Saskatchewan Ministry of Energy and Resources

# PROSPECT SASKATCHEWAN

## Red River

### Drilling Deeper for Additional Resources

## INTRODUCTION

As of January 1, 2012, Red River reservoirs have yielded 4.1 million $m^3$ (25.8 million bbls) of oil from 201 wells. The average single well production is 20 000 $m^3$ (125,800 bbls). The most prolific well, 191/11-26-003-21W2, a dual-legged horizontal well drilled in the Minton area in 2003, has produced 421 359 $m^3$ (2.65 million bbls) of oil in 3,162 days. These Upper Ordovician rocks, however, remain under-explored with only 631 wells penetrating the Red River in the study area (Tp.1 to 20; Rge. 1 to 30W2) in southeastern Saskatchewan.

## STRATIGRAPHY

The stratigraphic nomenclature for Red River strata in southeastern Saskatchewan (Figure 1) reflects an interpretation that three brining-upward cycles are present (Kendall, 1976). The Yeoman Formation and the Lake Alma Member of the Herald Formation represent the lowest cycle, the Coronach Member (Herald) includes rocks of the second cycle and the Redvers Unit (Herald) represents the third cycle, which is incomplete in Saskatchewan. Various interpretations of a more complex depositional history of these rocks are evolving based on core and geophysical well log data from more than 500 wells drilled into the Red River since 1976 (*e.g.*, Kreis and Kent, 2000; Pratt and Haidl, 2008).

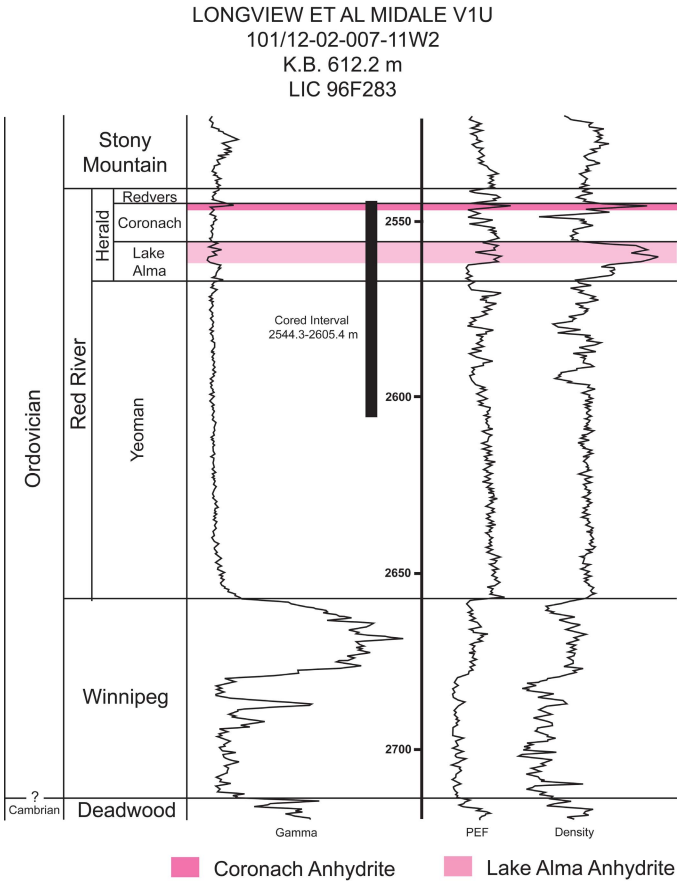



**Figure 1 – Reference well illustrating stratigraphic nomenclature of Red River and adjacent strata in southeastern Saskatchewan.**

## SOURCE ROCKS, HYDROCARBON GENERATION, AND MIGRATION

Kukersites, composed primarily of the microfossil *Gloeocapsomorpha prisca*, are the source of Red River oil in southeastern Saskatchewan (*e.g.*, Osadetz and Snowdon, 1995). These are present in the upper part of the Yeoman Formation from Township 23 in Saskatchewan south through Montana and North Dakota and into South Dakota. In Saskatchewan, mature to marginally mature source rocks are limited to near the International Boundary and to local areas of higher heat flow associated with the North American Central Plains Conductivity Anomaly (*e.g.*, 131/16-20-008-10W2; Osadetz and Snowdon, 1995). Thus most oil found in Saskatchewan migrated from the United States portion of the Williston Basin where source rocks are at greater depths. These source rocks are believed to have reached thermal maturity in the Late Paleozoic and therefore it is likely that oil migrated into structural and stratigraphic traps that existed between that time and a second generation event in the Late Cretaceous and Paleocene (Osadetz *et al.*, 2006).

