CHAPTER 5 — WINTERBURN (NISKU) RESERVOIRS

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INTRODUCTION

The Nisku Fm is a Late Frasnian (Upper Devonian) carbonate occurring immediately above the Ireton Fm in western Canada and northwestern U.S.A. It was deposited across most of Alberta, Saskatchewan, Montana and North Dakota as widespread, laterally extensive, regressive shelf carbonates, in an arid, near-equatorial environment (Anderson, 1985). These shelf carbonates surround the Winterburn Basin (Figs. 5.1, 5.2) in west-central Alberta, in which the “Winterburn Shelf” (Cynthia Mbr) (Fig. 5.3) was deposited. Nisku reefs occur on the southeast flank of the Winterburn Basin in the Pembina area and in the Olds-Windfall area of the basin.

The Canadian oil industry informally subdivides the widespread shelf deposits of the Nisku Fm of southern Alberta into Upper and Lower units (Fig. 5.3). The Upper Nisku is the main reservoir rock of the Nisku Fm in Southern Alberta. It was deposited as a widespread carbonate bank in a shallow, open marine, middle-shelf environment. The Upper Nisku is most often comprised of interbedded peloidal wackestones, primary dolostones and laminated anhydrites formed in the subtidal to supratidal environment. The Upper Nisku is most often comprised of continuous, regressive shelf carbonates, in an arid, near equatorial environment (Anderson, 1985). These shelf carbonates surround the Winterburn Basin (Figs. 5.1, 5.2) in west-central Alberta, in which the “Winterburn Shelf” (Cynthia Mbr) (Fig. 5.3) was deposited. Nisku reefs occur on the southeast flank of the Winterburn Basin in the Pembina area and in the Olds-Windfall area of the basin.

The Nisku Fm was deposited after a slight depositional hiatus on the gently west-dipping upper surface of the Ireton Fm. Shales of the Ireton Fm are the final Woodbend Basin filling sediments in Alberta (Stoakes, 1984). The Winterburn - Woodbend break within the Winterburn Basin is marked by a hardground surface. This surface has a distinct sigmoidal shape in cross-section known as a ‘fastnet’, and a velocity change occurs across the break which results in a regional seismic marker known as the Zm-marker (Stoakes, 1987a). It was this final basin filling event that provided the Winterburn Basin’s shape and morphology at the beginning of Nisku time (Anderson, 1985, and Stoakes, 1987a). According to Guy Masson (pers. comm.), who performed petrographic studies of the Nisku shelf reservoirs in southern Alberta for Canterra Energy Ltd in 1985, the intensity of the subsequent subarkositic process is the variable factor in reservoir development on the shelf. The Lower Nisku of the shelf complex is consistently pervasively dolomitized showing little variation in intensity. It appears that the lack of infilling of early solution vugs and molds with secondary anhydrite, after dolomitization was completed, controls reservoir preservation.

The Nisku Fm contains 170.6 x 10^6 m^3 of recoverable oil reserves and 40,334 x 10^6 m^3 of initial marketable gas reserves. These reserves occur (Fig. 5.1) in eight main pool types as follows:

1) Zeta Lake “pinnacle” reefs occurring on the southeast flanks of the Winterburn Basin. These reefs are small build-ups that grow in relatively deep water, downslope of the Upper Nisku Barrier. Examples of this pool type would be at Pembina, Brazeau River and Bigoray. Seismic examples and reviews of the Brazeau Nisku K and S pools, Whitehorse Nisku pool, Bigoray Nisku D, E, H and K pools, and Pembina Nisku F pool are presented in this chapter;

2) Shelf margin reefs, channelled banks, patch reefs and grainstone shoals within the Upper Nisku Barrier and “Outer Shelf” areas surrounding the Winterburn Basin. Examples of these types of pools are Meekwap, the Brazeau River Nisku P gas pool and Gone River;

3) Reefs, mounds and shools which were initiated on, and deposited over Ludlovia reefs in the Winterburn Basin. Examples of these pool types would be Olivia, Apetowun and Windfall. A review example and review of the Apetowun pool is presented in this chapter;

4) Large, stacked, reservoir-quality reefal complexes. The Zeta Lake “pinnacle” reefs and the “Outer Shelf” reefs described above may be considered as examples of this pool type.

