GeoDict

The Digital Material Laboratory

GeoDict - Innovation through Digitalization

The Digital Material Laboratory for Digital Rock Physics

MATH 2 MARKET

Innovation through Digitalization

Advanced digital solutions are becoming increasingly important due to the limited character of Earth's natural resources and the demand for increasingly efficient solutions in the digitalization of conventional processes for the Oil & Gas industry. Management decisions for oil and gas extraction and CO_2 injection require a substantial understanding of subsurface properties and a reliable determination of these physical properties is of great importance. Our digital solution provides such precise analysis tools for the digital transformation in the Oil & Gas industry.

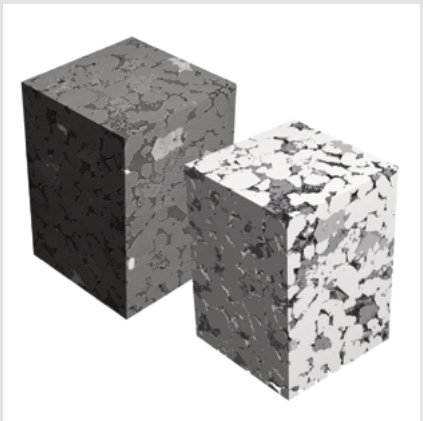
Drilling of reservoir rock cores and determination of sample properties thru laboratory-based SCAL is highly time-consuming and costly. Though trusted by the industry, a laboratory analysis takes over a year to be completed. A reduction of this crucial time investment to a single-digit percentage leads to a large cost reduction and puts analysis-based decisions for the industry's assets back into the time range required for today's management decisions. With our digital solution, we optimize and ease these processes for reservoir engineers, managers, and basically, all parties involved.

The Digital Material Laboratory

With the GeoDict software, rock parameters are determined non-destructively by using 3d images generated via several imaging techniques (e.g. CT, FIB-SEM). Only a fraction of the time and cost is required to determine these values when compared to conventional methods. In addition, the investigated samples remain intact, so that several properties may be determined using the same sample. Costs are already saved by using fewer samples through digital experiments, which is not always possible in conventional destructive laboratory experiments.

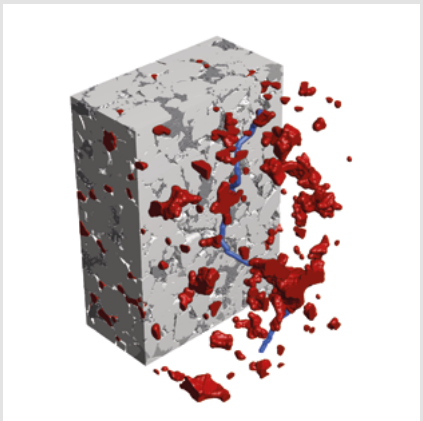
GeoDict - A competitive advantage

- **Automate digital Routine Core Analysis for Exploration and Production sites**
- **Perform digital Special Core Analysis by R & D teams**
- **Enhance efficiency and advance to Cloud Computing**
- **Investigate new technologies such as CO_2 Sequestration and Reactive Flow**
- **Invest in a constantly advancing software product and highly qualified support experts for digital core analysis**



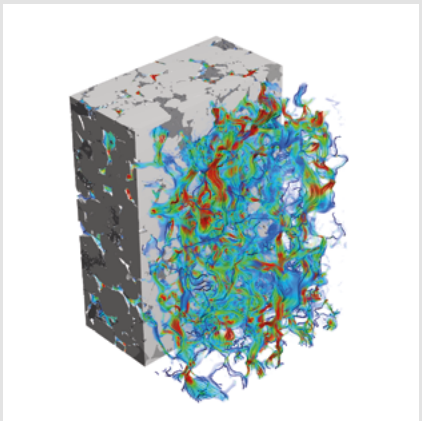
3d image processing & segmentation

Import and process 3d images of rocks scanned via µCT or FIB-SEM devices. Apply image filters to remove artifacts and reduce noise. Segment gray value images with thresholding techniques or advanced AI algorithms.



Geometrical characterization

Analyze pore space and material distribution to investigate connected porosity, pore size distribution, surface area, and much more. Identify individual pores, grains, and fractures, and obtain related statistics.



