MicroCT imaging of porous sandstone and limestone: Implications on permeability evolution and mechanical damage

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MicroCT imaging of porous sandstone and limestone: Implications on permeability evolution and mechanical damage

- Effect of porosity and connectivity on permeability and formation factor of porous sandstone.
- MicroCT imaging of Fontainebleau sandstone and simulation of hydraulic and electrical transport.
- Limestone as a dual porosity material: Elastic and inelastic behavior
- MicroCT imaging of Indiana limestone and damage evolution: partitioning of macro- and micro-porosity, macropore statisitics and micropore connectivity.

Fontainebleau sandstone: *pore geometry, permeability and formation factor*

- Laboratory measurements

  Bourbie & Zinszner (1985); *Doyen* (1988); *David and Darot* (1989); *Ruffet et al*. (1991); *Fredrich et al*. (1993); *Gomez* (2009)

- Network and percolation modeling

  Yale (1984); *Zhu et al*. (1995); *Mavko and Nur* (1997); *Bernabe et al*. (2011)

- MicroCT imaging and numerical simulation

  Auzerais et al. (1996); *Lindquist et al*. (2000); *Arns et al*. (2004)

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Virtual permeametry on microtomographic images

Christoph H. Arns[a,*], Mark A. Knackstedt[a], W. Val Pinczewski[b], Nicos S. Martys[c]

