

INTEGRATED RESERVOIR CHARACTERIZATION FOR CHEMICAL ENHANCED OIL RECOVERY, TAR SPRINGS FORMATION, ILLINOIS BASIN, U.S.A

PURDUE
UNIVERSITY

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Discovery Park

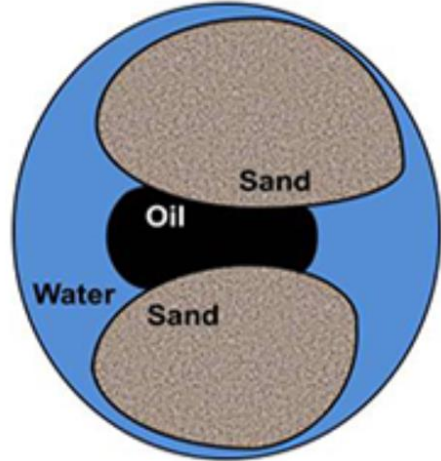


PIONEER
Oil Company

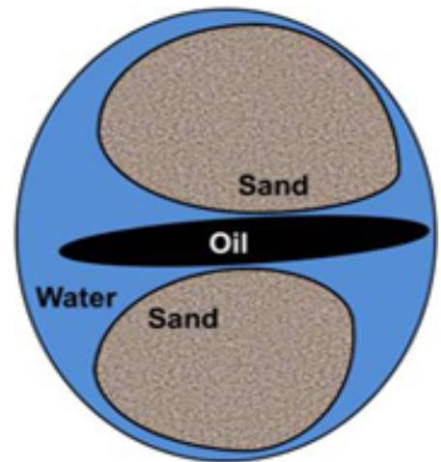


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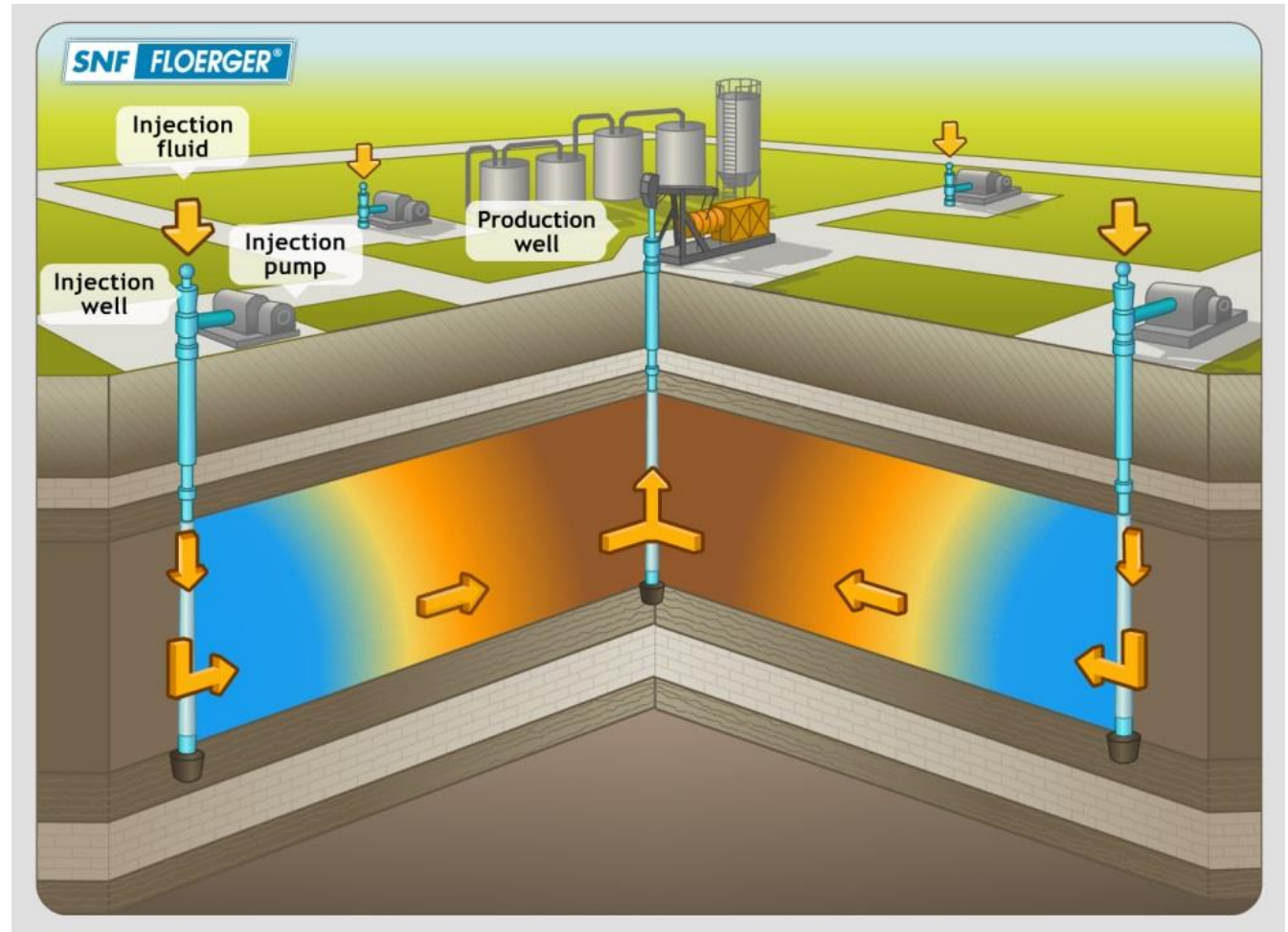
Chemical enhanced oil recovery (EOR) methods utilize injected chemicals (surfactant-polymer) to liberate and sweep oil.



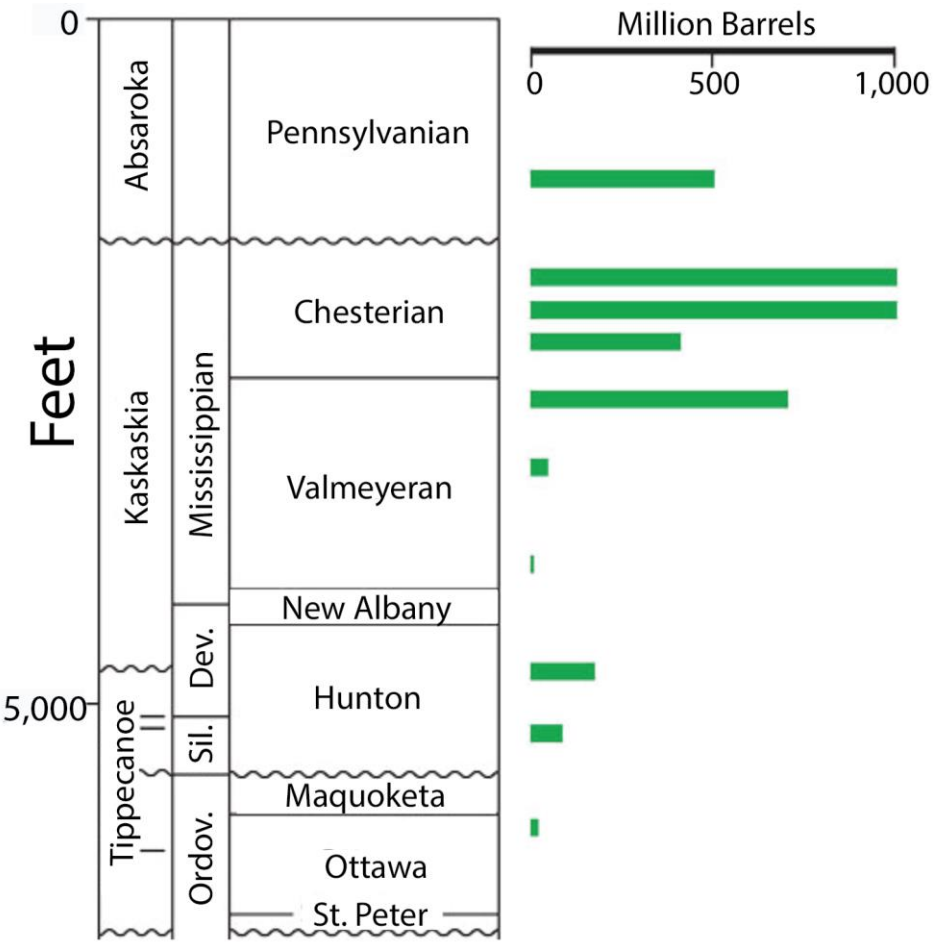
BEFORE surfactant treatment = oil trapped due to capillary forces



