thermoscientific

Improving Whole Core Characterization with Automated Log Generation in PerGeos

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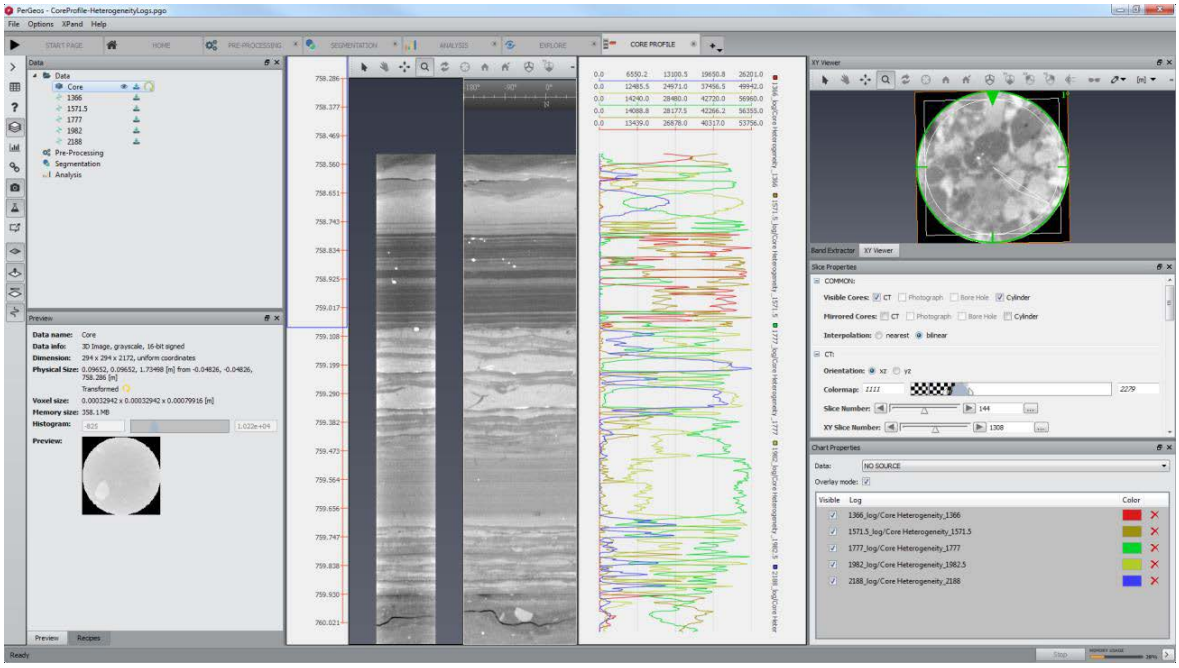
The Core Profile Extension, available for PerGeos, provides a powerful toolset for visualization and analysis of whole core CT data. Within this extension the user can load and visualize an entire wells worth of CT data as well as performing detailed analysis of geological and chemical features by utilizing the powerful image analysis library fundamental to PerGeos.

In this example, we illustrate the usefulness of core profile in augmenting traditional core analysis routines and providing robust data for geological and petrophysical analysis.



Background

The use of whole core CT data has seen a rapid rise in acceptance as an archiving tool and utilization as a characterization method. However, the large sizes of the data and the very focused routines needed to analyze these data has slowed and or limited the complete adoption of the data into many core analysis workflows. A good example of the utility of whole core CT in rock typing and direct comparison to petrophysical logs is illustrated in Fitzsimmons et al., 2016. The authors show how a combination of multiple data sources with CT data as a central asset can be used to more accurately define rock types and propagate those observations down the well.

Approaches as those described in Fitzsimons et al., (2016), typically require specialized knowledge of image analysis routines to execute. However, we have an integrated their approach into an automated workflow eases the generation of a detailed heterogeneity log into an easy to implement process extendable to any dataset. Next we will look at the workflow and results in more detail.

The Workflow

Creating a Digital Well

A processing step unique to PerGeos allows the cores barrel to be intelligently removed, the core to be re-oriented if it is not perfectly vertical, and all the cores to be stitched together regardless of the total size. These steps are achieved automatically without any interaction from the user. The data are then stitched into a single file from 100+ individual cores--generating file sizes that rapidly surpass 100s GB in size. Users, however, are still able to visualize the data via a proprietary multi-resolution file format (LDM) allowing an immediate and complete visualization independently of the machine power. This allows a user to browse in real time an entire 3D digital well of 100+ cores and apply post-processing operations such as logs generation from image segmentation and analysis without investing in specialized hardware.