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Seismic examples for this pool type (Zeta Lake reefs) are Stettler, Leduc-Woodbend, Clive and Drumheller. Examples of these types of pools are the Bellis gas pool, Youngstown, Enchant, Princess and Kisby (Saskatchewan); and Udny erosional edge traps in eastern Alberta, where solution-related porosity enhances reservoir quality. Traps occur in updip escarpment edges. Examples of these types of pools are the Bellis gas pool and the Wamwight heavy oil pool.

ZETA LAKE REEFS

INTRODUCTION

Nisku "pinnacle" reefs of the Pembina area were discovered in January 1977 by the drilling of the North Pembina 1-22-49-12 W5M well (Chevron Exploration Staff, 1979). Over 50 productive reefs have been discovered since. The reefs average 2 km in diameter and 100 m in thickness and were deposited as low relief coral mud-mounds on the slope of the Winterburn Basin (Anderson and Maciel, 1987). They are confined to a mature exploration fairway 40 km wide and 120 km long which trends NE-SW through the Pembina, Bigstone and Brazeau regions of west-central Alberta, corresponding to the southeastern slope of the basin (Fig. 5.1).

The term "pinnacle reef" for Zeta Lake reefs is actually a misnomer, probably resulting from their appearance in vertically exaggerated cross-sections. These reefs are actually low relief mud-mounds with funnel-shaped bases. The term "reef" is used for these build-ups in keeping with current practice.

These reefs were deposited downslope of the Upper Nisku Barrier which developed on the basin edge (Figs. 5.1, 5.2). This barrier is considered to be comprised of typical Zeta Lake Mbr reefal facies as seen basinward in the isolated reefs, except that it was deposited in a continuous, linear trend rimming the basin (Maciel, 1983). Estimates of the paleo-loads from bank to basin show a constant dip of 0.1° with no major break in slope in the vicinity of the basin edge (Anderson, 1985, p. 47). Breaks in the linear trend and
Figure 5.2. Nisku regional schematic cross section.
was accomplished by corals (Chevron Exploration Staff, 1979; Bigorary Fm as the time equivalent of the Cynthia Mbr in the basin, vugging and matrix dolomitization was considered by Chevron to have been particularly intense at the end of Bigoray time. However, Anderson (1985) and Machel (1985) concluded that no significant solution dolomitization was present stratigraphically. The majority of dolomitization appears to have been partial at times, mostly during Bigoray and perhaps some during Lobstick time, but the majority began growth during Bigoray time (Cherdon 1983).

Reservoir and seal characteristics of the Modeling Reef play type have been determined by the application of both modern and ancient analogs. The lobate development of the Winterburn Basin is seen as a series of lobes of carbonate shelf succession by the period ended with disphyllid corals dominating and ended with laminar packestones (Watts, 1987b).

Deposition of deep-water argillaceous siltstones of the Cynthia Mbr has been overlain by Wolf Lake Mbr. The Wolf Lake Mbr is described as being partially dolomitized argillaceous bioclastic limestones, silstones and calcareous silstones and the Bigoray Mbr as being wackestones, calcareous silstones and dolomitized argillaceous silstones overlain by silty argillaceous bioclastic wackestones and parkerites (Watts, 1987a).

Stabilization and colonilation of Zeta Lake reefs on these ramps was accomplished by corals (Chevron Exploration Staff, 1979; Anderson, 1985; Machel, 1985; and Watts, 1987b) possibly on small irregular highs (Stokes, 1987a). Water depths are estimated at approximately 55 m (Anderson, 1985). Reefs initiated as early as Lobstick time, but the majority began growth during Bigoray time (Machel, 1985).

Reef growth kept pace with subsidence during the early part of the Lobstick and Bigoray cycles, but was thought by Chevron Exploration Staff (1979) to have exceeded subsidence at the end of Bigoray time. The majority began growth during Bigoray time (Machel, 1985). Reef growth kept pace with subsidence during the early part of the Lobstick and Bigoray cycles, but was thought by Chevron Exploration Staff (1979) to have exceeded subsidence at the end of Bigoray time. The majority began growth during Bigoray time (Machel, 1985). Reef growth kept pace with subsidence during the early part of the Lobstick and Bigoray cycles, but was thought by Chevron Exploration Staff (1979) to have exceeded subsidence at the end of Bigoray time. The majority began growth during Bigoray time (Machel, 1985).