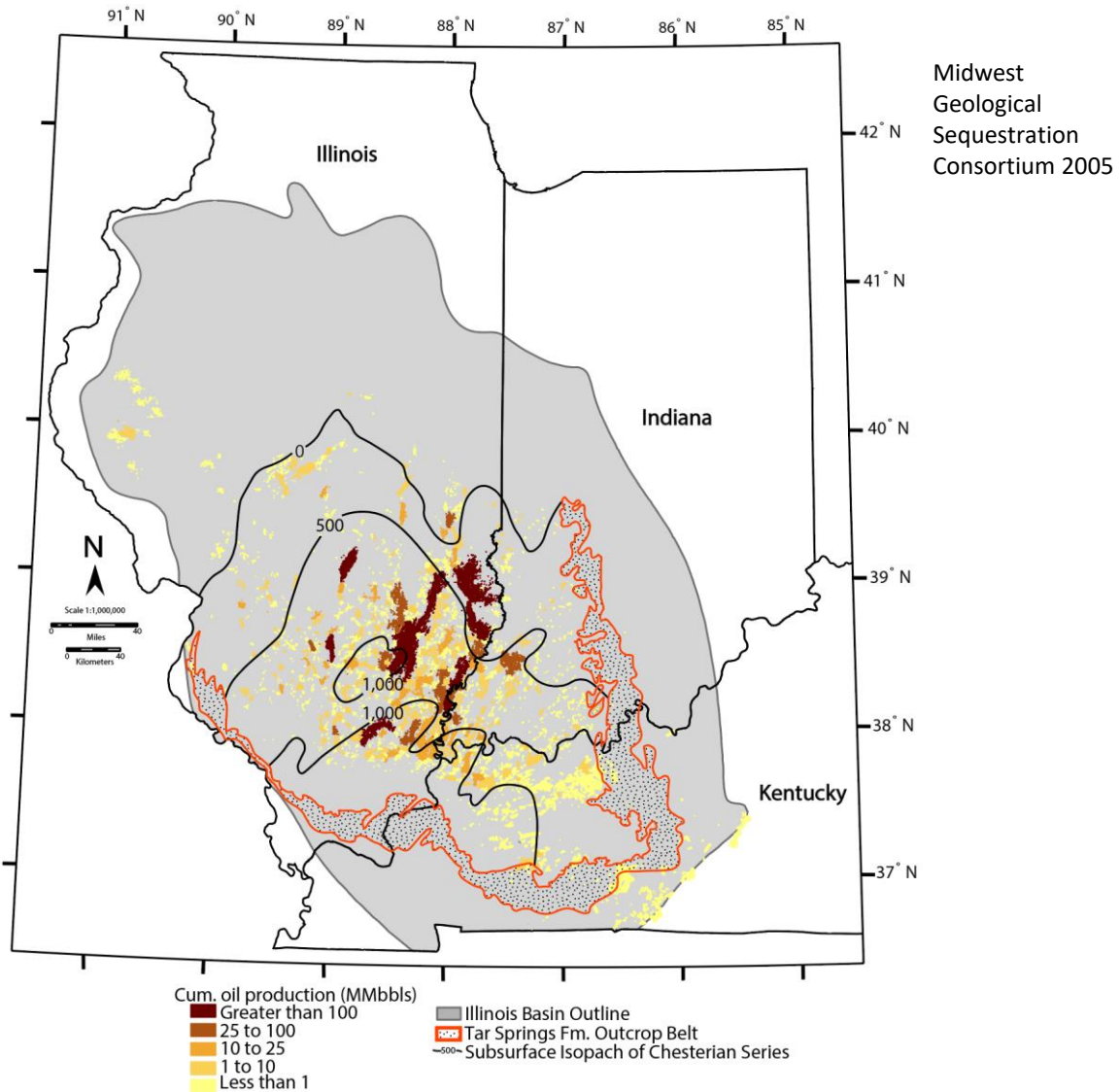
AFTER surfactant treatment = oil mobility increased



The Illinois basin contains an abundance of residual oil – much of the hydrocarbon production currently comes from mature fields with reservoirs rocks dating upper Mississippian (Chesterian) in age.

