PS How Artificial Fractures and Bedding Plane Influence the Fluid Movement in the Fracture-Matrix Dual-Connectivity System of Barnett Shale*

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Abstract

Barnett Shale outcrop samples were collected. Artificial fractures were created with different apertures. Co-current spontaneous imbibition tests were conducted. Fluid leak-off demonstrated in laboratory was studied. Fluid flow was examined in the directions of both parallel and transverse to the bedding plane. Fluid flow was isolated in fracture, bedding plane, and the matrix.

References

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ACE 2020 — AAPG Annual Convention & Exhibition, Incorporating SEPM & GCAGS — 29 SEPT – 1 OCT ONLINE AND ON DEMAND

University of Texas Arlington — University of Texas at Arlington Student Chapter

Abstract

- Barnett Shale outcrop samples collected
- Artificial fractures created with different apertures
- Co-current spontaneous imbibition tests conducted
- Fluid leak-off demonstrated in laboratory studied
- Fluid flow examined in the directions of both parallel and transverse to the bedding plane
- Fluid flow isolated in fracture, bedding plane, and the matrix

Study Area

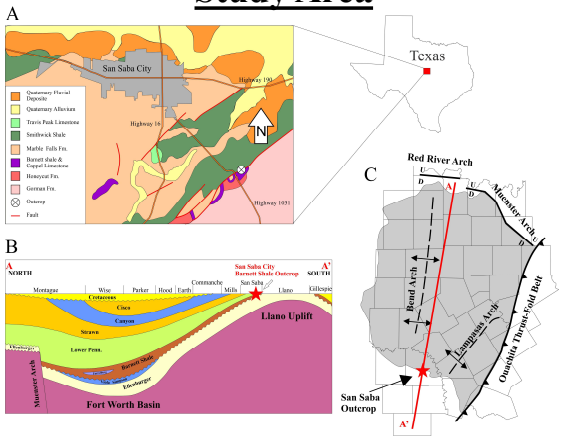
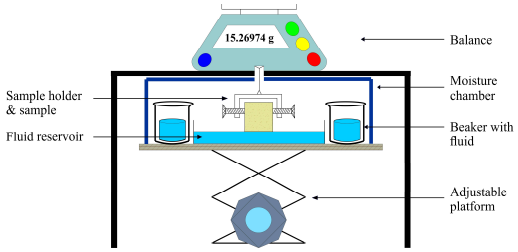
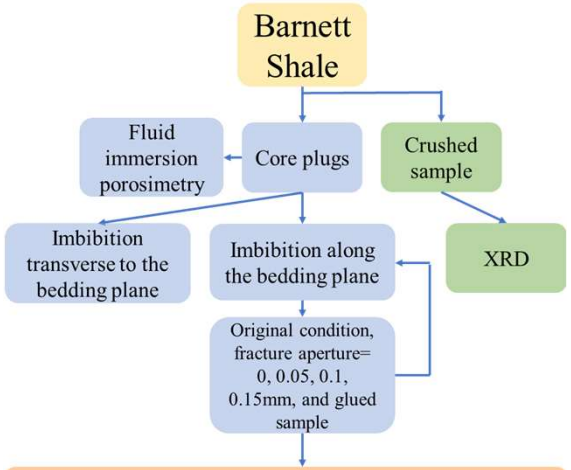


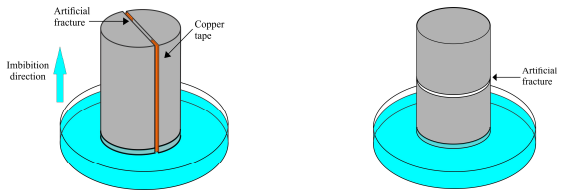
Figure A. Lithofacies distribution in the San Saba area (modified from USGS TWSC, 2014). B. Stratigraphy cross-section of Fort Worth Basin (modified from Gasparrini et al. 2014). C. Structure map of Fort Worth Basin (modified from Loucks and Ruppel, 2007)

Methods & Workflow



Imbibition setup





Imbibition parallel to the bedding plane (P sample)

Imbibition transverse to the bedding plane (T sample)