Absolute permeability

Compute the absolute permeability of digital rocks via (Navier) Stokes equation. Consider any microporosity below image resolution thru the Brinkman term. Integrate micron-resolution results to whole core data and upscale K(abs) via Darcy solver in GeoDict 2023.

Digital Core Analysis with GeoDict

GeoDict provides a variety of solutions to determine the most important rock parameters. Determination capabilities range from geometrical characterization and fluid flow properties to electrical and mechanical properties and may even be complemented by geochemical investigations. Thus, typical core analysis properties such as absolute and relative permeability, capillary pressure curves, resistivity index, and the overall mechanical properties are calculated in GeoDict.

The software also provides advanced tools for 3d image processing and segmentation that include the application of Artificial Intelligence. GeoDict covers the entire workflow from image import to reduction of artifacts and noise, and segmentation. This ensures that GeoDict is an all-in-one solution under consideration of the requirements in the Oil & Gas industry.

Easy-to-use

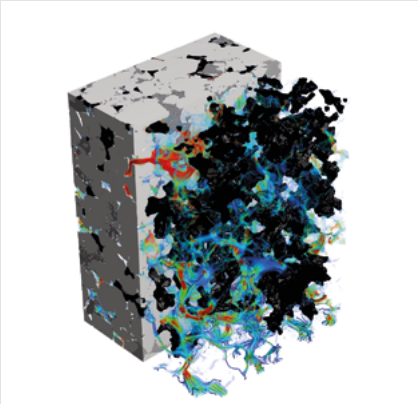
- User-friendly, intuitive graphical user interface
- Seamless integration into existing IT infrastructure
- Determination and prediction of material properties directly on 3d images
- Complete automation for Cloud Computing workflows – via Python interface
- No need for elaborate meshing - thanks to voxel grid

Advanced and powerful features

- Analysis and visualization directly on 3d scans from computed tomography (CT) or focused ion beam-scanning electron microscopy (FIB-SEM) devices
- Artificial Intelligence (AI) for segmentation of 3d images of digital rocks
- Fast and reliable property prediction of large and representative structures
- Relative permeability determination within several hours

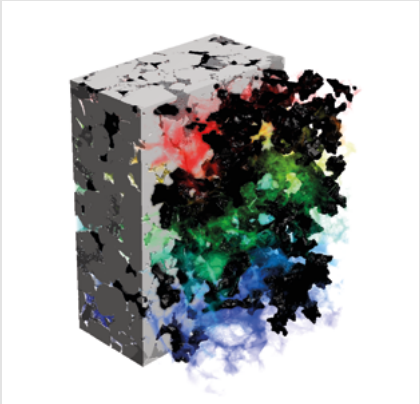
Accurate property prediction

- Accurate numerical prediction of rock properties based on digital images
- Unmatched range of physical parameters that are predicted with GeoDict
- Determination of the relative permeability based on rock wettability during the Hysteresis cycle
- Prediction of complex rock deformation and damage, as well as fracture behavior and fatigue at micro level



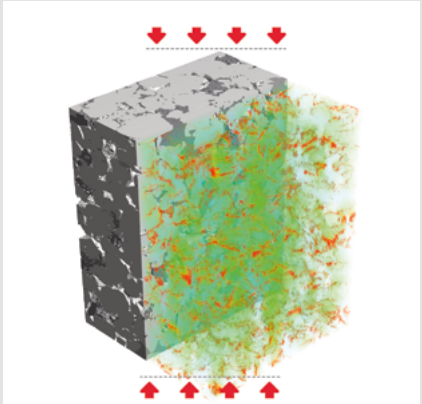
Capillary pressure and relative permeability

Compute capillary pressure curves of digital MICP experiments or two-phase flow setups for primary drainage, imbibition, and more. Determine relative permeability curves upon consideration of wettability and the hysteresis cycle.



Resistivity Index

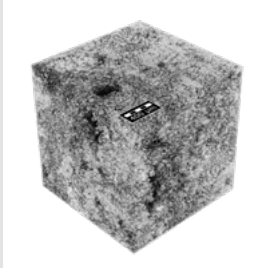
Determine the resistivity index based on previous GeoDict two-phase flow setups. Additionally predict cementation exponent, saturation exponent, and formation factor.