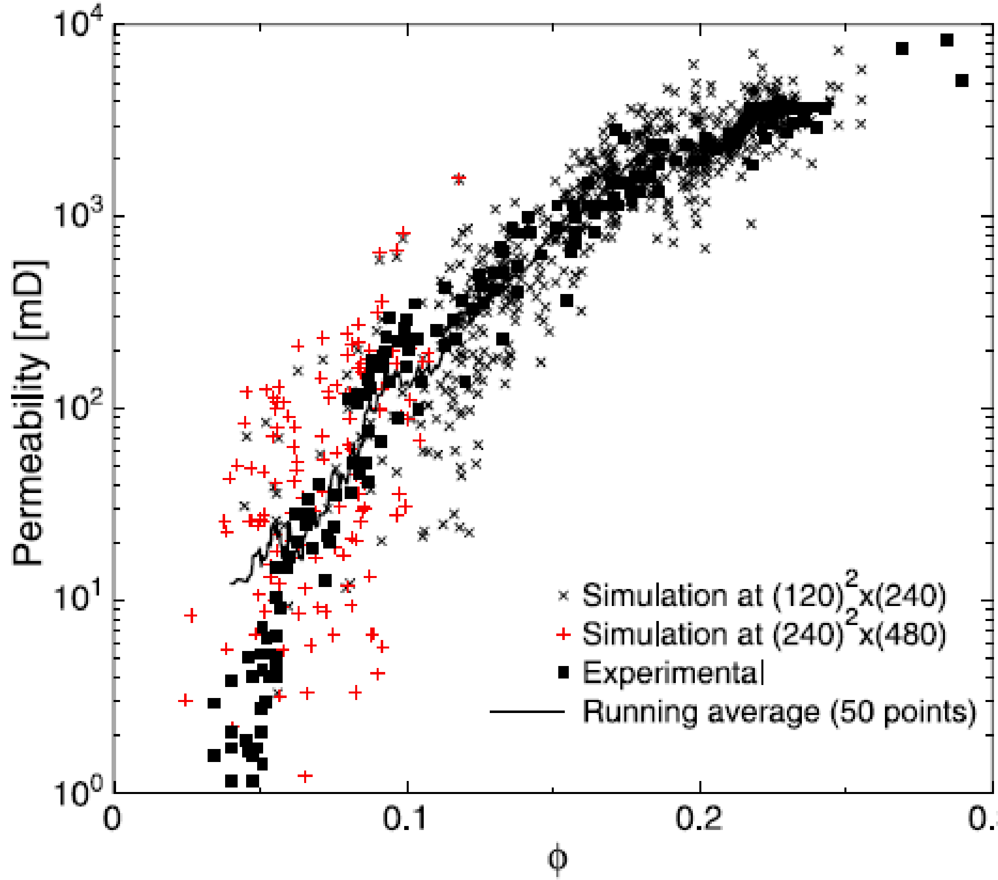
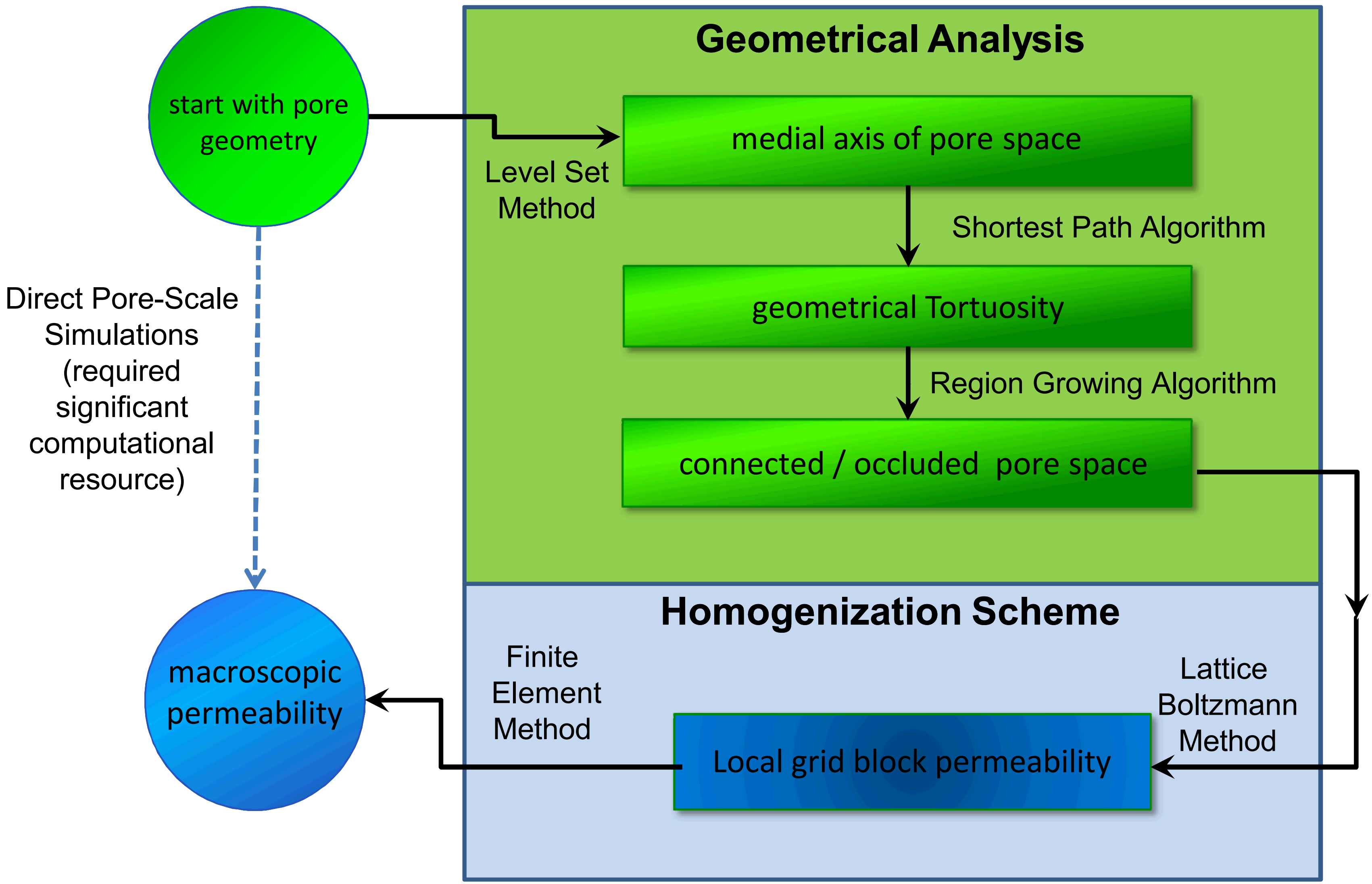


Fig. 2. Comparison of the numerical prediction of the permeability simulations for the Fontainebleau sandstone with experimental data. The lines indicate best fits to the numerical data.

