Quantitative Mineralogy and Microfractures in the Middle Bakken Formation, Williston Basin, North Dakota

Sonnenberg, Stephen [1]; Appleby, Sarah K.[2]; Sarg, J. F. 'Rick' [1] (1) Department of Geology, Colorado School of Mines, Golden, CO. (2) Advanced Mineralogy Research Center, Colorado School of Mines, Golden, CO.

Fractures are considered to play a key role in controlling Bakken petroleum production in the North Dakota part of the Williston Basin. Generally, wells are oriented to intersect the maximum number of fracture swarms, and fracture stimulation is employed resulting in initial producing rates of several hundred to over one thousand barrels per day in some fields.

This study utilizes a new approach to assess the impact of microfractures on fluid flow by integrating mineralogy and fracture analysis using SEM-based quantitative mineralogy on several drill core samples from North Dakota. Due to the high spatial resolution of the analysis (~2 µm) even very small fractures can be detected using this technique. In addition to fracture abundance quantification, fracture size, orientation and mineral associations can also be investigated.

Quantitative mineralogy shows that samples of the Middle Bakken Formation consist of silt-to sand-sized grains of quartz, feldspar (plagioclase and K-feldspar), dolomite and limestone with minor amounts of clays indicative of a marine depositional environment with water depths ranging from shallow (within wave base and tidal influence) to deep neritic. Texturally the samples may be massive, display cross stratified or subparallel bedding and laminated zones.

Preliminary results of quantitative mineralogy microfracture analysis show that microfractures generally are oriented parallel to bedding (i.e., horizontal microfractures), hence along natural planes of weakness. Fracture widths range from 2 µm to 25 µm, and fracture lengths from 6 µm to several 10s of microns. In the studied samples the vast majority (~95%) of horizontal fractures appear to occur within clay-rich horizons. Some areas in the Williston Basin, such as the Parshall Field, are known to contain additional fracture swarms that are oriented in a northeastern direction perpendicular to bedding resulting in a well fractured petroleum system. However, at least on a microfracture-scale, similar vertical fractures were not identified in the samples presented here.

This study demonstrates that the analysis of microfractures by quantitative mineralogy, in particular in conjunction with other macro- and mesofracture analyses, has the potential to be a powerful tool in well design and may provide new insights into fracturing behavior and fluid flow in petroleum reservoirs.