Mechanical properties

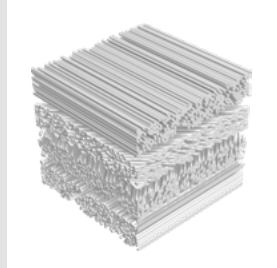
Determine Young's modules, Poisson's ratio, Bulk & Shear modulus. Compute compression with failure to obtain stiffness, stress-strain curves, and 3d von Mises stress distribution.

ImportGeo



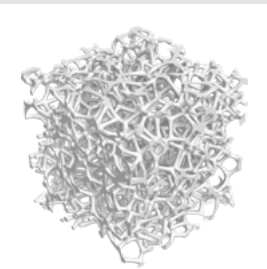
FiberGeo

FoamGeo

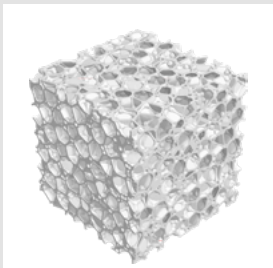


WeaveGeo

GridGeo



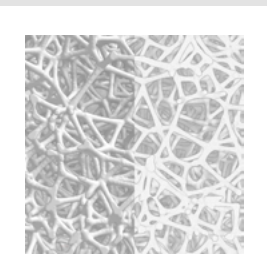
MeshGeo



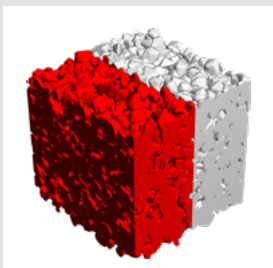
ExportGeo

PoroDict

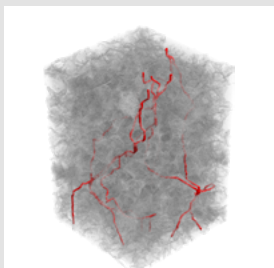
This is **Innovation** through **Digitalization**



