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A Fast and Less Expensive Test to Determine Permeability-Related Parameters on Well's Drilled Cuttings

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Motivation / Goals

Permeability tests are time consuming and/or expensive

Fast methodologies to determine permeability-related parameters on drilled cuttings and cores from wells are very helpful tools

Proposal of another methodology of absorption tests on sandstone drilled cuttings and cores into practice of Oil & Gas exploration

Range of sandstone permeability-related properties supporting fast test's procedures

Lithotypes of Lourinhã Formation analog → Statfjord Formation in North Sea

Improve knowledge (I&D)

Today's presentation

1. Introduction

2. Experimental Program

3. Experimental Results

4. Analysis of Experimental Results

5. Conclusions

1. Introduction

- Sandstone strata (main rocks of Lourinhã Formation), thickness up to 900 m (early Tithonian and Late Kimmeridgian)
- Stratigraphy and tectonics studies (Martinius and Gowland, 2011; Taylor et al, 2014)
- Samples collected from Lourinhã Formation analog → mineralogical and physical properties data
- Fast RILEM test carried out on sandstone specimens and also on drilled cuttings and cores, to evaluate permeability-related parameters
- Correlation to well logs, e.g. density, gamma ray, neutron, nuclear magnetic resonance, spontaneous potential, electrical resistivity and sonic
- Samples cleaned off oil using Soxhlet extraction methodology and dried
- Results in a faster way on rocks (higher open porosity values) in comparison to traditional laboratory methods

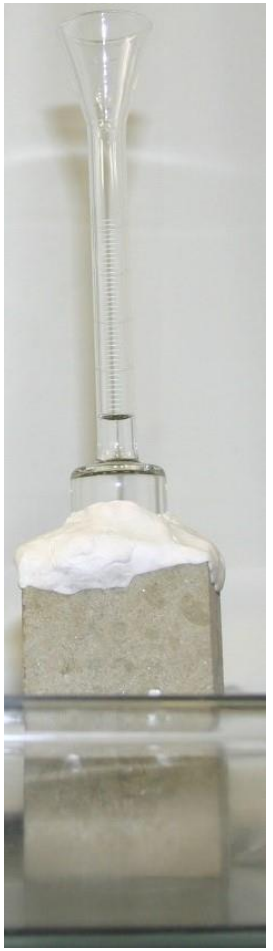
2. Experimental program

- Samples collected from sandstone outcrops
- Thin section observations (EN12407)
  - Petrographic polarizing microscope → point counting method: modal analysis
- Blocks of M variety were cut in 140 cubic (2 in.-long) and prismatic samples (2 in.-long on cross section and a length of 4 in.)
- Porosity and density of sandstone samples by hydrostatic weighing and Archimedes principle (RILEM and EN1936)
- Mercury Intrusion Porosimetry (MIP)
  - Pore size distribution
  - Permeability inferred (Katz and Thompson method)

2. Experimental program

- RILEM's Water absorption under low pressure (Karsten tube)
  - Height of water (0.322 ft) and a volume (1.41 x 10^{-4} ft^3)
  - Four graduation lines (maximum scale), each: 3.53 x 10^{-5} ft^3
  - Lower graduation scale: 3.53 x 10^{-6} ft^3
  - Water fills vertical tube from the upper opening up to the graduation ''0''
  - Sealed on sample surface by a removable putty
  - Graphs of water absorption: $\Delta m/S^2$ (vertical axis) and $\sqrt{t}$ (bottom axis)

    - Slope of the linear part → Water absorption coefficient ($lb/ft^2\sqrt{h}$)

