Cement sheath integrity during thermal cycling

— Recent results from DrillWell research centre

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P3.2 Life-cycle well integrity

Objective:
- To ensure well integrity throughout the life-cycle of the well

Focus areas:
- Well barriers
  - Why do well barriers fail?
- Well design
  - To optimize well design with a life-cycle well integrity perspective in mind

Based upon Celia et al.
Cyclic temperature variations

• Much work has been done on simulations/modeling of cement integrity during thermal cycling
  – Some experimental work as well

• Insufficient knowledge on:
  – Behavior of the whole system (rock, mud, cement and casing)
  – Size, geometry and location of leakage paths

Bois et al. SPE 124719
Ravi et al. IADC/SPE 74497
Garnier et al. SPE/PS/CHOA 117709
Our samples are downscaled sections of a well

Possible to exchange:
- Rock type
- Annular sealant type
- Muds, casing type etc…

12 1/4" borehole
9 5/8" casing
Sample preparation

Portland G cement poured by gravity
W/C = 0.42

Curing in an oven
@ 66°C for 5 days
Laboratory set-up
- Provides thermal cycling

• Thermal platform
  - Heats-up by electrical resistance
  - Cools-down by liquid N₂

• Computer controlled
  - Set temp. (-50°C to +200°C)
  - Set heating/cooling rates
  - Set number of repetitions

• Tests run from 10 °C to 90 °C
X-ray Computed Tomography (CT)

A tomographic method that provides specific information on size and location of potential leak paths

**Siemens Somatom Sensation 4**
- In-plane resolution ≈ 100-200 µm (w. 140 kV)
- Approximately 200 images per sample
Treatment of CT data

Segmenting of images

Compilation

3D volume

3D digitalization of sample (voids and solid materials)
Influence of Casing Centralization on Cement Sheath Integrity

IADC/SPE 168012
Samples with different casing centralization

Centralized casing

50% stand-off
CT scans of samples
- IADC/SPE 168012

Centralized sample

Before thermal cycling

After 3 thermal cycles

50% stand-off sample

Before thermal cycling

After 3 thermal cycles

Cement-casing debonded vol.

Voids/cracks in cement

Cement-rock debonded vol.
Quantification of cement bonding

These results indicate that casing centralization is not only important during well construction – it is also important for maintaining well integrity during production.
Influence of Casing Surface on Cement Sheath Integrity

Ongoing work
OBM film on casing surface

Before thermal cycling

After 10 thermal cycles
Conclusions

• Cement sheath integrity during thermal cycling is dependent upon initial well conditions
  - Such as casing surface and centralization

• We have a lab set-up for testing cement integrity
  - Work in progress to improve set-up further

Future work:
• Test different commercial cement systems
Thank you for your attention!

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