Drainage and Imbibition Experiments in a High-Porosity Micro-Model Using an Unstructured Pore-Network Model

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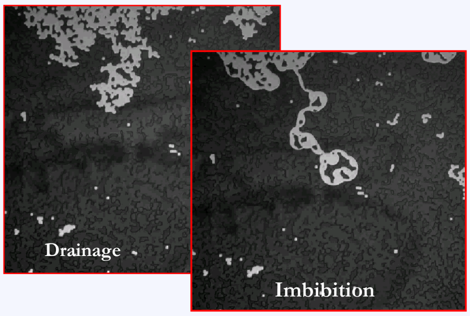
Objectives

Development of a pore-network model for simulating quasi-static drainage and imbibition experiments in a high-porosity unstructured micro-model.

Experiment Specifications

-Two-dimensional micro-model with dimensions 600μm x 600μm x1.28 μm.
-High porosity medium: 60-70%.
-Measurement of capillary pressure, saturation and interfacial area under static conditions.
-Displacement of decane (wetting) by nitrogen (nonwetting)
-Constant pressure in reservoirs.

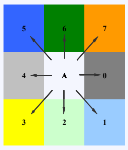


Pore-Network Tools

Using distance transform (DT) and a so-called flow operator (FO), medial pixels and their shortest distance to solid boundary are determined.

•Distance Transform $DT(P_i^v) = \min\{d(P_i^v, P_j^s) : \forall j \in \partial\Omega_s\}$

•Flow Operator $F(P_i^v) = DIR(\max\{\frac{DT(P_i^v) - DT(P_j)}{d(P_i^v - P_j)} : j \in \mathbb{N}_i \wedge P_j \in \Omega_v\})$

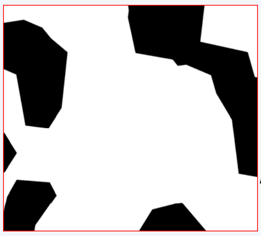


G	13.37	13.28	13.20	13.08	12.88	12.69	12.52	12.35	12.20
F	13.77	13.68	13.60	13.43	13.24	13.06	12.89	12.73	12.58
E	14.16	14.08	13.98	13.79	13.60	13.42	13.26	13.10	12.96
D	14.16	14.08	13.98	13.87	13.77	13.68	13.59	13.48	13.34
C	13.77	13.68	13.59	13.48	13.37	13.28	13.20	13.09	12.98
B	13.37	13.28	13.20	13.09	12.98	12.89	12.80	12.70	12.59
A	12.98	12.89	12.80	12.70	12.59	12.49	12.41	12.31	12.20
index	1	2	3	4	5	6	7	8	9

G	6	6	6	7	7	7	7	7	6
F	6	6	6	7	7	7	7	6	6
E	6	6	7	7	7	7	7	6	6
D	2	2	2	2	2	2	2	2	6
C	2	2	2	2	2	2	2	2	2
B	2	2	2	2	2	2	2	2	2
A	2	2	2	2	2	2	2	2	2
index	1	2	3	4	5	6	7	8	9

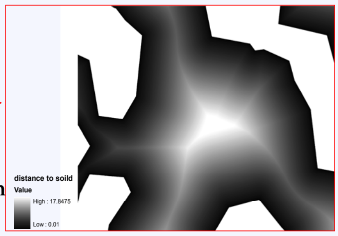
a) b) c)
An example of FO a) FO directions b) Distance map c)Flow map

Network Development



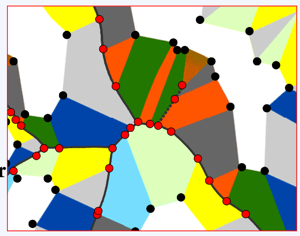
Pore Sample

Distance Transform

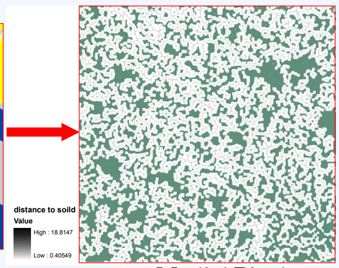


Distance Map

Flow Operator



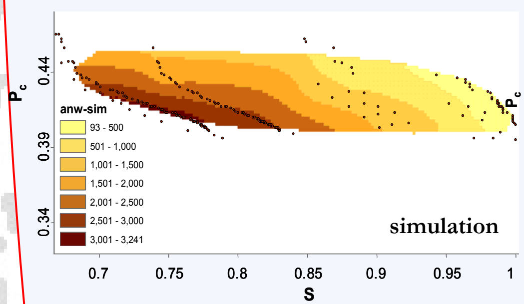
Flow Map

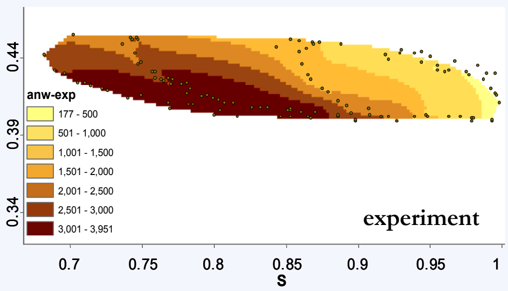


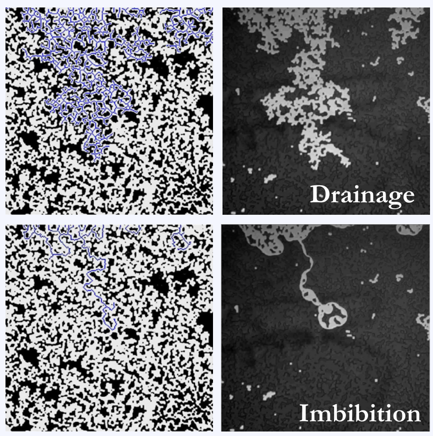
Medial Pixels

Simulation Results

After Network generation, simulations are implemented by considering Young-Laplace Equation for rectangular cross sections. It is assumed that wetting phase remains always connected to its reservoir through crevices.







Spatial distribution of interfacial area (a_{nw})within the Pc-S loop: a)simulation b)experiment

Conclusions

-A simple approach to generate a predictive pore-network model is presented.
-The approach is able to capture geometry and topology of the micro-model.
-It produces P_c-S and a_{nw}-S curves for drainage and imbibition experiments with a reasonable accuracy.
-It is a useful tool to analyse behaviour of a micro-model before manufacturing.
-Entry capillary pressure of a micro-model can be controlled by depth.

References

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http://www.physics.purdue.edu/rockphys/DataImages/
-Glantz, R., Hilpert M., AWR (30,31), 2007 and 2008
-Lindquist B., Contemporary Mathematics(295), 2002

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