

Correlation of magnetic pore fabrics (MPFs) with traditional pore fabric characterization and permeability anisotropy in typical sedimentary rocks and hot isostatically pressed samples

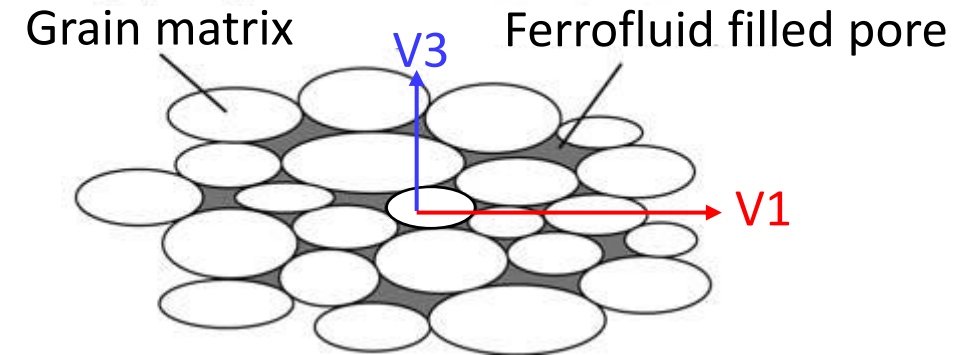
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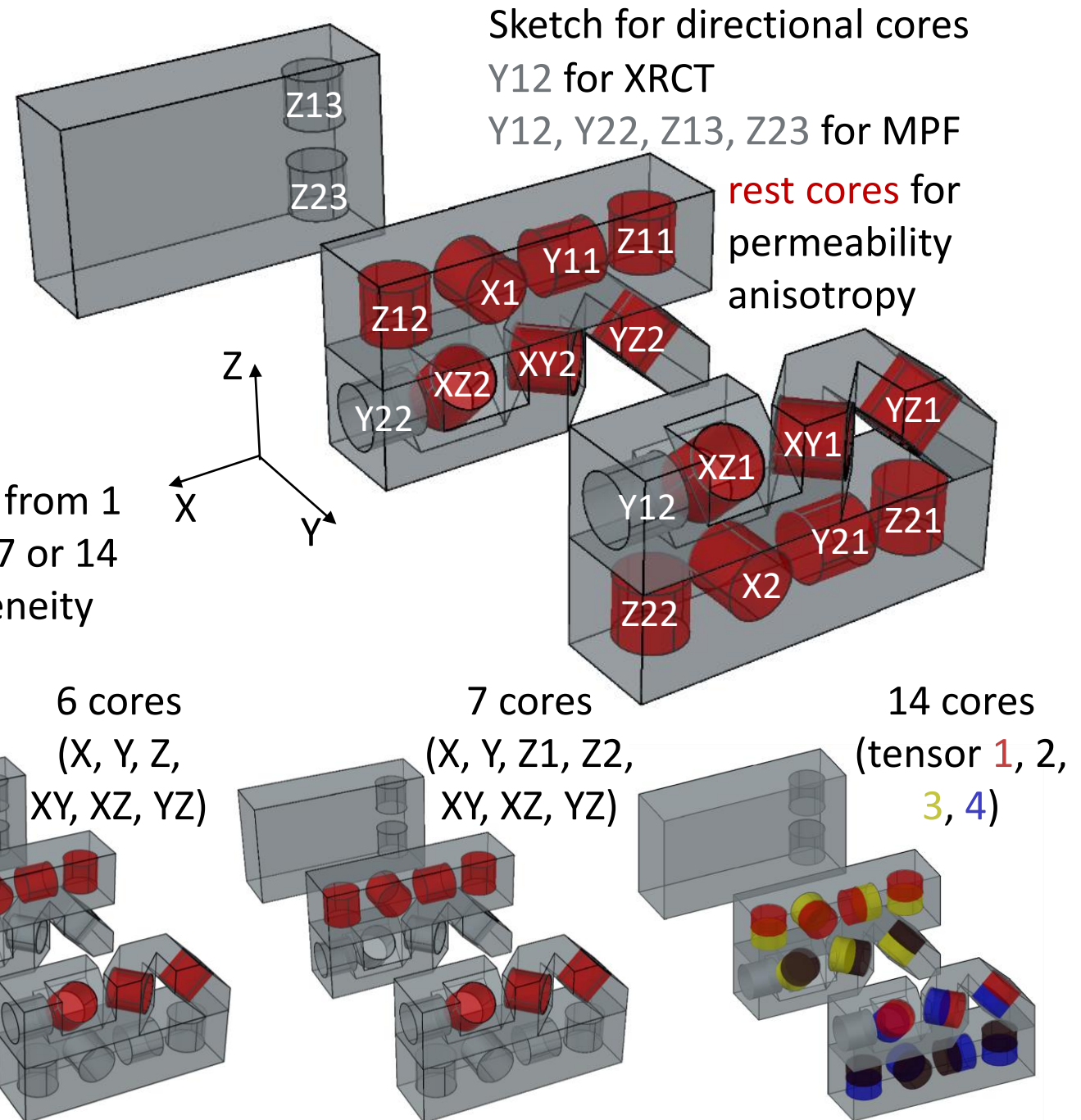
- Empirical relationships exist between MPF and pore fabric, as well as between MPF and permeability anisotropy
- Total shape ellipsoid for pore fabric, MPF, and permeability anisotropy are 2nd order tensors
- Six independent measurements are necessary to define the tensor, and we can calculate confidence limits if we have more data
- We want to establish quantitative correlations of pore fabric, permeability anisotropy and MPF



