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Technical Progress Report

Quarterly Report

Alkaline-Surfactant-Polymer Flooding And Reservoir Characterization of the Bridgeport and Cypress Reservoirs Of the Lawrence Field

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Disclaimer

Abstract

Laboratory Evaluation

Additional oil and produced water samples were collected for use in completing the laboratory work.

Reservoir Characterization

The Griggs 107 well has been designated the type well for the pilot study because it has the best core recovery of the six wells cored for the pilot flood. The Cypress Sandstone has been subdivided into five separate reservoir compartments in the pilot area. Graph of permeability measurements in core analysis report shows low permeability rocks separate the A, B, C, D, and E sandstones in the middle Cypress sandstone from one another. Examination of cores show that low permeability units are composed of siltstone, shale and interbedded shale and fine-grained sandstone. These permeability barriers separate reservoir compartments from one another in the Cypress Sandstone. Geophysical logs have been evaluated in each well in the pilot area. Formation depths have been established for all wells and the Cypress sandstone has been subdivided in each well in the pilot area. The Pennsylvanian Bridgeport A, B and D sandstones have also been subdivided in each well in the pilot area.

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Executive Summary

Laboratory Evaluation

The alkaline-surfactant-polymer technology has produced incremental oil recovery in multiple field projects.[i,ii,iii] The objective of this contract is to formulate two alkaline-surfactant-polymer solutions to be injected into the Bridgeport A and Bridgeport B, and the Cypress and Paint Creek. During the last quarter, new Bridgeport A, B, and D oil samples were collected. Future work will be to develop an alkaline-surfactant-polymer combination that recovers incremental oil in both the Bridgeport A and Bridgeport B. Interfacial tension, phase behavior, and radial coreflood evaluations will be performed. Numerical simulation of the Bridgeport A and B, and the Cypress and Paint Creek will begin next quarter as well.

