ELASTIC AND MECHANICAL PROPERTIES OF THE NIOBRARA FORMATION WITH APPLICATION TO HYDRAULIC FRACTURE DESIGN

by

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ABSTRACT

The Niobrara Formation is a major resource play in the Rocky Mountain Region, USA. The Niobrara is a self-sourced petroleum system and its reservoir intervals constitute low permeability marly chalks. The formation requires horizontal drilling and multi-stage hydraulic fracture stimulation in order to improve the connection between wellbore and the hydrocarbon bearing formation. Major production activity in Colorado occurs in the Wattenberg field, Denver-Julesburg basin, where the Niobrara is located at an average depth of 2300 meters.

Laboratory measurements of tensile strength, lithological and elastic properties of several facies within the Niobrara Formation were performed. This information is essential for designing hydraulic fractures in this tight formation. Samples were obtained from the CEMEX's Lyons Cement plant in Boulder County, Colorado, from where three lithofacies were sampled: the Fort Hays Member, the D Chalk and the Lower Marl. Tensional strength measurements were performed using Brazilian tests. Triaxial tests, using varying axial, confining and pore pressures, were conducted to obtain both static and dynamic Young's modulus and Poisson's ratio values under different pressure conditions. Correlations between static and dynamic properties are used to extract static elastic properties from well logs. Also, ultrasonic velocity measurements permit determination of effective stress coefficient from the measured samples.

Hydraulic fracture models are built for well State 2-13, Weld County, Colorado, using laboratory and well log data as input, with the purpose of evaluating the possibility of height containment between anisotropic marls for a fracture performed in one of the chalk facies. The value of the minimum in-situ horizontal stress is evaluated for two cases: one, when anisotropy is considered in the marl intervals and two, when the effective stress coefficient is different than 1. From these assumptions, four different cases are considered for the hydraulic fracture model of the Niobrara. Influence of natural fractures in the B Chalk is also considered, by decreasing the fluid efficiency in the model. Results show that, for the employed treatment, elastic properties differences and stress contrast between chalks and marls is not sufficient for fracture containment. Hydraulic fractures initiated in the B Chalk will penetrate into the A and C Chalks, however, the numerous thin layers of shales, volcanic ashes and intrinsic lamination of marls, must affect the final geometry of the fracture. Shear slippage and decoupling will translate to loss of fluid pressure that will reduce the height of the modeled fracture.