SUBTASK 1.8 – INVESTIGATION OF IMPROVED CONDUCTIVITY AND PROPPANT APPLICATIONS IN THE BAKKEN FORMATION

INTRODUCTION

The Bakken Formation in North Dakota is a significant portion of the largest contiguous oil reserve ever discovered in the lower 48 states (Donovan 2010). The U.S. Geological Survey's (USGS's) original study of the Bakken Formation found 4.3 billion barrels of recoverable oil in the Montana and North Dakota portion of the Williston Basin. According to federal testimony provided by the director of the North Dakota Department of Mineral Resources (Helms, 2009), "Hydraulic fracturing is a critical component of developing the Bakken Formation, indeed every shale play throughout the U.S. and Canada. Without hydraulic fracturing, under regulation of the states, this resource could not be produced." Hydraulic fracturing is the process of improving the ability of oil to flow through a rock formation by creating fractures. The process includes pumping a mixture of water and additives that include various sizes of sand or ceramic particles called proppants that are designed to "prop" the fractures open, creating greater conductivity of fluids to the wellbore. The proposed research seeks an improved understanding of proppant performance in the Bakken Formation.

The three basic types of proppant are ceramic (sintered bauxite, alumina, kaolin), sand (sorted silica sand), and resin-coated (ceramic or sand). Ceramic proppants comprise three groups: lightweight, intermediate density, and high density. The performance of ceramic proppants varies greatly both by composition and manufacturer; however, numerous ceramic proppants have been used in the Bakken Formation that are advertised to withstand closure stresses of 6000 to 14,000 psi. Relative closure stresses of the Bakken Formation in North Dakota cover the performance range of ceramic proppants. Fracturing sand is typically divided into two types: white sand and brown sand. White sand, the stronger of the two, is typically sourced from the St. Peter's Sandstone in Ottawa, Illinois, while brown sand is sourced from the Hickory Sandstone near Brady, Texas. Fracture sand is typically used in environments below 6000 psi (Halliburton, 2005). Resin coating of sand does not increase strength properties; however, resin-coated sand (RCS) is a popular proppant choice because of better consolidation, which reduces flow back and provides for better stress distribution across the proppant pack. Resin-coating ceramic proppant provides similar performance enhancements. All of the above are being used in Bakken completions.

Although it has been documented that propped fractures can be created to breach the lower Bakken Shale, field evidence to date suggests that operators are typically unable to sustain a hydraulic connection through this barrier (Taylor, 2010). At the current time, this challenge requires operators to drill redundant wells completed in each of the Middle Bakken and Three Forks Reservoirs. Similarly, Bakken operators have fractured into offset wells that are spaced more than 2000 feet away, demonstrating that very long propped fractures can be created. However, these fractures also lose hydraulic continuity over time. This research is targeted to identify what parameters are responsible for the collapse of these propped fractures and the resulting loss of conductivity, including:

1. The evaluation of formation integrity relative to exposure to various fracturing fluids and acidic conditions of native fluids.

2. The evaluation of proppant performance under reservoir conditions and exposure to fracturing fluids.

There is a need to examine proppant performance in the laboratory to ascertain the relative effects to conductivity of fluids in the reservoir. The choice between ceramic, sand, and blends of the two influences economic performance. Prices of ceramic proppant and fracture sand in 2009 ranged from $0.40 to $0.50/lb, and $0.08 to $0.10/lb, respectively (Roberts, 2009). Treatments in the Bakken Formation are using upward of 2 million lb of proppant (Sorensen and others, 2010) in 10,000-ft horizontal completions. Proppant quantity per well is expected to increase as some operators are having success with increasing the number of fracture stages from 10 to near 40 in a 10,000-ft lateral (Rankin and others, 2010). The cost differential between choosing ceramic over sand can be greater than $1 million a well. In addition, competition for proppant can limit the ability to obtain higher-performing ceramics. This has led to strategies in the Bakken Formation that include using large amounts of fracture sand followed by ceramic proppant (Continental Resources, 2009; Newfield Exploration, 2010), which enables operators to obtain the strength and longevity benefits of ceramics near the wellbore while supporting the majority of the fracture farthest away from the wellbore with low-cost proppant and, hopefully, limiting flow back while maintaining conductivity. **The proposed research is intended to reveal alternative strategies for proppant applications that can improve conductivity further into the reservoir than current practices**.