Simulation of Acidizing Treatments in Carbonate Reservoirs

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AAPG – SEG International Conference and Exhibition 2017

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MATH2MARKET GMBH COMPANY OVERVIEW

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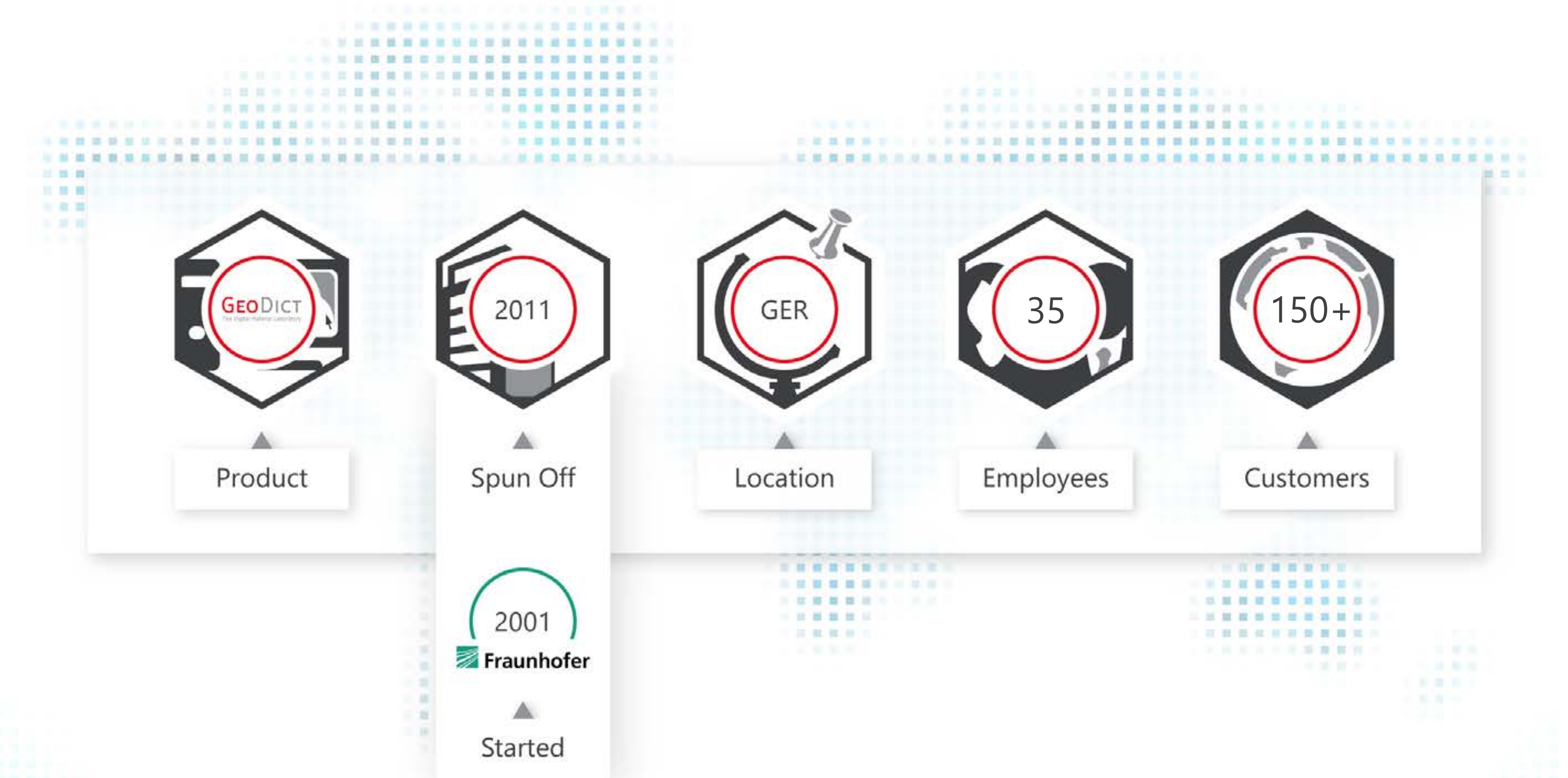
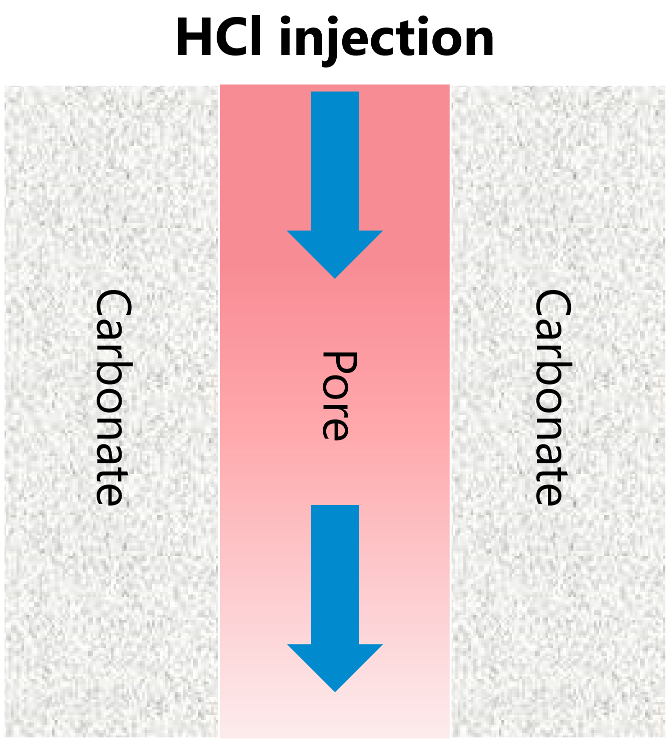
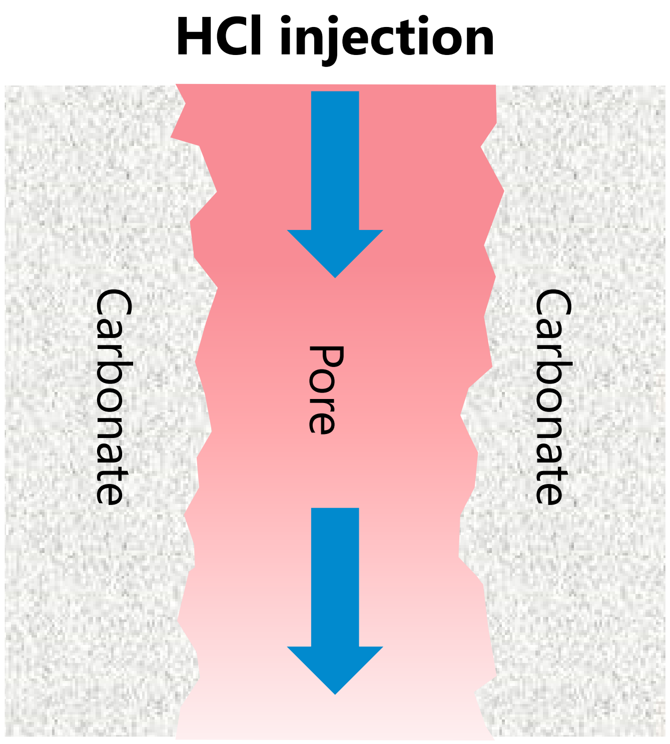