Reservoir Characterization

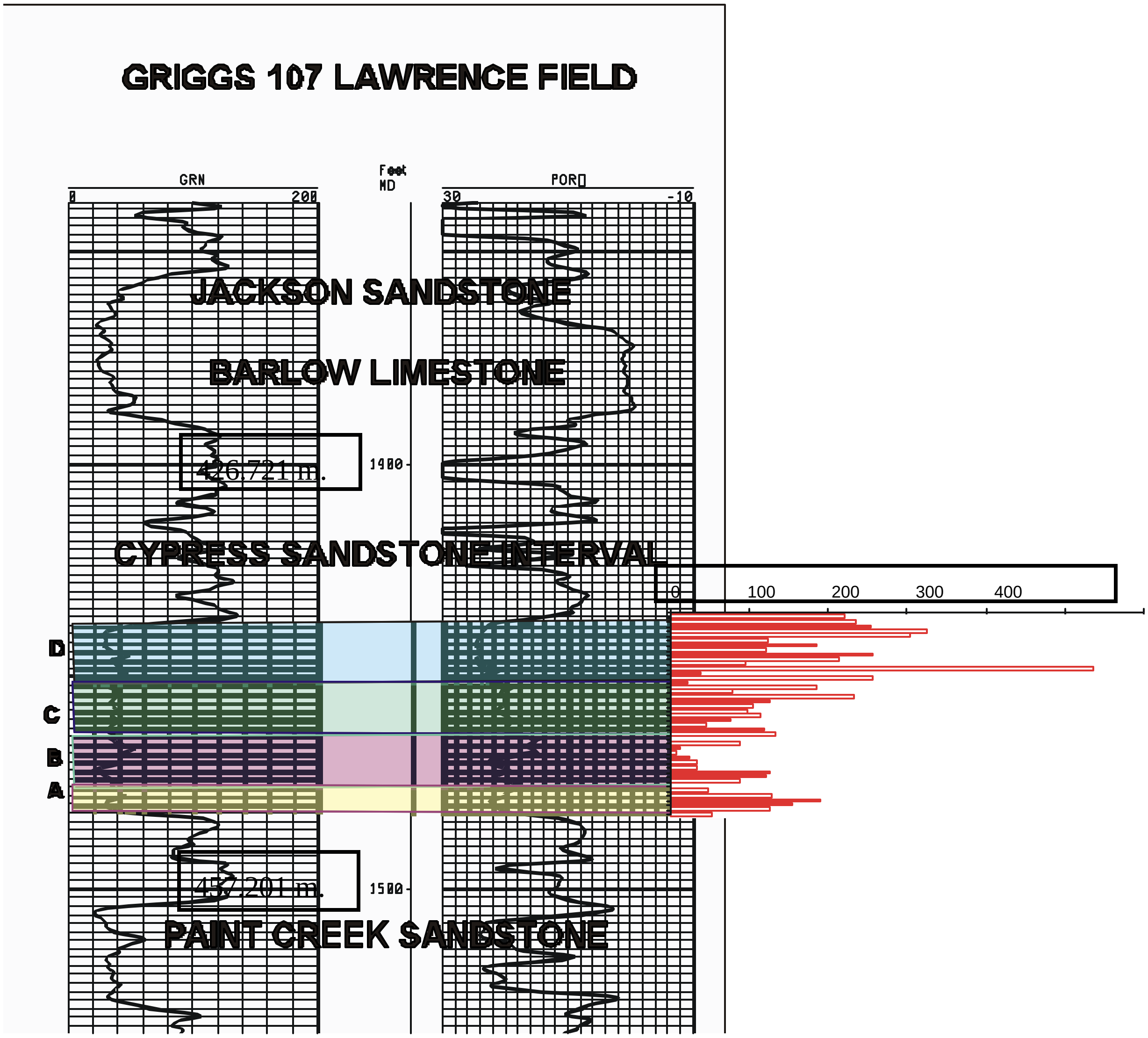
The Griggs 107 well has been designated the type well for the pilot study because it has the best core recovery of the six wells cored for the pilot flood. The Cypress Sandstone has been subdivided into five separate reservoir compartments in the pilot area. Graph of permeability measurements in core analysis report shows low permeability rocks separate the A, B, C, D, and E sandstones in the middle Cypress sandstone from one another. Examination of cores show that low permeability units are composed of siltstone, shale and interbedded shale and fine-grained sandstone. These permeability barriers separate reservoir compartments from one another in the Cypress Sandstone. Geophysical logs have been evaluated in each well in the pilot area. Formation depths have been established for all wells and the Cypress sandstone has been subdivided in each well in the pilot area. The Pennsylvanian Bridgeport A, B and D sandstones have also been subdivided in each well in the pilot area.

A talk entitled A "Mississippian Cypress Sandstone Architecture in the Illinois Basin" was presented at the Eastern Section American Association of Petroleum Geologists Meeting at Kalamazoo, Michigan on Sept. 23, 2001. An abstract was published in the AAPG Bulletin. This talk presented preliminary findings for the study.

Experimental

Reservoir Characterization

The Griggs 107 well has been designated the type well for the pilot study because it has the best core recovery of the 6 wells drilled for reservoir characterization and evaluation of the Alkaline-Surfactant-Polymer chemical flood. All well logs in the Pilot area have been evaluated and formation depths have been calculated. The Cypress Sandstone has been subdivided into 5 units (Figure 1). These five units have been designated the A, B, C, and D sandstones. Pennsylvanian Bridgeport Sandstones have also been subdivided and formation depths have been calculated. Formation depths have been calculated in preparation for construction of structure and isopach maps. Formation tops and bases have been calculated for the Seelyville coal, Bridgeport A, B and D Sandstones, Buchanan Sandstone, Glen Dean Limestone, Barlow Limestone, Cypress A, B, C, and D Sandstones, Paint Creek Sandstone, and the Ste. Genevieve Limestone, all available logs have been used. Preliminary structure maps and gross sandstone interval maps have been generated for most of these marker formations and reservoir intervals. Numerous cross- sections have been constructed to ensure correct correlation of units. Core analysis data including porosity and permeability have been evaluated with geophysical logs and core descriptions.