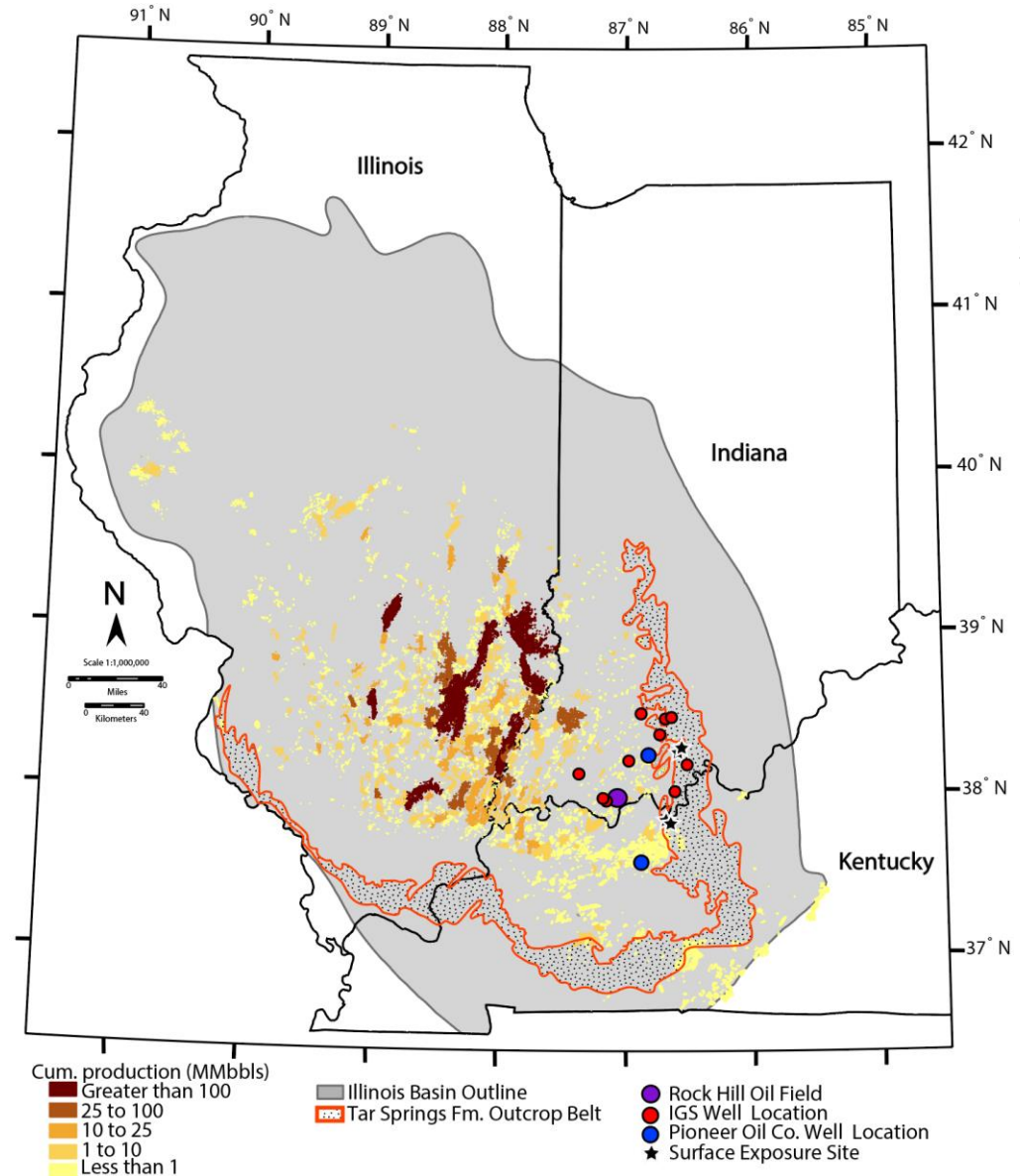
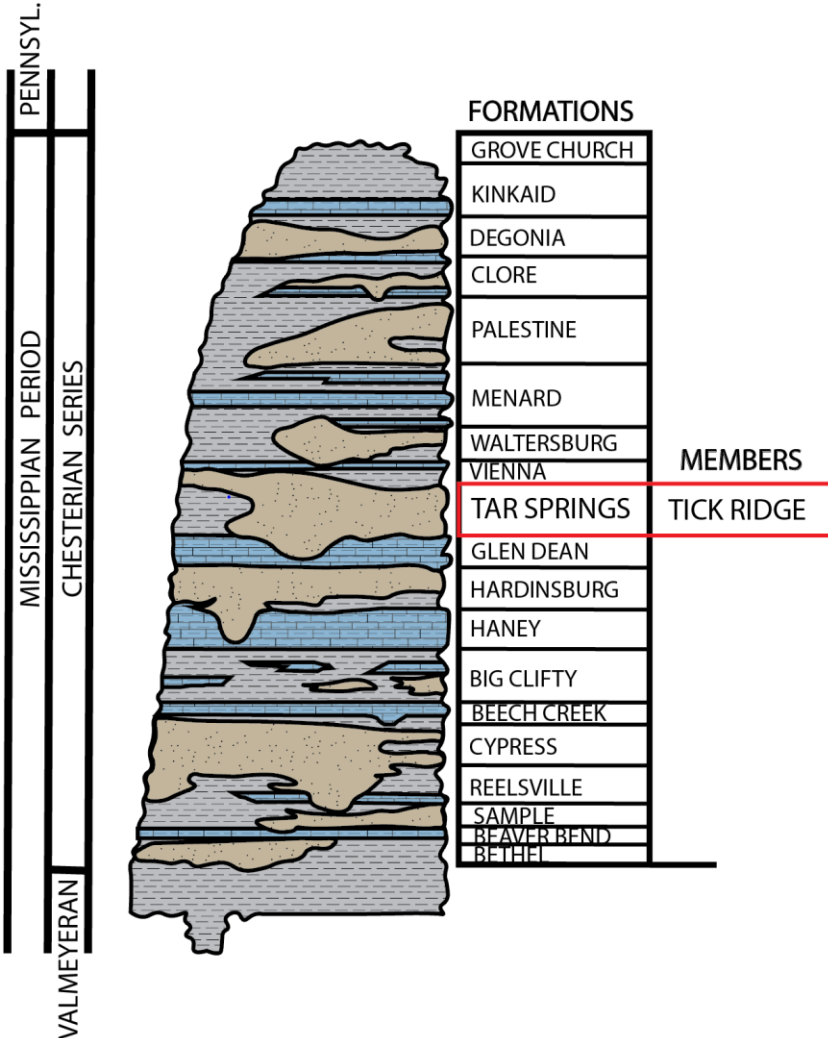


Howard 1990



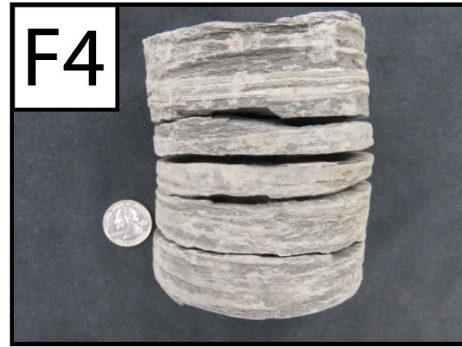
Midwest Geological Sequestration Consortium 2005

The target reservoir in this research is the Tar Springs Formation, one of several key upper Mississippian oil-producing intervals within the hydrocarbon-rich Chesterian Series.



Research Goal: Provide an accurate and quantitative model for reservoir architecture, connectivity, and flow properties as it relates to the mineralogy and chemistry of the reservoir.

Detailed sedimentological and petrographic descriptions of Pioneer reservoir cores and IGS cores show the TSF is composed of 5 distinct lithofacies with unique reservoir properties.

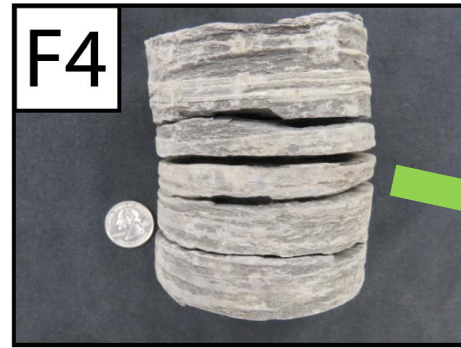
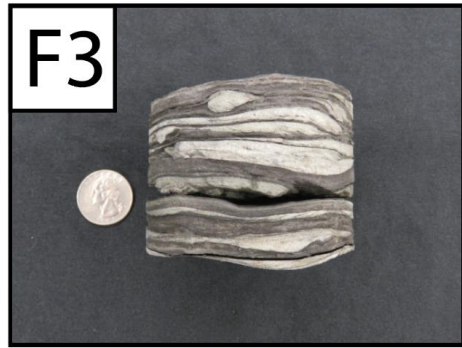
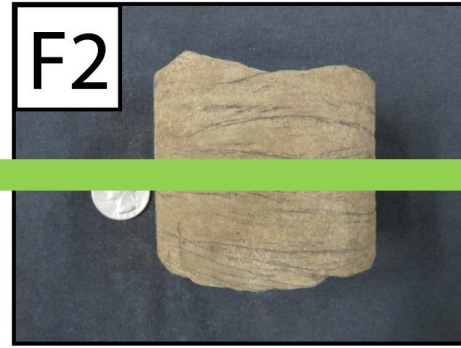
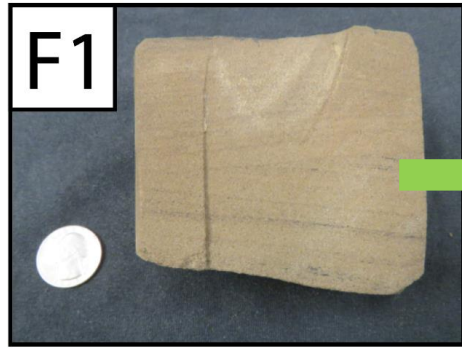