Why are we interested in Acidizing Treatments in Carbonate Reservoirs?

- **Formation damage** is a zone of reduced permeability within the vicinity of the wellbore (skin) as a result of foreign-fluid invasion into the reservoir rock.
- **Carbonate stimulation**: enhancement of permeability in carbonates after formation damage by acidizing the rock; i.e. dissolving minerals in the carbonate by HCl



Initial stage



Dissolved stage

WHY DO WE NEED A NEW NUMERICAL MODEL?

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- Lesson learned from digital rock physics: structure at the pore scale influences rock properties at the core scale

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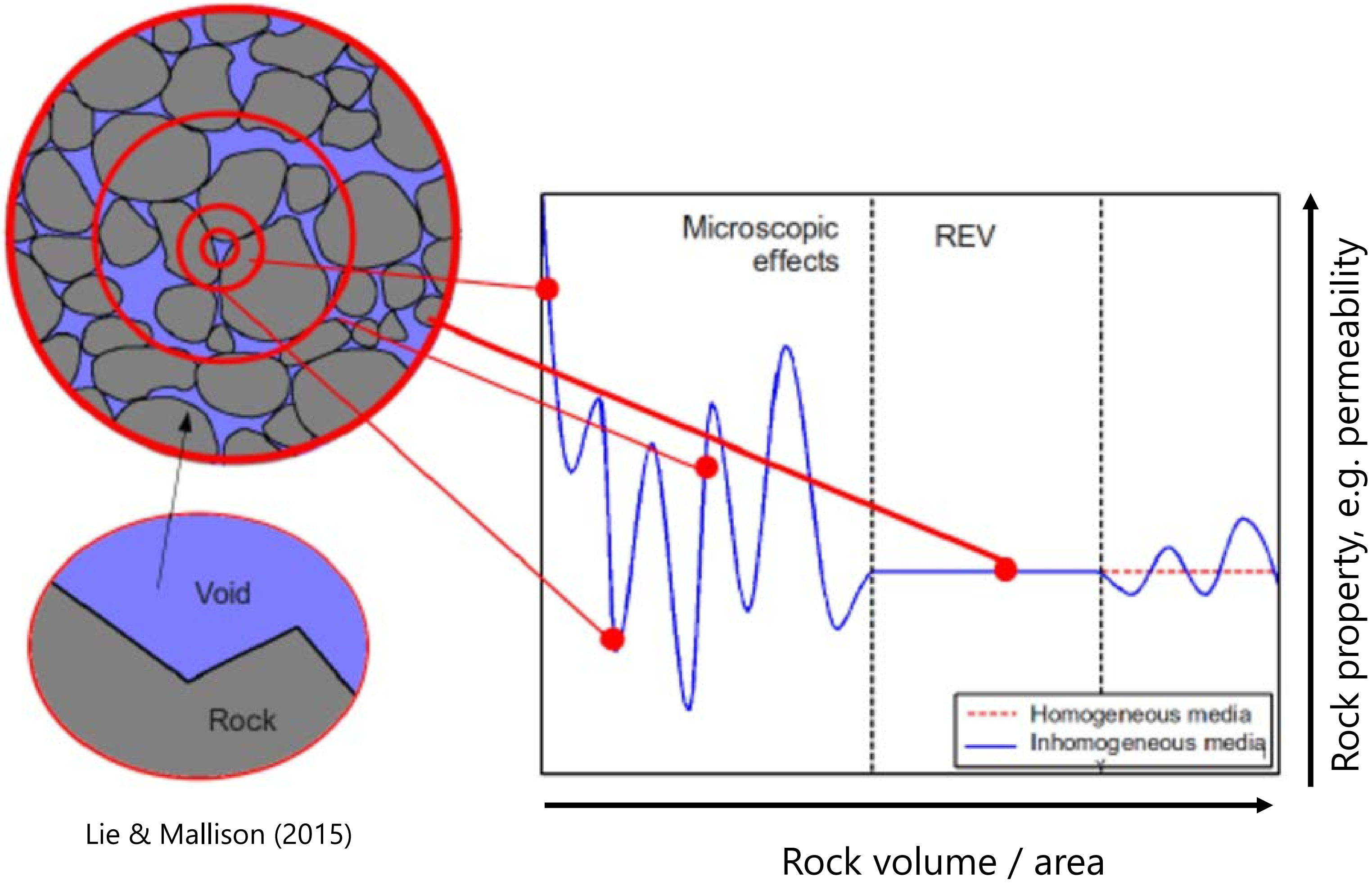
- Lesson learned from digital rock physics: structure at the pore scale influences rock properties at the core scale
- Simulations at the pore scale require REV and so large computational domains



Lie & Mallison (2015)

Why do we need a new numerical model?