Gamma -ray and porosity log for the Plains Illinois Griggs 107. The Cypress Sandstone is subdivided into 5 units. Permeability graph Shows low permeability intervals separate sandstone lenses.

Figure 1

Results and Discussion

Laboratory Evaluation

Additional oil and produced water samples were needed to complete the laboratory work. Fluid samples were taken from wells located in the ASP pilot project area:

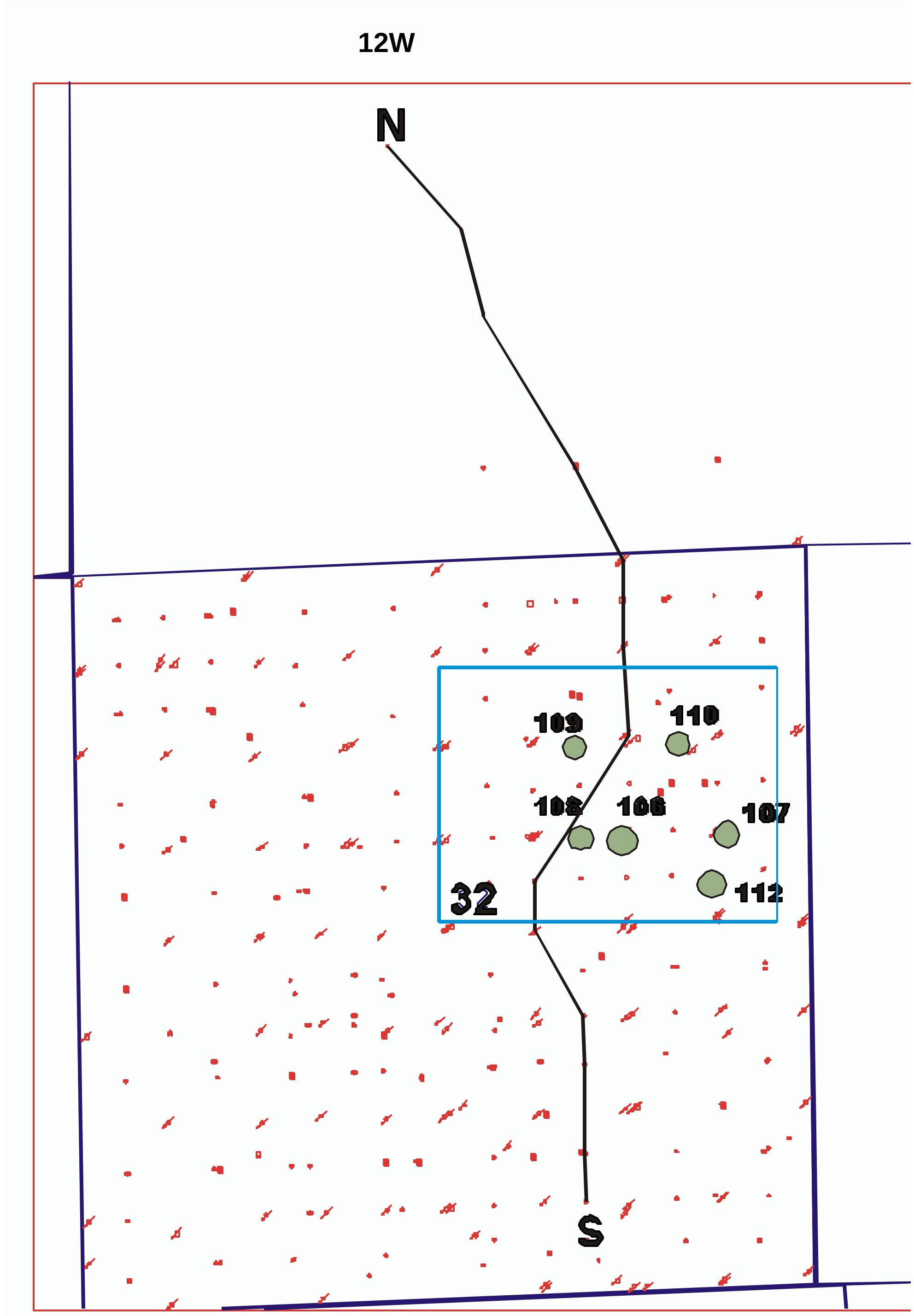
1) Bridgeport A oil and produced water samples were obtained from JT Griggs a/c1 # 80.
2) Bridgeport B oil and produced water samples were obtained from JT Griggs a/c1 # 79 and also from JT Griggs a/c1 # 80.
3) Bridgeport D oil and produced water samples were obtained from JT Griggs a/c1 # 79.