## RESERVOIR DEVELOPMENT AND TRAPPING MECHANISMS

Red River oil is produced from dolomitized strata in the Yeoman Formation and the Lake Alma Member of the Herald Formation. The Yeoman is composed predominantly of burrow-mottled fossiliferous lime mudstones and wackestones (Figure 2a). A variety of facies have been identified between these burrow-mottled strata and the Lake Alma laminated to thinly bedded, commonly argillaceous, dolomudstones that underlie the Lake Alma anhydrite (Figure 2b). Examples of these "transitional" facies include oolitic grainstones, bioclastic grainstones/packstones (Figure 2c), and thromboid and stromatoporoid boundstones (*e.g.*, Kendall, 1976; Kreis and Kent, 2000; Pratt and Haidl, 2008). Due to this variability, it is difficult to consistently define the Lake Alma/Yeoman contact. Dolomitization in the burrow-mottled and "transitional" facies is complex.

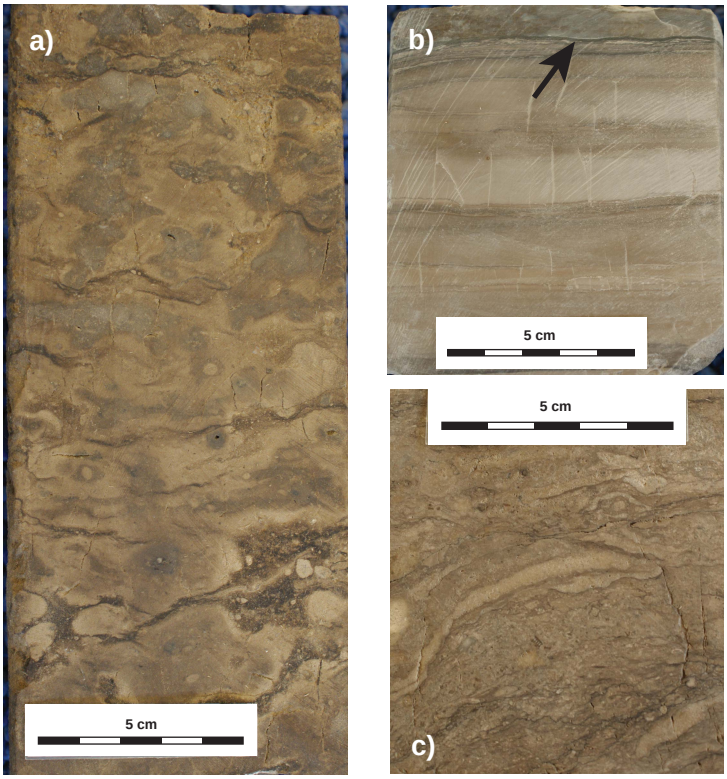



**Figure 2 – a) Burrow-mottled dolowackestone, Yeoman Formation (111/13-26-003-21W2, 2782 m); b) contact (black arrow) between Lake Alma anhydrite and laminated to thinly bedded dolomudstone (111/14-15-003-15W2, contact at 2934.1 m); and c) bioclastic dolograinstone in "transitional" unit; skeletal fragments include laminar stromatoporoids, crinoids, and other invertebrates; peloids and small intraclasts of microbial micrite are also present (111/02-29-013-13W2, 2149.3 m). All depths are based on correlation of core to geophysical logs.**

Precambrian basement structure played a major role in the development of Red River reservoirs and trapping mechanisms, and in the generation and migration of oil from the kukersitic source rocks (*e.g.*, Potter and St. Onge, 1991; Kreis and Kent, 2000; Pu and Qing, 2003; Potter, 2006; Kovac, 2007). Precambrian paleotopography associated with northwest- and northeast-trending structures controlled deposition of Deadwood strata as reflected in the northeast and northwest alignment of areas of thin to zero Deadwood strata (Figure 3). Subsequent differential compaction of these sediments, coupled with episodic movement of basement structures in the Phanerozoic, controlled Red River facies distribution and formation of low-relief small structural closures in which most Red River oil is trapped (Figures 4, 5, and 6). In addition, associated faults and fractures were important to the movement of dolomitizing fluids through Red River strata. Other factors that contributed to the complex pattern of dolomitized strata observed today (Figures 1 and 6) include seepage reflux associated with deposition of the Lake Alma anhydrite, and organic content and original depositional porosity of Red River carbonates.

## STACKED RESERVOIRS

Red River oil is often found in areas with production from other stratigraphic units. Examples include:

1. the Hartaven and Midale areas where oil is produced from reservoirs in Mississippian Midale carbonates, and Ordovician Red River dolostones and Winnipeg sandstones;
2. the Bryant area which has production from Mississippian Frobisher, Devonian Winnipegosis, Silurian Interlake, and Ordovician Red River carbonates;
3. the Froude area where Mississippian Frobisher, Devonian Bakken and Winnipegosis, and Ordovician Red River strata have produced oil; and
4. the Minton area with reservoirs in Winnipegosis and Red River carbonates.