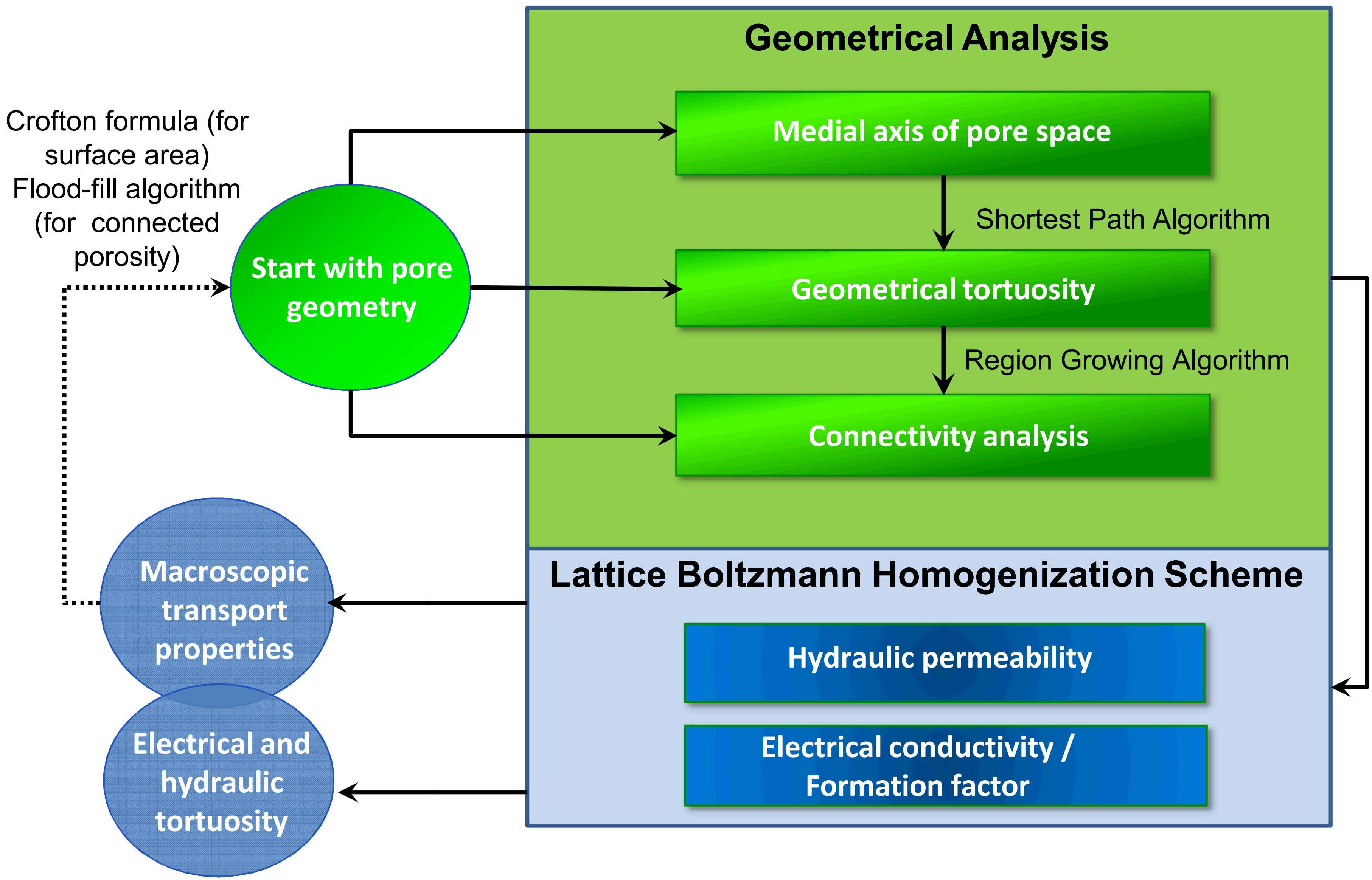
INTERNATIONAL JOURNAL FOR NUMERICAL METHODS IN ENGINEERING
Int. J. Numer. Meth. Engng 2011; 88:1260–1279

Multiscale method for characterization of porous microstructures and their impact on macroscopic effective permeability