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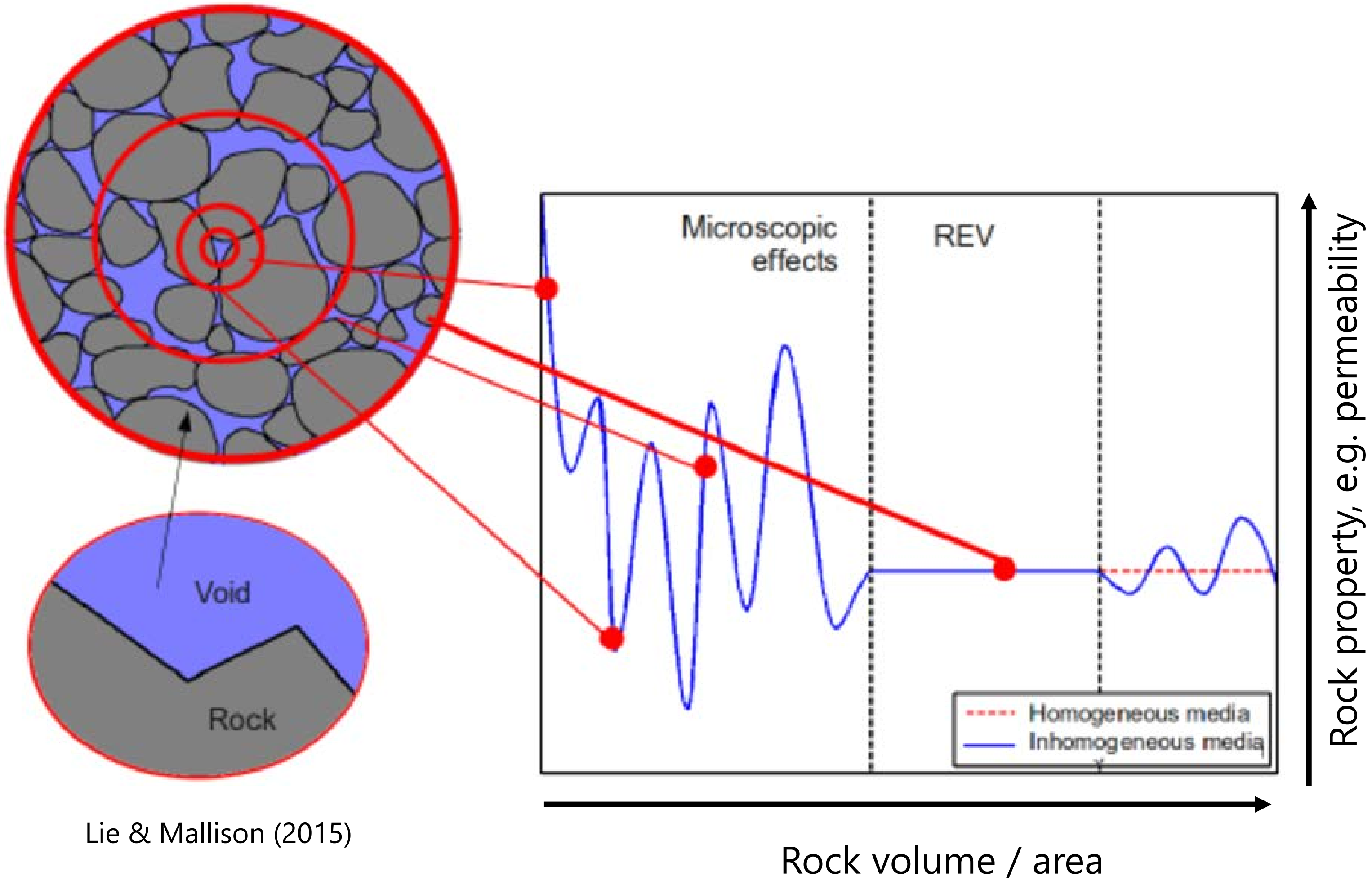
- Simulations at the pore scale require REV and so large computational domains
- Need for efficient solvers and simple rules for structure manipulation



Lie & Mallison (2015)

How do we model Acidizing Treatments?

- Compute fluid flow through the rock
- Simulate advective and diffusive transport of particles (H^+ ions) through the rock
- Model interaction of the particles with the rock
  - A single particle represents multiple H^+ ions (multiplicity)
  - Upon collision, H^+ ions dissolve the rock ($CaCO_3$):

