Organic Geochemical Patterns in the Bakken Source System

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Figure 1. North Dakota with the study area indicated by the light blue shaded block. The gray shaded portion of the map represents the areas in which the Bakken Formation is absent. The contour lines represent the structure of the Bakken Formation at latest sea level. Where the Bakken is absent the contour lines are drawn in the area of the Three Forks Formation, or the top of the Williston Basin where the Three Forks Formation is absent.

Figure 2. The color filled contours on this map represent the distribution of total organic carbon (TOC) in the Bakken Source System. The heavy contour shows the distribution of total organic carbon (TOC) that are greater than 0.5%.

Figure 3. The distribution of residual determined T_max (°C). The region enclosed by the heavy contours represent the portion of the Williston Basin in which the source rocks in the Bakken System are thermally mature (T_max ≥ 435°C). Thermal maturity in the Bakken Source System does not seem to be well represented by the subsurface, that has neither the structure of the Bakken Formation. The region for T_max to be due to certain conditions that result in the thrust fault interaction, which is consistent with the idea that the Bakken is a rapidly changing region. The rapid change in T_max is a result of the maturation process, and the cause for their presence is not currently known. However, the coincidence of the region with the field is related to the area between the two factors, the Production Facies Belt and the Jurassic Province may reflect variations in the search for oil.

Figure 4. A Hydrogen Index (HI) map (color filled contours) showing the petroleum generation potential of source rocks in the Bakken Source System. The Hydrogen Index (HI) reflects the amount of carbon in the source rock that is capable of being thermally converted into hydrocarbons. With advancing maturation, thermal cracking of organic matter produces oil and gas which reduces the HI and possibly increases the HI of the kerogen. Oil generates preferentially from kerogen that is capable of being thermally converted into hydrocarbons. With advancing maturation, thermal cracking of organic matter produces oil and gas which reduces the HI and possibly increases the HI of the kerogen. During the intense maturation phase (T_max ~435°C) oil generation begins to reduce the HI whereas the portion of the kerogen that contributes to the HI of some floor below of the shallower stop. The net result is a relative increase in the HI of oil, whereas kerogen where oil generation peripherally decreases the HI.

Figure 5. The slope of the Hydrogen Index surface is presented here as color filled contours with the heavy contour representing the portion of the basin that is deemed mature by T_max > 435°C. Areas in which there is a rapid lateral change in HI correspond well with the edge of the mature zone as defined by T_max. This pattern is consistent with the contour of rapidly maturing oil and gas generation that reduces the HI across the point T_max.

Figure 6. An Oxygen Index (OI) map (color filled contours) of the Bakken Source System with the heavy contours representing T_max values that outline the mature portions of the basin. The Oxygen Index (OI) is related to the amount of organically bound oxygen and inert carbon that is present within a source rock. Typically, high Oxygen Indexes are associated with younger kerogen derived from older, oxidized carbon. The OI contours trend remarkably well with the HI contours and are consistent with variations in Bakken source rock maturity.

Figure 7. The illustration combines a simplified version of the Hydrogen Index Slope map with a bubble map representing the total oil production from the Bakken Formation. The best wells found so far are associated with the HI and T_max contours. This suggests that rapid lateral change in HI where the portion of the kerogen that contributes to the HI of some floor below of the shallower stop. The net result is a relative increase in the HI of oil, whereas kerogen where oil generation peripherally decreases the HI.

Figure 8. A schematic diagram that illustrates the stage reaction zones in the Bakken Source System. These are evident in the various RockEval maps presented.

Figure 9. The average daily oil production from the Bakken or "Sanish" pools (shown as red dots) are plotted on the right side of the T_max map. The best oil production from the Bakken is found in the basin core and updip portions of the Bakken. The HI map is presented on the left side of the T_max map, showing the HI distribution and the oil production in the Bakken. This map is a result of the maturation process, and the cause for their presence is not currently known. However, the coincidence of the region with the field is related to the area between the two factors, the Production Facies Belt and the Jurassic Province may reflect variations in the search for oil.

Figure 10. The average daily oil production from the Bakken or "Sanish" pools (shown as red dots) are plotted on the right side of the T_max map. The best oil production from the Bakken is found in the basin core and updip portions of the Bakken. The HI map is presented on the left side of the T_max map, showing the HI distribution and the oil production in the Bakken. This map is a result of the maturation process, and the cause for their presence is not currently known. However, the coincidence of the region with the field is related to the area between the two factors, the Production Facies Belt and the Jurassic Province may reflect variations in the search for oil.

Figure 11. The average daily oil production from the Bakken or "Sanish" pools (shown as red dots) are plotted on the right side of the T_max map. The best oil production from the Bakken is found in the basin core and updip portions of the Bakken. The HI map is presented on the left side of the T_max map, showing the HI distribution and the oil production in the Bakken. This map is a result of the maturation process, and the cause for their presence is not currently known. However, the coincidence of the region with the field is related to the area between the two factors, the Production Facies Belt and the Jurassic Province may reflect variations in the search for oil.