AutoScan

AutoScan is an integrated system for scanning slabbed core, whole core or core plugs for gas permeability, resistivity, ultrasonic compressional and shear-wave velocities, composition, mechanical strength, and elastic stiffness.

The main hardware component of the AutoScan is a robotic gantry that allows automatic and repeated positioning of the measurement probe(s) using an XY-reference frame for table measurements (see figure). NER designed this measurement platform to facilitate the efficient testing of multiple core samples in a single automated experiment setup. Samples of whole or slabbed core are placed, in any order, anywhere on the usable range of the full table surface.

Multiple probes can be mounted on the scanner head to measure:

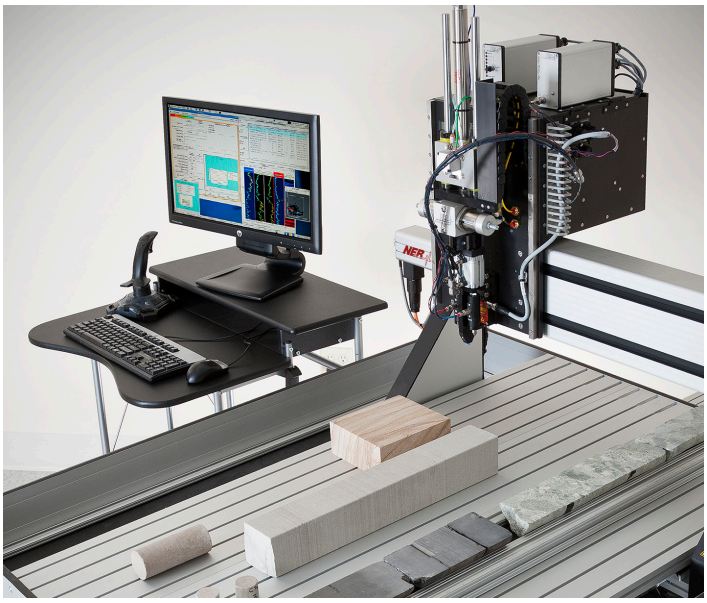
- Steady-State Gas Permeability
- Unconsolidated-Sample Gas Permeability
- Ultrasonic Velocity
- Electrical Resistivity
- Strength
- Composition

Discrete physical properties measurements are made on user-defined grids, lines, and points with sample measurement intervals as small as 0.5 mm.

Formation heterogeneity can be quantified using physical property measurements on rock slabs, cores, and plugs. Several meters of core (approximately

12 feet) can be examined in a single setup. The system is fully automated both for positioning and data acquisition. For all measurement types, the surface of a slabbed core can be scanned using a laser ranging device to avoid making measurements in the vicinity of fractures, vugs, or other defects, and to detect the edges of the specimen. This minimizes set-up time and avoids the need for editing large data files after the measu rements are completed, a feature that is particularly important when multiple cores are measured in parallel. The entire process is computer controlled. Data is acquired, processed, and plotted with minimal user intervention.

NER's DataMiner software allows for interactive plotting and data analysis, including petrophysical modeling, geostatistical model building and rock type identification through cluster analysis. Simple ASCII data files can be exported in common formats for specialized processing.



Applications

- Detailed core measurements for log calibration
- Rapid core screening for selection of representative samples
- Quantitative characterization of heterogeneity
- Petrophysical rock type identification
- Quantify anisotropy for calibration of induction logs
- Resistivity and FMI log calibration and interpretation
- Integration of well-log data and core lithology

Permeability

Permeability is measured using a steady-state gas injection technique. Permeabilities ranging from 0.1 millidarcies to 3 darcies are measured with the standard 4.0 mm Permeability Tip. In addition to the fully automatic mode, the measurement control and acquisition software allow user selection of pressure control or flow control based measurements, enabling detailed studies of Klinkenberg effects at low pressures and inertial and turbulence effects at high flow rates. NER's Smart-Flow technology allows the system to optimize measurement control parameters during the actual measurement to increase measurement speed, available range and precision.