W. C. Sun[1], J. E. Andrade[1,*,†] and J. W. Rudnicki[2]



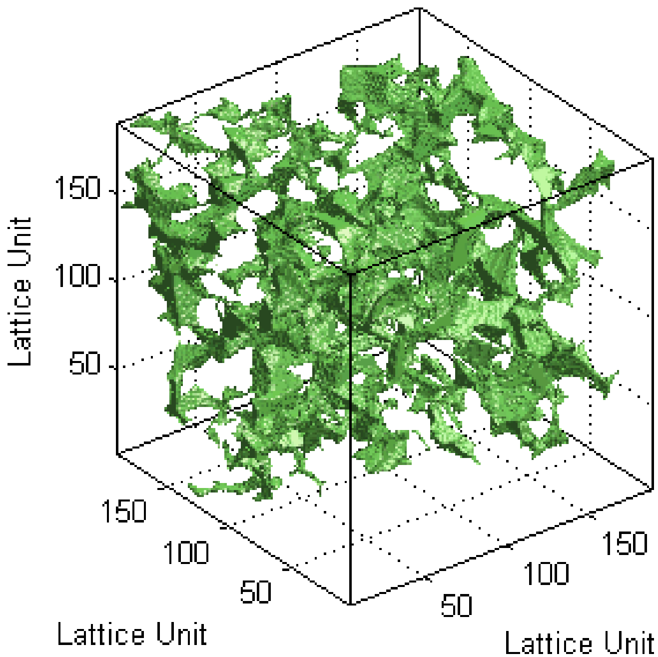
Multi-scale framework for analyzing pore geometry and transport properties



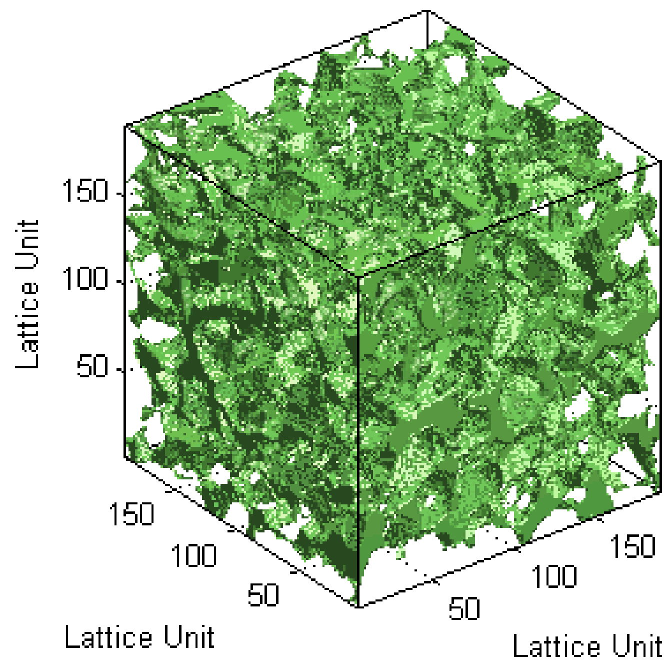
JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 105, NO. B9, PAGES 21,509–21,527, SEPTEMBER 10, 2000

Pore and throat size distributions measured from synchrotron X-ray tomographic images of Fontainebleau sandstones