The stratigraphy and nomenclature of Nisku basin units is shown in Figure 5.3. An initial transition started with a sequence of two shoaling up cycles, termed the Lobstick and Bigoray members, was deposited on top of the Lobstick Mbr. The Lobstick Mbr is described as being partially dolomitized argillaceous bioclastic limestones, silstones and calcareous silstones and the Bigoray Mbr as being wackestones, calcareous silstones and dolomitized argillaceous silstones overlain by silty argillaceous bioclastic wackestones and parkerites (Watts, 1987a).

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The well at 15-9-47-14 W5M was drilled into the Brazeau River Nisku 'K' and '5' pools and extends over the Nisku barrier at the east end. The seismic line has been divided into two parts: west (Fig. 5.6) and east (Fig. 5.7).

The east half of the seismic line (Fig. 5.7) shows the seismic expression of the Nisku Fm barrier from traces 1 to 168 at 1.85 - 2.00 seconds two way traveltime. This reflection could be caused by a very porous Nisku Fm and may indicate that the reef penetrated by the 15-9 well is more porous than the reef at 2-11. The absence of significant drape overlying the Zeta Lake reef penetrated by the 15-9 well. Velocity pull-up under the barrier is about 15 ms at the Wabamun Gp and 9 ms at the Viking Fm. Roll-over of reflections beneath the reef can mostly be accounted for by velocity pull-up caused by the slower velocity Cynthia Mbr shale being replaced by the higher velocity carbonates of the Zeta Lake reef. Structural roll-over of reflections above the reef can be attributed to drape due to differential compaction of the Zeta Lake carbonate and Cynthia Mbr shale.

The 13-5 reef is not seen on the seismic section. The crest of the reef is probably crosed by the profile.

The Zeta Lake reef encountered by the well drilled at 15-9 is more porous than the reef at 2-11. The Zeta Lake reef penetrated by the 15-9 well is more porous than the reef at 2-11. The absence of significant drape overlying the Zeta Lake reef penetrated by the 15-9 well. Velocity pull-up under the reef is very slight compared to the Zeta Lake reef penetrated by the well at 2-11. The absence of significant drape indicates that the Zeta Lake reef at 15-9 is not as thick as the Zeta Lake reef at 2-11.
Figure 5.5. Geological cross-section through Zeta Lake reef: Brazeau River Nisku 'K' and 'S' pool area.
Figure 5.6. Seismic section (west half) through Brazeau River Nisku 'K' and 'S' pool area.
Figure 5.7. Seismic section (east half) through Brazeau River Nisku 'K' and 'S' pool area.
The cause of this phenomenon is likely due to a combination of: 1) a gradually replace the lower velocity Cynthia Mbr shale; and 2) a Lake reef. Events deeper than the Ireton Fm do not consistently show this effect.

The flanks of the reef is particularly well demonstrated in this example. A defocussing effect caused by refraction through the lens shaped Zeta velocity shale is replaced by the higher velocity carbonates of the Zeta Lake reef is interpreted between traces 148 and 204 at 1.70 seconds two way traveltime. The amplitude of the peak representing the top of the Cynthia Mbr shale is not seen, perhaps indicating that a normal off-reef section is not present between the reef base at the 9-8 location.

The 14-4-51-9 WSM oilwell was drilled into the Bigoray Nisku ‘D’ pool (Table 5.1). The reef initiated at the top of the Lobstick Fm and is 92 m thick with 24 m of net porosity (>3%) at 14-4. The Bigoray Nisku ‘E’ pool OW contact occurs structurally lower than the reef base at the 9-8 location.

The 14-5-51-10 WSM oilwell was drilled into the Bigoray Nisku ‘D’ pool (Table 5.1). The reef initiated at the top of the Lobstick Fm and is 76 m thick with 48 m of net porosity at this location.

The 14-6-51-15 WSM oilwell was drilled into the Bigoray Nisku ‘E’ pool penetrated at a 20750 m³/day production test with a 7.5 mm choke. The reef at this location also initiated at the top of the Lobstick Fm and is 76 m thick with 55 m of net porosity (>3%).

SEISMIC SECTION

This seismic example is an east-west line over a Zeta Lake reef penetrated by two shot-in gas wells, 6-20 and 9-20 (Fig. 5.8). The seismic line is displayed at SEG normal polarity (Fig. 5.10). A Zeta Lake reef is interpreted between traces 148 and 204 at 1.70 seconds two way traveltime. The amplitude of the peak representing the top of the Cynthia Mbr shale diminishes over the anomalies where lower velocity shale is replaced by the higher velocities carbonates of the Zeta Lake reef.

The dimming of the Ireton Fm reflection immediately under the flanks of the reef is particularly well demonstrated in this example. This phenomenon is likely due to a combination of: 1) a complex tuning response from the higher velocity Zeta Lake carbonates gradually replace the lower velocity Cynthia Mbr shale; and 2) a defocussing effect caused by refraction through the lens shaped Zeta Lake reef. Forms deeper than the Ireton Fm do not consistently show this effect.

Prominent anticlinal structures are recognizable from the Beauchel Lake Gh through the Viking Fm. Roll-over of reflections beneath the reef up to 20 ms at the Beauchel Lake Gh can be partly accounted for by velocity pull-up. Structure roll-off of reflections above the reef up to 15 ms at the Wabamun Gp can be attributed to differential compaction of the Zeta Lake carbonate and Cynthia Mbr shale.

BIGORAY NISKU ‘D’ AND ‘E’ POOLS

GEOLOGICAL CROSS-SECTION

The 14-5-51-9 WSM oilwell was drilled into the Bigoray Nisku ‘D’ pool (Table 5.1). The reef initiated at the top of the Lobstick Fm and is 92 m thick with 24 m of net porosity (>3%) at 14-4. The Bigoray Nisku ‘E’ pool OW contact occurs structurally lower than the reef base at the 9-8 location.

The 14-4-51-9 WSM oilwell was drilled into the Bigoray Nisku ‘D’ pool (Table 5.1). The reef initiated at the top of the Lobstick Fm and is 92 m thick with 24 m of net porosity (>3%) at 14-4. The Bigoray Nisku ‘E’ pool OW contact occurs structurally lower than the reef base at the 9-8 location.

The 14-5-51-10 WSM oilwell was drilled into the Bigoray Nisku ‘D’ pool (Table 5.1). The reef initiated at the top of the Lobstick Fm and is 76 m thick with 48 m of net porosity at this location.

The 14-6-51-15 WSM oilwell was drilled into the Bigoray Nisku ‘E’ pool penetrated at a 20750 m³/day production test with a 7.5 mm choke. The reef at this location also initiated at the top of the Lobstick Fm and is 76 m thick with 55 m of net porosity (>3%).

SEISMIC SECTION

This seismic example is an east-west line over a Zeta Lake reef penetrated by two shot-in gas wells, 6-20 and 9-20 (Fig. 5.8). The seismic line is displayed at SEG normal polarity (Fig. 5.10). A Zeta Lake reef is interpreted between traces 148 and 204 at 1.70 seconds two way traveltime. The amplitude of the peak representing the top of the Cynthia Mbr shale diminishes over the anomalies where lower velocity shale is replaced by the higher velocities carbonates of the Zeta Lake reef.

The dimming of the Ireton Fm reflection immediately under the flanks of the reef is particularly well demonstrated in this example. This phenomenon is likely due to a combination of: 1) a complex tuning response from the higher velocity Zeta Lake carbonates gradually replace the lower velocity Cynthia Mbr shale; and 2) a defocussing effect caused by refraction through the lens shaped Zeta Lake reef. Forms deeper than the Ireton Fm do not consistently show this effect.

Prominent anticlinal structures are recognizable from the Beauchel Lake Gh through the Viking Fm. Roll-over of reflections beneath the reef up to 20 ms at the Beauchel Lake Gh can be partly accounted for by velocity pull-up. Structure roll-off of reflections above the reef up to 15 ms at the Wabamun Gp can be attributed to differential compaction of the Zeta Lake carbonate and Cynthia Mbr shale.

BIGORAY NISKU ‘D’ AND ‘E’ POOLS

GEOLOGICAL CROSS-SECTION

The 14-5-51-9 WSM oilwell was drilled into the Bigoray Nisku ‘D’ pool (Table 5.1). The reef initiated at the top of the Lobstick Fm and is 92 m thick with 24 m of net porosity (>3%) at 14-4. The Bigoray Nisku ‘E’ pool OW contact occurs structurally lower than the reef base at the 9-8 location.