An unsuccessful attempt was made to obtain Bridgeport A samples from JT Griggs a/c1 #112 (ASP pilot project core well & planned ASP pilot project injection well). Bridgeport A was perforated and acidized, but no oil was recovered.

Reservoir Characterization

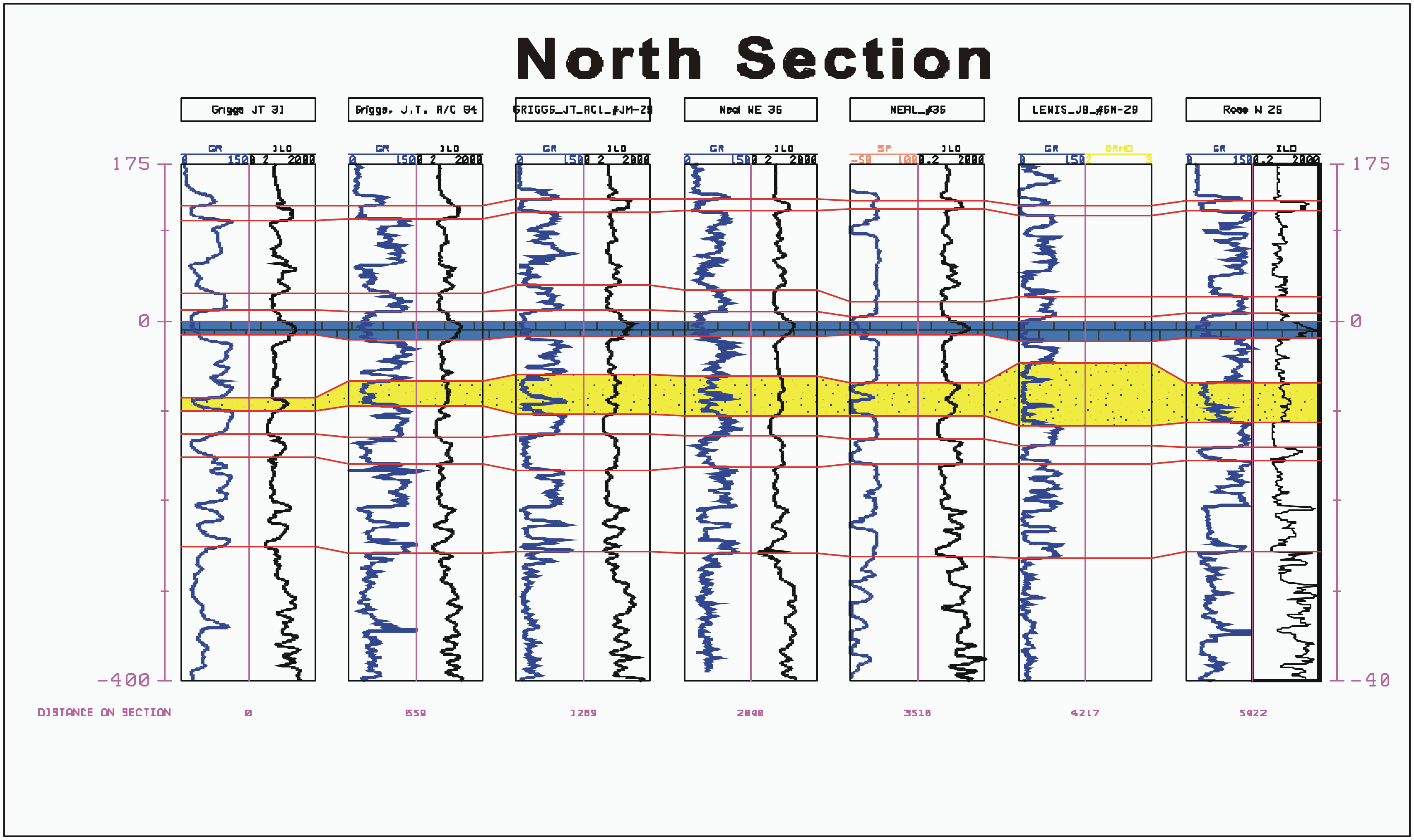
Five compartments have been identified in the Middle Cypress Sandstone in the pilot area. The reservoir compartments have been designated the Cypress A, B, C, D and E sandstones. The gamma ray and porosity log from the Griggs 107 well in the pilot area highlight the Cypress A, B, C, and D sandstones, the E sandstone is not present in this well. Permeability graph shows that permeability barriers separate the A, B, C, and D sandstones from one another. Examination of core from the Griggs 107 shows that low permeability shale and siltstones commonly separate the sandstone units. The best reservoir qualities in the Griggs 107 are found in Middle Cypress Sandstone D where permeability commonly exceeds 200 md. Reservoir sandstones in the A, B, and C sandstones are less permeable and porous than those in the D interval in the Griggs 107 well. The Griggs 107 well has been designated the type well for the pilot study because it has the best core recovery of the 6 wells drilled for reservoir characterization and evaluation of the Alkaline-Surfactant-Polymer chemical flood. All well logs in the Pilot area have been evaluated and formation depths have been calculated.