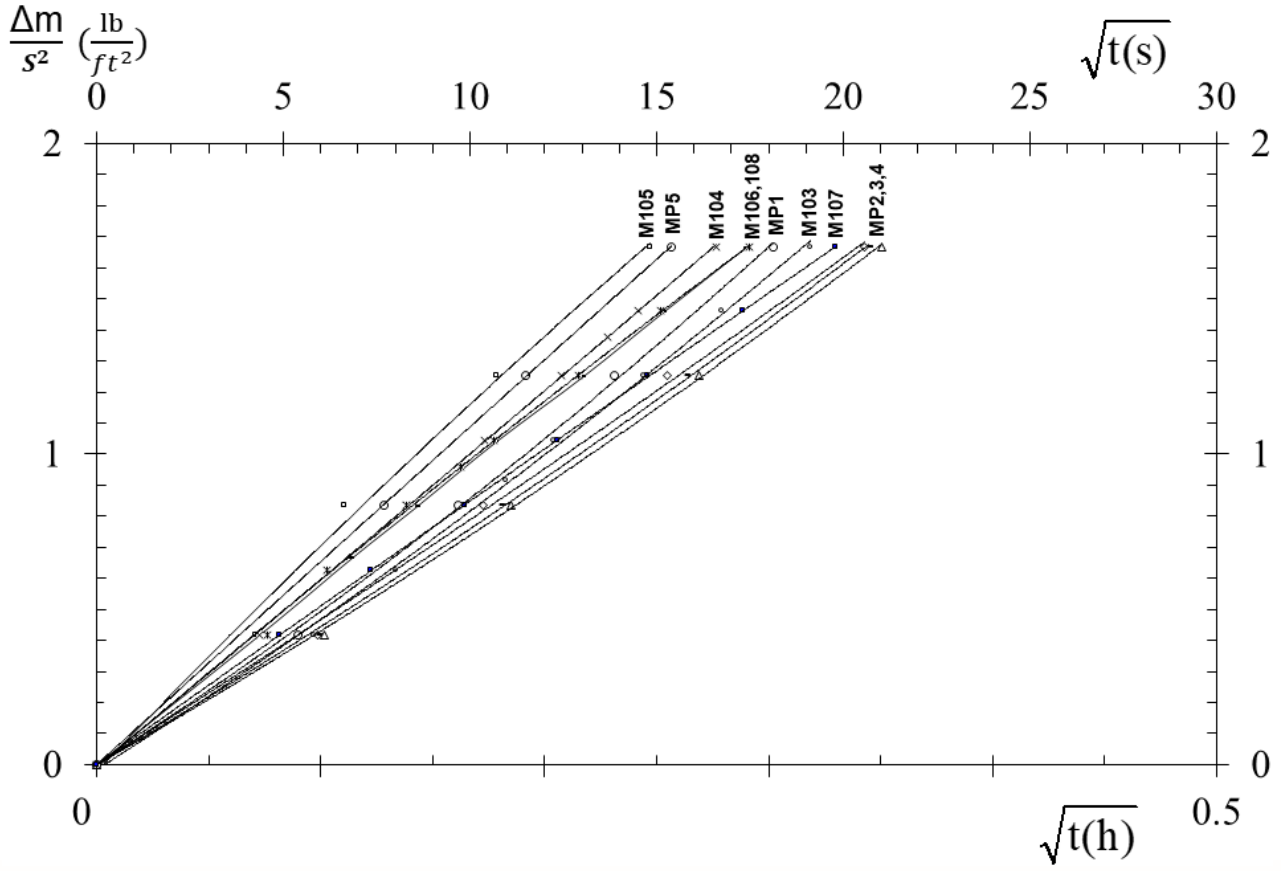


3. Experimental Results

- Mineralogical characterization
  - Two lithotypes of sandstones (A + B, C + M)
    - Lithic arkose with carbonate cement (Folk, 1974)
    - Lithotype A + B: 34–40% carbonates and 30–32% quartz
    - Lithotype C + M: 20–25% carbonates and 40–51% quartz
    - All these lithotypes: 4–6% of minerals of mica
- Physical characterization
  - Open porosity: 3.6% (A) to 12.7% (C) and 18.5% (M)
  - Bulk density (M): 446.5 lb/ft^3
  - Microporosity (M): 75%
  - Median pore radius (M): 3.6 µm (50% volume of mercury injection)
  - Permeability (M): 20 to 30 mD (Katz and Thompson method)

3. Experimental Results

- Physical characterization (continuation)
  - Water absorption (Karsten Pipe method)



3. Experimental Results

- Physical characterization (continuation)

Samples	Coefficient of water absorption, k ($lb/ft^2\sqrt{h}$)	Coefficient of water absorption, k ($lb/ft^2\sqrt{h}$) Average ± SD (CV%)
MP1	5.4	
MP2	4.8	
MP3	4.7	
MP4	4.8	
MP5	6.5*	5.5 ± 0.7 (12.7%)
M103	5.1	5.3 ± 0.5 (9.4%)*
M104	6.0	
M105	6.9*	
M106	5.8	
M107	5.1	
M108	5.8	

*Without higher values.

- Coefficient of water absorption, $k_{average}$ (M): **5.3 $lb/ft^2\sqrt{h}$ (C.V. <10%)**

4. Analysis of Experimental Results

- M variety samples of Lourinhã Formation, lithic arkose with carbonate cement
- Open porosity: 18.5 ± 0.4%
- Permeability: 20–30 mD.
- Water absorption coefficient under low pressure: 5.3 ± 0.5 lb/ft^2√h
- Siliciclastic world reservoirs with Median porosity statistical class of 17.5–22.5%, average permeability of 18 mD (Ehrenberg and Nadeau, 2005)
- Similar average values to these values are shown by samples of Sandstone M variety
- Permeability (mD) is 4–5 times higher than the water absorption coefficient (lb/ft^2√h)
- This test procedures, only several minutes or even seconds on rocks with open porosity higher than 15%
- Permeability from Mercury Intrusion Porosimetry took at least half a day
- Air permeability from steady state or transient pulse methods took similar times in comparison to RILEM method, but with much more expensive equipment

5. Conclusions

- This study aimed to propose another methodology of permeability-related tests on sandstone drilled cuttings and cores into Oil & Gas exploration practice
- Mineralogical and physical characterization of lithotypes‘s samples collected from Lourinhã Formation (analog of Statfjord Formation) was performed
- Based on experimental results, a practical correlation between permeability (mD) and the permeability-related RILEM´s water absorption coefficient (lb/ft^2Vh) was obtained on these rocks
- The procedures of this RILEM´s test are faster than other permeability tests and/or require less expensive equipments
- Based on this study contribution, Karsten pipe absorption test would be widespread recommended to Oil & Gas exploration on rocks porosity higher than 15%
- Further research should be carried out

Thank you!

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