Theory

The wetting front in vertical direction for rocks with well-connected pore space is proportional to the square root of time: $l \sim t^{0.5}$ (Handy, 1960).

$$l = \frac{V_{imb}}{A} = t^{0.5}\sqrt{\frac{2p_c k_w \emptyset S_w}{\mu_w}}$$

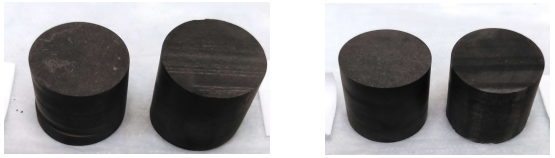
l: wetting front, cm
V_{imb}: imbibied water volume, cm^3
A: bottom area of sample, cm^2
t: time of imbibition, s
P_c: capillary pressure, Pa
k_w : permeability to water, md
$\emptyset$: porosity, fraction
μ_w : water viscosity, Pa. s

According to Hu et al. (2012), pore connectivity can be assessed from the slope of imbibition height vs. time in log-log scale:

- ✓ > 0.5: good connectivity
- ✓ 0.5~0.26: intermediate connectivity
- ✓ <0.26: poor connectivity

Results

Siliceous & Clay-rich (S&C) Sample Photos



S&C 1-T S&C 1-P S&C 2-T S&C 2-P

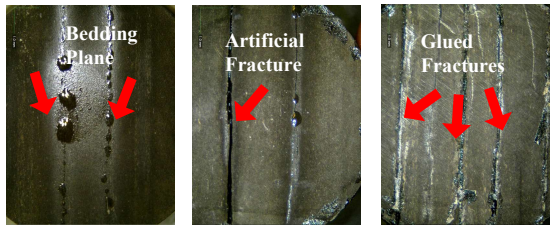
Sample information

Sample ID	Diameter (cm)	Height (cm)	Porosity (%)	Bulk density (g/cm^3)	Grain density (g/cm3)
S&C 1-T	2.504	2.021	13.775	1.869	2.167
S&C 1-P	2.505	2.317	13.037	1.855	2.133
S&C 2-T	2.505	2.227	12.452	1.849	2.112
S&C 2-P	2.502	2.195	12.690	1.875	2.147

Mineral compositions

Sample ID	Quartz	Orthoclase	Plagioclase	Calcite	Fluorapatite	Clay Minerals
S&C 1	37.5	0.7	0.9	5.3	13.8	41.8
S&C 2	44.8	1.4	1.8	4.1	4.5	43.5

