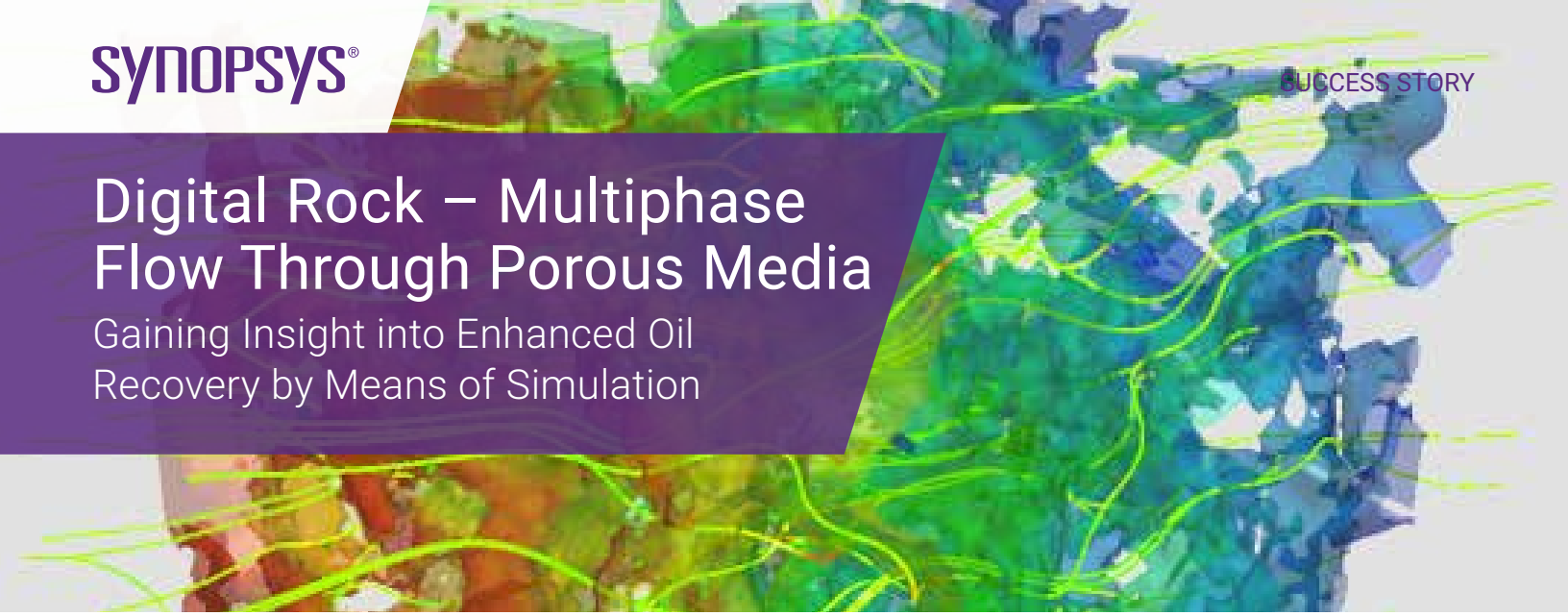
SYNOPSYS®

SUCCESS STORY

Digital Rock – Multiphase Flow Through Porous Media

Gaining Insight into Enhanced Oil Recovery by Means of Simulation



"Our initial results working with the Synopsys Simpleware product have been very positive. We see a real potential in digital rock technology in the Oil & Gas sector, particularly in challenging areas like EOR. In future, we hope to extend our success into new applications (e.g. hydrology) that can take advantage of the powerful features in the Simpleware-TransAT bundle ."

~Djamel Lakehal, Section Head Advanced Modelling & Simulation at Pöyry

Thanks to: PÖYRY

At a Glance

- Digital rock methodology optimizes both primary oil production and enhanced oil recovery (EOR)
- Synopsys Simpleware™ software enables simulation-ready meshes to be generated from 2D images of rock samples
- Pöyry's TransAT© CFD provides insights into multiphase flow at the pore level
- Proof-of-concept workflow with sandstone sample demonstrates the efficiency of the method
- Collaboration opens up new possibilities for characterizing porous media in complementary technologies

Overview

Digital rock technology is based on high-end simulation of pore-scale multiphase flow, a key ingredient in the process of analysis and evaluation of depleted and in-production wells. Digital rock technology serves to optimize primary oil production and characterizes enhanced oil recovery using water, gas, steam, chemicals or CO_2. The key outcomes of digital rock-intensive simulations include relative permeability, saturation and wettability.

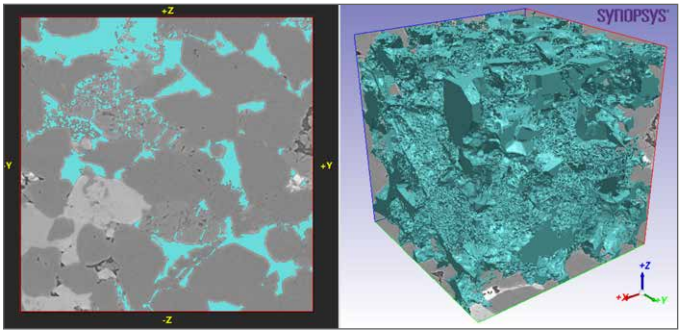
The challenge in conducting such high-end simulations is twofold: (i) clean digitization of the porous media, and (ii) the solution of the multiphase flow equations within the tortuous micro-scale (10-40 Microns) rock patterns, accounting for wettability under very low capillary-number flow conditions (Ca ~ 0.001-0.0001).