Maximum susceptibility parallel pore elongation and maximum permeability
(Modified after Jones et al., 2006)

1. Samples and methods

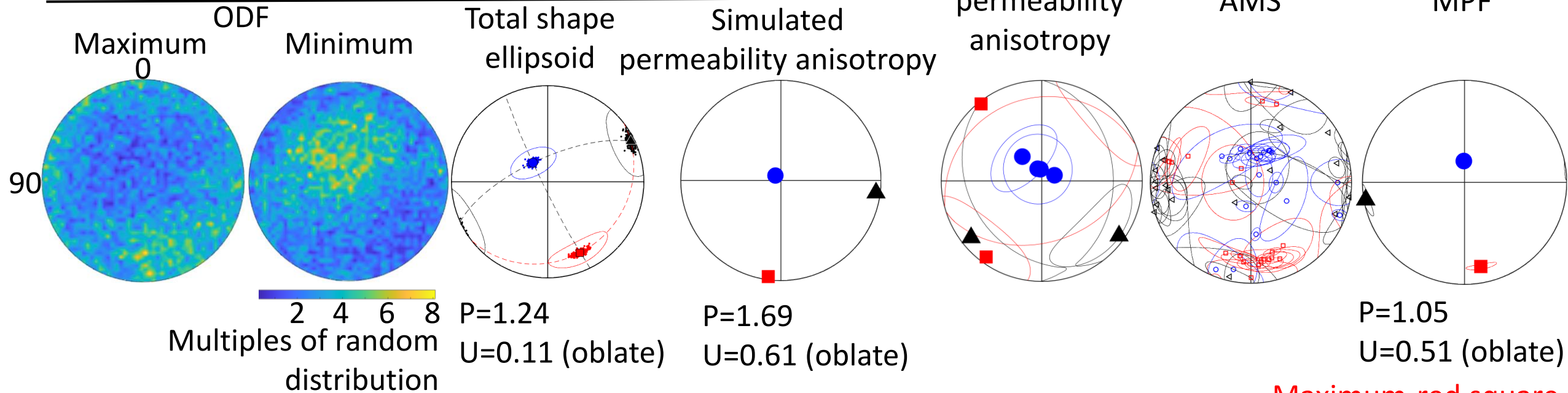
- Benchmark samples
 - Berea, Berea Spider, Bentheimer, Castlegate, Salt Wash North sandstone and Indiana limestone
- Hot isostatically pressed (HIP) samples
 - Calcite and mica powder (50/100 microns) with proportion 30:70, 50:50, 70:30
- With 6 cores the full tensor can be estimated (or from 1 core for MPF, or from 1 core for XRCT), and with 7 or 14 cores one can estimate uncertainty and heterogeneity