Indiana Geological Survey cores

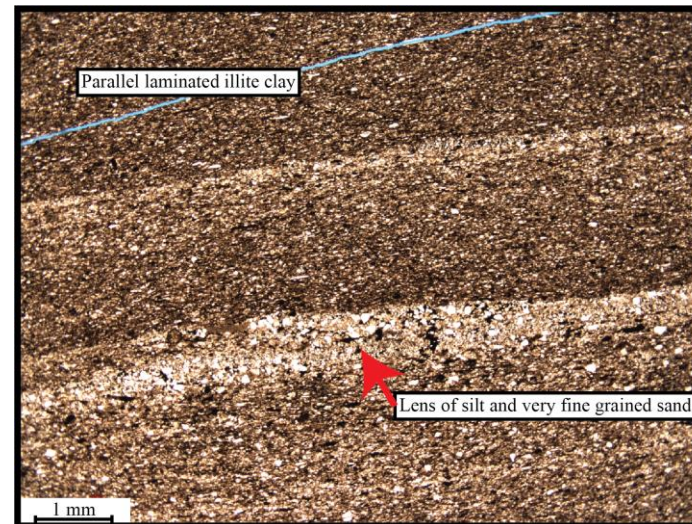
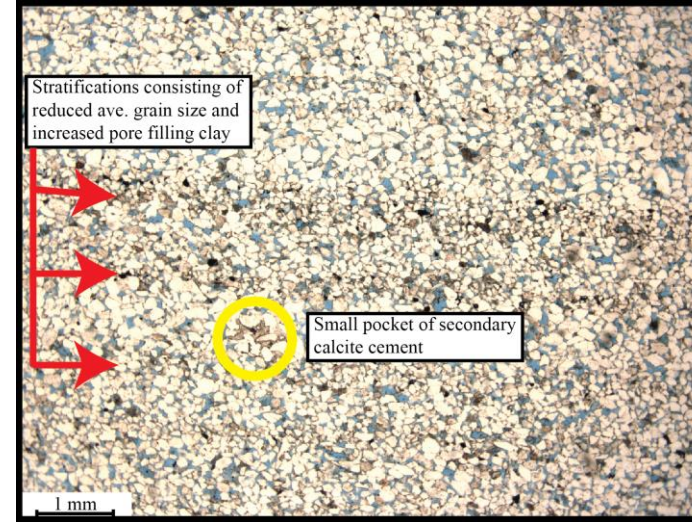


Pioneer reservoir cores

Detailed sedimentological and petrographic descriptions of Pioneer reservoir cores and IGS cores show the TSF is composed of 5 distinct lithofacies with unique reservoir properties.



Pioneer reservoir cores



Surface exposures of the TSF were studied and measured to get a 3D sense of the lateral continuities and internal geometries of individual facies.



Channel sandstone lens made of clean, mature sandstone (over-channel flow)

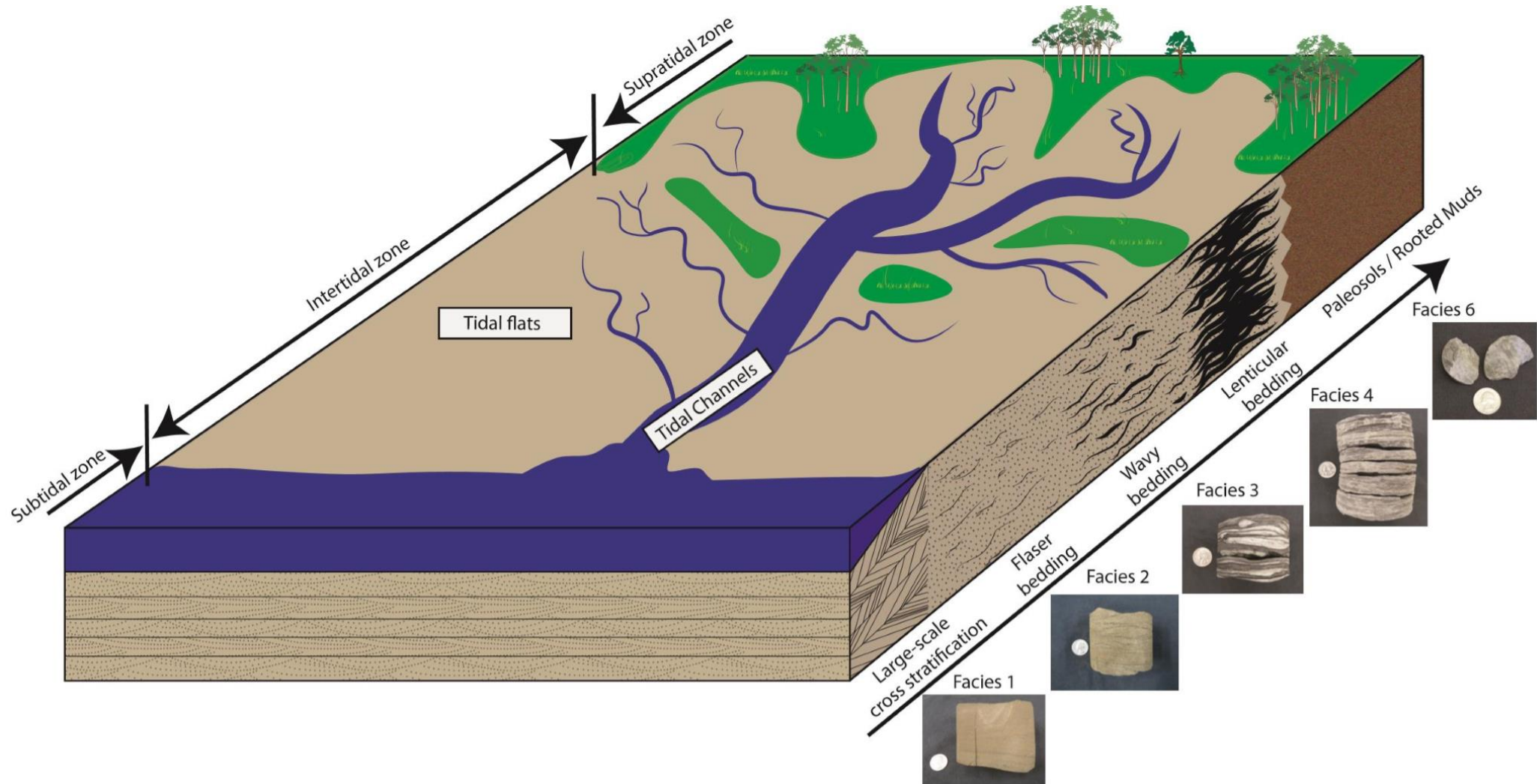
Ripple bedded and flaser bedded sandstone with increased clay content (over-bank flow)



