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Statistical Characterisation of Porous Media at the Pore Scale

Student:
Lukas Mosser

Supervisors:
Professor Olivier Dubrule
Professor Martin Blunt

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Presentation Outline

- **Introduction**
- **Aims & Objectives**
- **Workflow**
- **Industry Impact**
- **Timeline and Milestones**
- **Risks and Mitigation**

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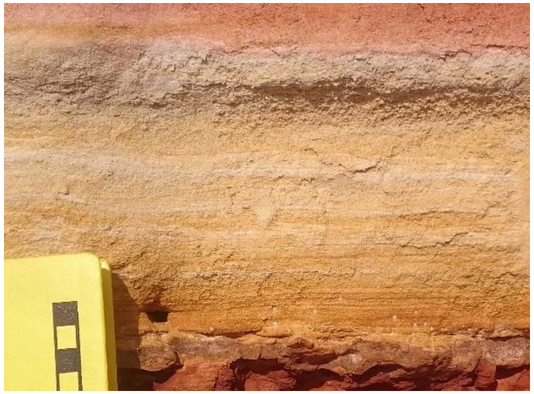
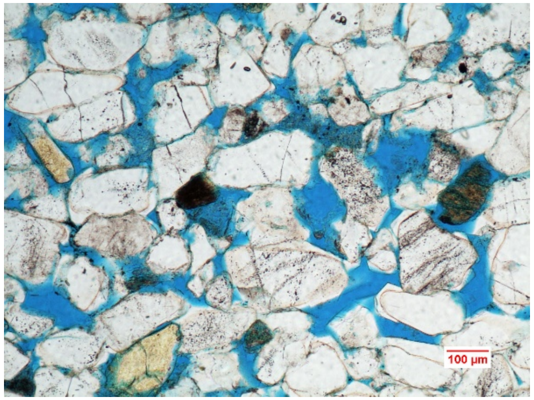
Introduction

- Reservoir rocks are random materials that often consist of siliciclastic grains or a carbonate matrix which are deposited and have been subjected to diagenetic processes.



- Porous Media such as reservoir, seal or source rocks can be described as spatial realizations of a distribution of material and void space arising from an underlying physical and stochastic process.



- Often the macroscale behavior is of interest, but many key properties such as permeability and porosity are governed by the spatial distribution of grains and pores on the pore scale.

$$q = -\frac{\bar{\bar{k}}}{\mu}\nabla P$$

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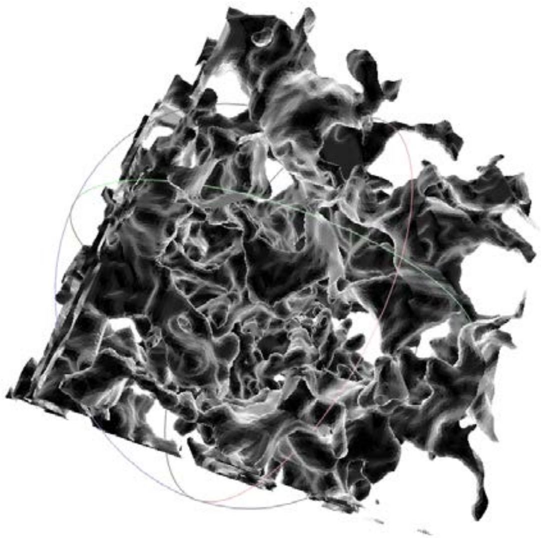
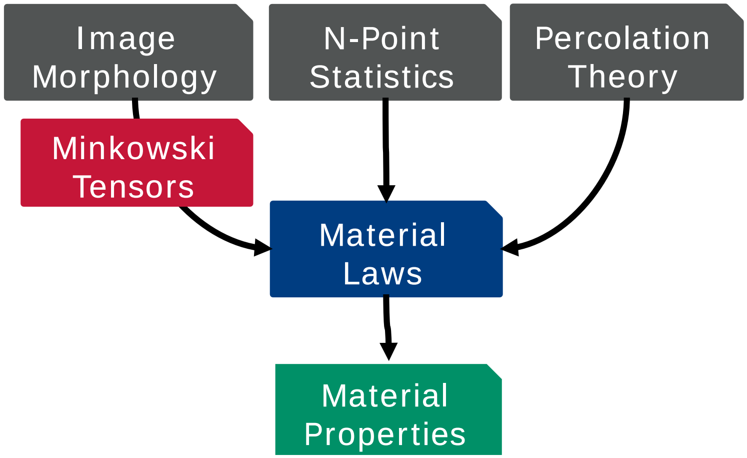
Aims and Objectives

- Micro-CT imaging allows characterization of pore space based on image morphological measures. Available resources at Imperial allow in-situ transient imaging of pore and fluid distribution under various displacement processes leading to a rich set of available data.

- A large variety of methods to quantify random materials have been proposed in the literature to describe porous media. Methods often not able to capture heterogeneity and anisotropy as well as provide a link to critical material properties.

- This thesis aims to evaluate the application of tensorial Minkowski functionals as an improved method to describe pore space structure and anisotropy and investigate possible application as a proxy for properties of porous media.