2. Methods and results

Berea sandstone B25

XRCT-derived pore fabrics



Workflow

- XRCT
 - Pore shape analysis
 - Permeability anisotropy simulation
- Permeability anisotropy measurement
- AMS measurement of dry sample
- MPF

$$a \geq b \geq c$$

$$P = a/c; U = (2*b-a-c)/(a-c), U > 1 \text{ (oblate)}, U < 1 \text{ (prolate)}$$

- Minimum directions of all data are sub-parallel to Z axis
- Maximum and intermediate axes are in the XY-plane (oblate)

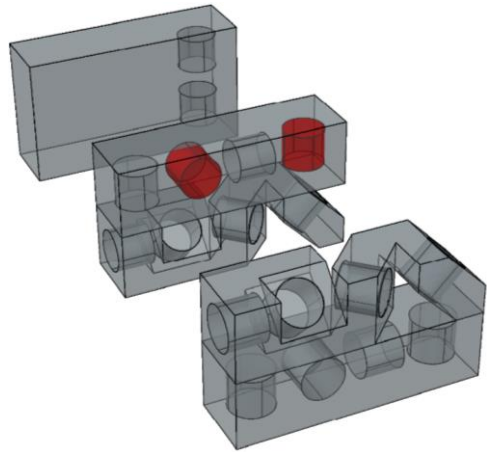
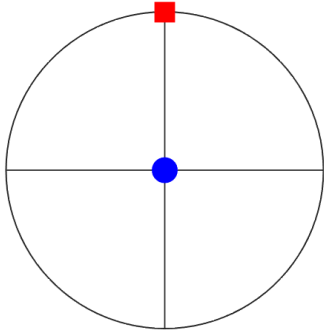
3. Permeability anisotropy

Berea sandstone B25

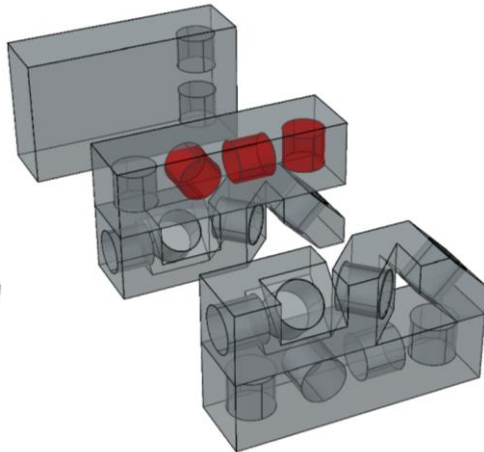
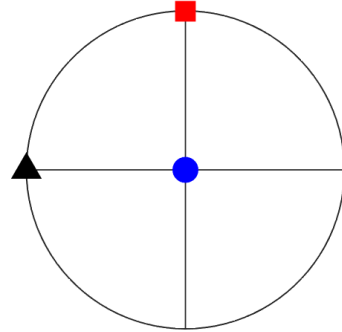
Permeability anisotropy

Maximum-red square
Minimum-blue circle

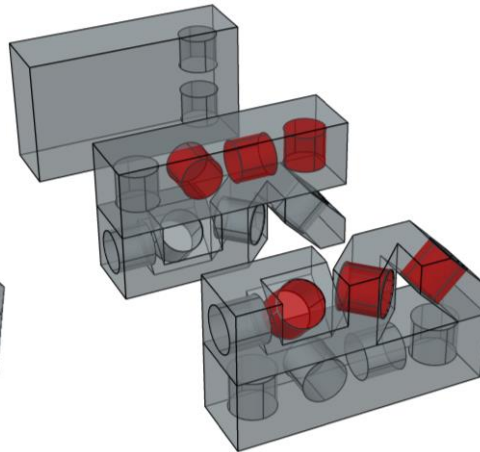
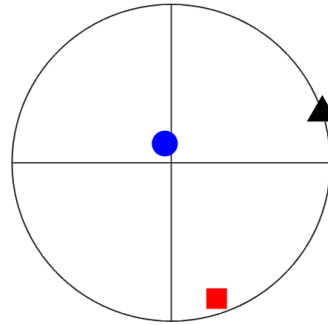
2 cores
(X, Z)



