Scaling-up Fracture Pore Space Permeability Approach to Mine Water Inflow Prediction

Eunjeong Seok & John E. Gale
Fracflow Consultants Inc.

Presented at IMWA 2010

Key Questions

- How does the approach taken to represent permeability heterogeneity affects computed flows when the system is characterized by spatial variability?
- What data are required to provide insights into the concept of 'scale effect' vs. 'spatial variability' in fractured rock systems?
- How much data are required to adequately characterize a system?

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What Do We Need?

- Fully characterized permeability and porosity fields with well-defined boundary conditions.
- For fractured rocks, the data set must be suitable for evaluating the applicable flow and transport laws.
- Fully characterized field sites are limited.
- For concept and approach evaluation, small and large scale laboratory experiments are an option.

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Outline

- Examine selected data on scale effect.
- Review a laboratory experiment with full characterized flow field.
- Compare approaches for generating input parameter for a flow model.
- Evaluate effects of sample size and data density on match between the measured and computed flux.

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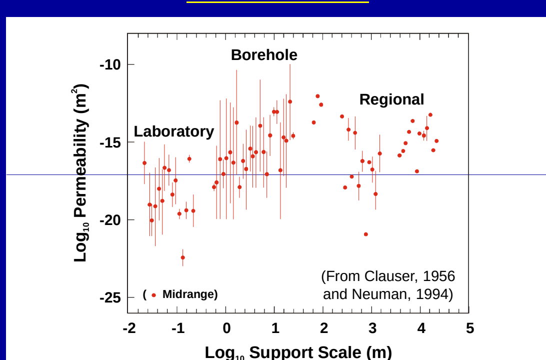
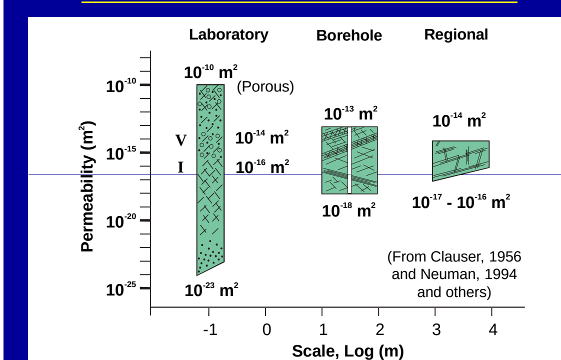
Scale Effect ?



Permeabilities at Different Scales



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Smal Scale Laboratory Study

- What can we learn from a system where the permeability field is fully characterized with well-defined boundary conditions?

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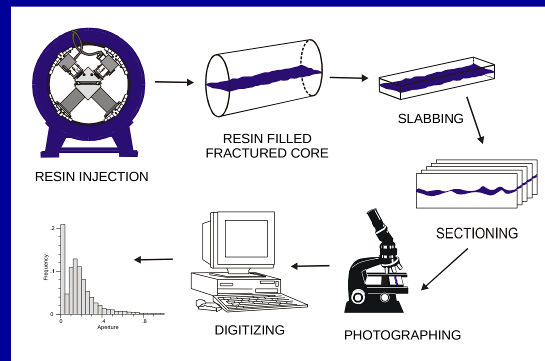
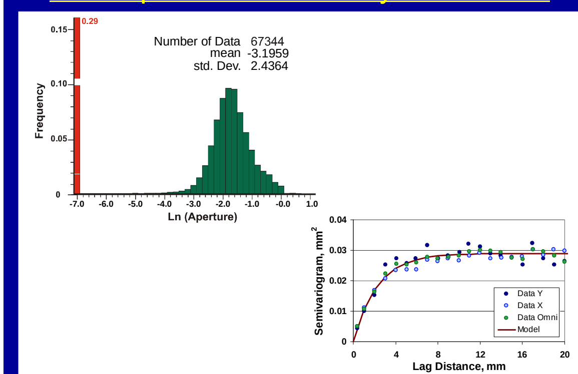
Pore Space Mapping



Pore Space - Permeability Distribution



Generating Pore Space Maps

- Option A
  - Using average aperture
- Option B
  - Measured pore space & variograms
  - Spatial variability using simulated annealing
- Option C
  - Randomly distributed aperture (not spatially distributed)

