A QUICK COMPARISON BETWEEN MODERN OIL GENERATION RATES AND KNOWN OIL PRODUCTION IN THE BAKKEN FORMATION OF NORTH DAKOTA

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During the past year production from the Bakken Source System topped one million barrels of oil per day. This remarkable achievement is the result of decades of research and development that involved defining the geologic boundary conditions that enabled the successful application of emerging technologies to the problem of establishing commercial recovery of oil from previously unproductive reservoirs in the Bakken Source System.

Meissner (1978) is credited with applying, what at the time was, a revolutionary idea that petroleum could accumulate within and adjacent to actively generating source beds. This model required the presence of a petroleum-generating source bed encased within porous but almost impermeable rock. Under these conditions, Meissner argued, oil generation increases source bed fluid volume and when generation occurs within almost impermeable confining layers, fluid pressures increase to the point of overcoming capillary pressures in the confining layers. As a consequence, source bed fluids, including petroleum, would be injected into and because of poor permeability, accumulate within the pore space of these confining rocks. Meissner was able to demonstrate that the source beds within the Bakken Formation contained petroleum over a large part of the Williston Basin and therefore had been capable, at some time, of generating oil. He also was able to demonstrate through mapping fluid pressure data in the Bakken Formation the possibility that oil generation was accompanied by elevated formation fluid pressures.

The North Dakota Geological Survey recently completed a preliminary evaluation of the current oil generation rate within the source beds of the Bakken Formation. This involved experimentally determining the kinetic properties of Bakken source beds in 29 wells. The kinetic parameters together with current bottom hole temperatures (BHT) provide a way to estimate the current oil generation rate within the Bakken across the basin. The procedure used to determine the kinetic properties (activation energy and frequency factor) is described elsewhere (Nordeng, 2013, 2014). The wells sampled are more or less evenly distributed across the basin so that it is possible to broadly map the “reactivity” of source beds within the Bakken Formation. Even though the measured activation energies are highly correlated with Tmax and therefore appear well suited to defining organic maturity within the Bakken, it is the use of these kinetic parameters along with formation temperatures that makes these data particularly interesting. The solid contour lines in figure 1 represent current reaction rates (moles/m.y.) where the Bakken shale members are currently generating oil and gas, as predicted by the Arrhenius equation using the measured kinetic properties and current Bakken Formation temperature. To get a sense as to how the reactivity of the Bakken corresponds to production, an overlay using color-filled contours to represent normalized Bakken production that is above the 40th percentile (Nordeng and LeFever, 2014) shows that a significant part of the best Bakken production coincides with elevated source bed reaction rates. Figure 1 only captures the reaction rate for each unit mass of kerogen present. In order to obtain a more complete picture of oil generation the total mass of “crackable” kerogen must also be included. The relationships between modern kerogen reaction rates and production is an interesting confirmation of Meissner’s basic concepts that may lead to a more complete understanding of the natural processes responsible for the accumulation of significant volumes of oil in the Bakken Source System.

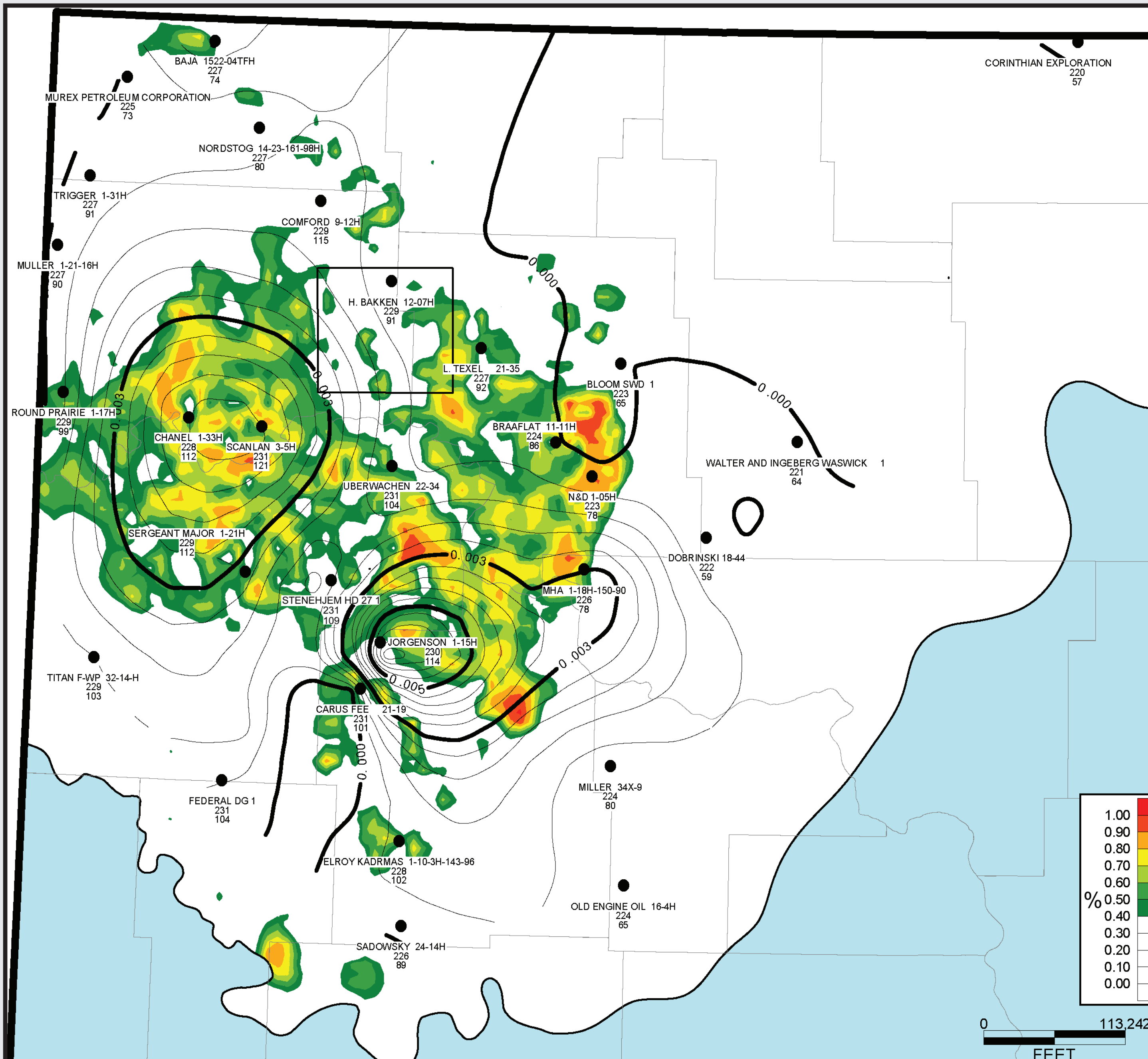

Figure 1. Map showing the extent of the lower Bakken shale with the sampled wells posted. The posted data include, in descending order, the well name, corrected activation energy, and the temperature (°C) of the Bakken Formation at the depth of the sample. The temperature is estimated from measured bottom hole temperatures reported on well log headers. Estimates from the Arrhenius equation are shown as solid contours (moles/m.y.). Initial well performance, in terms of percentile, at the 60 day mark is shown as color-filled contours (see color bar).

References

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