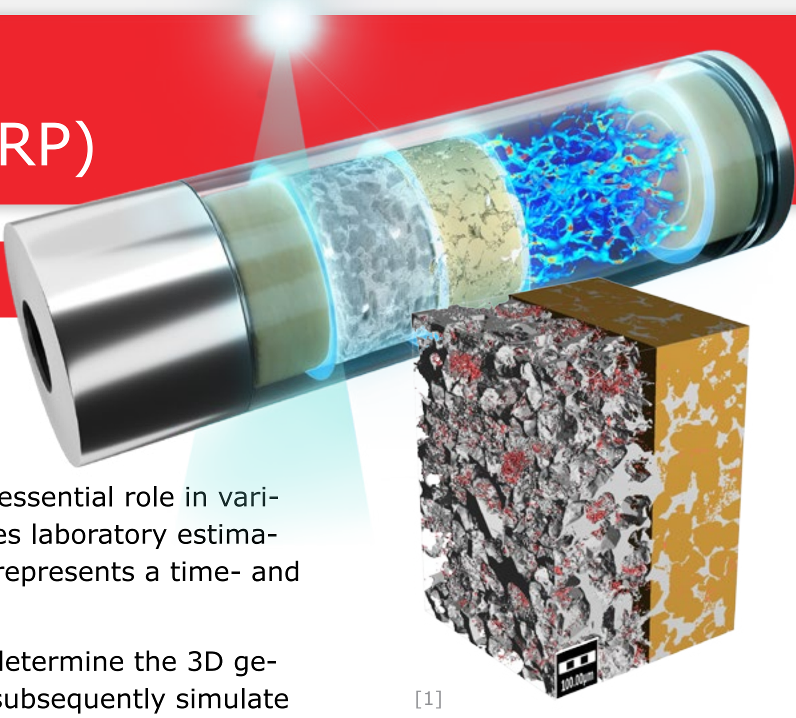
GeoDict

MATH 2 MARKET

Case Study

Digital Rock Physics (DRP)



[1]

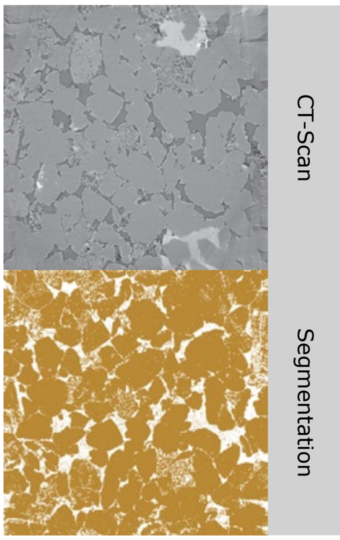
Our Mission

Physical rock properties of reservoir rocks play an essential role in various aspects of E&P in the oil and gas sector. Besides laboratory estimation of such properties, digital rock physics (DRP) represents a time- and cost-effective alternative for their determination.

Imaging and calculation, the basis of DRP, aim to determine the 3D geometry of pore space and mineral phases, and to subsequently simulate physical properties in these digital objects.

The digital laboratory software GeoDict quickly and efficiently determines the geometrical parameters and simulates the physical processes in the digital object at the pore-scale by DRP. GeoDict's DRP package consists of a set of modules to compute physical rock properties. In this way, fluid flow is calculated to quantify permeability, electrical current flow to quantify resistivity, and the elastic deformation to quantify elastic moduli and rock deformation, and to simulate in-situ conditions.

GeoDict runs in-house, on standard workstations. Estimations on very large data sets are sped up and automated through parallelization and easy-to-use scripting.



[2]

3D-model of Berea sandstone [1] created from imported and segmented [1, 2] µCT slices (ImportGeo) [2]. Sandstone matrix shown in ochre, open pores in grey, and closed pores in red. Voxel-based model of 720 x 720 x 1024 voxels. Resolution 0.74 µm/voxel.