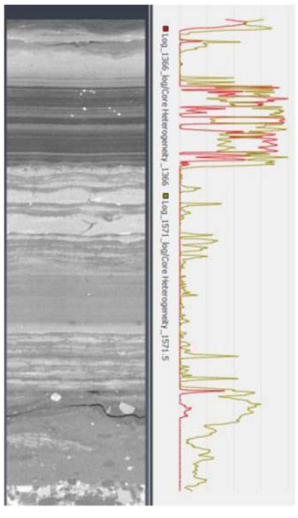
Generating Logs on big data

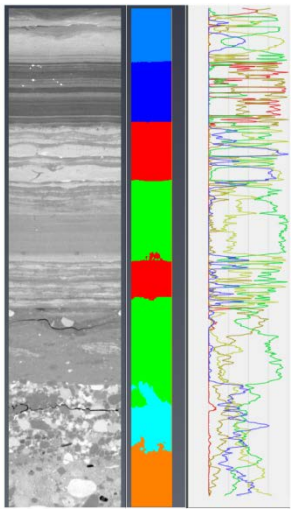
Once the Digital Well has been created, we now have to approach how to process an extremely large dataset and follow a complex workflow to extract parameters of interest. Using the powerful scripting/customization tools in PerGeos we can easily automate even the most complicated analysis. A dedicated script module that computes the heterogeneity logs following the approach of Fitzsimons et al., (2016) has been developed and successfully applied on different whole cores.

Compute Process:

- The module written in TCL will compute for every Z-slice of the core the greyscale histogram given a fixed range.
  Note: the pre-processing barrel removal step guaranties that the histogram only reflects the core data
- N values will be retained, equally distributed, and for each of them a log will be generated along the core.
  Note : pre-processing steps such as beam hardening correction and de-noising can be utilized prior to the histogram computation
- A histogram is computed for every slice. The histogram values for a single intensity (number of pixels with that value) are written in one log

The results of the log generation can be visualized alongside the parent CT data. In addition, the user can import other logs for visualization/correlative purposes. The PerGeos generated logs can also be easily exported and utilized in other petrophysical/geo focused applications. Users can then use a combination of log results and image-based computations to generate a quantitative and repeatable method of rock typing. The respective volumes and 3D extent of the respective rock types are easily computed and visualized within PerGeos. Again, the depth ranges and various statistical information related to the rock types can be exported and incorporated into a larger analysis of petrophysical data.

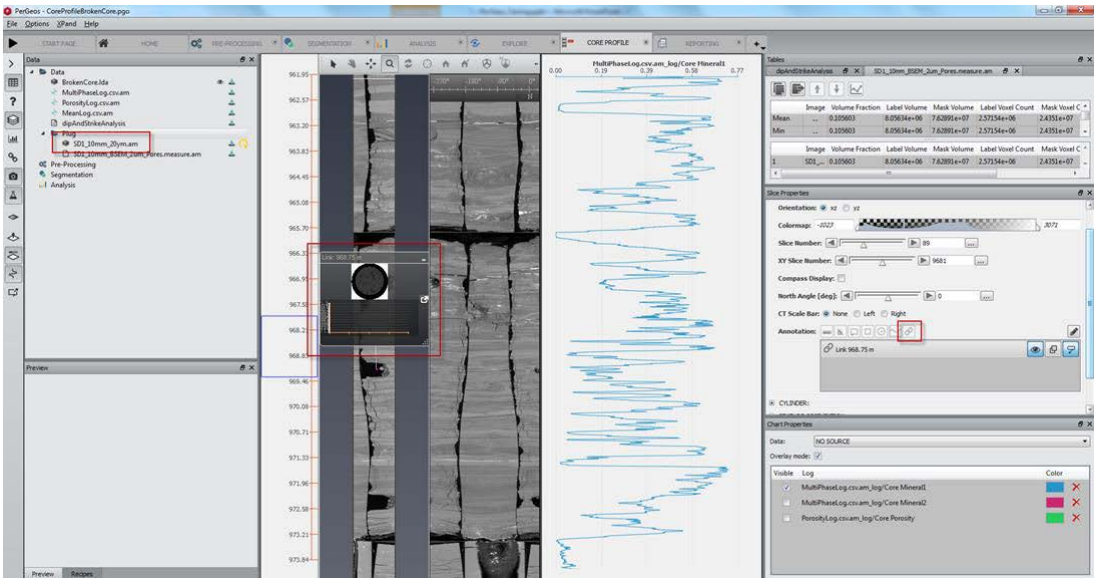




Integrating Observations

In addition to image processing and analysis related computations, PerGeos has an available family of physical property solvers including permeability, porosity, MICP, resistivity, and thermal diffusion that can be applied to

imagery datasets that can resolve the porosity of a sample (typically micro-CT and FIBSEM). Combining plug scale analysis with whole core CT data within PerGeos allows one to place each data point within the context of the local rock type-further defining the properties of each lithology and adding more concrete characterization of the physical property distribution within a formation.



To aid using PerGeos as a correlative workflow solution, the CoreProfile extensions links digital images and petrophysical results of plugs and subplugs to whole core CT data through a unique annotation interface. That way, the results can be cross-checked with the depth and the associated logs. At any time, a new porosity / permeability / MICP simulation can be run from the microCT sub-plug in the PerGeos workspace and added to the overall interpretation of the well bore data. PerGeos can fill multiple roles and apply to various sub-disciplines in core analysis and petrophysical characterization workflows. Using PerGeos in this way provides a unique solution that puts the reality of the reservoir, the rock itself, at the center of evaluation. All other lab and indirect methods of inspection can be placed in the context--and ground truthed--back to the geology via the images preserved and analyzed using PerGeos.

Reference for Workflow:

Fitzsimons, D., Oeltzschner, G., Ovens, C., and Radies, D. 2016. Integration and data analysis of conventional core data with NMR and CT data to characterize an evaporitic carbonate reservoir. SPE-183145-MS.