Velocity

The Velocity Tip measures ultrasonic compressional and shear wave velocities. Since the Velocity Tip is fully integrated with the Permeability Tip, the two measurements can be made

The impulse hammer probe is used to characterize the variability of elastic stiffness and mechanical strength

sequentially during the same scan. Both compressional and shear velocities can be measured in two orthogonal orientations on the core, providing a means to quantify anisotropy in elastic properties.

For many permeametry applications it is advantageous to relate permeability to porosity. Measuring porosity directly on a slabbed core is not feasible, however, there are well established correlations between acoustic wave velocities (P and S wave) and porosity. The fully integrated nature of the Velocity Tip and the Permeability Tip allows for convenient constraint on permeability/porosity correlations using a single scan on a rock core.

Resistivity

The Resistivity Tip measures the spatial variability in electrical properties. The probe is a true four electrode device, with an electrode pair located in the central cavity and an electrode pair configured as rings around the outside of the rubber tip.

FTIR

The addition of an FTIR probe provides a measurement sensitive to chemical composition. The spectrometer is configured as a non-contacting probe that measures IR reflectance over a broad spectral range (1330 nm – 26700 nm). Measurement spot size is 3 mm with typical point measurement times on rock samples of 20–40 seconds. The FTIR probe option includes a mid-infrared spectrometer, quick connect mounting hardware, data acquisition software, and custom spectral data viewing and support software that display data in real time.

Impulse Hammer

The impulse hammer probe is used to characterize the variability of elastic stiffness and mechanical strength. The probe measures an elastic stiffness that in the elastic regime is dominated by Young's modulus. The probe can be configured to produce an additional strength index as well. Unlike competing methods such as the scratch test, the Impulse Hammer probe is virtually non-destructive (only a millimeter scale indentation is made, even in soft materials). Measurement area size is 2 mm with typical measurement times of 10 seconds per point. The addition of the Impulse Hammer probe provides a point measurement sensitive to mechanical properties that can be used to map variations in elastic stiffness and strength. Some example data is shown above.

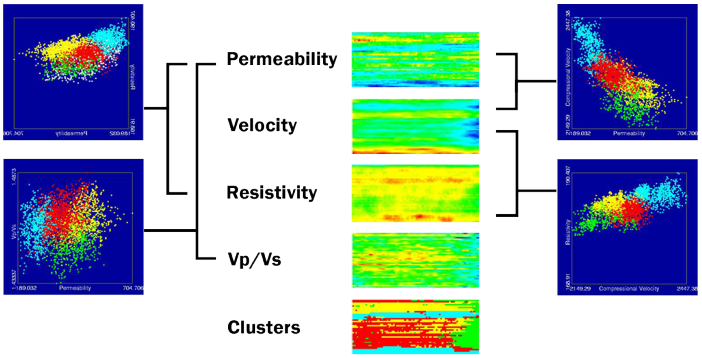
The Impulse Hammer probe option includes the quick connect probe assembly, mounting hardware, data acquisition software, and custom data viewing and support software that allow force-time plots to be viewed by the user during the measurement (see figure above).

Camera

In addition to these measurement probes, the AutoScan can be outfitted with a digital camera and integrated LED lighting for photographic documentation of samples. The camera option enables quick and accurate photo-documentation of samples and the integration of core photographs that are automatically depth registered with the AutoScan data.

DataMiner

Using NER's DataMiner software, the data from each of the probes can be combined with core images and any other depth based core data. In the example at right, we combine the FTIR and Impulse Hammer data on the shale core and a core image. The DataMiner software provides data mining and manipulation capabilities, allowing the user to identify correlations between properties and to objectively define rock types based on different combinations of data and different scaling options.



Geostatistical cluster analysis is used to find regions of the sample that are petrophysically similar