W. Brent Lindquist and Arun Venkatarangan
John Dunsmuir Teng-fong Wong

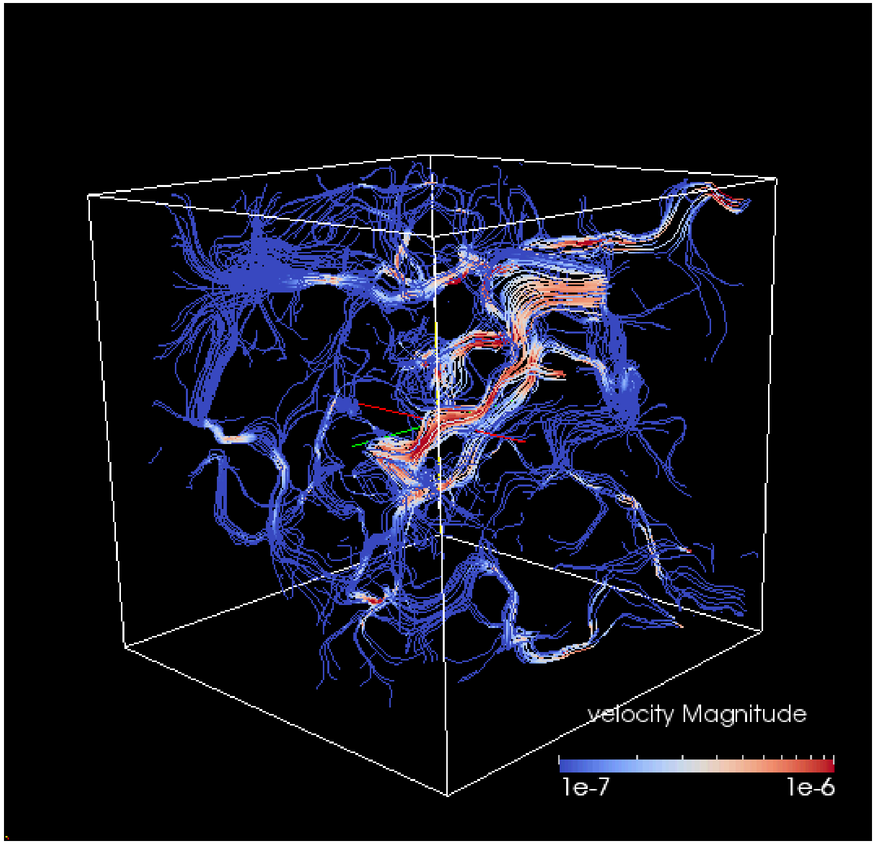


Porosity= 7.43%

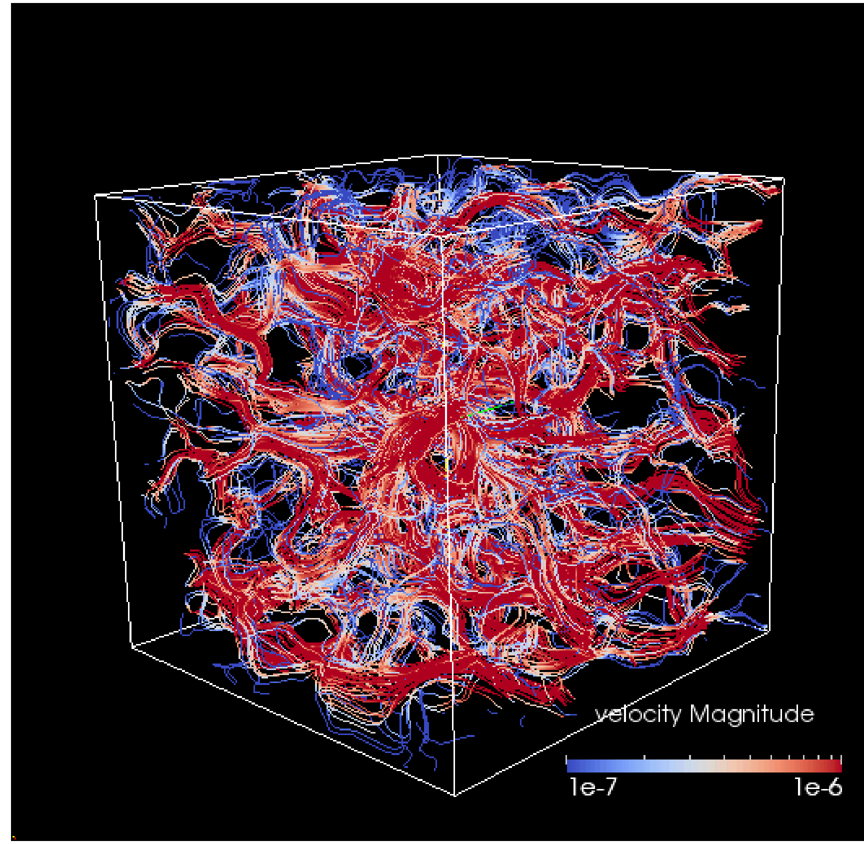


Porosity= 19.2%

Lattice Boltzmann simulation of fluid flow

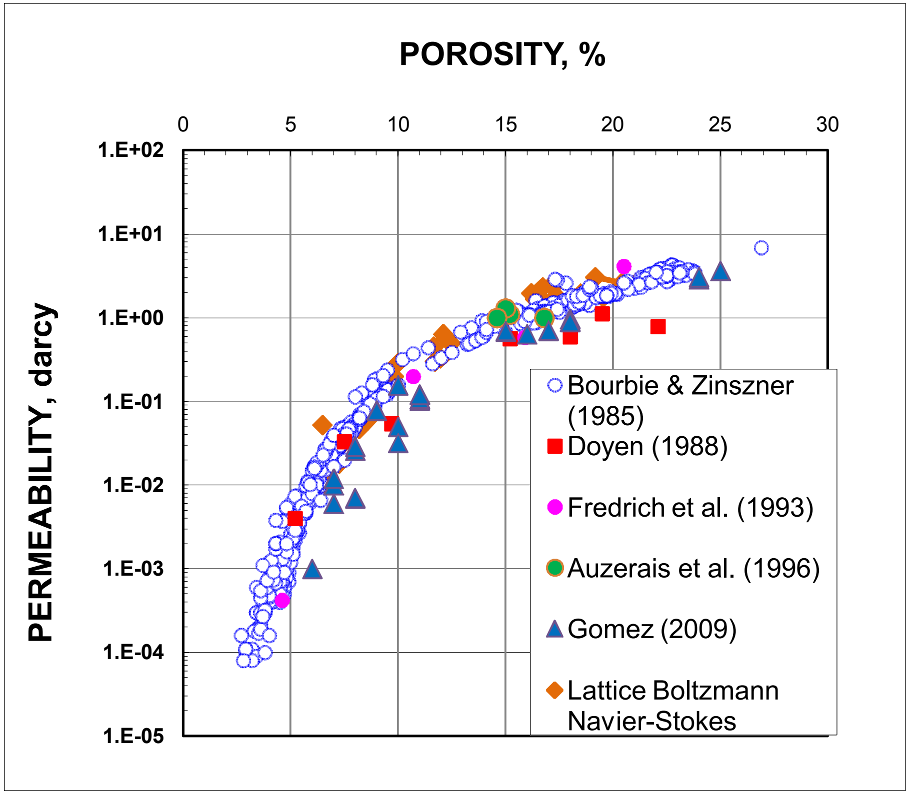