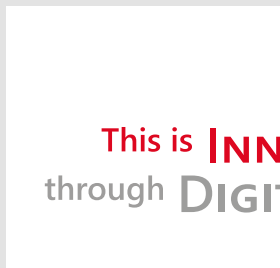
DiffuDict



ConductoDict

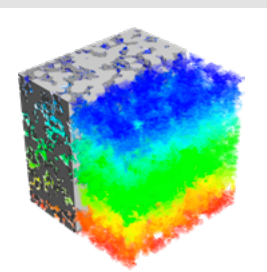


FlowDict

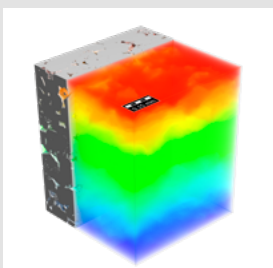


Reactive Flow

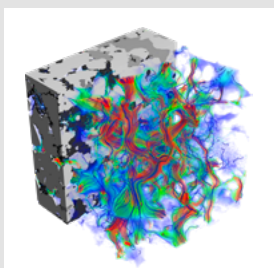
ElastoDict



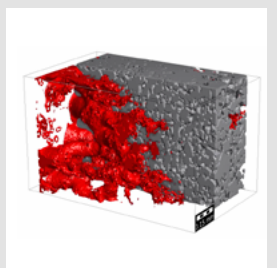
AddiDict



SatuDict

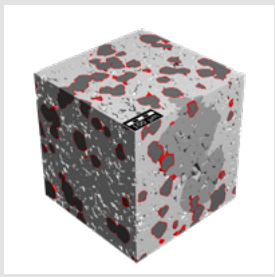


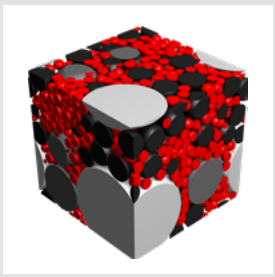
AcoustoDict



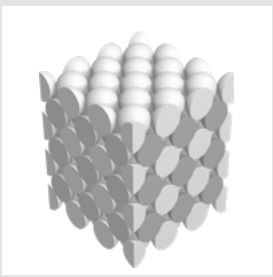
FiberFind

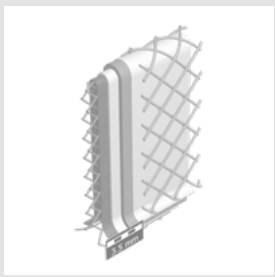
PaperGeo

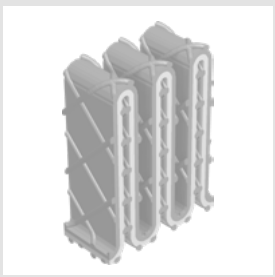




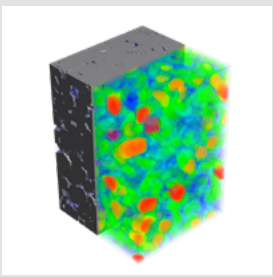
GrainGeo



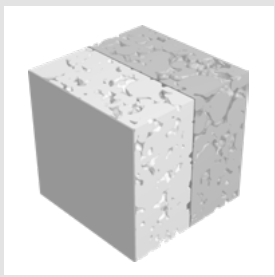


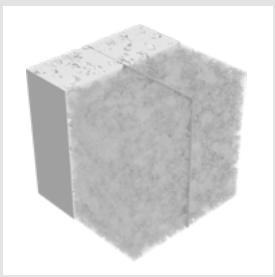


PleatGeo

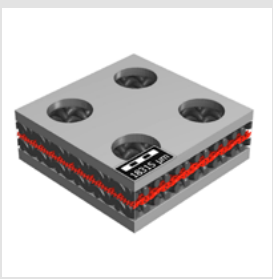


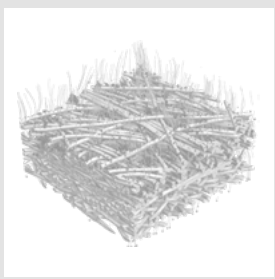
MatDict

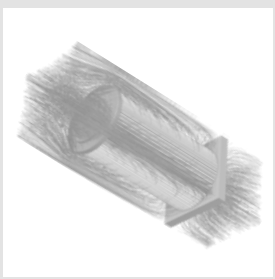




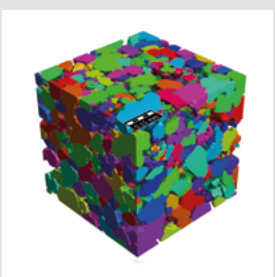
BatteryDict







FilterDict Media & Element



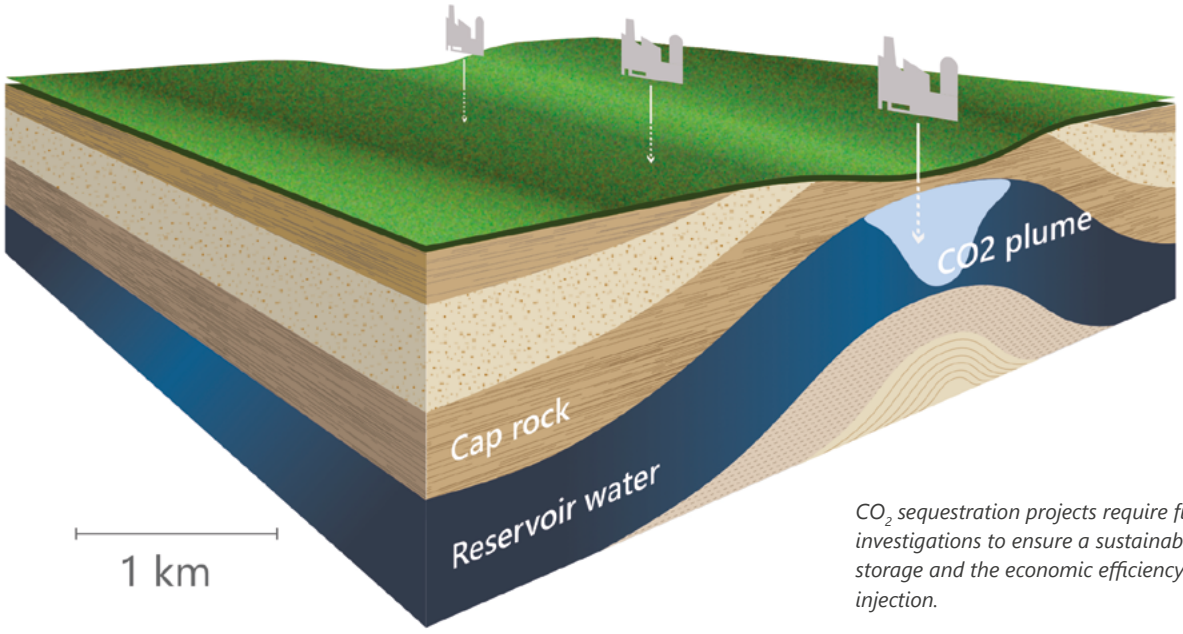
GrainFind

GeoDict Modules

GeoDict is used worldwide for R&D and production in industrial and academic settings mainly in the fields of Digital Rock Physics, filtration, structural and composite materials, batteries, and fuel cells.

The modular setup of the GeoDict software is essential to its versatility and adaptability to the specific requirements of diverse applications. In this way, GeoDict is a customized solution, tailored to the development or research task of the user. For Digital Rock Physics, the GeoDict modules involved are ImportGeo-Vol, PoroDict, MatDict, GrainFind, FlowDict, SatuDict, ConductoDict, ElastoDict, and AddiDict. Each of them is dedicated to the analysis of rock properties. In contrast, the optional GrainGeo module is even capable of generating digital rocks based on grain size distributions.

GeoDict in Industrial and Academic Settings



CO_2 sequestration projects require field-scale investigations to ensure a sustainable carbon storage and the economic efficiency of CO_2 injection.

Digital Core Analysis

Digital Rock Physics and Digital Core Analysis deal with the determination of the most relevant rock parameters via digital analysis of scans obtained by a variety of imaging techniques. GeoDict provides all the tools for the analysis of parameters needed by energy companies in an upstream environment. Usually, a distinction is made between Routine Core Analysis (RCA) and Special Core Analysis (SCAL). Analyses executed during both workflows may be performed digitally with GeoDict.

