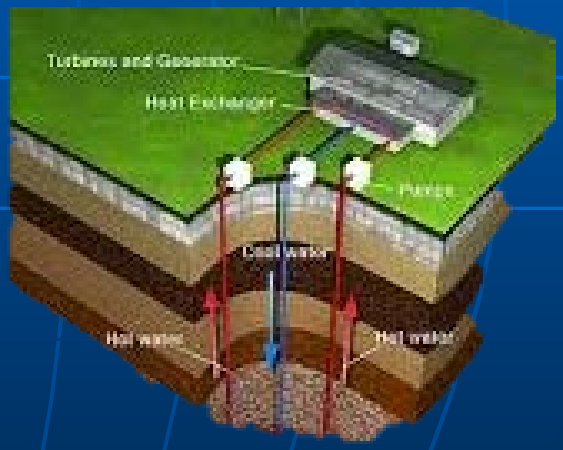


6 weeks

⇨ **LOSS OF WELL INTEGRITY**

HPHT Environments

- When ?
  - Temperature > 150 degC
  - Pressure > 10,000 psi
- Where ?
  - Deep wells
  - Geothermal wells
  - Overpressured wells

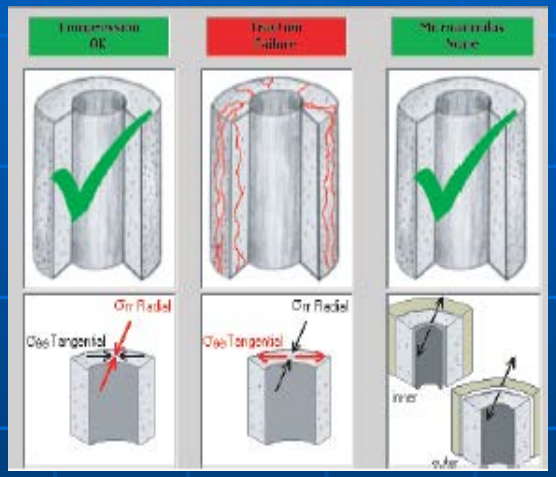


HPHT Cementing Challenges

- What ?
  - Strength retrogression
  - Negative impact on slurry rheology and thickening time
- Cement sheath cracks due to stresses
- Narrow Frac and Pore pressure margin
- Possible inflow of formation fluids

Engineered solutions P/T changes

a) Pressure and Temperature Fluctuations



- Software simulation & analysis of stresses:

  Input: - given ΔP and ΔT cycles
  - formation properties
  - casing size and weight
  - cement slurry properties

  Output: - plots of stresses
  - location and time of (evtl.) failure
  - sensitivity analysis of different parameters

- Cement system with tailored mechanical properties:
  - Flexibility of set cement (low Young's Modulus)
  - Expansion of set cement

Solutions for corrosive environments

b) Corrosive Fluids

- Cement system with:
  - Low permeability and low porosity
  - Long term stability under CO_2 exposure
- Computer-controlled reactor for testing
- Applicability:

Density

1.50 SG — **1.90** SG

Salinity

0 % — **20 %**

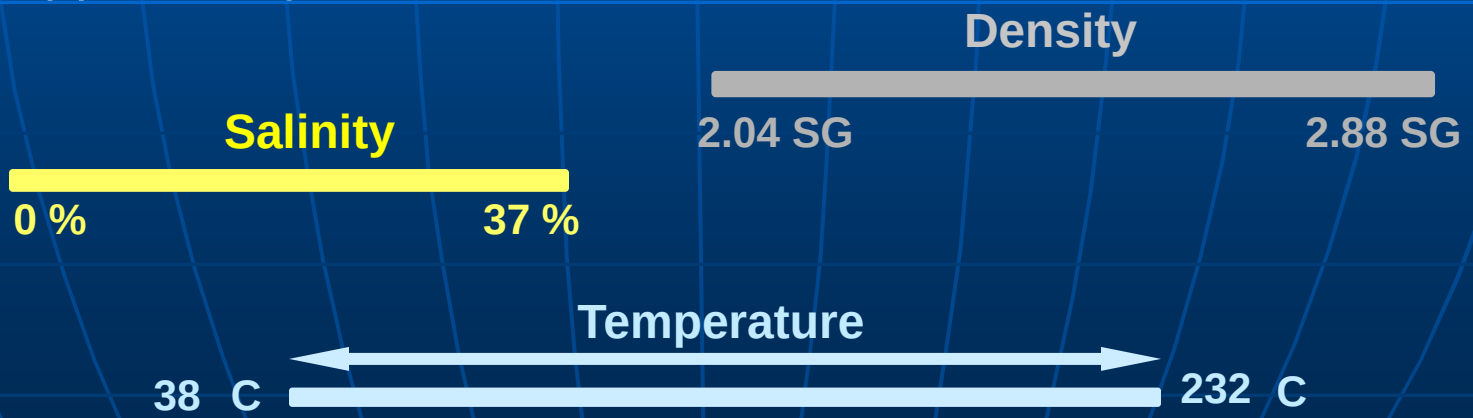
Temperature

40 C — **130 C**

Solutions for HPHT environments

c) HPHT environments

- Software simulation & analysis of stresses
- Flexibility properties of set cement
- Cement system with excellent flow properties even at high densities
- Applicability:



Case history #1

Job: 7 inch casing
Year: 2013

Depth: 2860 m MD / 2804 m TVD
BHST: 155°C

Challenges:

- HT environment
- Post cementing ΔP due to press. tests, mud (1.6 SG) → water swap

Risks:

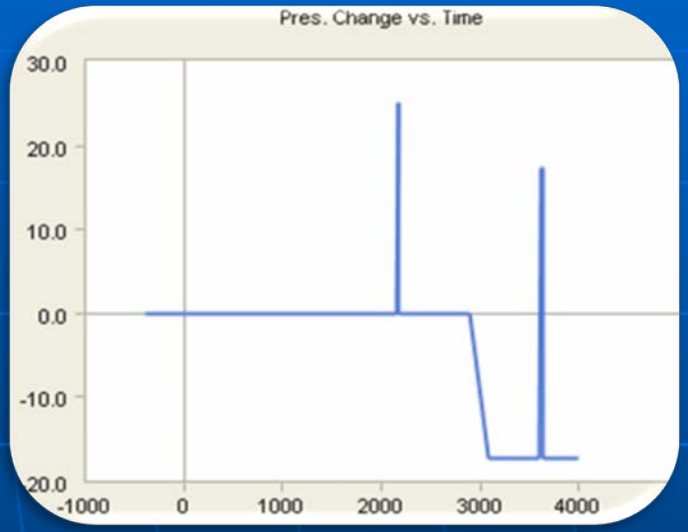
- Microannuli and cracking of cement sheath

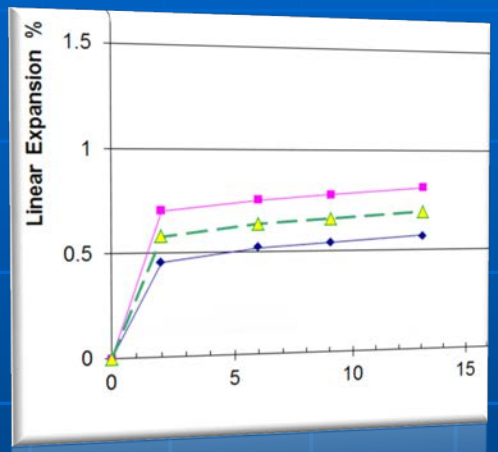
Solutions:

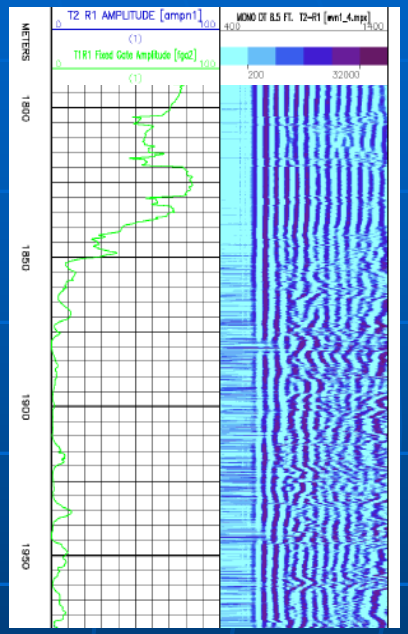
- Cement system with tailored flexibility properties of set cement
- HT expanding agent and tests
- Software analysis of stresses causing microannuli and/or cement fractures

Case history #1

Analysis and Results:





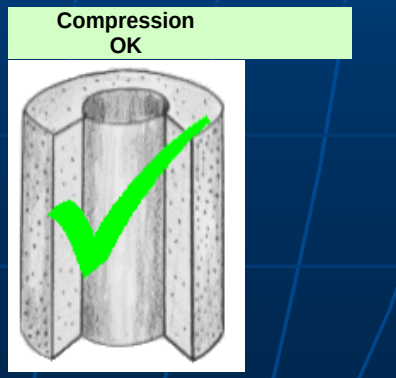


Conventional system:

- Young's Modulus 12,000 MPa
- No expansion

Innovative system:

- Young's Modulus 2,900 MPa
- Expansion



Case history #2

Job: 7 inch casing
Year: 2014

Depth: 1105 m MD / TVD
BHST: 70°C

Challenges:

- CO2 bearing formation

Risks:

- Degradation of cement
- Corrosion of casing
- Gas migration

Solutions:

- CO_2 resistant cement system as Tail slurry
- Conventional cement slurry as Lead slurry
- Gas migration control additives

Case history # 2

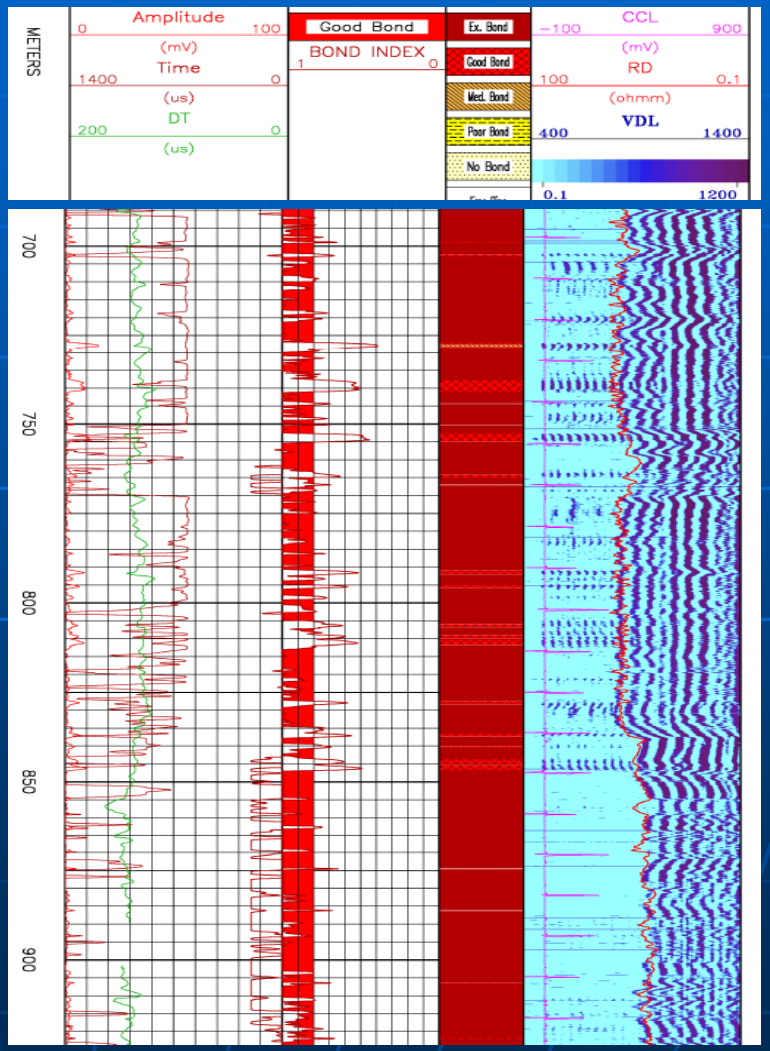
Results:

Short term

excellent CBL/VDL

Long term …

… please wait



Case history #3

Job: 7 inch liner
Year: 2013

Depth: 3650 m MD / 3588 m TVD
BHST: 153°C

Challenges:

- HPHT environment (MW = 1.90 kg/l)
- Salt environment
- Post cementing ΔP due to press. tests, mud → water swap (-238 bar)

Risks:

- Undesired reaction of cement slurry with salt
- Microannulus and cracking of cement sheath

Solutions:

- Salt saturated high density cement slurry (2.1 kg/l) / spacer (2.0 kg/l)
- Software analysis of stresses causing microannuli and/or cement fractures
- HT expanding agent

Case history # 3

Analysis and Results: