Geologic Investigations No. 93, Sheet 1
Edward C. Murphy, State Geologist
February 2010

Structural Transect of the Sanish and Parshall Fields, Bakken Formation, Mountrail County, North Dakota

Stephan H. Nordeng, Julie A. LeFever, Fred J. Anderson and Eric H. Johnson

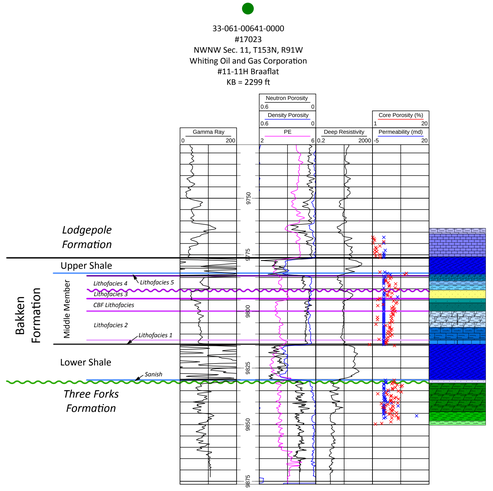

Figure 1. Reference section (LeFever, 2007) and wireline logs from the Braaflat #11-11H drilled in NWNW Sec. 11, T153N, R91W. The wireline display includes gamma ray, neutron porosity, density porosity, photo-electric and deep induction logs. Core porosities and air permeabilities are plotted alongside the wireline logs as discrete points.

Discussion

One of the prevailing themes that has emerged over the course of more than 50 years of Bakken exploration is the central role that natural fractures play in enhancing oil production. Murray (1968) recognized that production from the Bakken source system depends on processes that induce fracturing in the Bakken and Three Forks Formations. Murray noted that in the Antelope Field, enhanced production is associated with the most intensely "bent" parts of the Antelope Anticline along the northeastern limb of the structure. He was able to show a relationship between higher rates of production and the degree of structural flexing indicated by a second derivative map of the structure drawn on the top of the Three Forks Formation. In this model the degree of enhanced permeability depends upon the density of tension fractures that are caused by structural flexure.

A second derivative map of the Williston Basin in Mountrail County, North Dakota is presented in Fig. 4. Areas with structural configurations similar to the Antelope Field are outlined by negative values (shades of blue and purple). These areas correspond to upwardly convex structural features. The most obvious of these features is the crest of the Nesson and Antelope Anticlines. However, a number of other areas, including the Parshall Field, contain similar though much less intense structural flexures that could still enhance fracturing of susceptible rocks within the middle member of the Bakken, Three Forks and possibly Lodgepole Formations. The monoclinal flexure found in the Parshall Field is evident on the cross-section A-A' when an extreme vertical exaggeration is used to illustrate the structure. This same structure is present on the highly exaggerated 2-D seismic line shown in Fig. 6. The seismic line suggests that the monoclinal structure in the vicinity of the Parshall Field is downwardly continuous with the apparent displacement increasing with depth. This may be a reflection of some minor basement faulting that has been episodically active since at least the Cambrian.

References

Murray, G.H., Jr., 1968, Quantitative fracture study, Sanish pool, McKenzie County, North Dakota: American Association of Petroleum Geologists Bulletin, vol. 52, p. 57-65.

LeFever, J. A., 2007, Bakken Formation middle member lithofacies, North Dakota Geological Survey, Geological Investigation 45, 5 Plates.