    $$CaCO_3 + H^+ \rightarrow Ca^{2+} + HCO_3^-$$

  - Keep track of consumed H^+ and dissolved volume

CARBONATE SAMPLE

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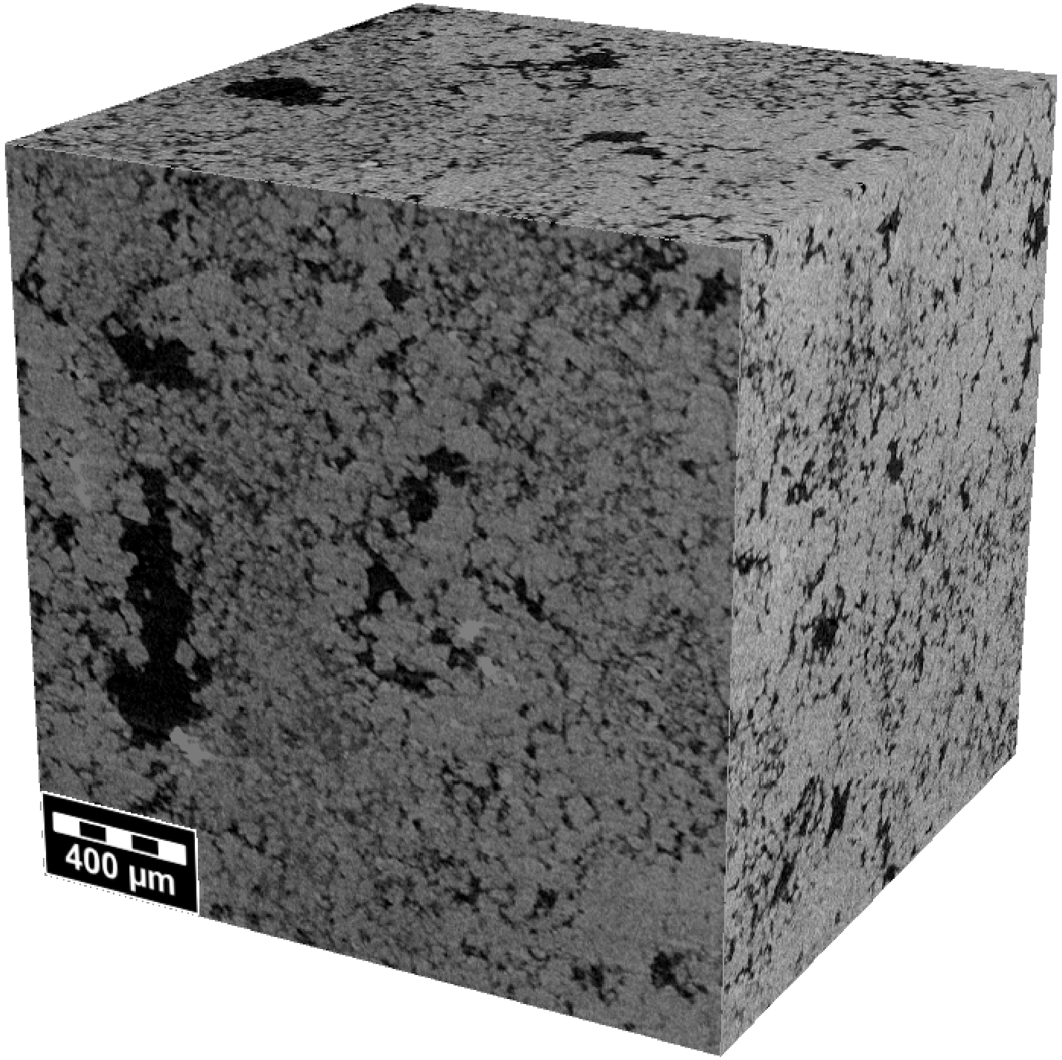
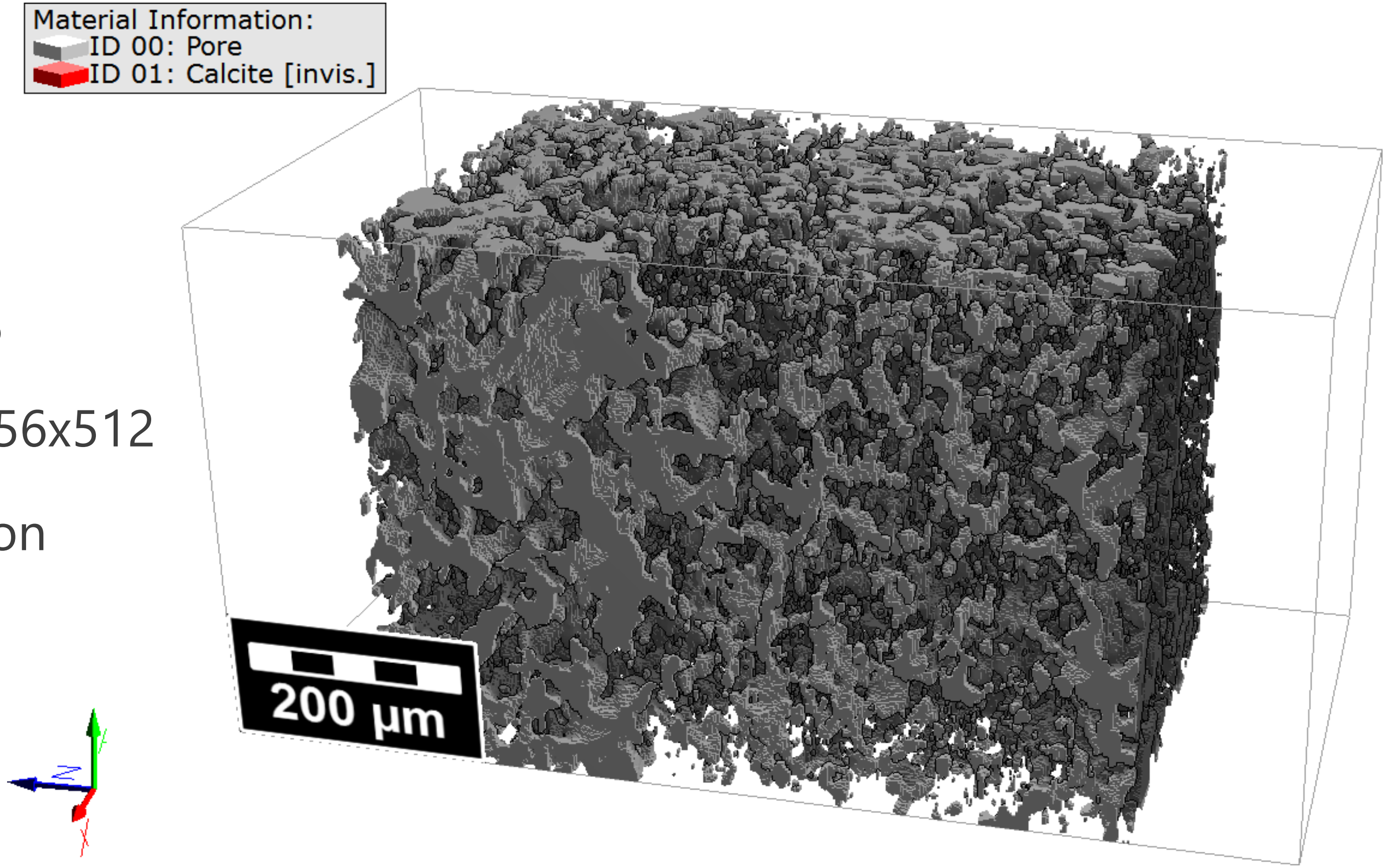
- Grosmont formation, Alberta, Canada
- Porosity: 21%, permeability range: 150 mD – 470 mD
- Data set is published in DRP benchmark paper (Andrae et al. 2013)