## KEY POINTS

- Current production is from dolostone reservoirs associated with small structural closures linked to structural elements in the Precambrian basement.
- Dolomitization patterns in Red River carbonates are complex.

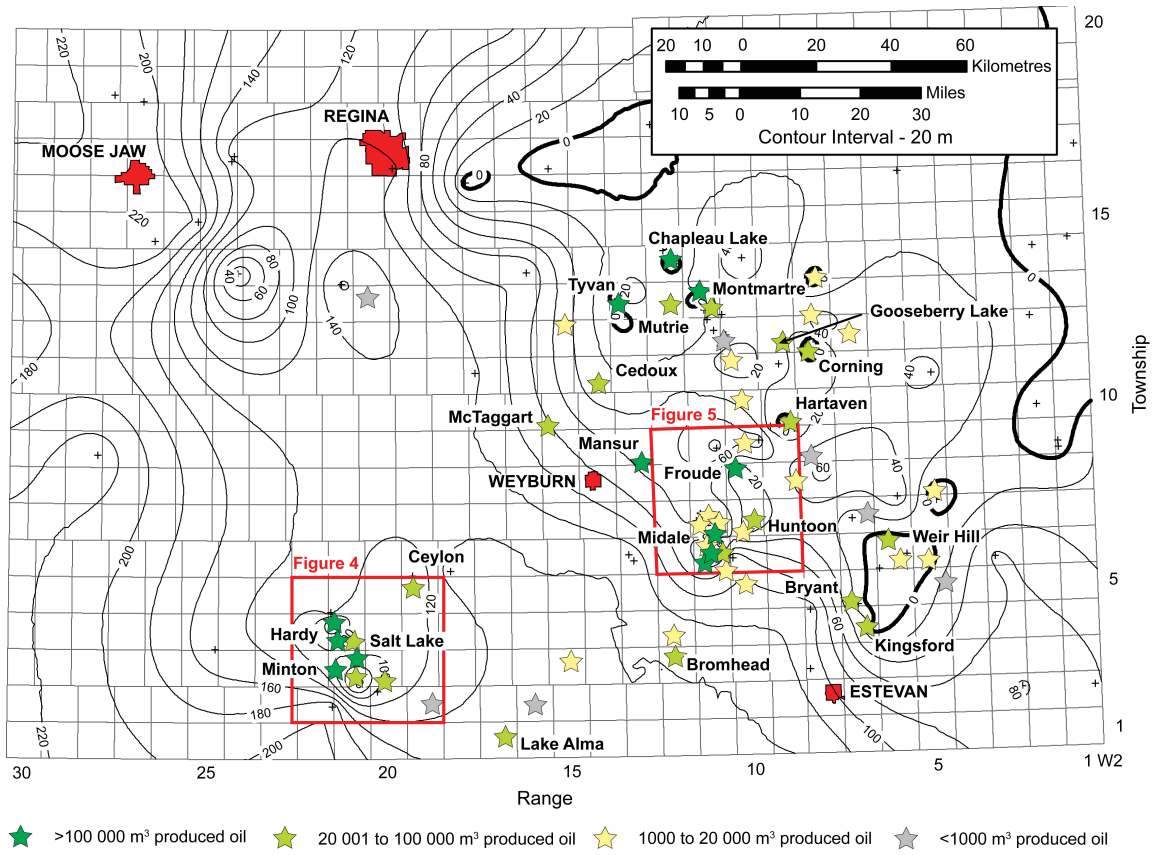



**Figure 3 – Areas of Red River oil production superimposed on an isopach map of Deadwood strata. Note that many Red River oil accumulations coincide with areas of thinning of Deadwood strata. Only areas that produced >20 000 m³ of oil are named.**

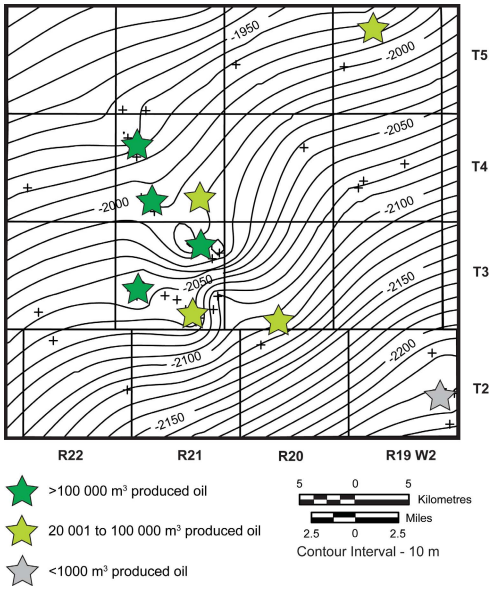



**Figure 4 – Red River structure map in the Minton-Hardy-Salt Lake area illustrating the association of oil accumulations with small structural closures. Kovac (2007), with the aid of 2-D and 3-D seismic data, further refined the delineation of structural closures; he identified eight structures, ranging in size from 123 to 307 hectares, in Tp. 3 and 4, Rge. 20 and 21W2.**