The 14-4-51-9 WSM oilwell was drilled into the Bigoray Nisku ‘D’ pool (Table 5.1). The reef initiated at the top of the Lobstick Fm and is 92 m thick with 24 m of net porosity (>3%) at 14-4. The Bigoray Nisku ‘E’ pool OW contact occurs structurally lower than the reef base at the 9-8 location.

Very subtle dipole can be observed on the top Wabamun Gh reflection above the reefs. Pull-up effects of the reefs are slight, up to 10 ms, at the Beauchel Lake Gh reflection under the crest of the reef encountered by the 14-4 well.

PEMBINA NISKU ‘F’ POOL

GEOLOGICAL CROSS-SECTION

This seismic example is an east-west line over a Zeta Lake reef penetrated by two shot-in gas wells, 6-20 and 9-20 (Fig. 5.8). The seismic line is displayed at SEG normal polarity (Fig. 5.10). A Zeta Lake reef is interpreted between traces 148 and 204 at 1.70 seconds two way traveltime. The amplitude of the peak representing the top of the Cynthia Mbr shale diminishes over the anomalies where lower velocity shale is replaced by the higher velocities carbonates of the Zeta Lake reef.

The dimming of the peak representing the top Ireton Fm is evident under the reef flanks and continues to remain dim for approximately one kilometre in the off-reef position. The interpretation of the Ireton Fm reflection increases under the reefs.

The separation between the two reefs is poorly imaged but can be justified by:

1) A subtle character change in the trough/doublet trough event immediately below the top Nisku Fm/Cynthia Mbr event;
2) The amplitude increase of the peak representing the top Ireton Fm is not seen in the area between the reefs;
3) The weak top Nisku Fm/Cynthia Mbr reflection seems to be lost in the gap between the reefs. The characteristic strong Cynthia Mbr shale amplitude is not seen, perhaps indicating that a normal off-reef section is not present between the features.
Figure 5.9. Geological cross-section through Zeta Lake reef: White Horse Nisku pool area.
Figure 5.10. Seismic section through Whitehorse Nisku pool area.
Figure 5.12. Geological cross section through Zeta Lake reef: Bigoray Nisku 'D' and 'E' pool area.
Figure 5.13. Seismic section through Bigoray Nisku 'D' pool 'E' pool area.
Figure 5.15. Geological cross section through Zeta Lake reef: Pembina Nisku 'F' pool area.
Figure 5.16. Seismic section through Pembina Nisku 'F' pool area.
Figure 5.18. Geological cross section through Zeta Lake reef: Bigoray Nisku 'H' and 'K' pool area.

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Figure 5.19. Seismic section through Bighorn Nisku 'H' and 'K' pool area.
Figure 5.21. Geological cross section through Nisku reef: Apetowun Nisku pool.
Figure 5.22. Seismic section through Apetowun Nisku pool.
oilwell) and at 15-25-50 WSM (dry and abandoned) illustrate the regional basin stratigraphy.

Well 6-11-51-10 WSM is an abandoned Nisku oilwell drilled into the Pembina Nisku Fm oil pool (Table 5.1). The reef initiates in the Leduc Fm and is 90 m thick with 66 m of net porosity (> 3%) at the 6-11 location.

The well at 2-11-51-10 WSM is an off-reef abandoned Nisku oilwell, which produced 1158 m^3 of oil prior to abandonment. This zone is in communication with the main Zeta Lake reef encountered at the 6-11 location.

SEISMIC SECTION

This seismic example (Fig. 5.16) is an east-west seismic section through the Pembina Nisku Fm oil pool penetrated by the wells located at 2-11 and 6-11 (Fig. 5.14). The seismic line is displayed at SEG normal polarity.

A Zeta Lake reef is interpreted on the seismic section between traces 73 and 101 at 1.43 seconds two way time. Seismic detection of the reef is difficult because dimming of the peak representing the top Cynthia Mbr shale is not seen. The very porous carbonate of the Zeta Lake reef causes the top Cynthia Mbr/Nisku Fm reflection to remain strong over the entire reef. Also, the top Ireton Fm reflection is strong under the reef crest but weak under the reef flanks and remains weak in the off-reef position.