Workflow

Scanning small rock pieces to resolve pore-scale features e.g. by µCT. In the resulting grayscale image, the brightness correlates to the materials within the digital object.

Segmenting refers to the identification and labeling of pore space and mineral phases within the image, thereby separating the pore structure from the mineral matrix and obtaining a foundation for later simulations. To handle the ensuing large 3D-data sets, GeoDict includes helpful image processing tools.

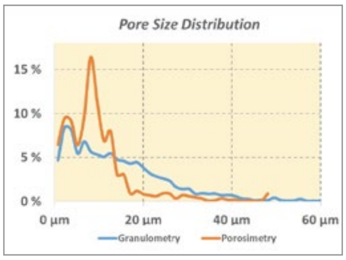
Predicting physical processes within the 3D digital representation of the microstructure to determine its effective properties. GeoDict's modules can compute absolute and relative (saturation dependent) permeability, diffusivity, electrical resistivity, and the elastic moduli, including the anisotropy constants if needed.

Effective rock properties simulated with GeoDict

Pore Structure

of the rock-model determined by GeoDict with various methods. Pore size distribution is calculated by granulometry, a purely geometrical analysis, or by porosimetry, modeling the intrusion of a non-wetting fluid.

Overall porosity	18.41	%
Open porosity	18.12	%
Closed porosity	0.30	%

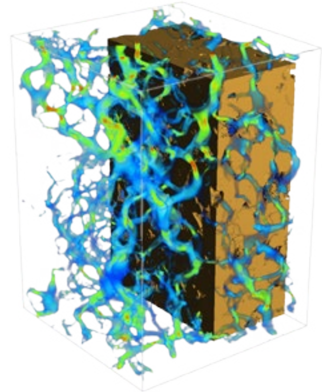


[3]

Effective permeability

and water flow in the pore structure computed with FlowDict.

	Permeability	
X-Direction	139.3	mDarcy
Y-Direction	178.3	mDarcy
Z-Direction	136.8	mDarcy



[4]

Effective molecular diffusivity and tortuosity factor

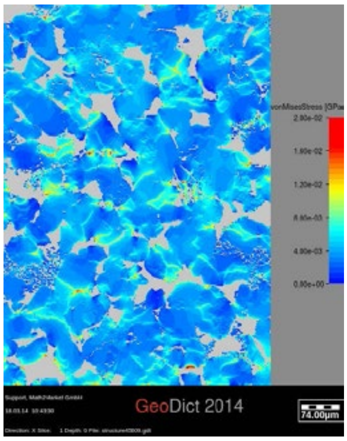
computed with DiffuDict.

	Effective Diffusivity		Tortuosity Factor
X-Direction	4.34	%	4.24
Y-Direction	4.16	%	4.43
Z-Direction	3.96	%	4.65

Electrical conductivity and formation factor

computed with ConductoDict. The pore space is filled with a conductive fluid (5 S/m).

	Electrical Conductivity		Formation Factor
X-Direction	0.22	S/m	23.0
Y-Direction	0.21	S/m	24.1
Z-Direction	0.20	S/m	25.3



[5]

Effective linear elastic properties

of the dry rock-structure calculated with ElastoDict, assuming quartz properties for the sandstone matrix, i.e. Bulk modulus 37.0 GPa and Shear modulus

Bulk modulus	19.14	GPa
Shear modulus	23.49	GPa

References

[1] Digital rock physics benchmarks - Part I: Imaging and segmentation,
Computers & Geosciences 50, 25–32, 2013.

[2] Digital rock physics benchmarks - Part II: Computing effective properties,
Computers & Geosciences 50, 33–43, 2013.

[3]: Pore size distribution in Berea sandstone (PoroDict module)
[4]: Velocity of water in the pore space of Berea sandstone (FlowDict module)
[5]: Von Mises Stress in the sandstone matrix of Berea sandstone (ElastoDict module)

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