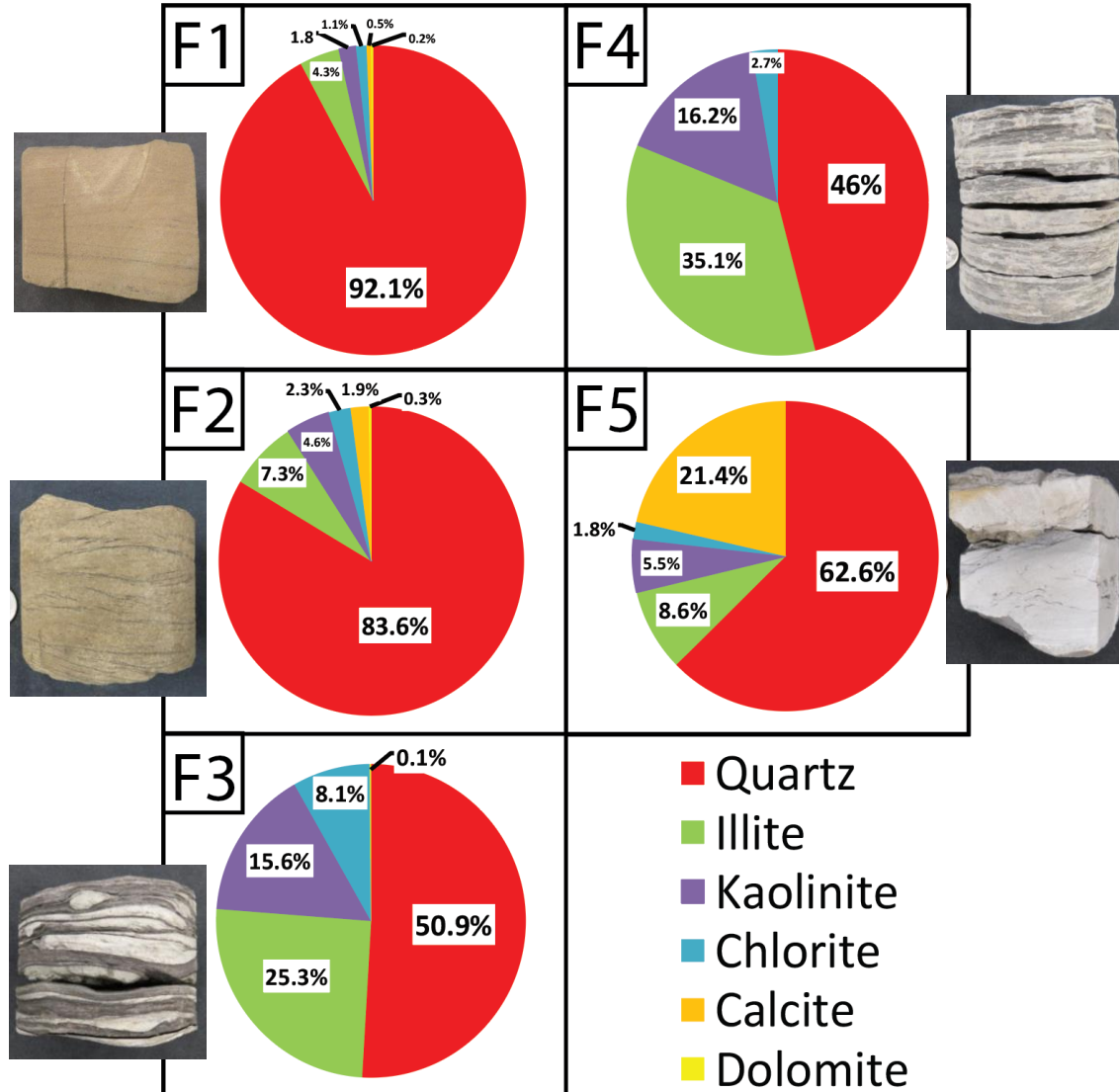
F1

F2

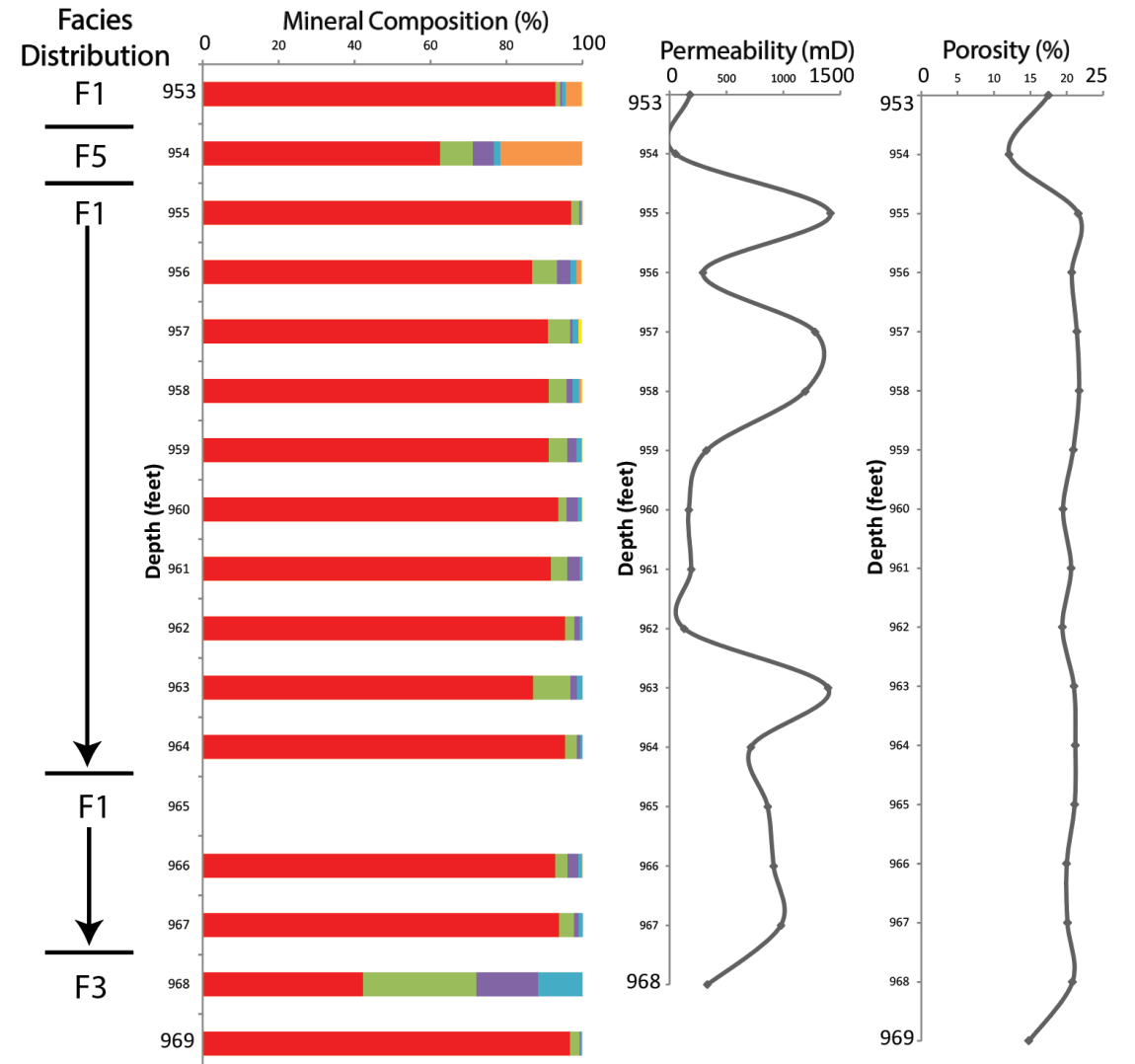
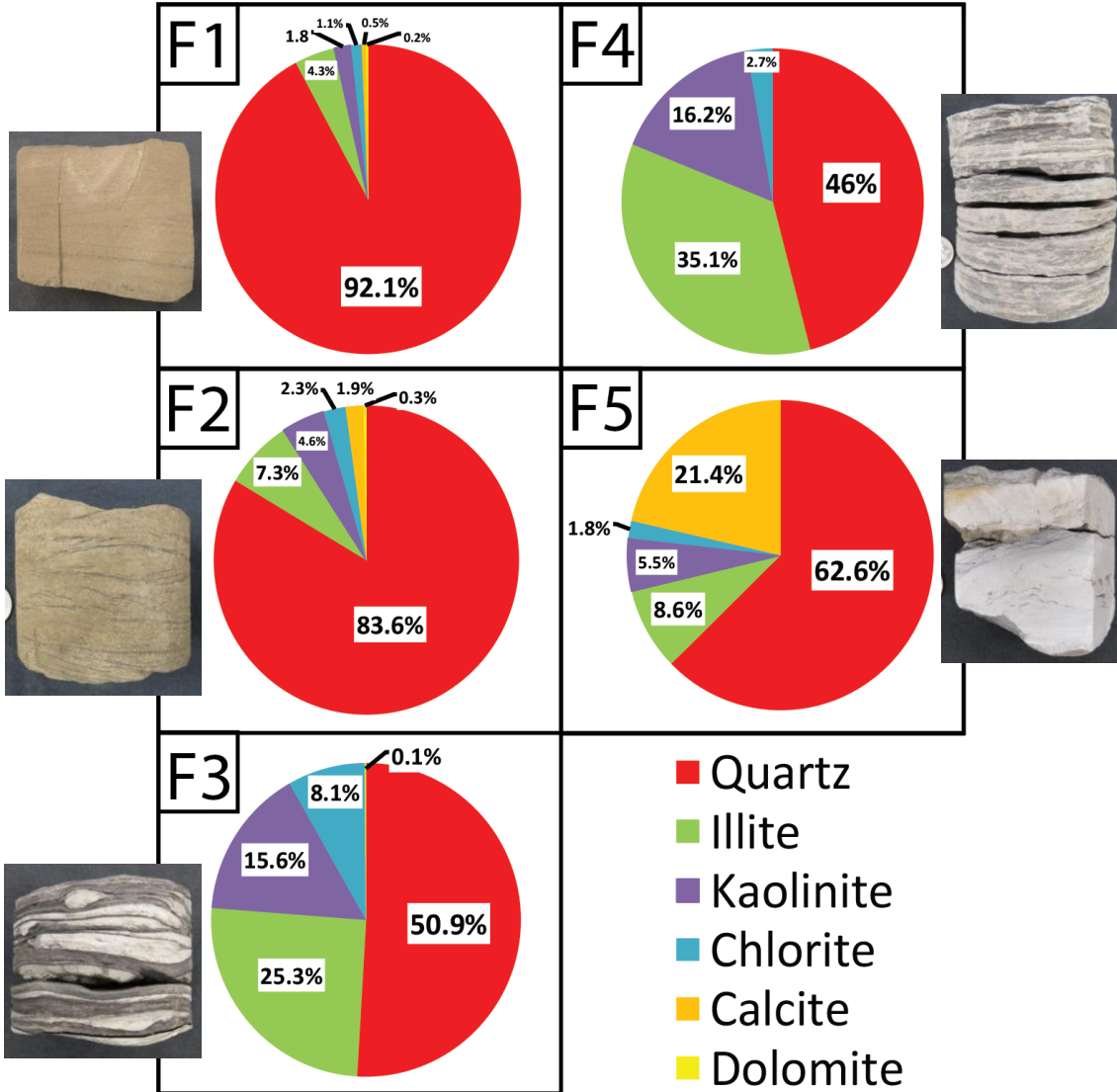
The various sedimentary structures, fossil occurrences, and lithofacies observed in cores and outcrops of the TSF reflect depositional conditions associated with a channel-related tidal flat environment.



