

Characteristics of pore structures in Selma Chalk using dual FIB-SEM 3D

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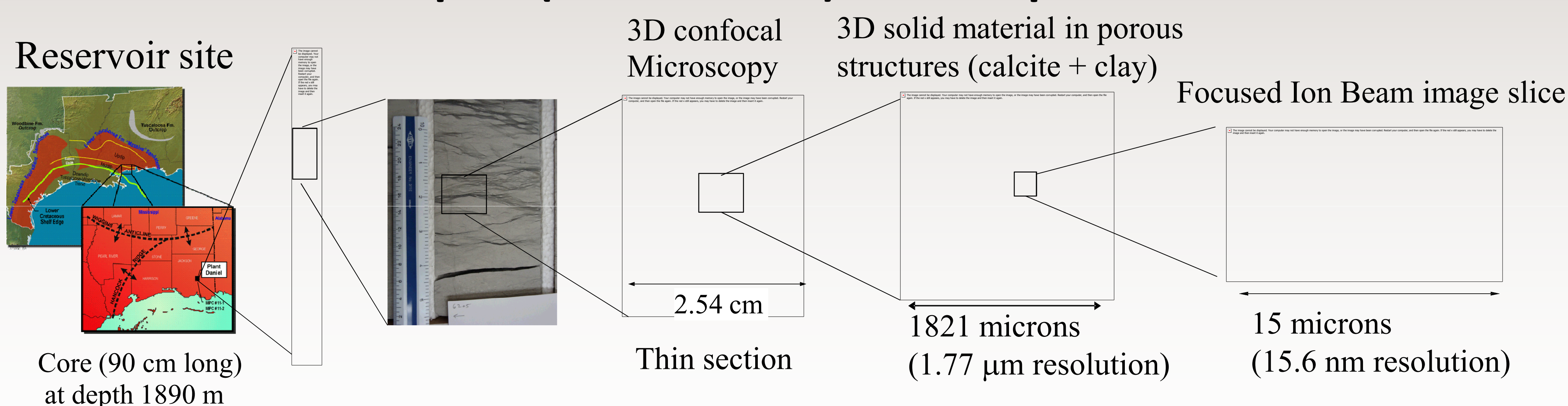
Summary

Accurate prediction of coupled geophysical and chemical processes at the pore scale requires realistic representation of pore structures. This is especially true for chalk materials, where pore networks are small and complex, and often characterized at sub-micron scale. Focused ion beam-scanning electron microscope (FIB-SEM) and laser scanning confocal microscopy methods are used for 3D imaging of nanometer-to-micron scale microcrack and pore distributions in samples of the Cretaceous Selma Group Chalk.

The Selma Chalk is considered the seal for oil and gas fields in the Mississippi Interior Salt Basin and a proposed regional-scale seal identified for CO2 sequestration sites. A series of image analysis techniques is used to process raw images in order to recover both nano-scale pore structure and continuous fracture networks. We apply 3D imaging techniques for characterizing geometric pore body and throat distributions and other topological properties, and lattice-Boltzmann method (LBM) for obtaining permeability at several different scales.

Comparison of primary flow paths obtained from 3D image analysis and LBM demonstrates that image analysis results may have too many equally plausible flow paths, compared to LBM results. Upscaling of permeability and LB multiphase flow simulations will be performed with emphasis on understanding microfracture-matrix interaction during multiphase flow, and seal analysis for geologic CO2 storage.

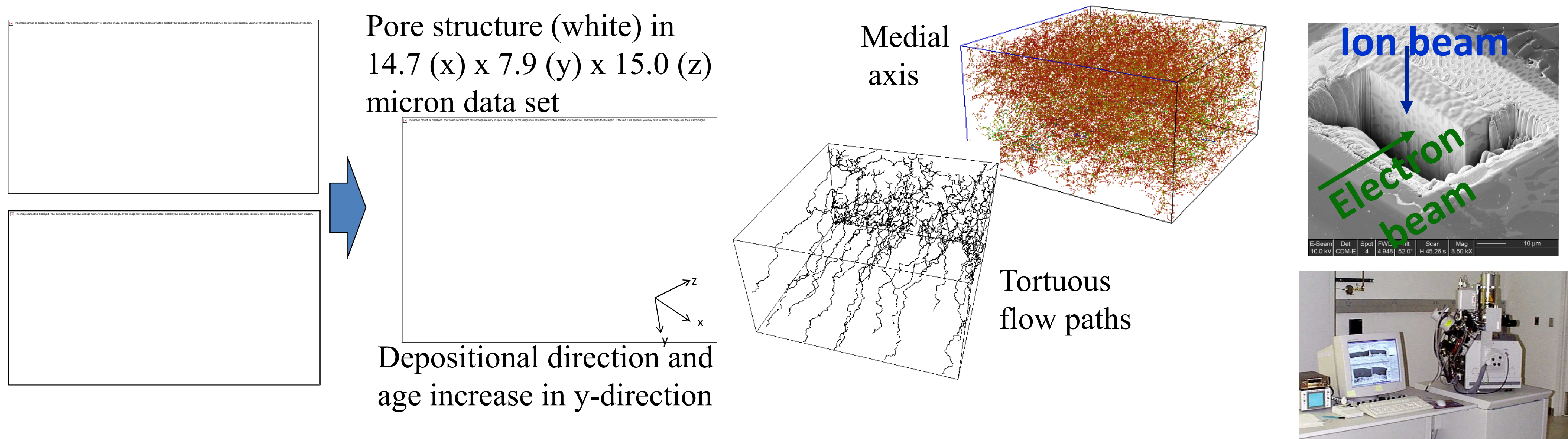
Reservoir Rock Samples (Selma Chalk) at Multiple Scales



Reconstruction of 3D Pore Structure

- Image analysis includes background subtraction, filtering noises (median & FFT bandpass filters), segmentation, dilation & erosion, and interpolation in z-direction

Serial Sectioning with FEI DB-235 FIB/SEM



Single- and multi-phase LB Modeling, Upscaling and More

Single phase flow & streamlines

Static contact angle simulation with Lattice Boltzmann model

3D Laser scanning confocal microscope

LB Simulated k (md)

Length Scale of Subvolume (micron)

◆ k_x ▲ k_y ● k_z

Microfluidic pore network (left) & Linkam optical pressure flow-through cell (right)

Highly connected fractures over horizontal plane
Permeabilities (mD): $k_x = 0.27$; $k_y = 0.056$; $k_z = 0.15$

Multiphase modeling: CO₂ (left) residual water saturation (right)

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