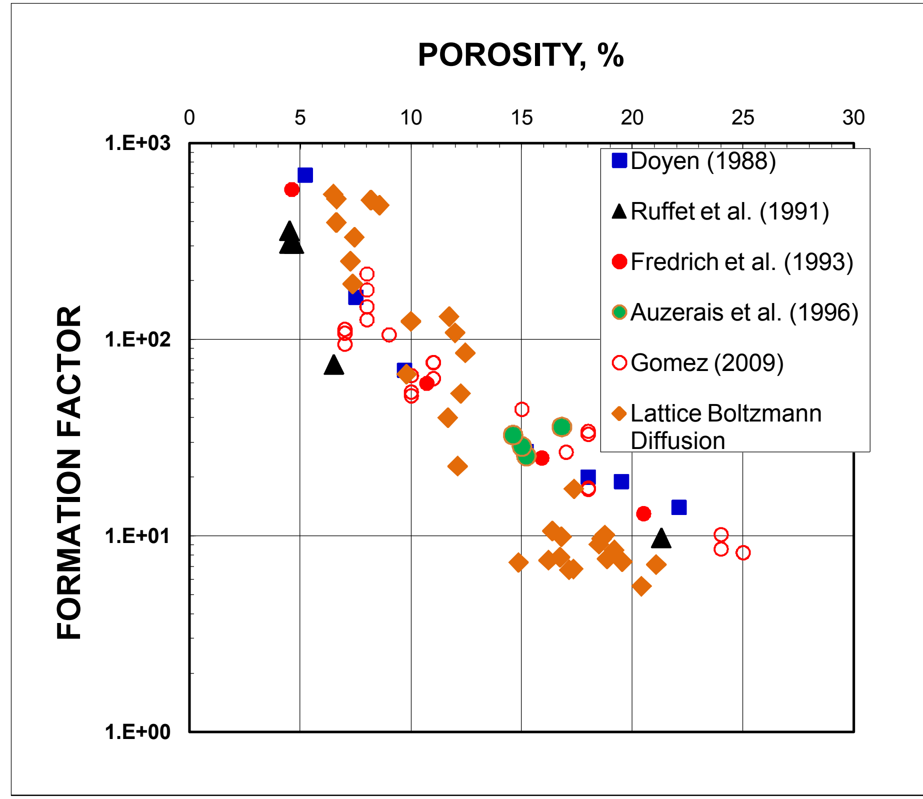
Porosity= 7.43%
k = 0.0316 darcy; FF = 332
Isolated/Connected Pore Volume = 0.5
Connected Pore Volume/Surface Area = 8.9 μm



Porosity= 19.2%
k = 3.08 darcy; FF = 8.5
Isolated/Connected Pore Volume = 0.036
Connected Pore Volume/Surface Area = 12 μm