The RCA workflow, usually performed experimentally in laboratory settings, is performed digitally with GeoDict in a fraction of the time. Petrophysical properties of rock cores gathered from reservoirs or other geologic formations are evaluated efficiently in cost and time, allowing for quick decision making. The analysis covers rocks such as sandstones, carbonates, shales, cemented and un-cemented sediments, and coals. In them, connected and non-accessible porosity, pore size distribution, formation factor, surface area, and absolute permeability are determined using GeoDict as part of a digital RCA.

The SCAL workflow is carried out in GeoDict to obtain properties of rocks through digital two-phase flow experiments or mechanical simulations. These properties include e.g., capillary pressure curves, relative permeability, resistivity index, cementation exponent, and the overall mechanical properties.

GeoDict is the all-in-one tool for digital SCAL workflows at the outstanding performance level that the industry demands.

Digital Rock Modelling

In addition to the functionality of property determination of real rock structures, it is also possible to digitally model rocks with GeoDict. All it needs is a proper grain size distribution obtained either experimentally or digitally from within GeoDict.

Thus, 3d rock geometries can be remodeled (Digital Twin) and completely new structures might be generated. Rock properties may, of course, be determined on such generated rock samples, as an alternative to using scans from µCT and similar devices.

Automation

The GeoDict-Python interface (GeoPy) is embedded in the software and provides access to any kind of GeoDict results from within these GeoPy scripts. GeoDict's automation capabilities cover a vast range, from import and simulation to visualization and the generation of PowerPoint reports with the predicted rock properties.

Cloud Computing

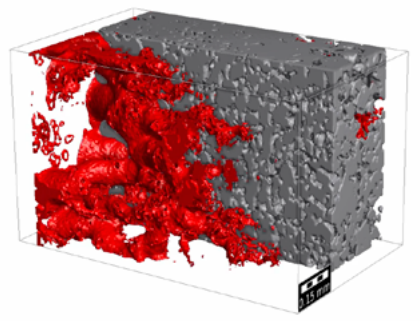
For GeoDict, available cloud solutions range from web-based desktop interfaces to batch computations. Such cloud setups may complement physical workstations or even replace them completely. Math2Market provides support for the installation and setup of GeoDict on digital platforms with the aim of providing a highly automated Digital Core Analysis to E&P teams.