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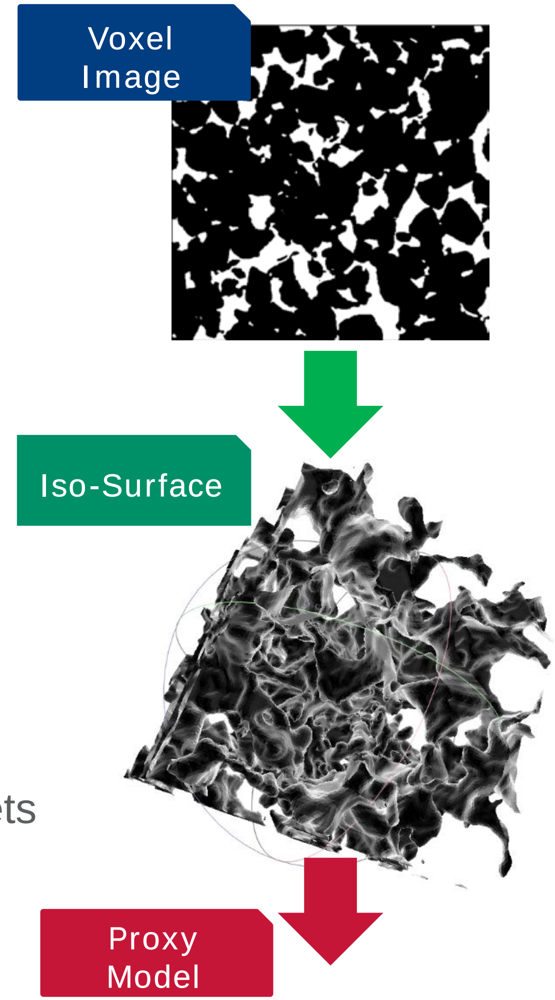
Workflow

- Critical literature:
  - pore scale imaging
  - image morphology
  - random materials
- Collection and screening of available datasets.
- Development of workflow to facilitate computation of tensorial Minkowski functionals based on voxel Micro-CT images:
  - Extraction of iso-surfaces based on image segmentation
  - Computation of tensorial functionals on triangulated surface
- Computation of tensorial functionals on available datasets
- Evaluation of tensorial Minkowski functionals as proxies for material properties and as classifiers of pore scale structures of porous media



$$\bar{\bar{k}} = a\bar{\bar{W}}_1^{0,2}$$

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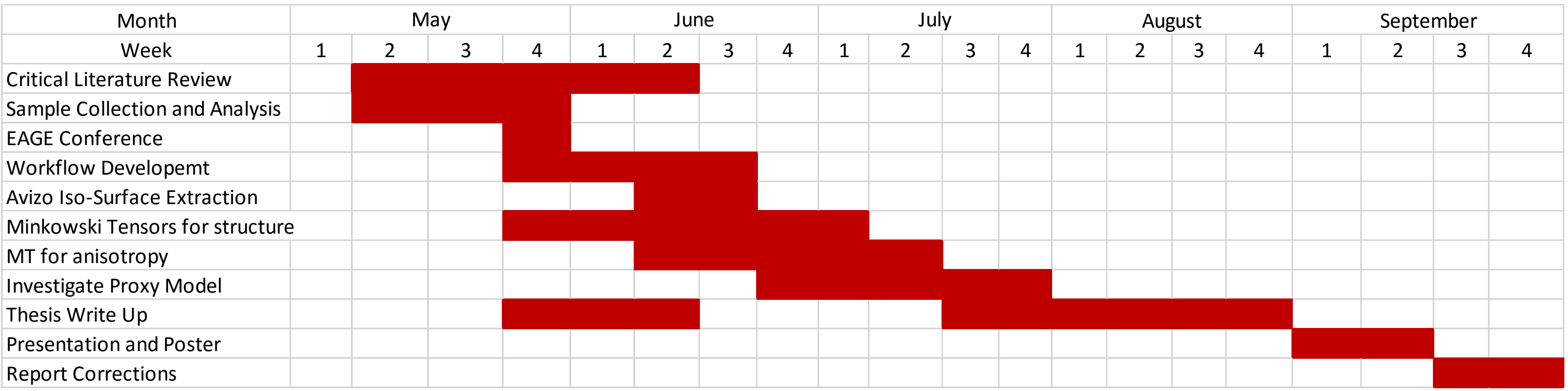
Timeline



Milestones

- Outline Presentation: 31st of May
- Bi-Weekly Reports: June 8, June 22, July 6, July 20, August 3, and August 17
- Report Deadline: August 31st, 16:00
- Presentation: 13-14th September
- Final Corrections: September 30th, 16:00

Industry Impact

- Evaluate application of tensorial Minkowski functionals to describe pore space topology and anisotropy of reservoir rock samples
- Provide new workflow to determine Minkowski functionals from gray-scale or binary voxel Micro-CT images
- Evaluate tensorial Minkowski functionals as proxies to material properties of porous media e.g. permeability
  - Tensorial nature allows to include anisotropy of pore space in proxy model
- Interdisciplinary approach to pore-scale analysis taking into account applications and results from a variety of different fields related to random materials and their properties.
  - Minkowski Tensors previously applied to:
    - » Astronomy: Shape description of galaxy star distributions
    - » Chemical Engineering: Chemical Reaction Patterns
    - » Material Science: Orientation of grain phases

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Risks and Mitigation

Risks	Mitigation
Limited Data and Sample count	• Classification and grouping of available samples. Begin with "homogeneous" samples continue with heterogeneous datasets.
Applicability of Minkowski Tensors	• Investigate variety of links in material texture and material properties. • Base thesis on previous applications then move forward to breaking new ground
Availability of software and documentation	• Utilize available software where possible. • Implement algorithms where no software available. • Continuous documentation of methods
Supervisor Availability	• Supervisor availability awareness • Preparation for meetings and discussions • Pro-active communication • Bi-weekly report and updates on progress
Time Constraints	• Continuous report writing • Allocate 4 weeks for thesis write-up • Deadline awareness • Time management

Thank you!

Questions?