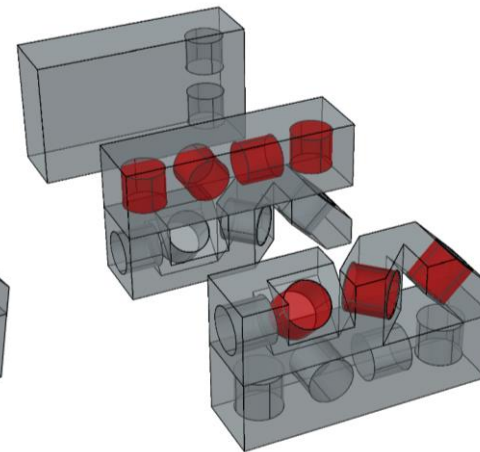
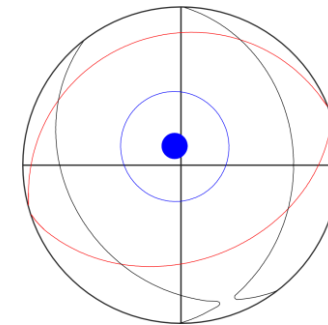
3 cores
(X, Y, Z)



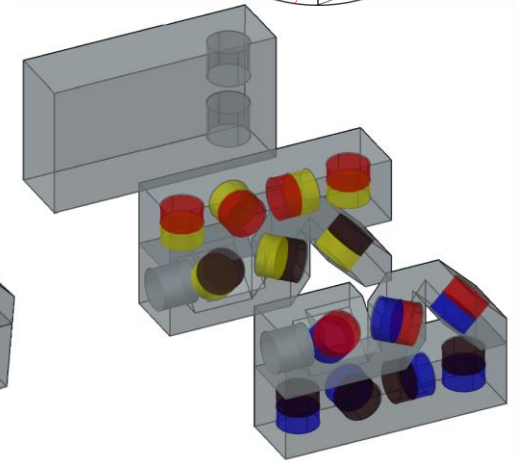
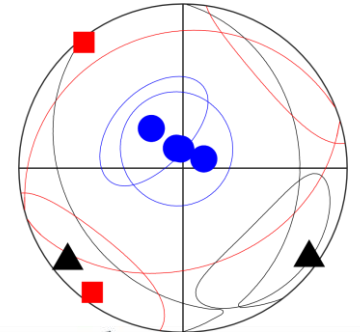
6 cores
(X, Y, Z, XY, XZ, YZ)



7 cores
(X, Y, Z1, Z2, XY, XZ, YZ)



14 cores
(4 tensors)



- 2-3 directional measurements may over- or underestimate the permeability anisotropy
- 14 directional measurements allow to evaluate the heterogeneity of the blocks

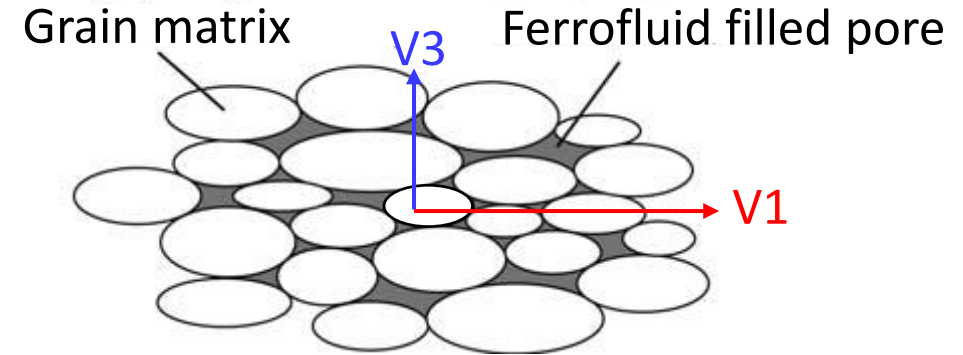
4. Implications

- Quantitative correlations of pore fabric, permeability anisotropy and MPF were established
- Determine the MPF first, to get an overview of fabric orientation and heterogeneity
- Knowing the directions, horizontal and vertical permeabilities can be measured to calculate permeability anisotropy

Paper

Quantitative correlations between direct and indirect measures of 3D pore fabrics and permeability anisotropy from X-ray tomography, permeability measurements and magnetic pore fabrics in sedimentary rocks and synthetic samples

-->Coming soon



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