Devonian Petroleum Systems and Exploration Potential, Southern Alberta, Part 3 Core Conference

Andy Mort (1), Leonard Stevens (2), Richard Wierzbicki (2)

Abstract

<u>Part 1: Devonian Petroleum Systems Dr. Andy Mort (Presentation 1)</u>

The Devonian in Southern Alberta has many porous and permeable reservoirs but few major hydrocarbon traps and limited exploration drilling. Part of the concern with this stacked carbonate dominated system is questions about source rock presence, quality, maturity, migration and charge.

Previous work has shown there is proven source rock and hydrocarbon being generated in the Winnipegosis, Nisku, and Exshaw/Lower Banff in Southern Alberta. There is associated hydrocarbon production in the Lower Banff to Big Valley (Alberta Bakken), in the Nisku, and in the Winnipegosis. There are oil shows and oil stain in the Leduc and in the Beaverhill Lake equivalents and minor production from a DST in the Cooking Lake.

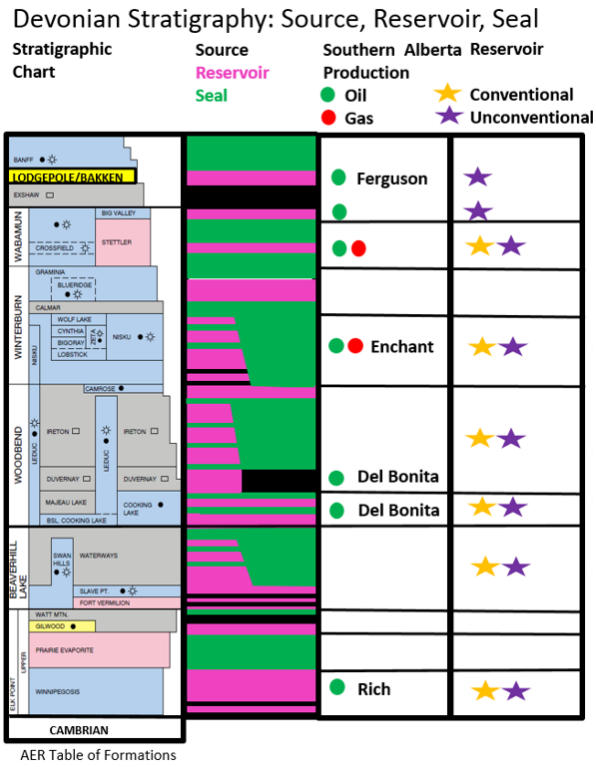

Figure 1: Summary Chart: Source, Reservoir, Seal Intervals, Southern Alberta

In the last few years Andy Mort of the GSC has been doing source rock evaluation of selected samples from core in the Beaverhill Lake and Winnipegosis in the study area. These samples show the presence of oil prone source rocks within these intervals. The oils evaluated in the Nisku, Leduc, Beaverhill Lake and Winnipegosis all indicate an evaporite related source.

This paper is a synthesis of existing data and the new information and an evaluation of the remaining exploration potential of known reservoirs in the Devonian of Southern Alberta in light of the current understanding of the petroleum system.

Part 2: Reservoirs and Traps Len Stevens, Rick Wierzbicki (Presentation 2)

Existing and potential reservoirs in the Devonian of Southern Alberta will be reviewed in relation to the identified source rock intervals. In addition concise reviews will be done of known pools: reservoir, trap type, seal, hydrocarbon type, and reserves.

Starting at the base of the section the Winnipegosis will be the first formation reviewed. Oil is being produced from a dolomite in the Winnipegosis in the Rich area immediately to the south of the Big Valley Stettler Leduc platform. In this area the Winnipegosis depositional environment was in the evaporitic interior of a carbonate platform. The dolomite is overlain by the salt of the Prairie Evaporite. The trap has been reported as a local structural closure, perhaps over a Cambrian high. The oil trapped in the reservoir is slightly heavy at 25 API, the geochemical analysis indicates an evaporitic algal source, which should be common in a platform interior.

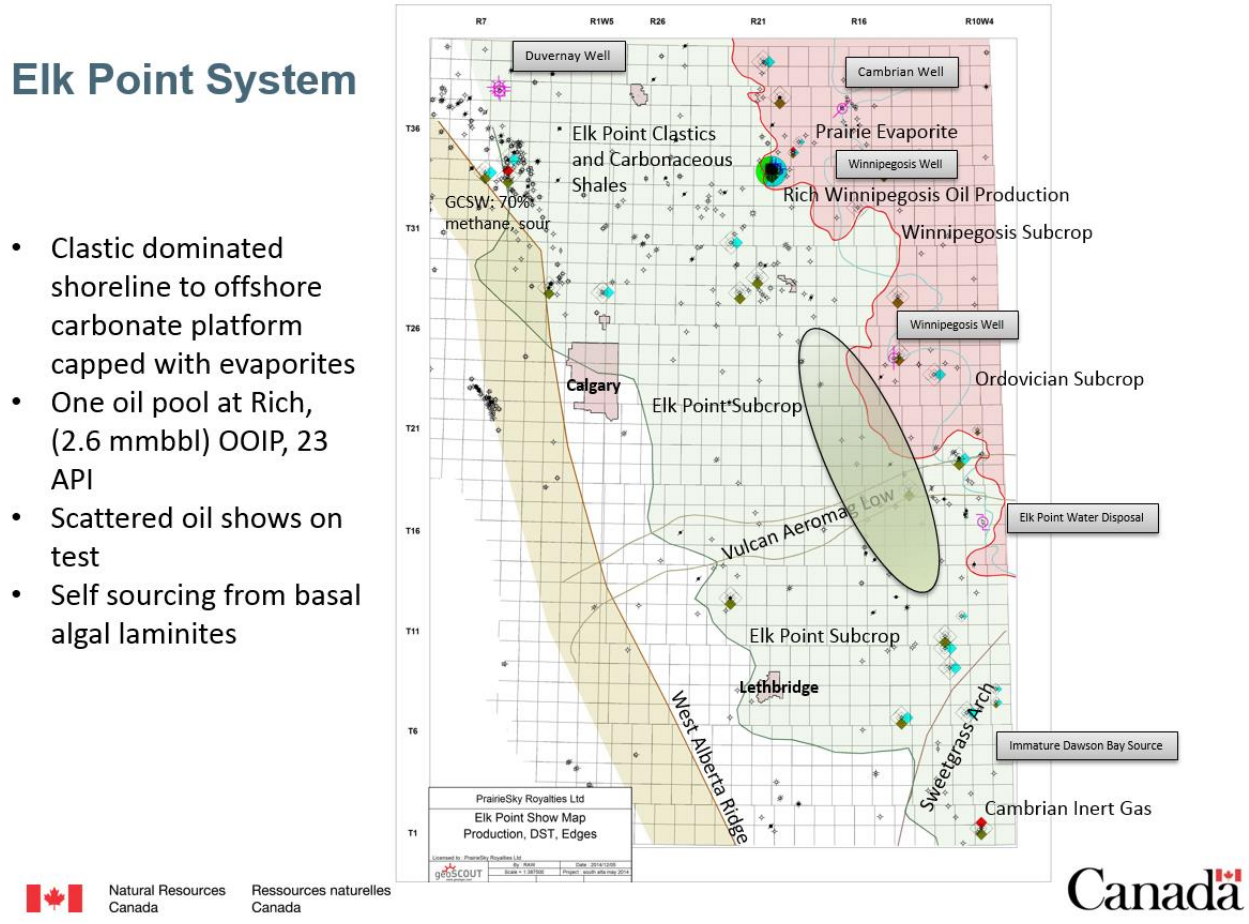

Figure 3: Elk Point System

The Beaverhill Lake group in Southeastern Alberta was deposited as a series of prograding to the NW carbonate ramps (Souris River Platform). The ramp complex is time equivalent to the aggrading and backstopping Swanhills platform which developed on the West Alberta Ridge to the north and west. At the base of the system the Slave Point equivalent had a salt basin deposited surrounded by evaporitic platform interior sediments. Oil stain and show was observed in samples collected from core in this area, the geochemical data again indicates an evaporitic source. There is no production from the Beaverhill Lake despite dolomitized reservoirs being present and indications of internal source rock.

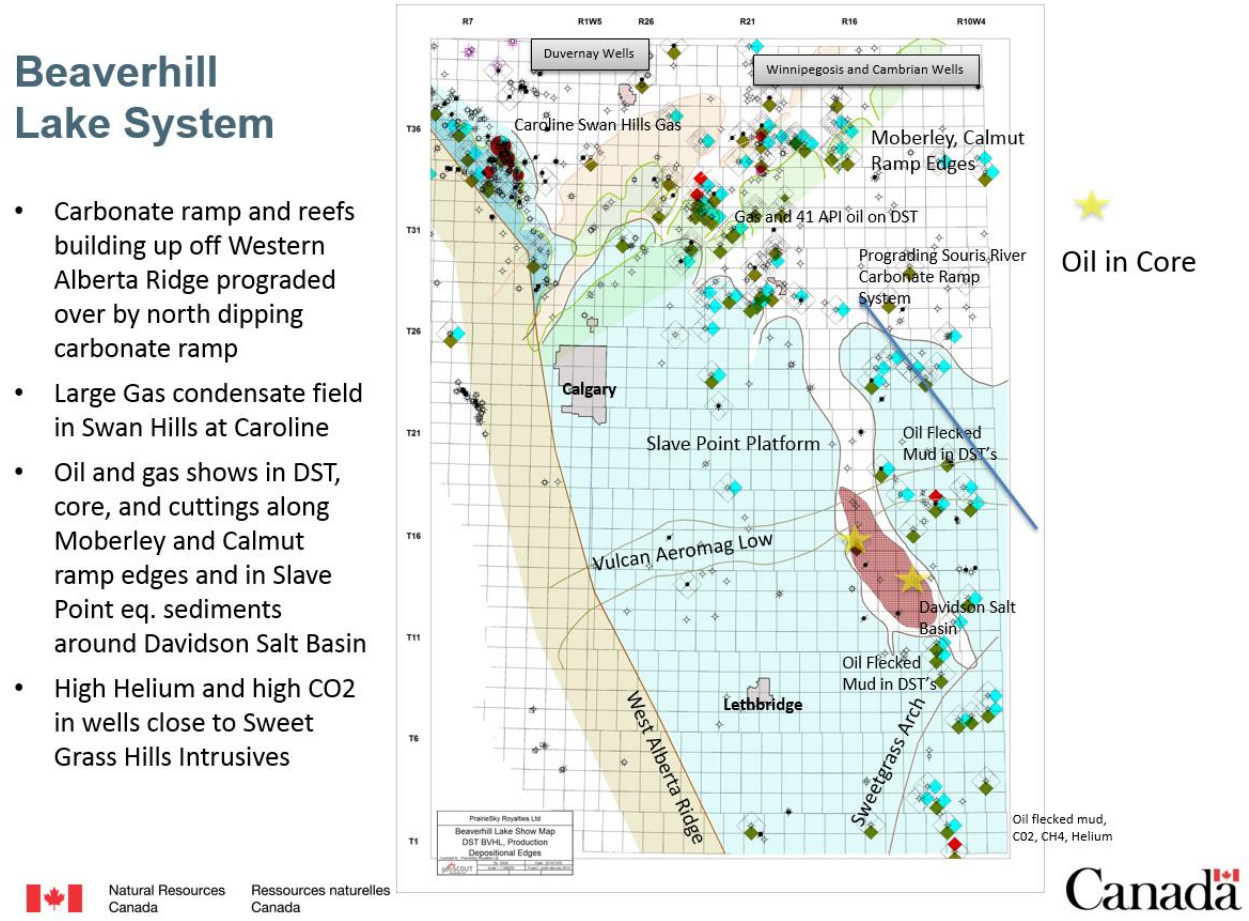

Figure 4: Beaverhill Lake System

The Leduc formation was deposited as a carbonate platform with margins to the north and west. The margins have well developed dolomite porosity in vuggy stromatoporoid rudstones and in skeletal grainstones. The interior of the platform consists of peritidal carbonates and evaporates. Vertical seals are present but lateral seal would have to due to structural events or porosity pinch out. The well 16-35-001-22W4 tested oil out of the Cooking Lake on a structural high adjacent to a fault and produced 4262 barrels of 39.6 API oil. An oil sample was obtained from the drill stem test and evaluated and appears to correlate with the Montana Nisku oil family. This raises some interesting questions about migration pathways from stratigraphically shallower source rock to deeper reservoir or perhaps a deeper source for a shallower reservoir.

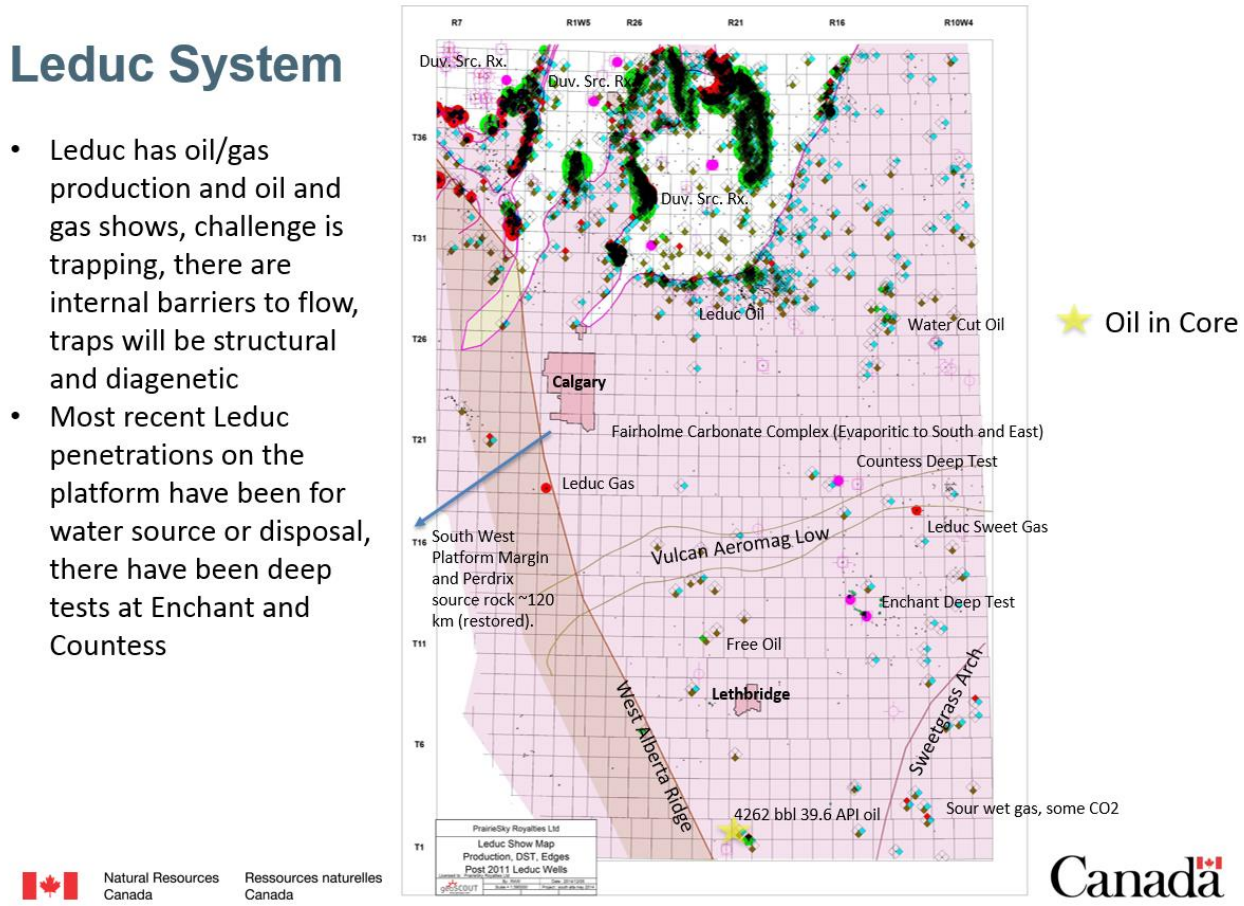

Figure 5: Leduc System

The Nisku is the proven productive formation in Southern Alberta. An early Nisku prograding carbonate platform is present in the South with a biostromal barrier and a platform interior evaporitic basin. These evaporitic dolomites have variable thickness due to syndepositional salt dissolution which results in structural closures which are charged with light oil. In the EnChant area over forty million barrels have been produced from Nisku/Arcs dolomites. Geochemical data indicates the Nisku in the area is most likely charged from self sourcing evaporate related algal laminates. Further to the west the Nisku/Arcs has produced light oil in single well pools, notably at 6-17-009-24W4, where 60,000 barrels of light oil (38.2 API) were produced from low permeability dolomites.

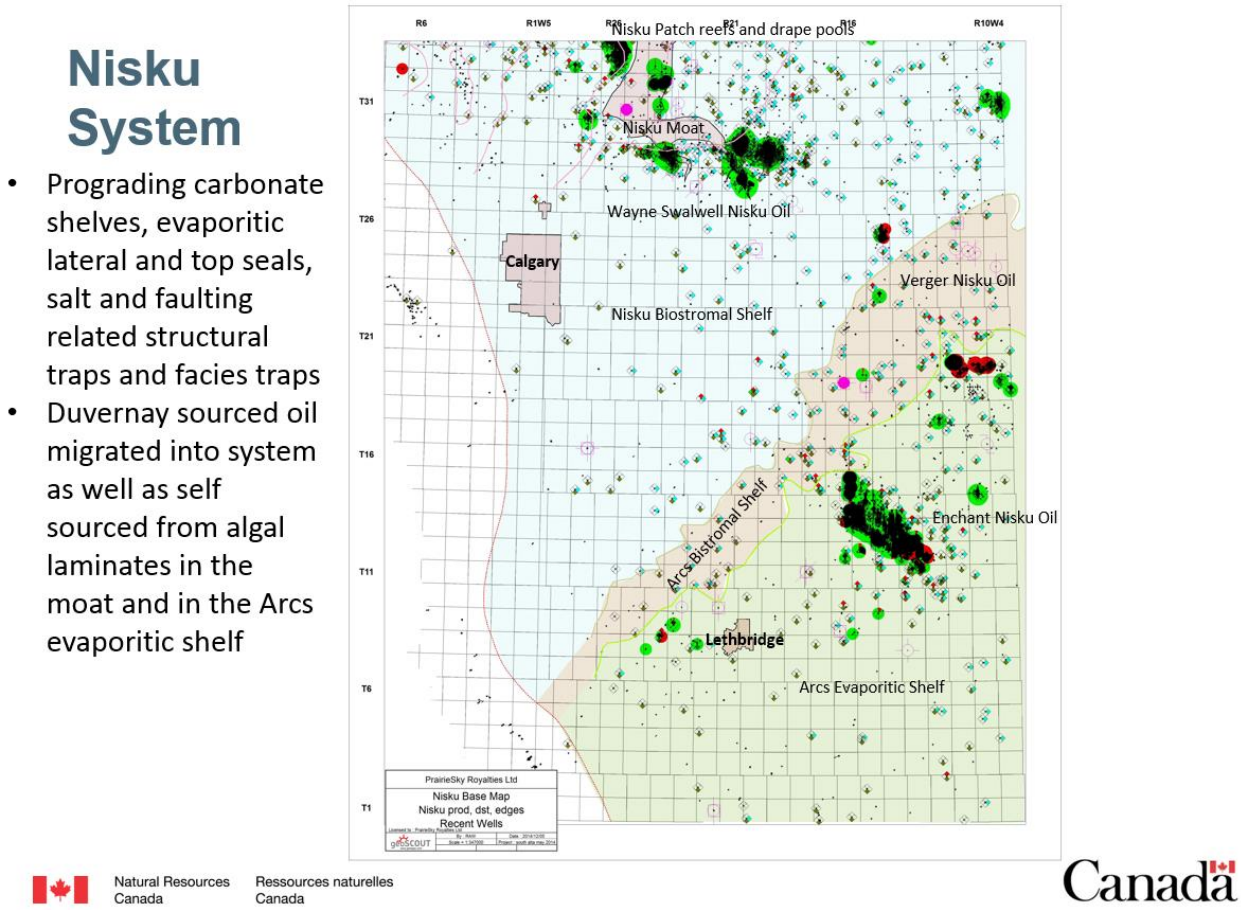

Figure 6: Nisku System

The Wabamun Stettler member in the area is tight evaporates and dolomites deposited in a platform interior evaporate basin and is non-reservoir. The overlying Upper Wabamun Big Valley member is a marly limestone but does become dolomitized in areas and is producing gas and oil from horizontal wells. The likely source is the overlying Exshaw formation source rock. This reservoir is part of the halo reservoirs around the Exshaw source rock, the Alberta Bakken, made up of Big Valley dolomites, Bakken dolomitic siltstones, and the most productive member, the Lodgepole lower Banff sandstone to siltstone.

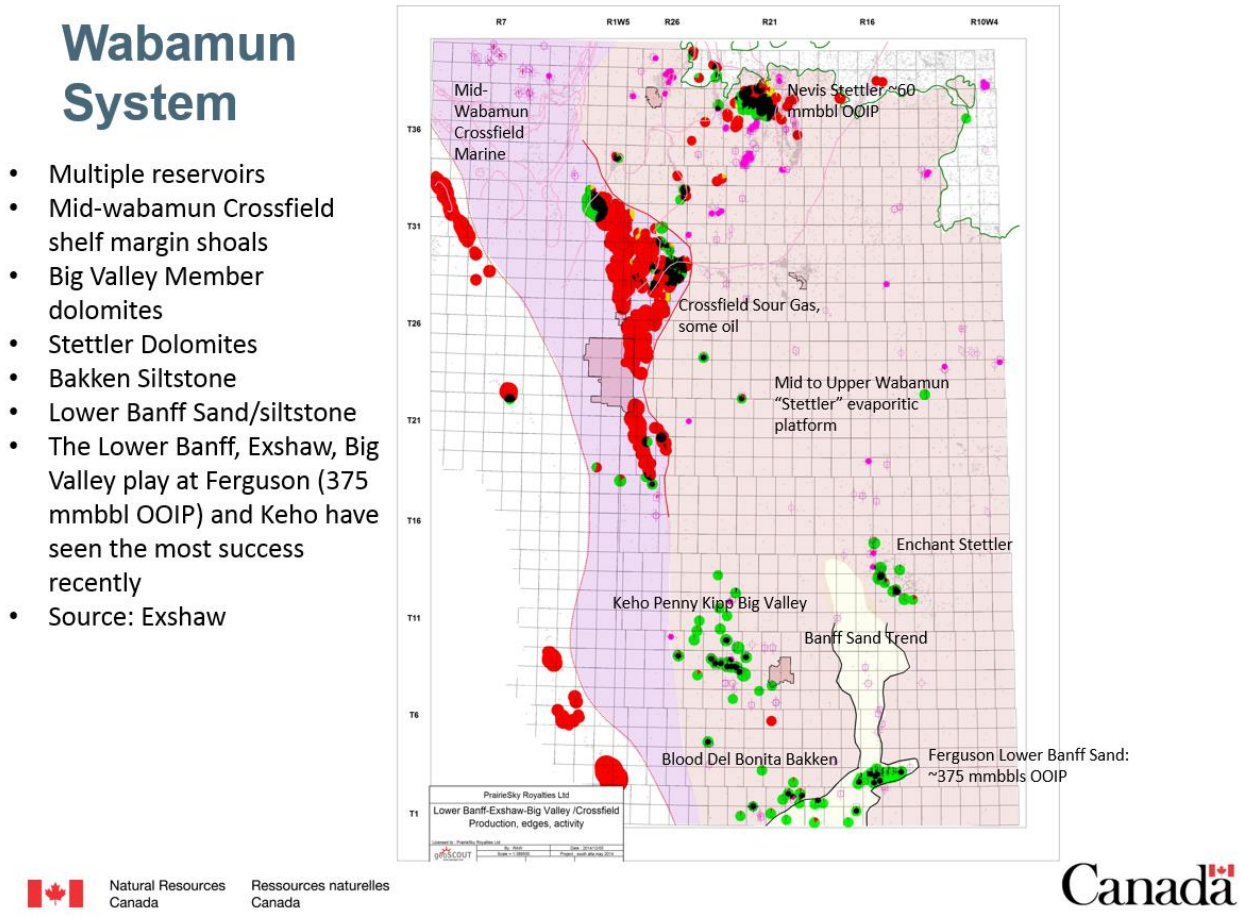

Figure 7: Wabamun System

The structural history of Southern Alberta has been complex and has resulted in the development of a horst and graben system. The presence of the Sweet Grass arch results in the regional dip changing from down to the west southwest to being down to the northwest. As a result many of the faults blocks remain open to the south but four way closures have been identified that have not been tested. Conventional traps could also occur due to porosity pinch out within the carbonate platforms.

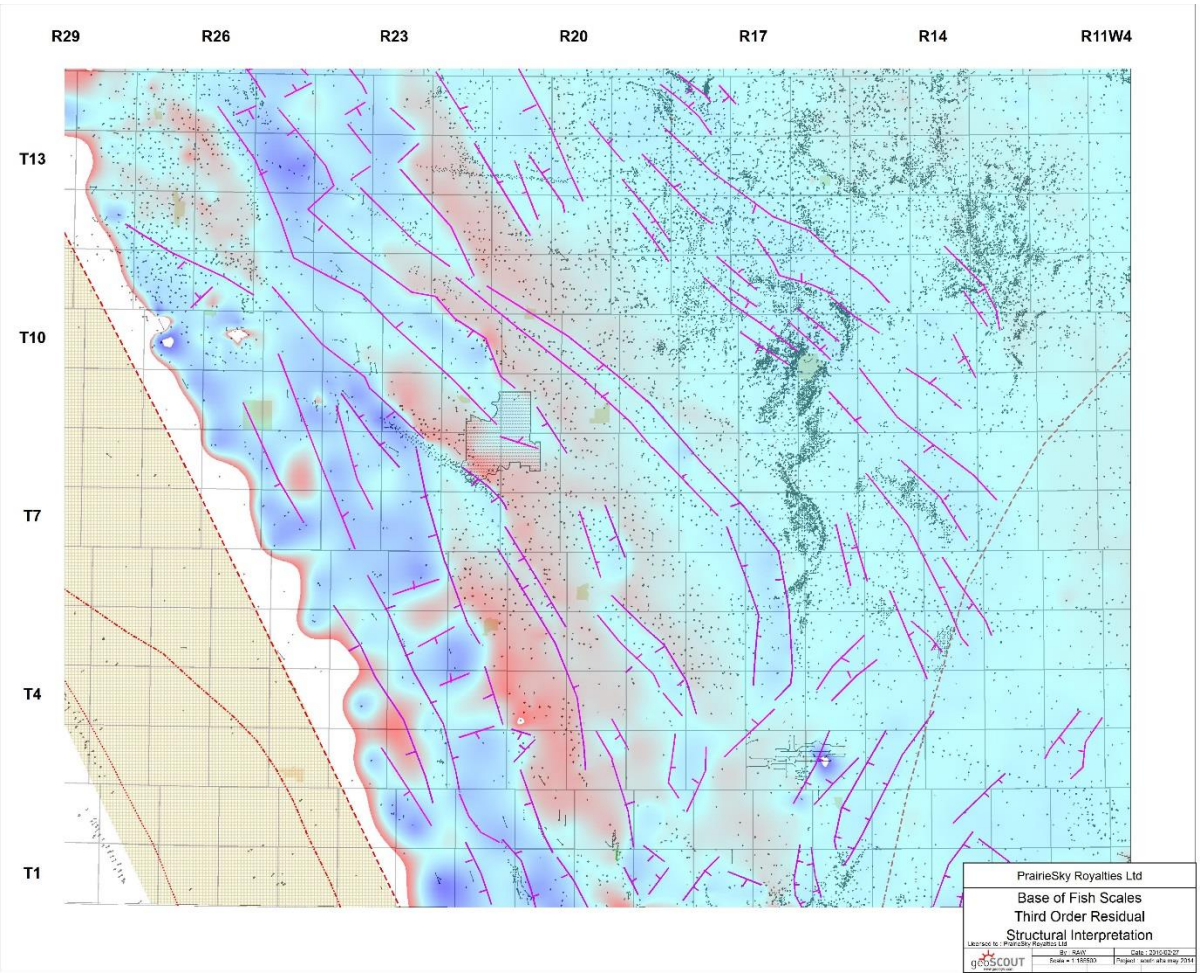

Figure 8: Inferred structure from third order residual on BFS surface.

In addition there is potential for unconventional regional hydrocarbon traps developed in porous but low permeability dolomites within the evaporitic interiors of the carbonate platforms. The dolomites could be charged from inter-bedded evaporitic algal laminates. These reservoirs would have to be developed using horizontal drilling and completion techniques.

Part 3: Devonian Petroleum System Core Presentation. Andy Mort, Len Stevens, Rick Wierzbicki (Core Conference)

Examples of source rock and reservoir from the Devonian of Southern Alberta will be presented and discussed in the context of exploration potential.

Core from the Winnipegosis from the reservoir at Rich and from the source rock will be displayed. The reservoir consists of fine grained dolomite while the source rock intervals appear to be algal laminates.

11-35-38-10W4 Winnipegosis Source Rock, Drees 1995,

6-25-34-21W4, Winnipegosis Reservoir

Core from the Lower Beaverhill Lake zone which was tested for source rock potential will be shown.

11-18-16-16W4, Beaverhill Lake oil stained core

Core from Leduc and Cooking Lake intervals that had oil saturations in core will be shown.

5-16-002-22W4, Cooking Lake Porosity

Core from the Nisku reservoir in the Enchant area and from source intervals will be shown.

8-3-15-16W4, Nisku Enchant Source Rock

Core from the Big Valley which forms the reservoir in the Keho area will also be shown.

15-27-009-20W4 Bakken Interval and Big Valley

12-01-009-20W4 Big Valley Porosity

1: GSC

2: Prairie Sky Royalty Limited

References:

1) Devonian Hydrocarbon Source Rocks and Their Derived Oils in the Western Canada Sedimentary Basin; Martin G. Fowler, Lavern D. Stasiuk, Mark Hearn, Mark Obermajer; Bull. Of Cdn Pet. Geology, 2001
2) Petroleum Geology of the Middle Devonian carbonates and evaporates in east-central Alberta; Meijer Drees N.C., Palmer B.C., Fowler M.G., Stasiuk L.D., Nowland G.S., and McGregor D.C.; GSC Open File 3058.

Acknowledgements:

Thank you to EnCana for having the GSC geochemistry work undertaken and thank you to PrairieSky Royalty Limited and the GSC. for permission to present this information