Structural drape of the top Wabamun Gp reflection (approximately 10 ms roll-over) due to differential compaction of the Zeta Lake carbonate and Cynthia Mbr shale is visible on the seismic section. Reflections under the reef crest show 5 to 10 ms of relief, which can be largely ascribed to velocity pull-up under the reef. The peak representing the top Cynthia Mbr shale reflection. The top Ireton Fm/Cynthia Mbr shale reflection shows about 30 ms of relief over the reef. The peak marking the top of the Ireton Fm is dim under the entire reef, in contrast to the previous examples where the dimming occurred only under the flanks of the reef.

The reef between traces 74 and 125 clearly exhibits dimming of the peak representing the top Cynthia Mbr shale reflection. The top Nisku Fm/Cynthia Mbr shale reflection shows about 10 ms of relief over the reef. The peak marking the top of the Ireton Fm is dim under the entire reef, in contrast to the previous examples where the dimming occurred only under the flanks of the reef.

Structural drape of the Wabamun Gp reflection (10 ms roll-over) due to differential compaction of the Zeta Lake carbonate and Cynthia Mbr shale is evident on the seismic section. Reflections under the Zeta Lake reef show 5 to 10 ms of relief, which can be largely ascribed to velocity pull-up under the reef.

APETOWUN NISKU POOL

GEOL O GICAL CROSS-SECTION

Figure 5.28 gives the location of the southwest to northeast geological cross-section (Fig. 5.21) which shows the reef to basin relationship of the "Nisku reef" which comprises the Apetowun Nisku gas pool. It shows the intimate association and development of the "Nisku reef" over the Leduc reef.

The well at 9-15-58-8 WSM is drilled into the Bigoray Nisku 'H' oil pool (Table 5.3). The well does not fully penetrate the Zeta Lake reef as drilling was stopped before reaching in base. The reef is estimated to be 75 m thick with net porosity thicker than 34 m (>3%).

SEISMIC SECTION

This seismic example is a north-south seismic section through the Bigoray Nisku 'H' pool penetrated by the well at 9-15 and the Bigoray Nisku 'K' pool penetrated by the well at 14-3 (Fig. 5.17). The seismic line is displayed at SEG normal polarity (Fig. 5.19).

Two Zeta Lake reefs are interpreted on the seismic line between traces 1 and 15 at 1.36 seconds two way traveltime and between traces 74 and 123 at 1.35 seconds two way traveltime. The Zeta Lake reef between traces 1 and 15 is difficult to interpret because it is located at the end of the seismic line. Dimming of both the top Cynthia Mbr shale and top Ireton Fm reflections are seen on the seismic sections indicating the reef encountered by the well at 14-3.

The reef between traces 74 and 125 clearly exhibits dimming of the peak representing the top Cynthia Mbr shale reflection. The top Nisku Fm/Cynthia Mbr shale reflection shows about 30 ms of relief over the reef. The peak marking the top of the Ireton Fm is dim under the entire reef, in contrast to the previous examples where the dimming occurred only under the flanks of the reef.

The dry and abandoned well at 10-34-51-22 WSM illustrates the regional basin stratigraphy of the Upper Devonian sequence in the Woodbend "West Ireton Shale Basin" (Stokes, 1980, Fig. 2) and overlying Winterburn Basin (Fig. 5.1). A total of 83 m of Ireton Fm shale and 128 m of Winterburn Shale were deposited above the Lower Leduc or Cairn Fm. In this location a very thin Cairn Fm (approximately 35 m) is present above the Swan Hills Fm.

The dry and abandoned well at 7-15-52-22 WSM was drilled into a full Leduc build-up. This well penetrated a 15 m thick zone of clean Nisku carbonate which is separated from the Leduc Fm by 5 m of Winterburn Shale.
The Nisku gas well at 2-22-52-22-WSM is the discovery well and currently the only well recognized as having recoverable gas reserves in the Apetowun Nisku gas pool. This well encountered a full thickness of clean Nisku carbonate which is separated from the underlying Leduc Fm at 2-22-52-22-W5M. The Nisku Fm has 26 m of net porosity (p>3%) and the reservoir contains 360 x 10^6 m^3 of gas (Table 5.1).

