

PerGeos

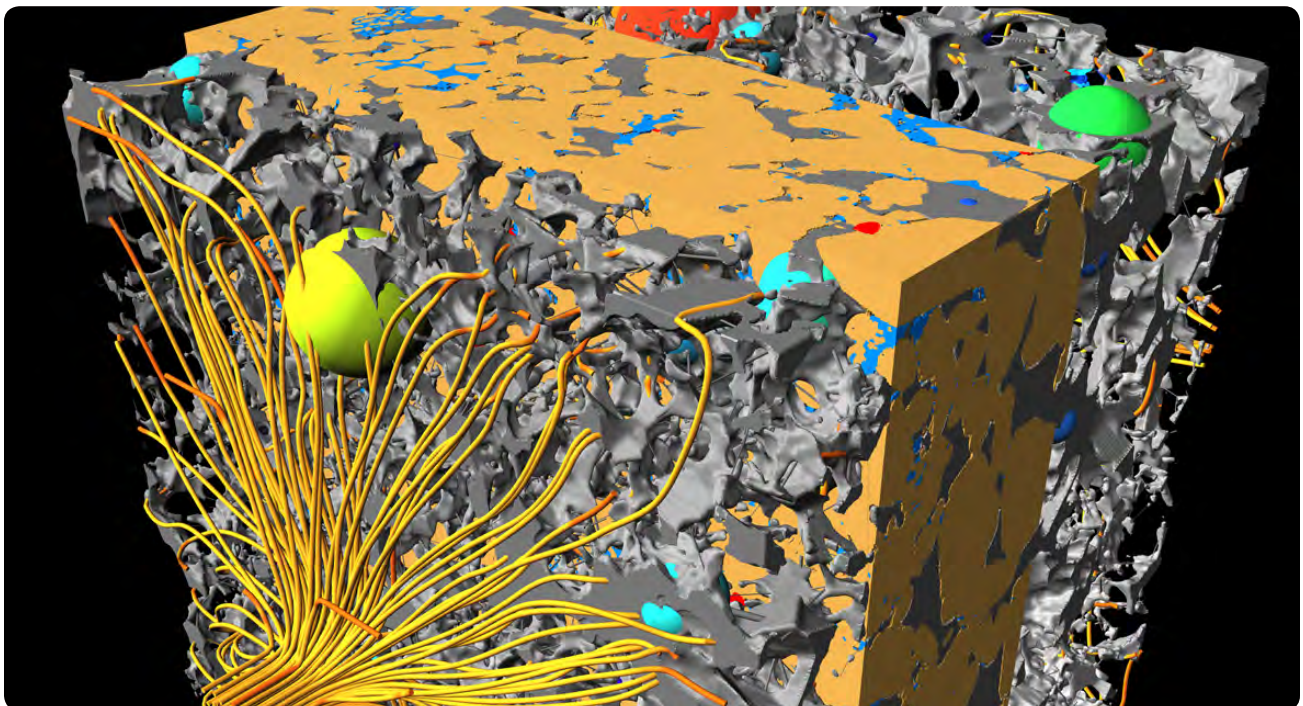
Innovative Software for Digital Rock and Core Analysis

PerGeosTM is a robust software platform that enables E&P engineers to better understand the quality and performance of hydrocarbon reservoirs.

PerGeos is the industry's first digital rock software designed to help geoscientists rapidly interpret digital rock imagery so that E&P engineers can quickly and easily obtain meaningful, actionable data. Its visualization, processing, and analysis of 2D and 3D digital rock imagery enables improved evaluation of reservoir quality and faster understanding of static and dynamic rock properties that impact production. PerGeos can be used as a standalone software platform or bundled with a variety of applications to customize the user experience with additional functionality for digital core analysis.

Key Benefits

- **Collaborative Core Analysis** Multi-disciplinary sharing of information to build a common rock model.
- **Confidence in Results** Multi-scale, multi-modal image analysis to help users validate observations and properties from a variety of datasets.
- **Consistency in Data Processing and Modeling** Automated workflows to streamline efficiency and implement best practices.
- **Customized for Oil and Gas** The most advanced set of artifact removal and analytical tools on the market for designed specifically for oil and gas reservoir characterization and digital rock analysis.



↑ **Digital Rock Model and Simulations.** Application image illustrating pore network, flow paths, segmented pore space, grains and pore filling material of a 3D rock model. (Pore space - gray; grains - tan; and pore-filling material - blue.)