Carbonate sample

- Porosity of subdomain: 21.9 %
- Computational domain 256x256x512
- Homogeneous pore distribution



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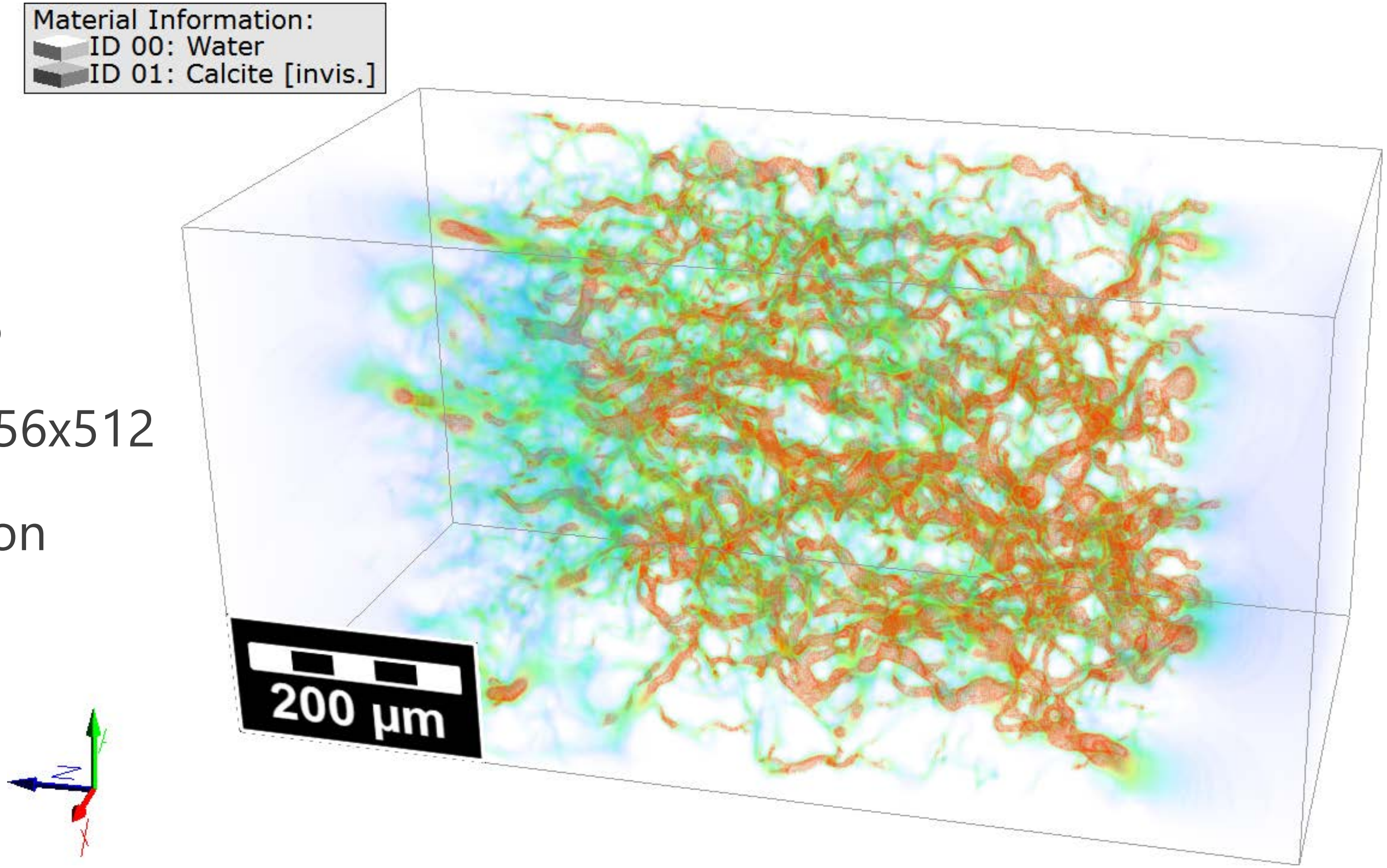

DISSOLUTION PATTERN – UNIFORM DISSOLUTION

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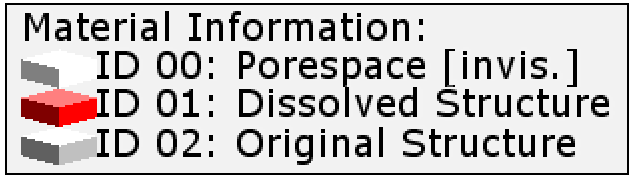
Simulation settings:
Domain: 256x256x512 voxels
Runtime: 29 h
Average velocity: 0.1 m/s