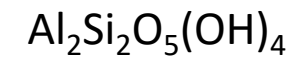
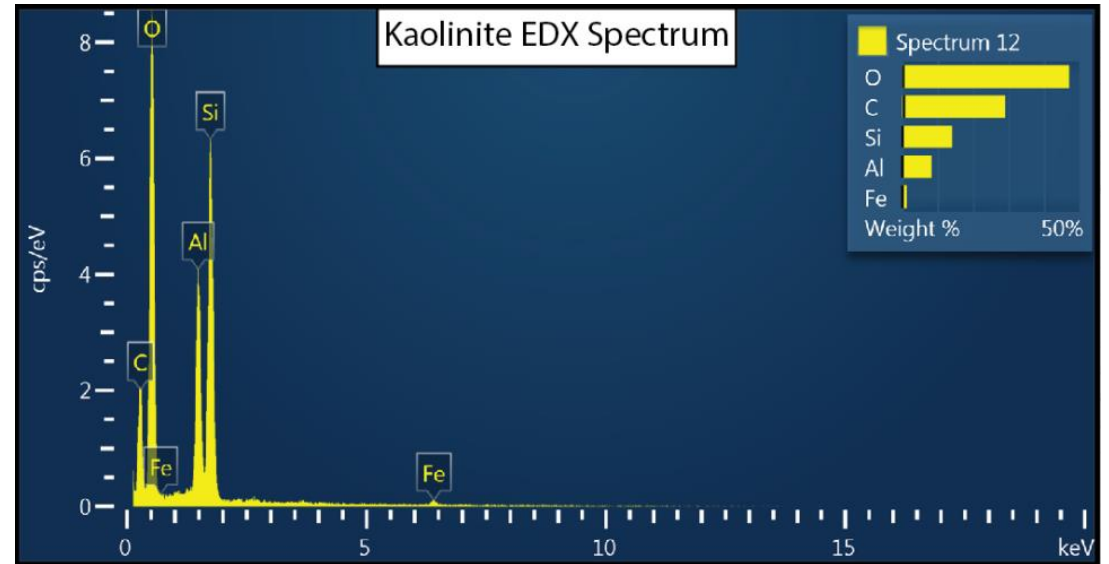
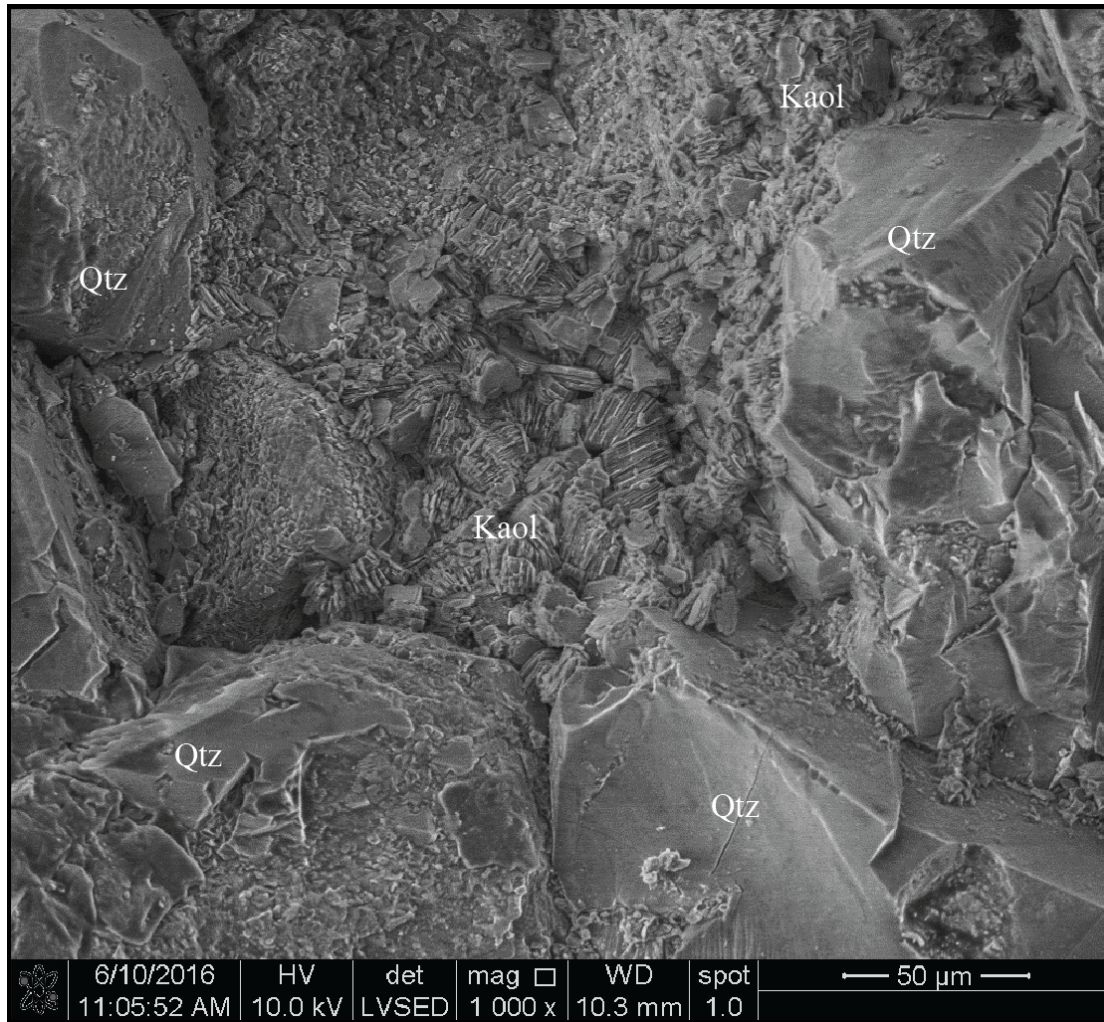
Quantitative X-ray diffraction (XRD) identified mineral variations associated with each facies and helped isolate which mineral constituents were most detrimental to reservoir quality.