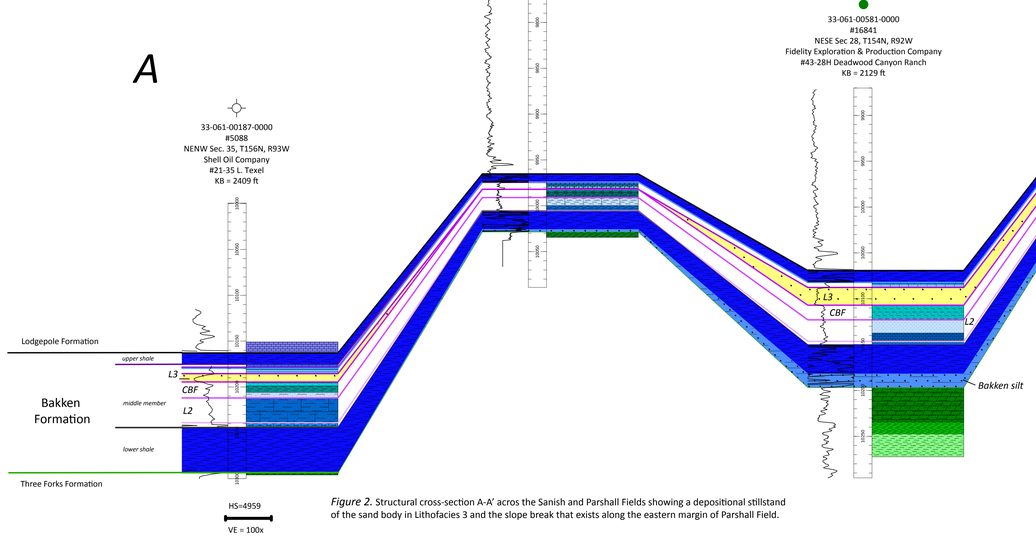

Figure 2. Structural cross-section A-A' acros the Sanish and Parshall Fields showing a depositional stillstand of the sand body in Lithofacies 3 and the slope break that exists along the eastern margin of Parshall Field.

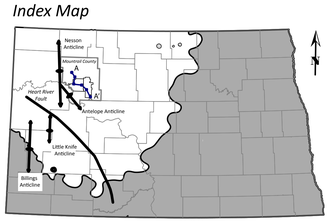

Figure 3. Location map showing the location of the wells along the cross-section A-A'. The map also shows main structure features in North Dakota and the un-shaded portion of the map shows the subsurface distribution of the Bakken Formation.

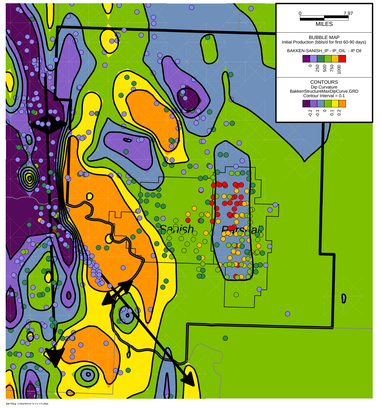

Figure 4. A dip curvature (2nd derivative) map constructed from the structure drawn on the top of the Bakken Formation. The contours of this map show the sense and degree of flexure that is present in the structure of the Bakken Formation in Mountrail County, ND. The map includes the approximate axis of the north-south trending Nesson Anticline and the southeastwardly plunging Antelope Anticline. The circles show the location of wells producing from the Bakken/Sanish pools with the fill color of the circle representing the average daily production (bbls/day) for the first 60 to 90 days of pumping.

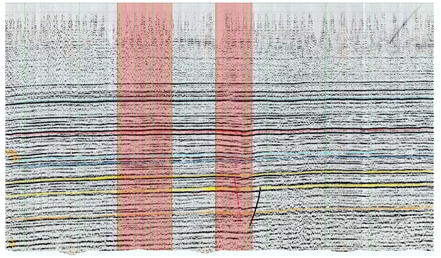

Figure 5. The East-West seismic line used to construct the interpreted seismic section in Figure 6. This line runs from east to west and lies south of the Parshall Field along the strike of the Bakken structure.

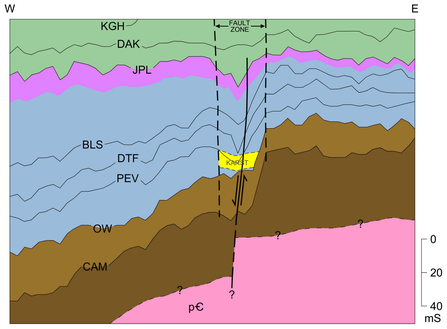

Figure 6. Interpreted seismic section showing the two way travel times for 7 reflectors in Mountrail County. The times are "hung" on the Greenhorn (KGH) reflector and show a prominent change in reflector dip when the vertical scale is exaggerated approximately 40 times. The tops portrayed include reflectors on the Dakota Formation (DAK), Piper Limestone (JPL), Base of the Last Salt (BLS), Three Forks (DTF), Prairie Evaporite (PEV), Winnipeg (OW) and the "Cambrian" (CAM). The maximum 2 way travel time displacement across the fault is on the order of 20 msec. which for a limestone (P-velocity ~ 6,000 ft/sec) translates to a physical displacement of about 60 ft. The structure on the Precambrian (pЄ) is inferred from the displacements apparent in the overlying section.