COMPARISON UNIFORM DISSOLUTION PATTERN

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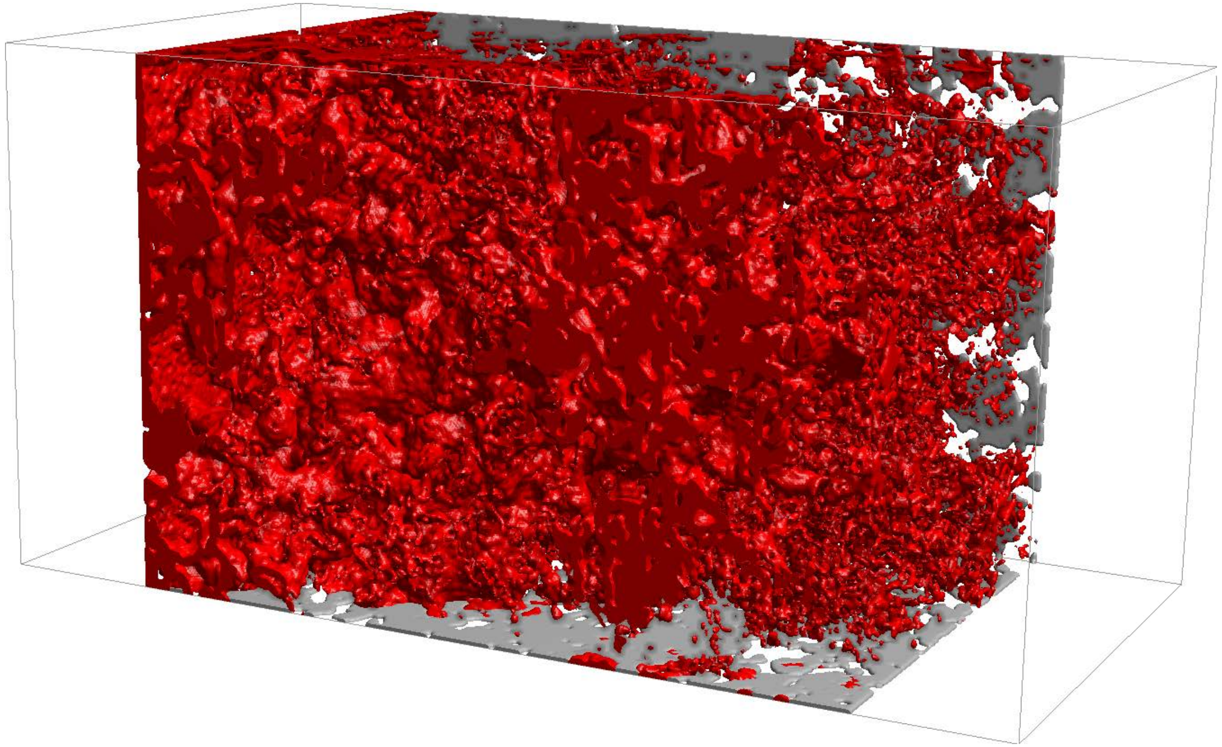
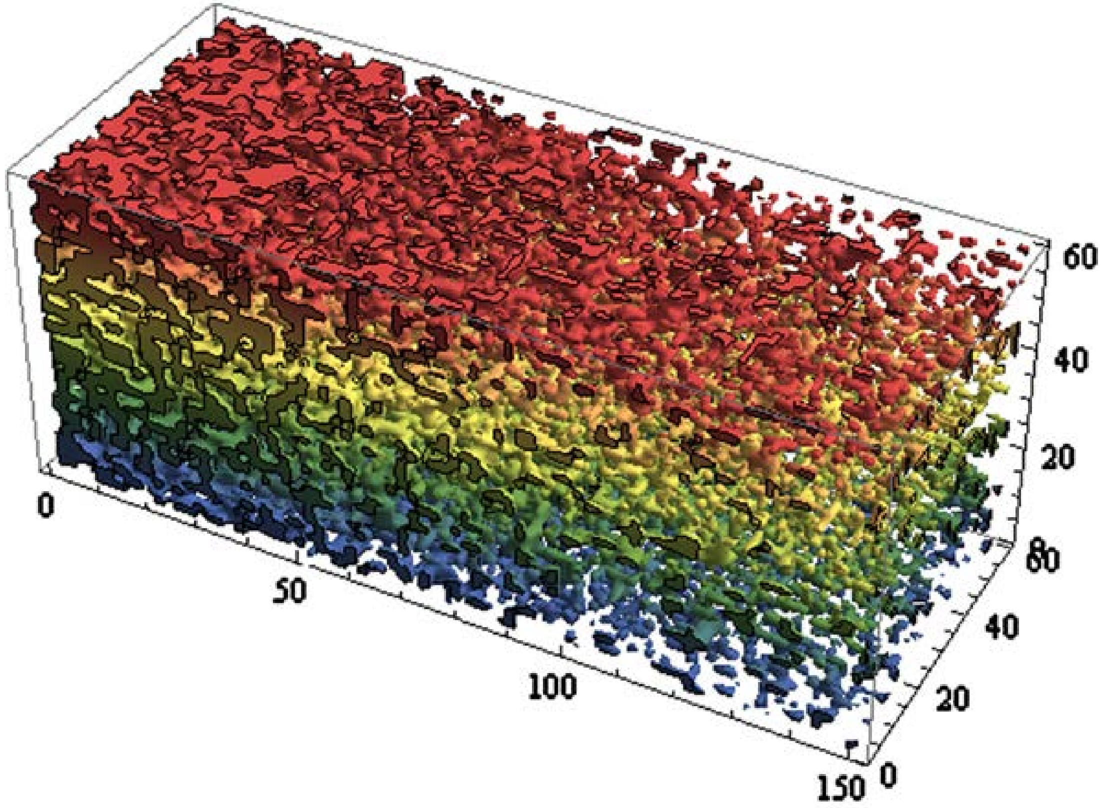


GeoDict simulation



Maheshwari et al. 2013

Dissolution pattern – Wormholes

Simulation settings:
Domain: 256x256x512 voxels
Runtime: 36 h
Average velocity: 0.01 m/s

Material Information:
ID 00: Porespace [invis.]
ID 01: Dissolved Structure
ID 02: Original Structure