Synopsys and Pöyry AMS have recently joined forces to offer a joint solution capable of treating this class of flow for a variety of rock types: sandstone, limestone, etc. Synopsys' Simpleware's™ unique meshing technology based on digitizing millions-of-pixel rock samples is combined with Pöyry's TransAT© CFD, a powerful CFD tool dedicated to capillary-driven multi-fluid flows.

Proof-of-concept Workflow

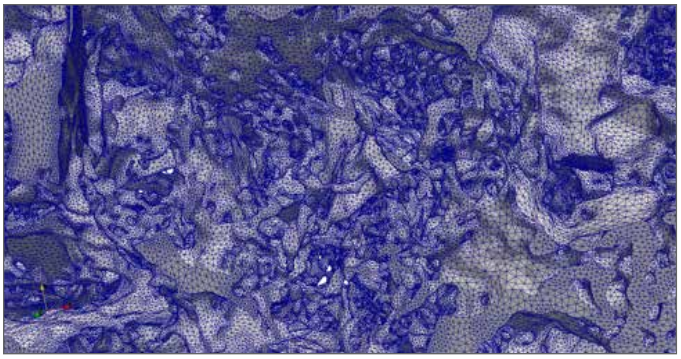
This case study involved study of the flow of oil through Berea sandstone. This example was chosen as an early proof-of-concept, with the idea that future work and collaborations will explore a wider range of geological samples for multiphase rock segmentation. The workflow for this project is as follows:

- the Simpleware mesher provides a very high quality STL file describing the pores,
- the STL is then loaded within TransAT UI to read the files.



3D pore rendering of Berea sandstone in Simpleware ScanIP

This process involves importing a stack of 2D images to Simpleware ScanIP, before using a median filter to remove image noise. The software's image processing tools are then applied to crop the data to a sub-sample, and a threshold tool is used to select pores. Island removal then creates a single connected region and exports a watertight STL file of the pore segmentation.

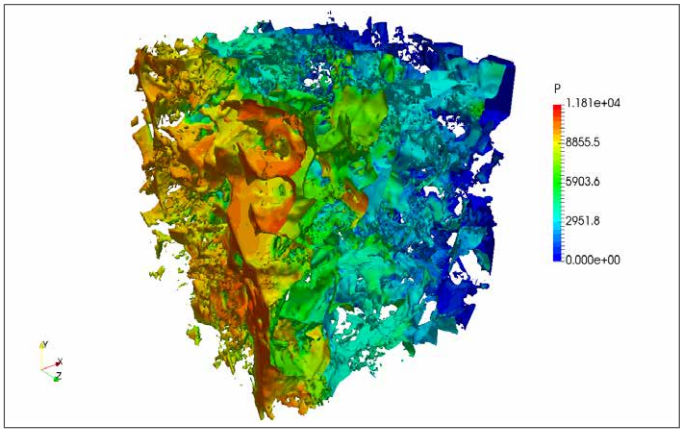


Very high-quality STL file describing sandstone pores created using Simpleware software

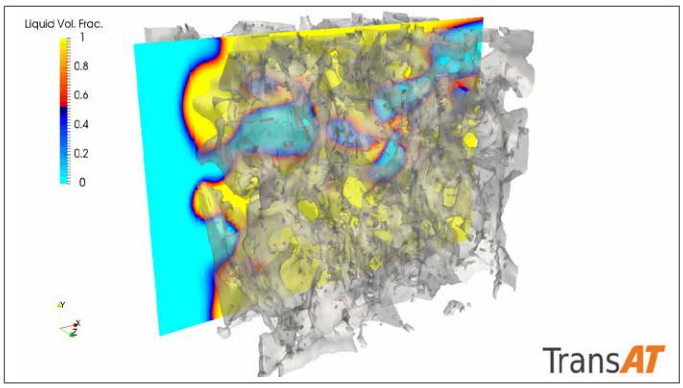
Using IST meshing technology, TransAT reconstructs a CFD mesh based on the Simpleware STL. A multiphase mixture model of TransAT runs for the flow conditions below on Pöyry's HPC cluster:

- Berea sandstone; Pore scale ~10 Microns
- Oil and gas flow; Capillary number = 0.001
- Mesh size 30 µm
- Inlet velocity = 1 m/s
- Density = 1000 kg/m^3
- Viscosity = 1 cP

The results of TransAT simulations using Simpleware meshes are presented in the images below, depicting the pressure field and the oil-gas front propagating along the rock scan. These results also agreed well with analysis in Simpleware software, namely meshing via the Simpleware FE module, and calculation of the absolute permeability tensor within the Simpleware FLOW module.



Pressure field in the sample obtained using TransAT CFD



Oil-gas front propagating within the rock pores obtained using TransAT CFD

Conclusions

The joint workflow with Synopsys Simpleware and Pöyry AMS shows the benefits of a fast and accurate method for modeling porous media and carrying out multiphase simulation. The particular example of the Berea sandstone discussed here is notable for showing the insights into oil flow that can be obtained using this combined solution. Given the high value of these workflows for oil production and oil recovery, this efficient method makes simulation of pore-scale multiphase flow more accessible to industry.