The dry and abandoned well at 10-13-52-22-WSM shows the tendency to the regional basin stratigraphy. A total of 77 m of Iredell Fm was drilled through 124 m of Wabamun Shale were deposited over 56 m of Lower Leduc Fm at this location.

SEISMIC SECTION

This seismic example (Fig. 5.22) is a northeast-southwest seismic section through the Apetowun reef complex (using the 2-22, 7-15 and 10-12 wells (Fig. 5.20)). The seismic line is displayed at SEG normal polarity. A Nisku reef is interpreted on this line between tracts 191 and 230 in 2.1 seconds travel time. This Nisku reef differs from those of the West Pembina area in that it is underlain by a full thickness Winterburn Shale.

The top of carbonate (Cairn Mbr) reflector climbs and dips near the edge of the Leduc reef. The Iredell Fm is marked by a peak immediately above the Cairn Fm horizon. The Iredell marker and the overlying broad trough also dip and lose their coherency as the Iredell Fm shales are replaced by the Leduc Fm. The Wabamun Shale peak diminishes as the off-reef material is replaced by high velocity carbonates of the Nisku reef at the 2-22 location. Also note the Shale peak diminishes as the off-reef material is replaced by high velocity carbonates of the Zeta Lake reef above the 2-22 location.

Structural roll-over of reflections beneath the Zeta Lake reef which is attributed to roll-over due to differential compaction of the Zeta Lake Mbr carbonate and Cynthia Mbr shale. Structural roll-over of up to 15 m at the Wabamun Gp reflection is present on the seismic and:

1) Dimming and sometimes total loss of the Cairn Fm reflection which is a result of the drape due to differential compaction of the Zeta Lake Mbr carbonate and Cynthia Mbr shale.
2) Dimming of the Cynthia Mbr reflection which is a result of the replacement of the Cynthia Mbr shale with the higher velocity carbonates of the Zeta Lake reef.
3) The Winterburn Shale reflection diminishes as the off-reef material.
4) Roll-over of reflections beneath the Zeta Lake reef which is attributed to velocity pull-up effects under the reefs due to higher velocity carbonates of the Zeta Lake reef; and
5) Velocity pull-up effects under the reefs due to higher velocity carbonates of the Zeta Lake reef. Roll-over of up to 20 m is present at the Beaverhill Lake Gp reflection on the seismic. Sometimes the roll-over is more than expected from velocity pull-up effects. Some workers have suggested that pre-existing highs may be present in the overlying broad trough also dim and lose their coherency as the Nisku reefs in the Otter-Apawatou area of the deep Basin are recognized using the following criteria:

1) Dimming and sometimes total loss of the top of carbonate (Cairn Mbr) reflection which is a result of the drape due to differential compaction of the Zeta Lake Mbr carbonate and Cynthia Mbr shale. Structural roll-over of up to 15 m at the Wabamun Gp reflection is present on the seismic and:

1) Dimming and sometimes total loss of the Cairn Fm reflection which is a result of the drape due to differential compaction of the Zeta Lake Mbr carbonate and Cynthia Mbr shale.
2) Dimming of the Cynthia Mbr reflection which is a result of the replacement of the Cynthia Mbr shale with the higher velocity carbonates of the Zeta Lake reef. Roll-over of up to 20 m is present at the Beaverhill Lake Gp reflection on the seismic. Sometimes the roll-over is more than expected from velocity pull-up effects. Some workers have suggested that pre-existing highs may be present in the overlying broad trough also dim and lose their coherency as the Nisku reefs in the Otter-Apawatou area of the deep Basin are recognized using the following criteria:

1) Dimming and sometimes total loss of the top of carbonate (Cairn Mbr) reflection which is a result of the drape due to differential compaction of the Zeta Lake Mbr carbonate and Cynthia Mbr shale. Structural roll-over of up to 15 m at the Wabamun Gp reflection is present on the seismic and:

1) Dimming and sometimes total loss of the Cairn Fm reflection which is a result of the drape due to differential compaction of the Zeta Lake Mbr carbonate and Cynthia Mbr shale.
2) Dimming of the Cynthia Mbr reflection which is a result of the replacement of the Cynthia Mbr shale with the higher velocity carbonates of the Zeta Lake reef; and
3) Velocity pull-up effects under the reefs due to higher velocity of the off-reef section.

REFERENCES