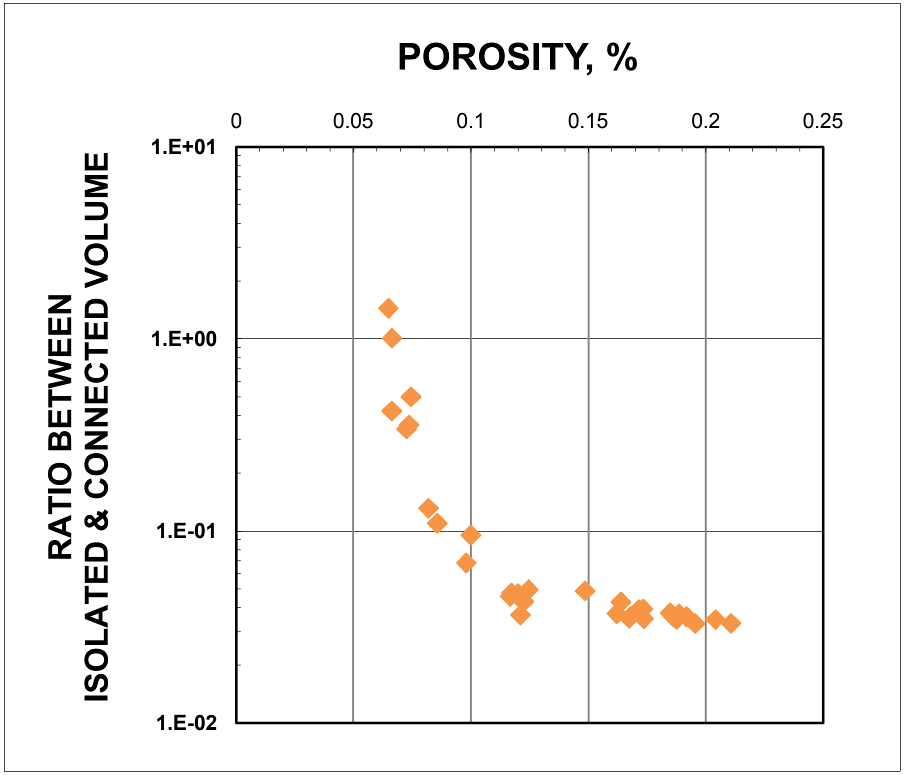
Comparisons of lattice Boltzmann simulation results with laboratory measurement

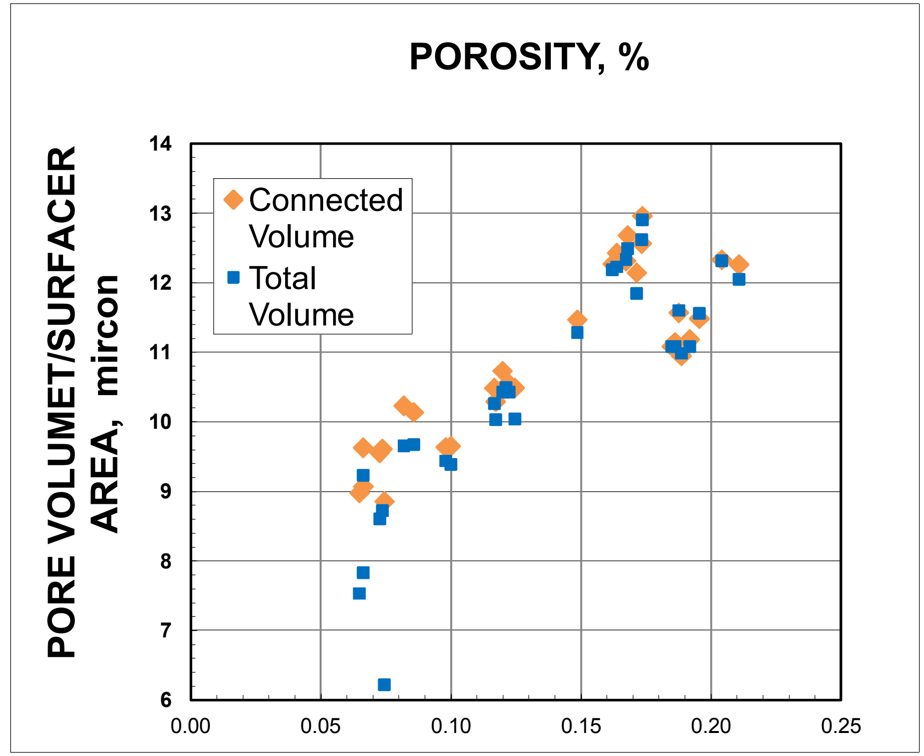




- 8 subvolumes (190X190X190, voxel size 5.7 μm) of 4 Fontainebleau sandstone samples with nominal porosities of 7.5, 15, 15 and 22% were analyzed.
- 32 Lattice Boltzmann (Navier Stokes and diffusion) simulations were conducted.
- Permeability and formation factor results are in good agreement with published experimental data, and previous simulation of *Auzerais et al*. (1996).