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Key Features of PerGeos

- A new user interface (UI) for direct side-by-side comparison and analysis of datasets.
- A collection of built-in automated workflows.
- Non-scripting-based, user-defined automated workflows.
- A robust set of tools for processing and filtering image data, including new advanced artifact removal algorithms for computed tomography data.
- A modular architecture and open source platform supporting add-on applications from the PerGeos software suite (Core Profile, Petrophysics, and Pore Statistics) for advanced analysis and calculation of physical properties.
- Support for all relevant image modalities (tomography, electron microscopy, and optical/light microscopy).

Workflow Automation

Comprised of the most advanced set of artifact removal, filtering, and analytical tools on the market, PerGeos accurately characterizes rock properties. The advanced toolkit is available through an intuitive UI and easily integrates into user-defined automated workflows. PerGeos allows for more time spent analyzing results than processing image data.

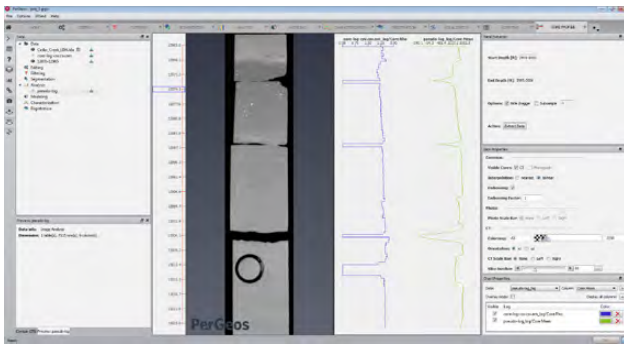
Multi-Modal and Multi-Scale Analysis

Oil companies currently analyze a wide array of image data types and formats when trying to understand the physical characteristics of reservoir rock. By learning how those characteristics relate to the potential value of a reservoir, researchers can then relate those observations to the production techniques required to optimize that value. Information extracted from these disparate sources can now be managed digitally with PerGeos via a collaborative workspace. Such dynamic collaboration facilitates the creation and sharing of a common rock model much faster than with traditional core analysis methods.

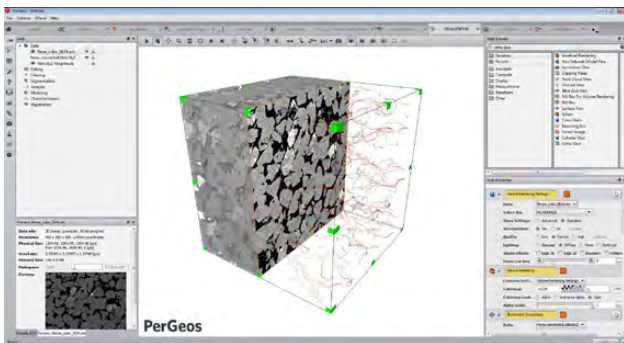
From whole core-scale CT to nanometer-scale-resolution electron microscopy, PerGeos supports all relevant imagery technologies in a single software environment. This wide range of integration, combined with PerGeos' ability to overlay images, annotate, and share rock descriptions and physical property simulation results, allows users to investigate ways in which the distribution of pore-scale features impacts physical properties and reservoir performance.



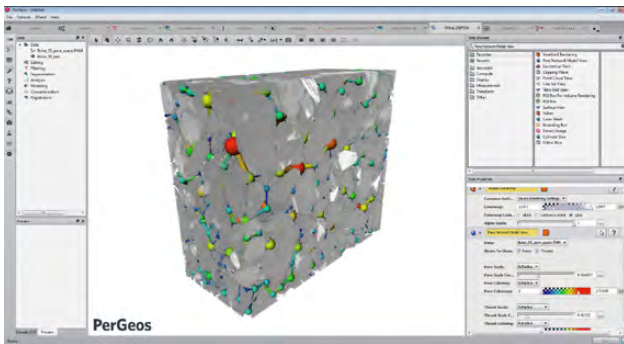
↑ False color 3D visualization of whole core CT data. Image detail of five 3-foot segments of whole core aligned and stitched together.



↑ **Core Profile Application.** Co-visualization of whole core CT data with petrophysical log and virtual log plots generated from whole core.



↑ **Petrophysics Application.** A flow simulator and absolute permeability calculation.



↑ **Pore Network Application.** A pore network model extracted from a microCT dataset of Berea sandstone (spheres represent pores; size and color are scaled to their respective size and distribution).

Flexible Design and Automation

PerGeos delivers a flexible, modular architecture designed to facilitate rapid deployment of new capabilities as they are developed. This flexibility gives the end-user an adaptive environment suited to their daily interactions with core samples. In addition to built-in automated image processing workflows, PerGeos offers a suite of applications that provide a customizable user experience.