Reactive Flow

Geochemistry is becoming an increasingly important part in reservoir simulations. Various industrial setups drive a disequilibrium of brine composition

Customer Service & Support

and injected fluid regarding certain mineral phases. GeoDict provides a tool to simulate reactive flow at the pore-scale of subsurface reservoirs in a range of applications including, for example, acidizing treatments and CO_2 sequestration.



For applications of acidizing treatments, GeoDict computes carbonate dissolution based on the pH value, on a given mineral reaction rate, or based on fluid compositions and geochemical equilibrium thermodynamics through the geochemical calculator PhreeqC (USGS).

CO_2 Sequestration

In the field of geological CO_2 sequestration, GeoDict features the simulation of structural trapping, capillary trapping, and mineral trapping. In addition to trapped phase saturations, GeoDict computes individual data points of a porosity-permeability development as part of mineral reactions (precipitation) in the CO_2-brine-rock system.

An intensive exchange of information, trainings, workshops, and our annual User Meeting ensure for our customers and partners the transfer of know-how and the same high-service standard for all GeoDict users.

In complex projects and applications, Math2Market offers consulting and carries out project work for our customers, sometimes together with our service partners.

Digital Rock Physics team
Individual trainings onsite and online, individual consulting, and industry-specific support

GeoDict Consulting and Projects team
Individual automation, app engineering, validation projects, and customization projects

GeoDict Development team
Annual software releases, regular updates, and individual software development projects

Customer Support team
Professional support on technical and scientific questions related to GeoDict

Service partners worldwide

Germany	**Math2Market GmbH** | www.math2market.de
China	**Flight Technology CO., LTD.** | www.lcdfly.com
Japan	**SCSK Corporation** | www.scsk.jp
South Korea	**Trinity Engineering CO., LTD.** | www.trinity-eng.co.kr
Brasil	**Tennessine Instrumentação Analítica** | www.tennessine.com.br
Taiwan	**Pitotech Co., Ltd** | www.pitotech.com.tw

GeoDict - Licensing flexibility

1

License Type	Description	Maintenance (Updates and Support)
Purchase	unlimited time license	1 year included, afterwards cost-effective renewal
or		
Lease	limited time license	defined by lease period

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License Type	Description
Node-locked	Fixed license, limited to a specific workstation
or	
Floating	local server-based license management
or	
Cloud	Online license for cloud environments with optional pay-per-use extension

Math2Market - The Company

GeoDict combines cutting-edge scientific advances and powerful software development into a user-friendly solution for innovative digital material analysis, research, and development in industrial and academic settings.

Math2Market GmbH was founded in September 2011 by three members of the GeoDict software development team as a spin-off from the Fraunhofer Institute for Industrial Mathematics (ITWM, Institute für Techno- und Wirtschaftsmathematik) in Kaiserslautern, Germany. Some of the founders had been working on the software since its inception in 2001. Today, Math2Market has a workforce of over 50 employees at its Kaiserslautern site and, with GeoDict, is one of the worldwide leading providers of digital solutions in the field of material analysis, research, and development.

Over 400 universities, research institutes, and large companies from various industries worldwide use GeoDict to develop innovative materials and optimize their material analysis and development processes. With our unique pool of top mathematicians, physicists, geologists, chemists, biologists, engineers, and computer scientists, we believe in making available the benefits of cutting-edge, university-level research to our clients, to be applied by non-experts using our software GeoDict.

Our customers also benefit from the comprehensive services of Math2Market, including regular updates of GeoDict, intensive customer assistance and consulting, as well as training and reliable support by our experts in their respective fields.

Math2Market cooperates in diverse ways with international partners from industry and academia and participates regularly in scientific congresses and technical trade fairs with innovative contributions.

„We aim at enhancing and optimizing the core analysis workflows of our customers. With GeoDict, they reduce time and cost spent in their process from laboratory work to management decision."

Dr. Christian Hinz
Business Manager Digital Rock Physics / Math2Market GmbH

Math2Market GmbH | Richard-Wagner-Str. 1 | 67655 Kaiserslautern, Germany
☎ +49 631 205 605 0 +49 631 205 605 99 support@math2market.de
www.GeoDict.com

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