Comparison Wormhole pattern

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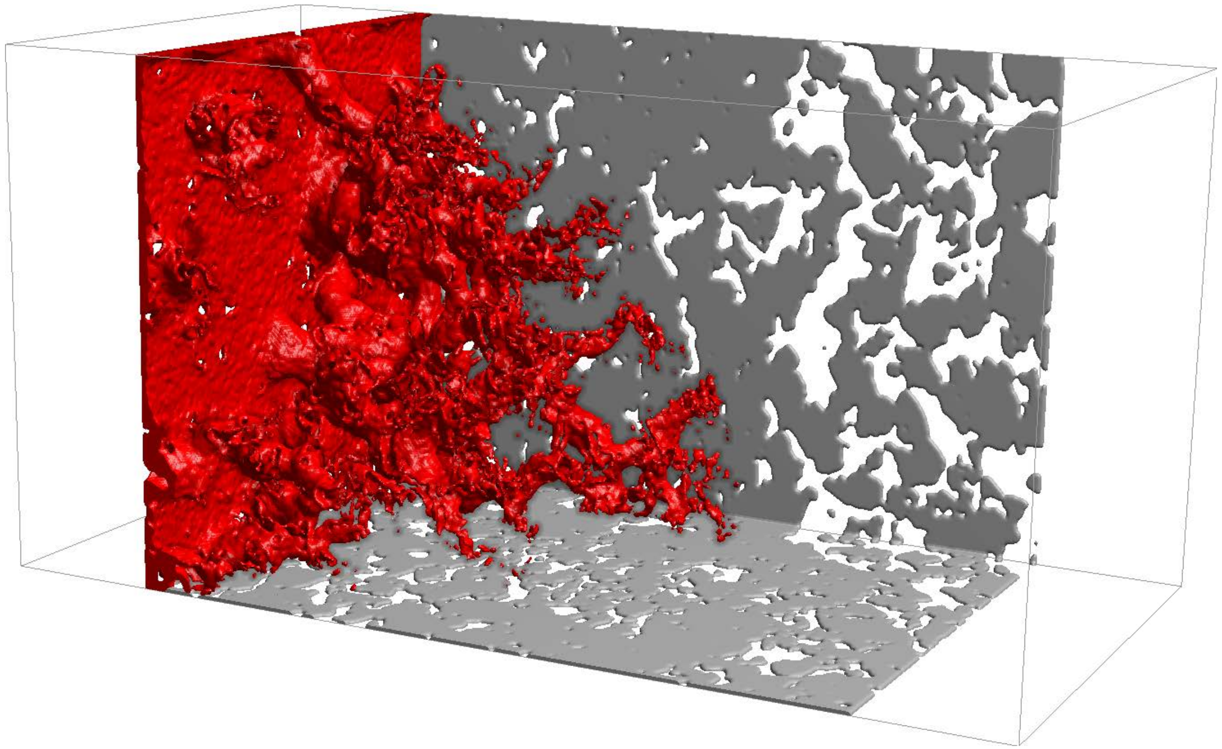
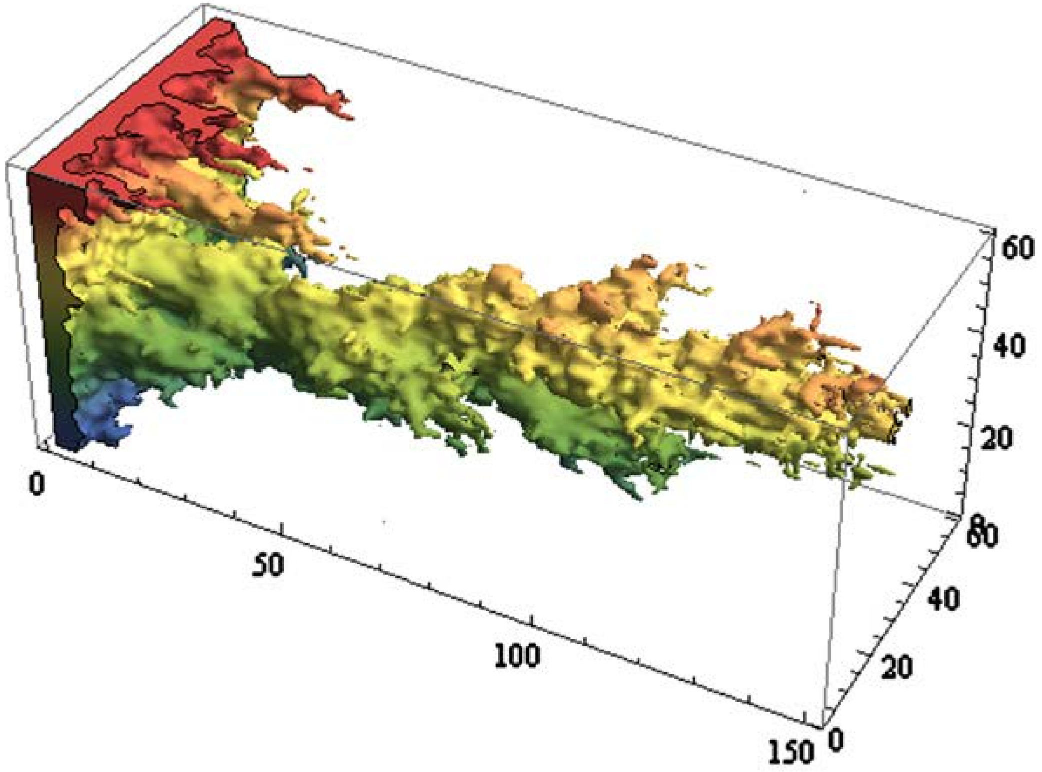


