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# Integration of experimentally derived rock properties into characterization workflows

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## Summary

The integration of plug and log scale characterization is key to generating representative petrophysical and geomechanical models at all stages from exploration and development to production. The importance of plug measurements is especially vital in finely laminated rocks where well-log scale measurements miss mechanical heterogeneities that are required for realistic mechanical models. The presence of mechanical heterogeneity and anisotropy under the well log resolution is commonplace in unconventional plays and can deeply impact geomechanical assessments ranging from wellbore integrity to horizontal stress estimates. Yet, in order to fully realize the value of lab-based geomechanical characterization, it appears critical that laboratory workflows be optimized in terms of both outputs and turnaround times. In this paper, we present an in-house core scanner for fast and non-destructive physical measurements (not just scanning) of elastic, transport and compositional properties of rocks at a very fine scale (down to mm) as well as a set of workflows to incorporate aforementioned properties in unconventional reservoir characterization.

## Introduction

AutoScan (Fig 1) is a laboratory core scanner that allows spatially coupled, point-focus scanning of core or benchtop samples for Fourier Transform Infrared Spectroscopy (FTIR), mechanical hardness, gas permeability, resistivity, and ultrasonic compressional and shear wave velocities. Physical properties measurements are made on user-defined grids, lines, or points at spacings as small as 0.1 mm over length scales of 1 meter, which permits the detailed study of multiple meters of core in a single setup. The ability to combine velocity, permeability, and resistivity scanning offers a unique capability for core selection and screening, log calibration, and petrophysical rock type identification. Once petrophysical properties are acquired, a number of protocols are used to help constrain petrophysical models of transport and elastic properties with geochemical, mineralogical, and microtextural characteristics.

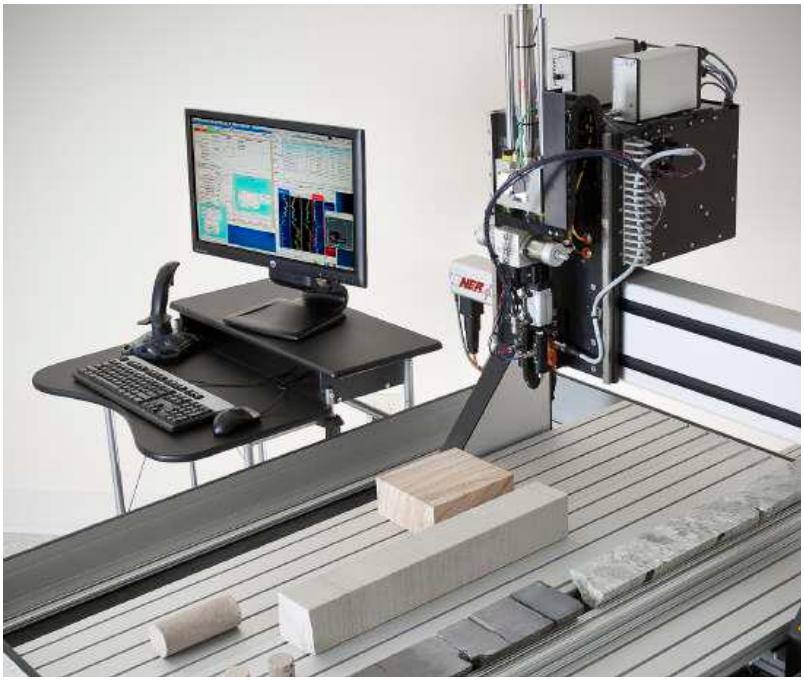

**Figure 1.** AutoScan – robotically-controlled gantry system for physical property measurements of several different types of core.