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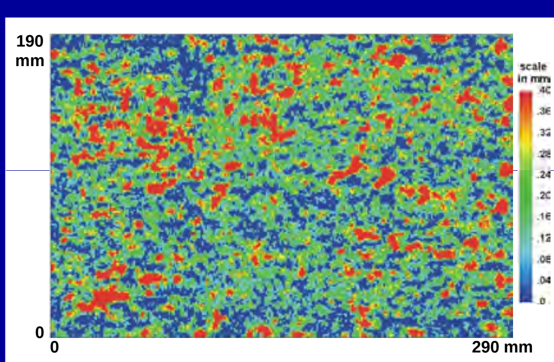
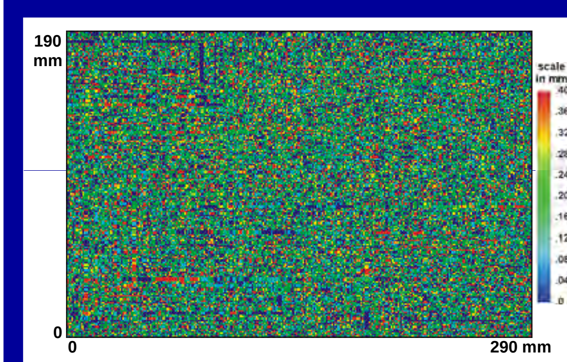
Pore Space Map – Spatial Variability



Pore Space Map – Random



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Numerical Model Results

Method	Flux (ml/s)
Measured	0.5
Average	1.4
Random	0.33
Spatial Distribution	0.43 – 0.56

- Fracture plane sample
  - Average K & randomly assigned K vs. measured K → did not match
  - K with spatial variability vs. measured K → good match

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Effects of Sample Size and Data Density

- Sub-sample the pore space
  - Sample size: 0.2% to 2.9%
  - Randomly selected 30 sub-samples for each sub-sample size
  - Total sampled area: 5.4% to 78%
- Computed flux for each sub-sample
- Compared statistics of measured vs. computed flux

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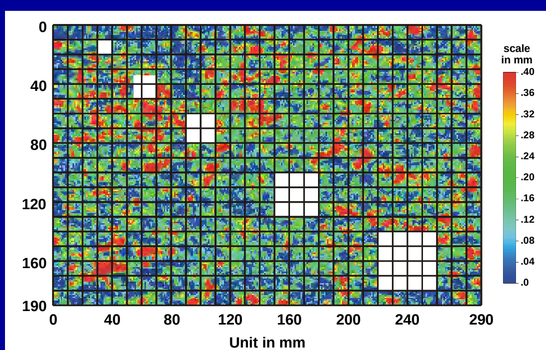
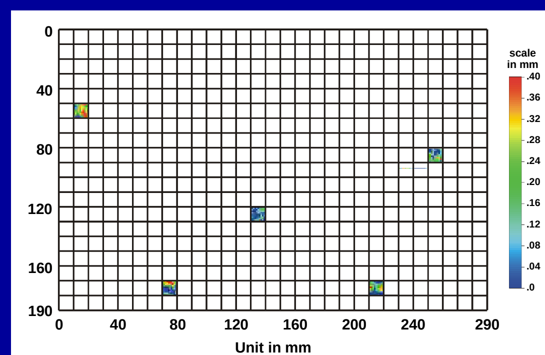
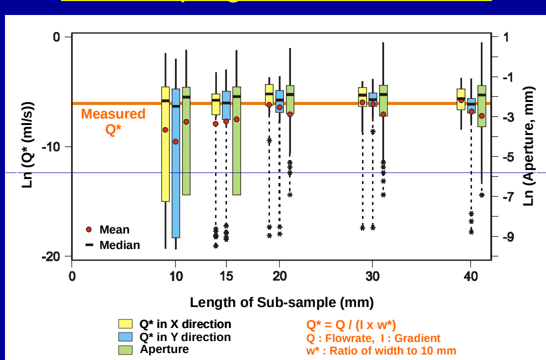
Sub-sampling



Effects of Sample Size or Area Investigated



Sub-sampling at Different Scales



Numerical Model Results

- Comparison of the computed & measured flux
  - Smaller sub-samples showed greater variability
  - Computed flux gradually increased with increasing sample size until it converged to 400 mm^2

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Conclusion

- Numerical models whose input parameters reflect underlying spatial variability of the permeability field give good match between computed and measured flows.
- When sample size reaches 0.7% and the data density equals 22%, the central tendency of flow distribution gave a reasonable match to the measured flow.
- Need to develop an approach to incorporate spatial variability in 3D models with sparse data sets.

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