GeoDict simulation



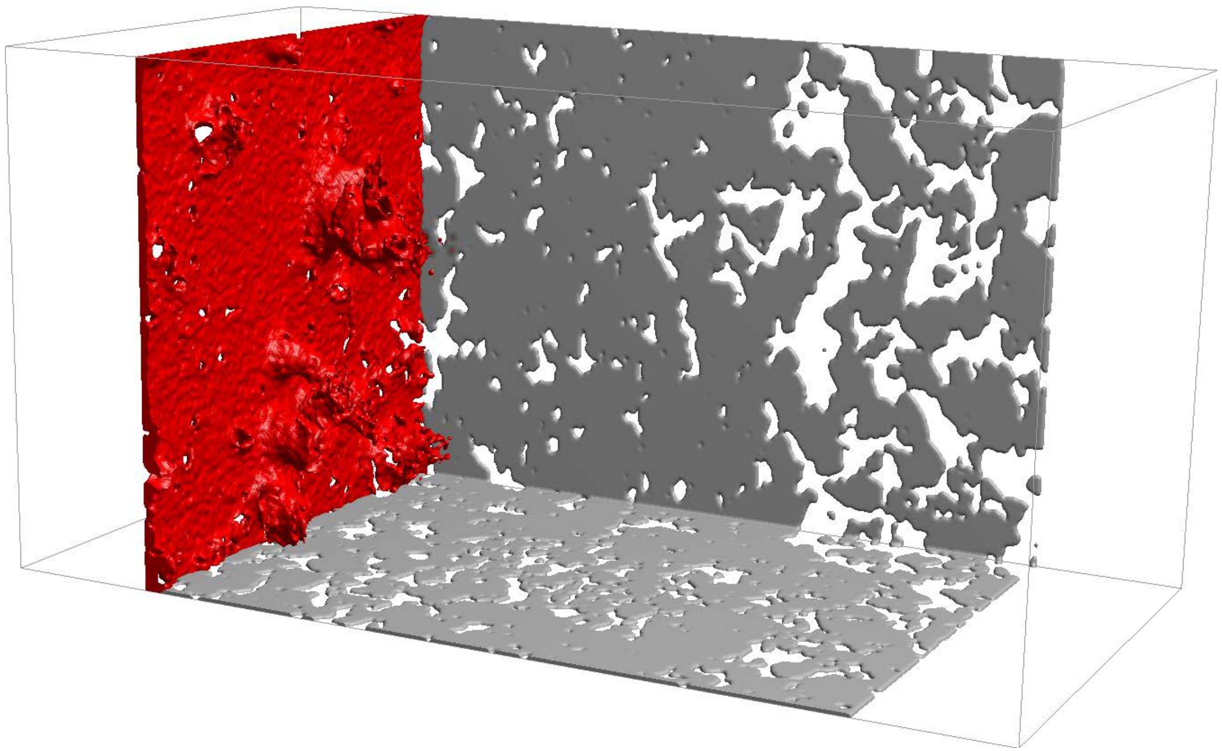
Maheshwari et al. 2013

Dissolution pattern – Face dissolution

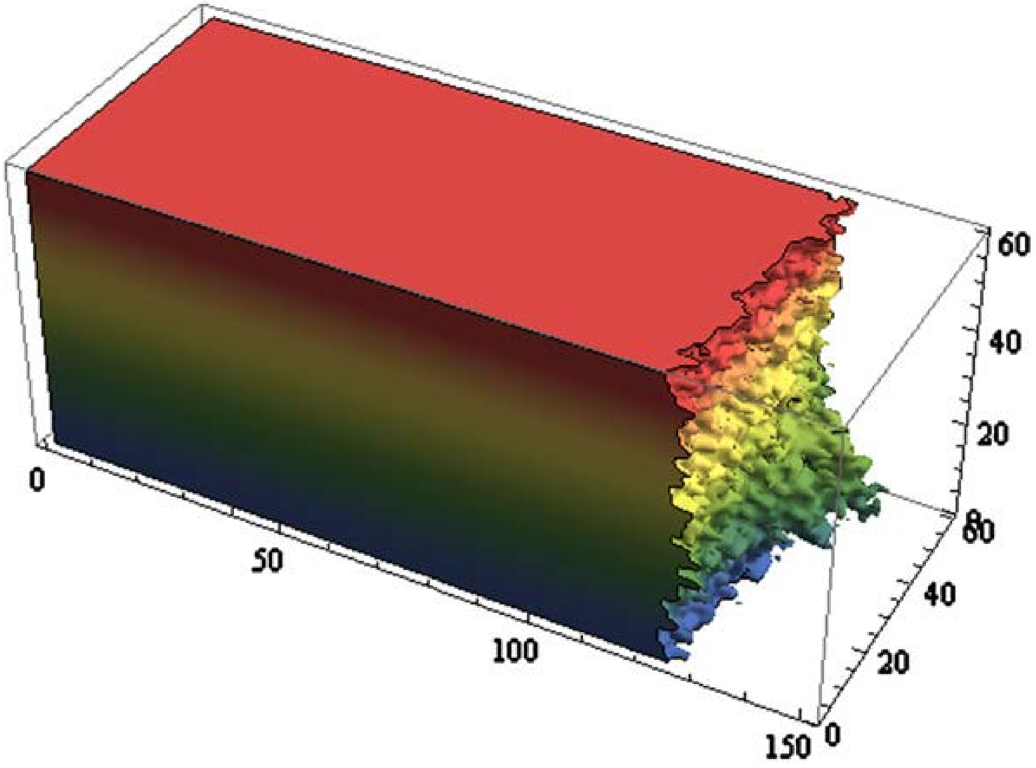
Simulation settings:
Domain: 256x256x512 voxels
Runtime: 50 h
Average velocity: 0.001 m/s

Material Information:
ID 00: Porespace [invis.]
ID 01: Dissolved Structure
ID 02: Original Structure

Comparison face dissolution pattern



GeoDict simulation



Maheshwari et al. 2013

„Large“ Simulation

Simulation settings:
Domain: 512x512x768 vo
Runtime: 24 h
Average velocity: 0.1 m/s

Material Information:
ID 00: Porespace [
ID 01: Dissolved S
ID 02: Original Str

OUTLOOK

- Finalize MATLAB prototype – generally applicable to reactive transport
- Compare simulations with an experimental data set
- Transfer MATLAB code into C++ and incorporate it in GeoDict to reach computational domains of 1500x1500x1500 voxels

REFERENCES

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THANK YOU FOR YOUR ATTENTION

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Please come to our booth for more information about GeoDict®

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Senior Applications Specialist

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