Sample top after 24 hours imbibition



Original (non-fractured) sample

Fractured sample

Fractures-glued sample

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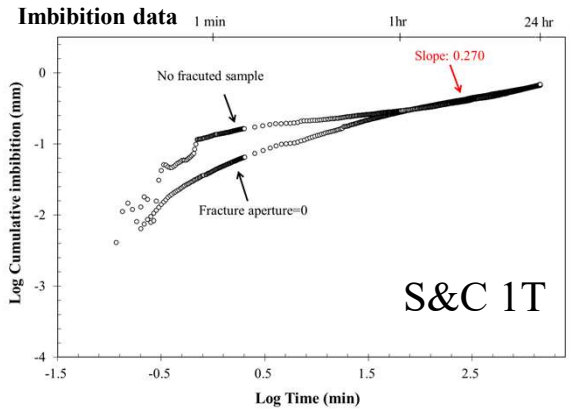
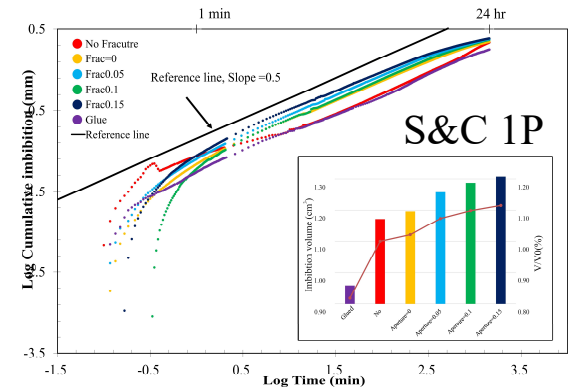
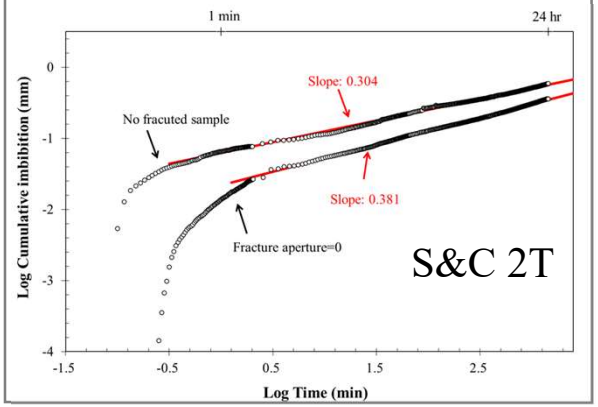
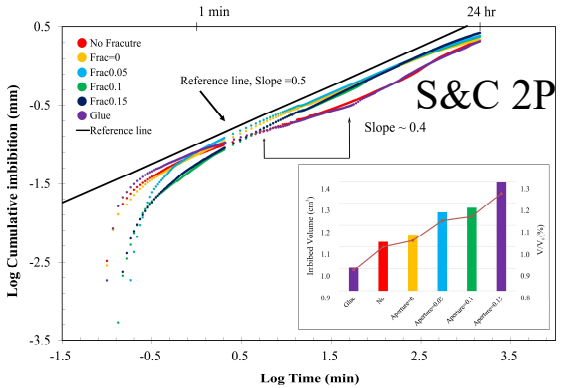
Imbibition data

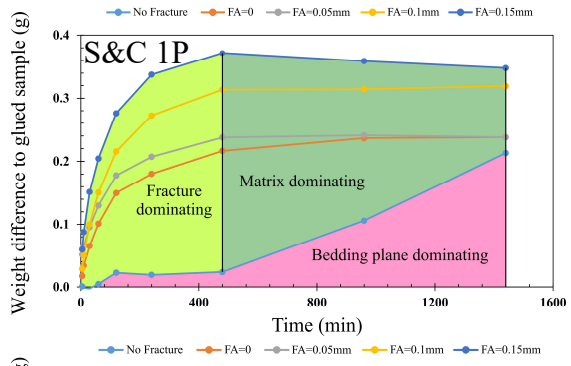


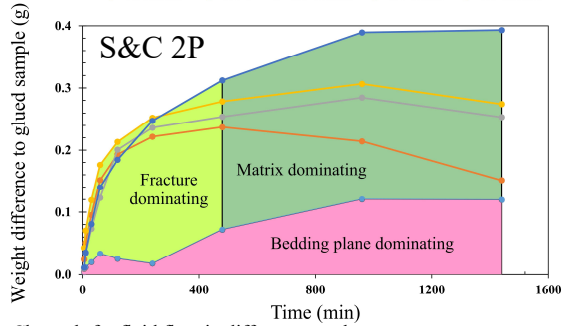






Discussion





Channels for fluid flow in different samples:

- Original (non-fractured): bedding plane and the matrix
- Fractured: artificial fracture, bedding plane, and the matrix
- Glued: the matrix

Then influence of bedding planes and artificial fracture can be subtracted by:

$$W_d = W - W_g$$

W_d: difference in sample weights
W: water-imbibed weight of current sample
W_g: water-imbibed weight of glued sample

The outcrop Barnett S&C sample is well laminated.

T sample:

- Similar imbibition behavior indicating the wetting front cannot reach the artificial fracture

P sample:

- Fluid flows which FA=0 is similar as it in the unfractured sample
- When FA>0, the imbibed water volume show a large increase and the pore connectivity changes from intermediate to good connection

Conclusions

- In original condition, the bedding planes provide preferential pathways for fluid flow
- Artificial fractures provide preferential pathways but limited storage space, while the matrix provides extra surface area for fluid imbibition
- The fluid flow stages in fractures, bedding planes, and the matrix can be delineated

References

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