- **Core Profile:** A powerful, new whole-core data application that enables co-visualization of whole-core CT, core photography, and petrophysical logs in a single workspace. Also creates virtual logs based on whole-core CT data.
- **Petrophysics:** A suite of models for rock property analysis and simulations to derive measurements such as absolute permeability, Archie m (from formation factor F), thermal properties, and MICP porosity.
- **Pore Statistics:** An application that extracts a pore network model (PNM) from a segmented 3D dataset (FIB-SEM or microCT). Includes automated workflows to quantify 2-phase and 3-phase fluid storage and helps characterize pore and pore throat size distributions.

PerGeos includes several built-in, automated workflows designed by industry experts to simplify and standardize processes, speeding “time-to-data” so users can generate meaningful statistics faster. Additionally, users can design their own automated workflows. These workflows can then be easily distributed to encourage best practice implementation.

PerGeos limits the amount of required image processing expertise by implementing a powerful automation package. The accuracy of data derived from digital rock imagery and simulation depends on the quality of the images and the ability of the user to identify and remove artifacts, use appropriate filters, and segment the image into extractable features. PerGeos’ automation package requires no knowledge of scripting and is compatible with our entire workflow—from data input to simulation result.

PerGeos supports

- Whole-core CT, micro-CT, nano-CT, image logs, and synchrotron.
- Microscopy Sources: Scanning electron microscopy (SEM), DualBeam microscopy (FIB-SEM), and optical/light microscopy (mineral maps, CL, etc.)
- Other Sources: Radiography and MRI datasets.

These datasets can be used for multi-scale analysis of a variety of samples:

- Whole core and whole core sections
- Core plugs
- Large 2D SEM mosaics
- Optical thin section mosaics
- Trim ends and cuttings

Robust Qualitative and Quantitative Analysis

PerGeos helps petrographers, geologists, core analysts, and petrophysicists with qualitative and quantitative rock analysis via its suite of image processing, filtering, and segmentation tools. These tools help users understand and share reservoir information.

PerGeos for Geology

Powerful algorithms support image analysis, segmentation, and built-in automation, adding statistical weight to observations from core material. Analysis capabilities help users quantitatively extract and measure data such as:

- Laminations
- Fracture density and orientation
- Organic versus inorganic porosity
- Depositional features

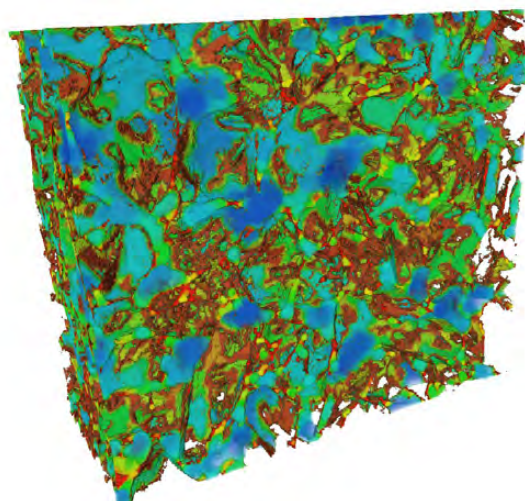
Reservoir quality geologists can explore the impact of formation diagenesis on the evolving flow behavior in a basin using these same tools. The Core Profile Application provides an easy and efficient way to create, annotate, and share core descriptions. The ability to plot log data next to the whole-core CT scan provides a common workspace to share observations and export to third-party data integration platforms, such as geocellular modeling packages.

PerGeos for Petrophysics

PerGeos provides easily automated workflows for calculating pore statistics from image data such as pore size and network connectivity. Users have access to a suite of tools in the Pore Statistics Application to help accurately:

- Visualize pore size distributions and pore types.
- Characterize pore and pore throat size distributions.
- Evaluate connected and isolated porosity.
- Compare whole core CT data directly to logs.

The accuracy and speed with which PerGeos delivers digital rock results is important for reservoir engineers awaiting critical inputs for their geomodels, such as capillary pressure, porosity, and permeability. Knowledge of these properties helps asset managers visualize and understand the ultimate potential recovery of a reservoir, thereby improving their estimates of reserves and overall production-related CapEx investments.



↑ **3D Visualization.** 3D MICP simulation illustrating distribution of local capillary pressure.

The built-in features and automated workflows in the Petrophysics Application can help derive rapid digital RCA properties to QC traditional lab and third-party digital rock measurements, such as:

- Absolute permeability
- MICP
- Electrical resistivity
- Formation factor

The PerGeos Core Profile Application enables visualization of whole-core CT data with side-by-side comparison of well logs to improve log interpretation. Used with the geologist annotations, the Core Profile Application becomes a robust collaborative workspace for sharing information to make smarter plug selection, improving the overall reliability of data generated from a core program.

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