Modeling the Impact of Deep Structures on Liquid Production in the Bakken Oil Shale Play of the Williston Basin of Canada and the USA

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Abstract

The Mississippian - Devonian Bakken Formation of the Williston Basin overlies the Upper Devonian Three Forks Formation and underlies the Lower Mississippian Lodgepole Formation. It has been subdivided into three members: Lower, Middle and Upper Members. The Lower and Upper members are dark shale layers with a high organic content. The Middle member has a variable lithology and consists of interbedded siltstones and sandstones with lesser amounts of shale, dolostone, and limestone. Deep seated structural anomalies have played important roles in controlling the Bakken Oil Play in the Williston Basin, e.g. the Trans-Hudson Orogenic Belt.

A horizontal well in the Bakken Formation may develop highly variable liquid production which has various impacts on the economics of development. The reason for the variable results in this play is complex. High water cuts may be due to communication out of the zone into water laden formations such as the overlaying Lodgepole. Low oil productivity may be the result of sub-optimal completion in zones of natural fracturing.

In this talk we will examine the cause and effect of various styles of structures and their relationship to a variety of fracture patterns. It will be demonstrated that these fracture patterns can be modeled and predicted using a new statistical fracture modeling tool called 4DFrac*. This software provides fracture network characterization giving insight into fracture patterns as well as direct volumetric and directional outputs for reservoir simulation. The main approach for fracture modeling in 4DFrac is the generation and visualization of a Discrete Fracture Network (DFN) model on appropriate surface geometries (paleo-structural anomalies). This workflow driven approach allows rapid scenario testing and will be used to predict a variety of the fractures caused by deep seated structural anomalies. Finally, we will use local well control to identify the model that most closely simulates the observed fracture pattern.

Combining this modeling technique with field data allows us to predict, and therefore avoid, areas that have a propensity for faulting and fracturing in the shale. The results of

this study will allow a higher degree of success in drilling and completing horizontal wells in the Bakken formation of the Williston Basin.

* 4DFrac is part of the Move suite of structural modeling software written by Midland Valley Exploration, Glasgow, UK.

Biography

Ruikun Liu, B.Sc., M.Sc., Gran Tierra Energy Inc., Consultant, Calgary, Alberta
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Ruikun Liu is a geologist specializing in structural geology with approximately 5 years industry experience. He has a solid geological background and broad structural experience in both compressional and extensional deformation regimes. His experience in hydrocarbon exploration and development are mainly in the Andes Foothills of South America with Gran Tierra Energy, in the Canadian Rocky Mountains Foothills with BG Canada, in China (Ordos Basin) and in Yemen (Marib-Shabwah & Saywn-Masila Basin) with Sinopec China. In addition to his conventional geological expertise, Ruikun also has a strong background in geomechanics. He has been involved in several fracture studies in the fractured structural plays in the NEBC Foothills and in the Bakken oil play in SE Saskatchewan since 2009. Ruikun now resides in Calgary, Alberta, and is an expert in using balanced cross section drawing software and 4DFrac.

Ruikun graduated with a B.Sc. in geology from the Hefei University of Technology, Hefei, China in 2003. He obtained his M.Sc. in structural geology from the University of Western Ontario in Canada in 2009. Ruikun is a member of both AAPG and CSPG.

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Andrew Newson has 35 years of experience in the geological and geophysical evaluations of structurally controlled plays. He is a Professional Geological Consultant registered in the province of Alberta and is currently living in Calgary. Andrew graduated in 1972 with a B.Sc. (Hon) in geology from London University, England. Since then he has worked as a structural geologist specializing in the exploration and exploitation of hydrocarbon prospects around the world.

As a consultant for nearly 20 years, Andrew has been involved with numerous projects for clients among the major, independent and junior oil and gas companies. To facilitate this he incorporated Moose Oils Ltd. in 1993. Through Moose Oils Ltd he teaches in-house workshops on structural play evaluation techniques and regularly leads field trips for industry. He is closely involved in developing computer software to assist in the interpretation of structural plays.

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Terry has 35 years of industry experience where he has been honing his skills in petrophysics, geology, geophysics and prospect and play evaluation across a broad

geologic spectrum mainly concentrated in the Western Canadian and Williston Basins. He has a thorough understanding of logging tool theory, application and dynamics which he parlays into better evaluation of rock and fluid properties essential to maximizing well productivity. Of late he has been focusing on unconventional plays including fractured and resource types. Terry has a degree in engineering from the University of Alberta (1974) and is a member of APEGGA and CSPG.