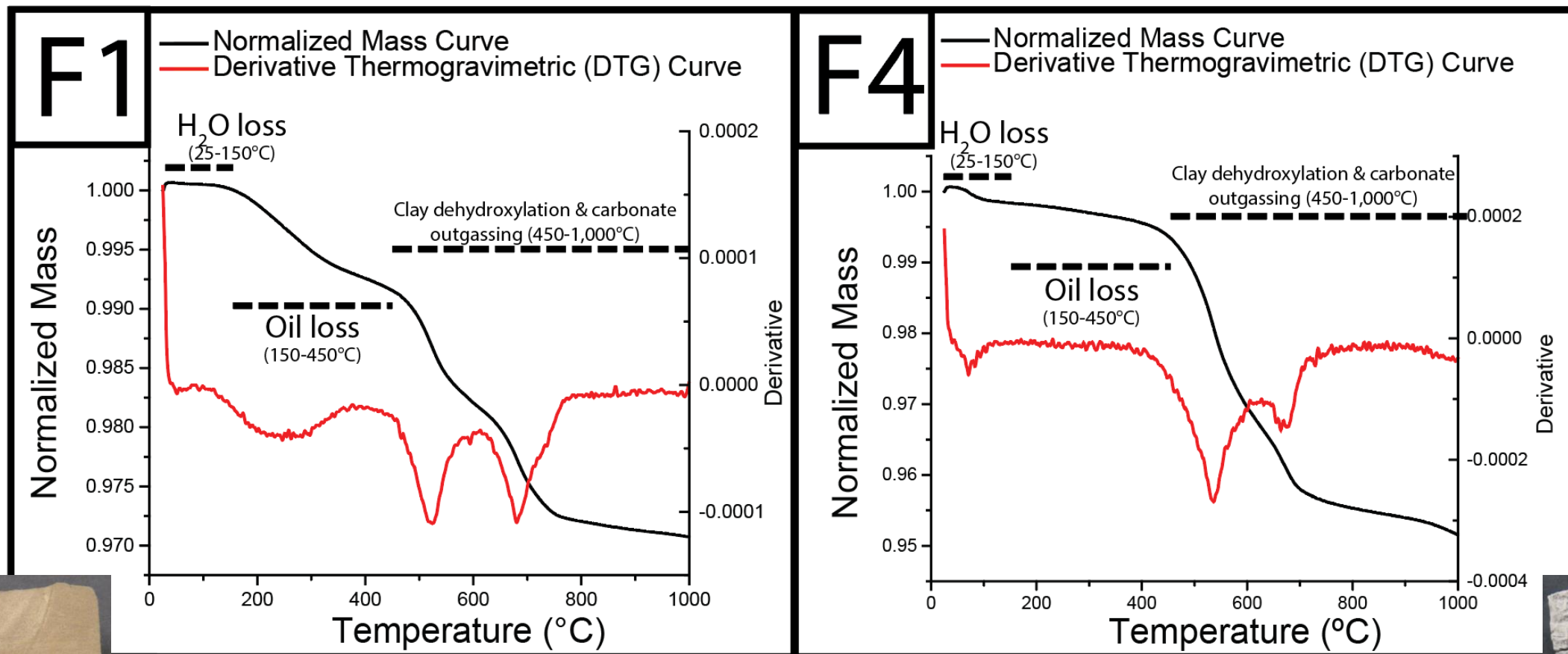
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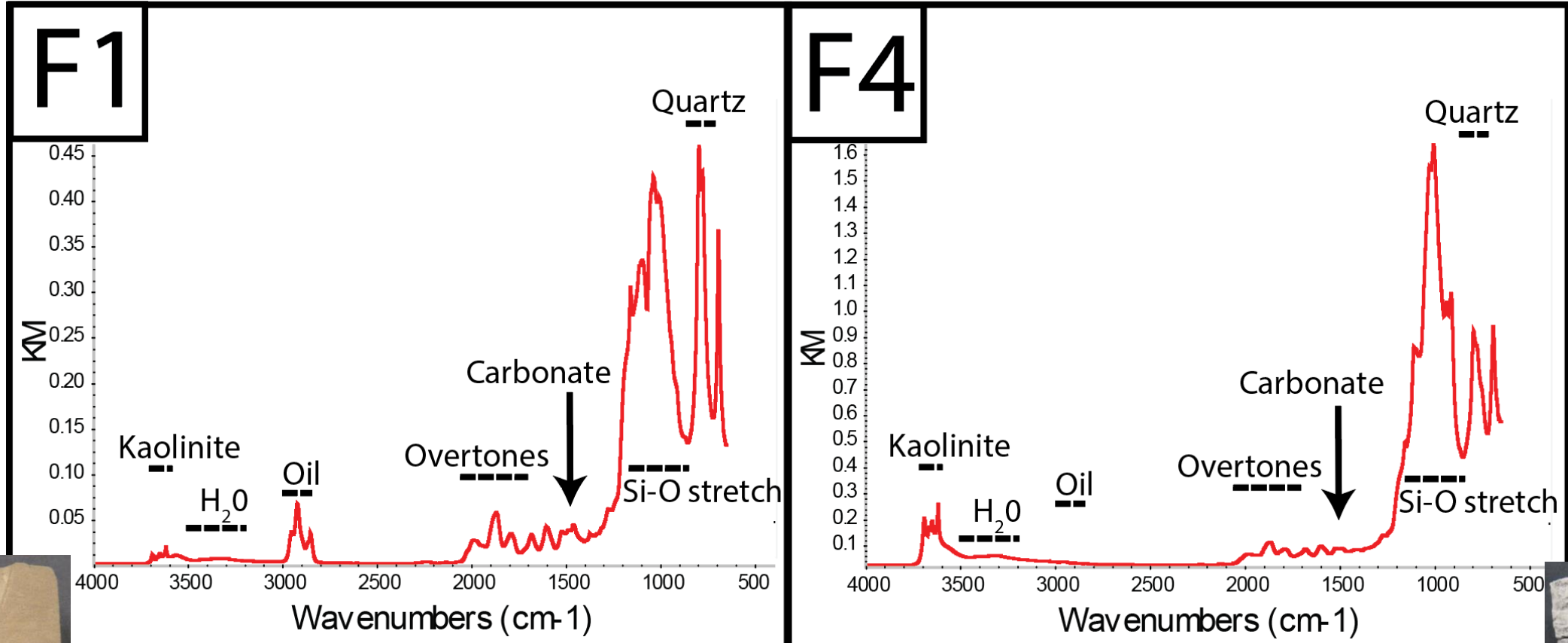
Scanning electron microscopy (SEM) and energy dispersive X-ray spectrometry (EDX) reveal pore network structures and how clay minerals/cements influence reservoir flow properties.



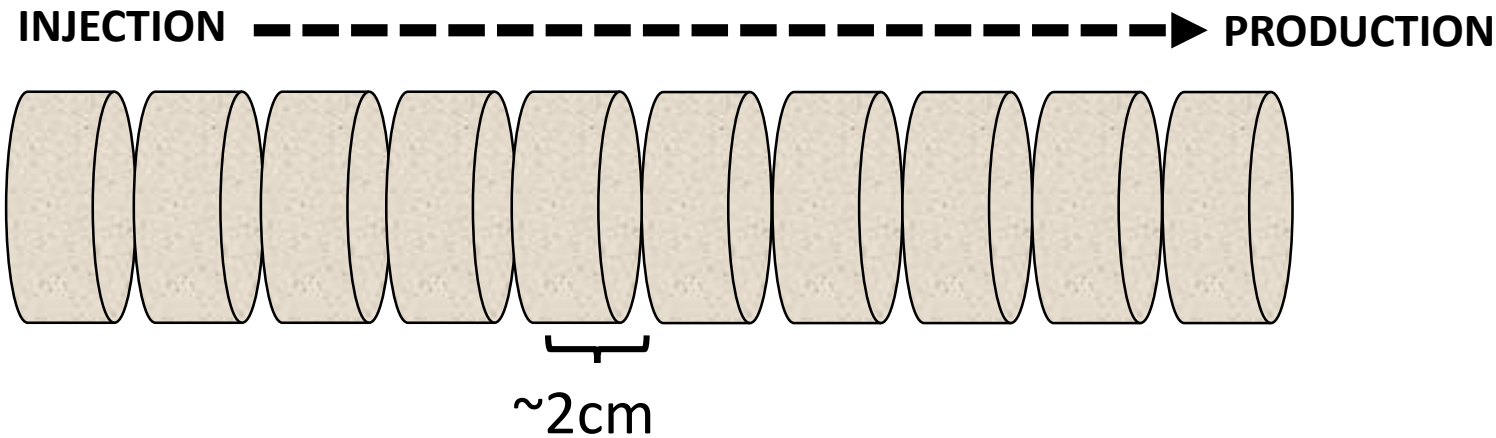
Thermal analysis (TGA-EGA) were performed to accurately quantify non-crystalline volatile components of TSF reservoir cores as well as determine oil saturation.



Fourier transform infrared spectroscopy (FTIR) analyses help confirm crystalline mineral phases and assess non-crystalline volatile phases present in TSF reservoir cores.



Combined methods from this research also apply to EOR coreflood materials to understand rock-fluid interactions and sweep efficiencies of various chemical formulations.



Sampling of coreflood materials can shed insight into:

- oil saturations along section
- mineral variations along section
- chemical adsorption sites

Conclusions

1. Our integrated approach to reservoir characterization provides new data on the sedimentological and chemical heterogeneity of a mature reservoir from outcrop exposures to pore spaces.
2. Sedimentologic analysis has identified five distinct lithofacies with characteristic reservoir properties. Textural and sedimentary features preserved in both Tar Springs cores and outcrop exposures are interpreted as a product of a channel-related tidal flat depositional setting.
3. Horizontally stratified sandstone facies F1 and flaser bedded sandstone facies F2 represent the highest quality reservoir horizons of the Tar Springs Formation in terms of flow parameters and residual oil saturations.
4. The design and implementation of successful EOR projects in U. Mississippian reservoirs of the Illinois basin will require a comprehensive understanding of the distribution, types, and interactions of clay minerals with respect to pore networks and various interactive chemical injections.

Thank You

The various sedimentary structures, fossil occurrences, and lithofacies observed in cores and outcrops of the TSF reflect depositional conditions associated with a channel-related tidal flat environment.