A cross section connecting the pilot area in Section 32-T4N-R12W with a previously mapped area in Sections 19, 30- T4N- R12W is shown in Figure 2. The previous mapping (iv) separated the middle Cypress Sandstone into 5 reservoir units and were designated the A, B, C, D, and E sandstones. Isopach maps of the A, B, C, D and E sandstones show elongate northeast - southwest oriented sandstone bodies with thicknesses of approximately 3 meters (10 feet). This cross-section shows (Figures 3 & 4) that the same sandstone units that are present in Sections 19 and 30-T4N-R12W are also present in the pilot area. The cross section also shows that individual sandstones come and go between wells. Some or all of the A, B, C, D, and E sandstones may be missing in any given well. Additionally, several sandstones may coalesce into a single thick sandstone in some localized areas. In some wells none of the middle Cypress sandstones are present. Therefore, mapping the middle Cypress Sandstone as an interval or mapping the net sandstone thickness of the middle Cypress doesn’t provide reliable information regarding reservoir geometry. Each sandstone must be mapped separately to determine reservoir geometry. This applies to the Bridgeport Sandstones as well. Communication of reservoir fluids may be limited between sandstone compartments or may be relatively unimpeded depending on the thickness and completeness of shaley intervals separating reservoir compartments.



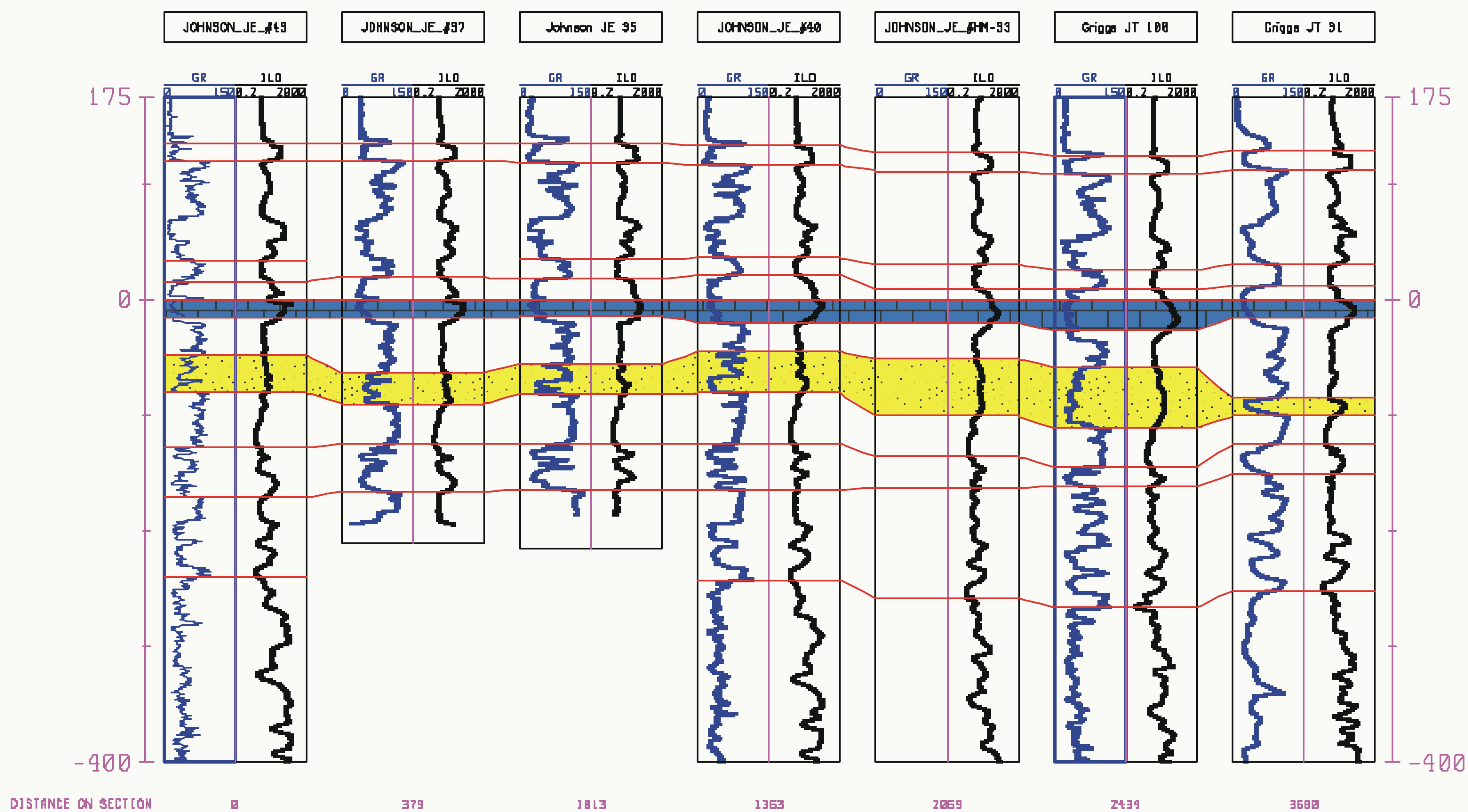
Location map showing cross-section and section lines for Section 32 - T4N - R12W. Outline of pilot area is shown as well as location of cored wells drilled on the Griggs lease for this project.

Figure 2



Cross Section from pilot area in Section 32- T4N-R12W and Sections 19 and 30 T4N-R12W in Lawrence Field. Cross Section is split between north and south sections.

Figure 3



Stratigraphic Cross Section. Barlow Limestone is datum. Cypress Sandstone highlighted in yellow at depths of approximately 430 m.