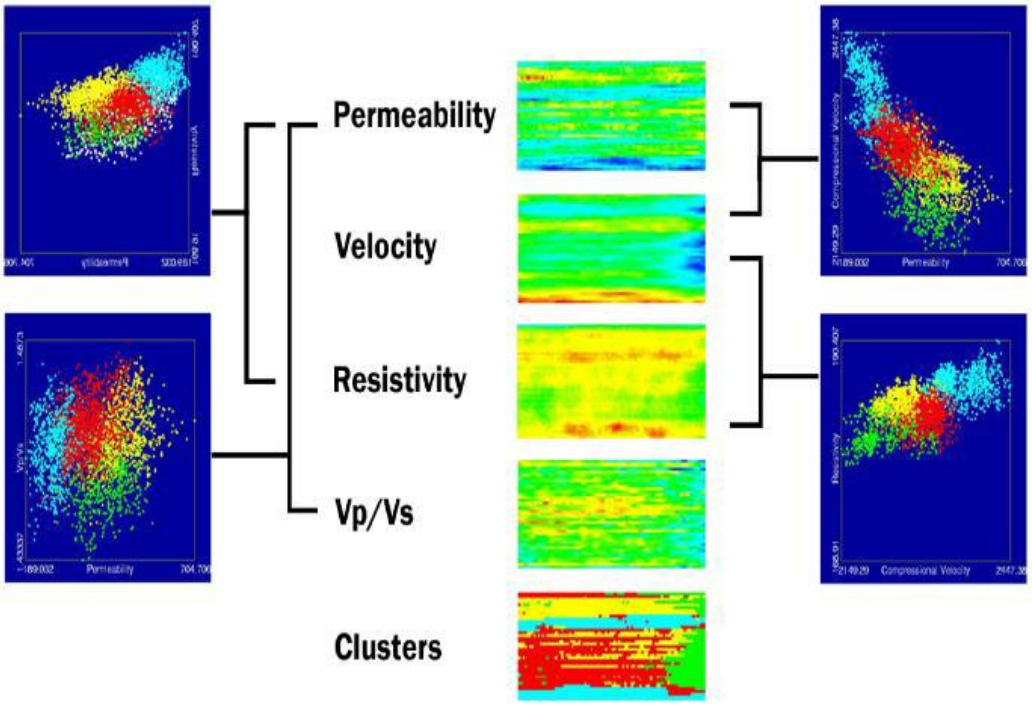


**Figure 2.** Geostatistical cluster analysis is used to find regions of the sample that are petrophysically similar.

## Theory and/or Method

The first part of the presentation will focus on a few laboratory-based inputs that are increasingly being recognized as high impact and which are progressively becoming more routine at a number of vendors. More specifically we will address the topics of continuous mechanical profiling (mm to inch-scale heterogeneity assessment), non-uniform core plug selection based on acquired petrophysical data and recommended rock typing routine.

Then we will address the optimization aspect, which is no less essential in realizing the value of laboratory-based characterization. To that effect, we will suggest ways to greatly increase workflow relevance and efficiency by relying on the use of petrophysical core scanning for screening, rock typing and core plug picking. New closed loop workflows allow for upscaling laboratory observations to the wireline log scale at different stages of the process, thus providing an early option for decision making.

## Examples

A 350-ft section of slabbed core from Wolfcamp shale was analyzed and measured at mm-scale to quantify heterogeneity in sonic velocities, FTIR and mechanical properties (Young's Modulus). The measurements were then calibrated to more conventionally derived measurements and upscaled to provide predictive power and direct comparison to wireline log derived data (Fig 3).

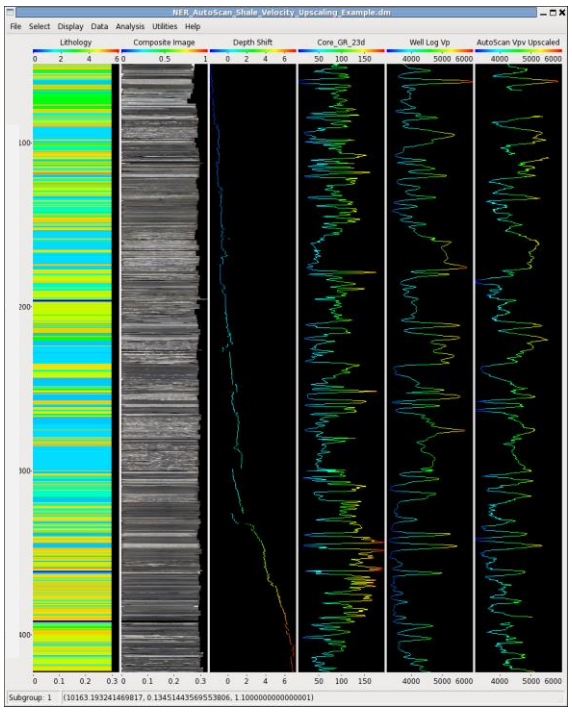


**Figure 3.** Comparison of wireline-log derived compressional sonic velocity with upscaled velocity.

## Conclusions

The combination of fast and non-destructive physical property measurement platorm with workflows capable of relating these measurements across scales is a powerful tool at all stages of field life from exploration and development to production.

**References**

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Bussod, G.Y., Svyatskiy, D., Zyvoloski, G., Boitnott, G.N., Lichtner, P.C., and Moulton, J. D. (2009)**, "**Upscaling of Heterogeneous Porous Rocks Using High-Resolution Hydrogeophysical Scanning Measurements" Trans. Amer. Geophys. Union, Fall Meeting**.**