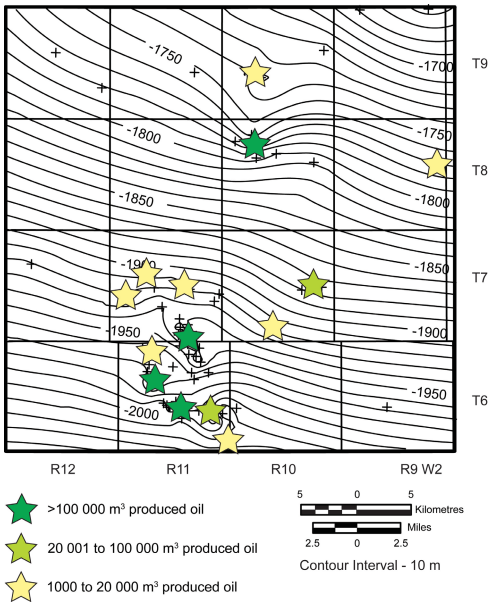



**Figure 5 – Red River structure map in the Midale-Froude-Huntoon area illustrating the association of oil accumulations with small structural closures. With the aid of 3-D seismic data, Pu and Qing (2003) defined >10 structures in Tp. 6 and 7, Rge. 11W2.**

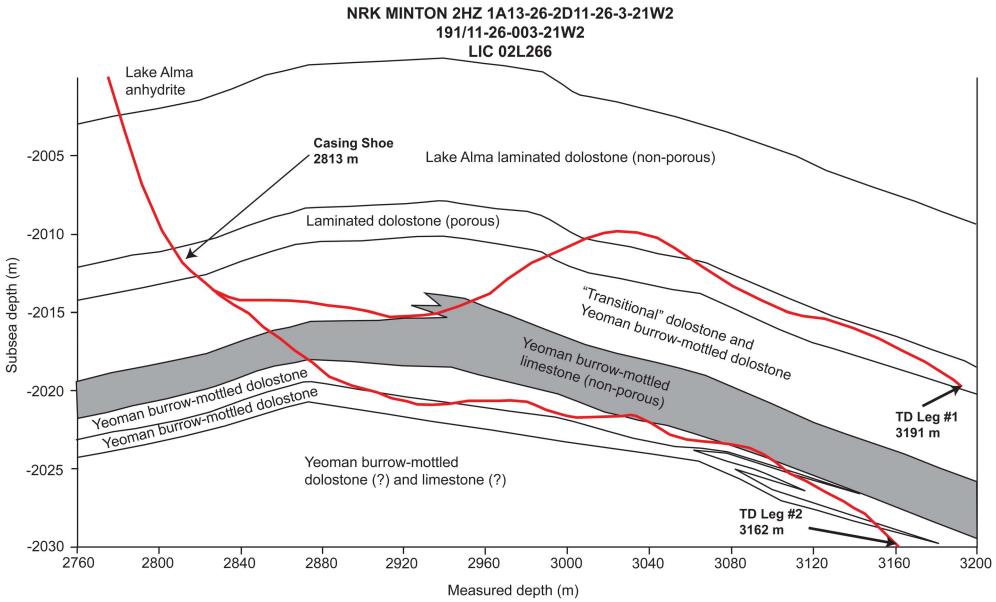



**Figure 6 – Schematic illustration of lithologies encountered along trajectories of Legs 1 and 2 in 191/11-26-003-21W2. To January 1, 2012, this well, drilled in 2003, had produced 421 359 m³ of oil in 3,162 days. Modified from illustration in well report submitted to Saskatchewan Energy and Resources.**


## Summary

**Analogs:**
Minton, Midale, and Tyvan pools.

**Traps:**
Small structural closures; potential stratigraphic and combined structural-stratigraphic.

**Reservoir:**
Dolostone with a wide range of textures including mudstone, wackestone, packstone, grainstone, and boundstone.

**Seal:**
Lake Alma anhydrite.

**Source:**
Kukersites in upper Yeoman.


## KEY POINTS (CONT'D)

- Use of 3-D seismic and horizontal well technology facilitates exploration for and development of these complex Red River reservoirs associated with small structures and can result in enhanced production volumes (*e.g.*, Pu and Qing, 2003; Kovac, 2007).
- Complex dolomitization patterns create the potential for stratigraphic traps and for combined structural stratigraphic traps.
- Stacking of reservoirs throughout the geologic column provides an added incentive to explore for this underdeveloped play.

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