South Section

Figure 4

Conclusion

Laboratory Evaluation

Future work will be to develop an alkaline-surfactant-polymer combination that recovers incremental oil in both the Bridgeport A and Bridgeport B. Interfacial tension, phase behavior, and radial coreflood evaluations will be performed. Numerical simulation of the Bridgeport A and B, and the Cypress and Paint Creek will begin next quarter.

Reservoir Characterization

Five compartments have been identified in the Middle Cypress Sandstone in the pilot area. The reservoir compartments have been designated the Cypress A, B, C, D and E sandstones. Permeability graph compared with geophysical log characteristics shows that permeability barriers separate the A, B, C, and D sandstones from one another. Examination of core from the Griggs 107 shows that low permeability shale and siltstones commonly separate the sandstone units. The best reservoir qualities in the Griggs 107 are found in Middle Cypress Sandstone D where permeability commonly exceeds 200 md. Reservoir sandstones in the A, B, and C sandstones are less permeable and porous than those in the D interval in the Griggs 107 well. The Griggs 107 well has been designated the type well for the pilot study because it has the best core recovery of the 6 wells drilled for reservoir characterization and evaluation of the Alkaline-Surfactant-Polymer chemical flood.

A previously mapped area located near the pilot unit separated the middle Cypress Sandstone into 5 reservoir units and were designated the A, B, C, D, and E sandstones. Isopach maps of the A, B, C, D and E sandstones show in the mapped area show elongate northeast - southwest oriented sandstone bodies with thicknesses of approximately 3 meters (10 feet). A cross-section connecting the pilot area with the previously mapped area in Sections 19 and 30 - T4N-R12W shows that these same sandstone units are also present in the pilot area. The cross section also shows that individual sandstones come and go between wells. Some or all of the A, B, C, D, and E sandstones may be missing in any given well. Additionally, several sandstones may coalesce into a single thick sandstone in some localized areas. In some wells none of the middle Cypress sandstones are present. Therefore, mapping the middle Cypress Sandstone interval or mapping the net sandstone thickness of the middle Cypress doesn't provide reliable information regarding reservoir geometry. Each sandstone unit must be mapped separately to determine reservoir geometry. This also applies to the Bridgeport Sandstones. Communication of reservoir fluids may be limited between sandstone compartments or may be relatively unimpeded depending on the thickness and completeness of shaley intervals separating reservoir compartments.

General

The work done to date continues to suggest a successful project and that the process will be applicable to other areas of the Lawrence Field and to other fields with similar sand types and characteristics.

References

[i] Meyers, J.J., Pitts, M.J., and Wyatt, K.: "Alkaline-Surfactant-Polymer Flood of the West Kiehl, Minnelusa Unit", SPE 24144, presented at the Eight Symposium on Enhanced Oil Recovery in Tulsa, Oklahoma, April 1992.

[ii] Gao, S., Li, H., Yang, Z., Pitts, M.J., Surkalo, H., and Wyatt, K.: "Alkaline-Surfactant-Polymer Pilot Performance of the West Central Saertu, Daqing Oil Field", SPE 35383, presented at the Tenth Symposium on Improved Oil Recovery in Tulsa, Oklahoma, April 1996, SPE Reservoir Engineering, Volume 11 number 3, August 1996, pages 181-188.

[iii] Vargo, Jay, Turner, Jim, Vergnani, Bob, Pitts, Malcolm J., Wyatt, Kon, Surkalo, Harry, and Patterson, David: "Alkaline-Surfactant-Polymer Flooding of the Cambridge Minnelusa Field," SPE Reservoir Evaluation and Engineering, vol 3 number 6, December 2000, pages 552-558.

iv Seyler, B. and John P. Grube, 2001, Mississippian Cypress Sandstone Architecture in the Illinois Basin; AAPG Bulletin, V. 85/8, p. 1539.