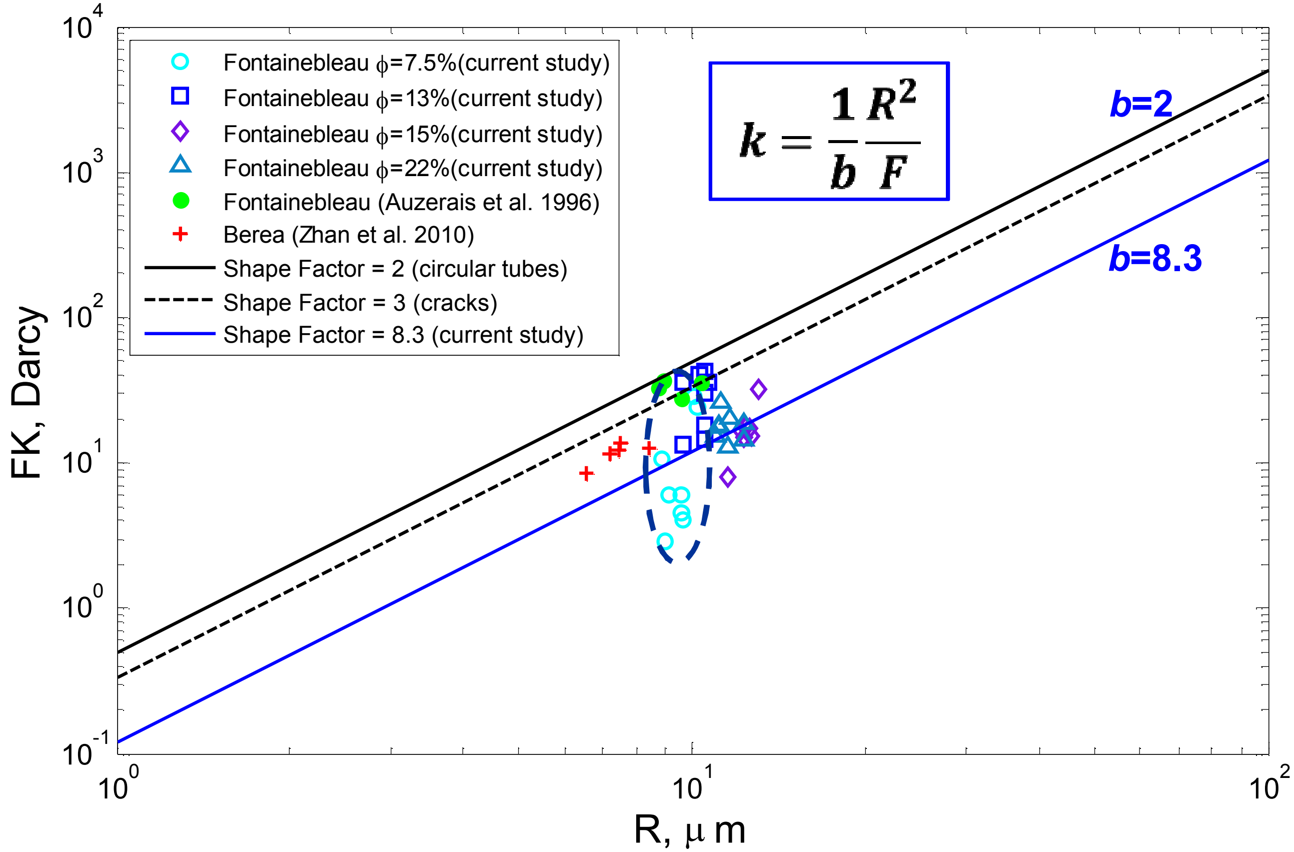
Direct geometrical measurements of pore geometry in CT images





- Measurement obtained from 32 1mm^3 cubic 3D pore geometry in Fontainebleau Sandstone.
- Specimen with lower porosity tends to contain more isolated volume and lower connected volume per surface area.

Permeability, Formation Factor and Hydraulic Radius



- In the **equivalent channel** model, paths for hydraulic and electrical transport have identical "tortuosity" which can be canceled out by multiplying permeability and formation factor (*Paterson*, 1983; *Walsh and Brace*, 1984).
- That the product *kF* spans over 1 order of magnitude in the 7.5% sample indicates that the hydraulic and electrical hydraulic tortuosities are significantly different.
- The geometric factor *b* depends not only on the geometric shape, but also statistical variation of aperture and shape of the conduits (*Bernabe et al*., 2011).