CHAPTER 8 — THE LOWER CRETACEOUS

Dale A. Cederwall, Poco Petroleums Ltd.

INTRODUCTION

In this chapter the geological characteristics and the seismic signatures of selected Lower Cretaceous hydrocarbon reservoirs are illustrated. These data were selected objectively, in order to display a variety of Lower Cretaceous reservoir types in the basin.

The introduction to the chapter consists of six parts: 1) introduction; 2) geological setting of the Lower Cretaceous; 3) stratigraphy and nomenclature; 4) depositional mode and lithologies; 5) economic significance; and 6) reservoir types. Following this introduction are 17 individual subsections which are presented in a south to north and east to west order of occurrence. In each of these subsections a selected pool is described under the headings: 1) an introduction; 2) reserves and productivity; 3) geological section; 4) seismic section; and 5) conclusions.

For several reasons, but primarily due to data availability and data response these examples focus largely on Alberta with some exceptions such as areas of subcropping Devonian shales or Triassic, Jurassic and Mississippian clastics. These problems will be discussed in the specific examples of this chapter.

For several reasons, but primarily due to data availability and data response these examples focus largely on Alberta with some significant reservoirs such as deep basin gas, tar sands and the disturbed belt being omitted.

GEOLOGICAL SETTING OF THE LOWER CRETACEOUS

Lower Cretaceous sedimentary rocks form a nearly complete record of Neoconian, Aptian and Albian stages in the subsurface of Western Canada (Rudkin, 1965). The strata as illustrated in Figure 8.1 are intricately subdivided by area and units. However, these subdivisions, as shown by Jackson (1985), can be interrelated when studied as facies or environmental variations of major depositional cycles (or sea level variations).

The pre-Cretaceous unconformity and the base of the Fish Scales marker which form the stratigraphic boundaries of the Lower Cretaceous, are generally well-defined by lithological changes and/or well log responses in the subsurface. The lower boundary of the Cretaceous is a major low angle unconformity. Pre-Cretaceous rocks, which subcrop at the unconformity, dip to the southwest except where affected by regional structure associated with the Williston Basin, Sweetgrass Arch, Peace River Arch or the disturbed belt of the Rocky Mountain Foothills (Fig. 8.2). Erosion at the unconformity has exposed progressively older rocks from west to east and south to north. Wright et al. (1984) cross-sections C - C' and D - D' (in Introduction to this volume) show rocks from Jurassic to Cambrian exposed at this surface. Pre-Mesozoic strata in Western Canada are largely carbonates in comparison to the dominantly clastic lithologies of the Mesozoic and younger strata. This contrast of lithologies generally makes subsurface identification easier, but problems do invariably occur where pre-Cretaceous clastics are present such as areas of subcropping Devonian shales or Triassic, Jurassic and Mississippian clastics. These problems will be discussed in the specific examples of this chapter.

The pre-Cretaceous unconformity has a characteristic seismic signature in the basin which is normally a strong peak in the log-normal polarity convention utilized herein (where a positive acoustic impedance generates a peak). This seismic event often shows the characteristic undulating relief of the pre-Cretaceous unconformity in the basin. This relief is significant in that it is a principal factor in controlling traps, oilfield, compaction, and drainage patterns in the Lower Cretaceous. A compilation of major relief and drainage features of the Lower Cretaceous strata in Western Canada is shown in Figure 8.3 and is based on the work of Christoph (1980), Hayes (1986), Jackot (1985), McLean (1977) and Williams (1979).
Figure 8.1. Stratigraphic correlation chart of the Lower Cretaceous strata of the Western Canadian Sedimentary Basin.
The boundary between the Lower Cretaceous and the Upper Cretaceous is conformable and is commonly recognized and set at the base of the Fish Shale Zone. This widespread syndepositional marker is a shale encased zone of fish remnants which occasionally grades to a thin sandstone. The marker is characterized by an aragonite-anhydrite grain shift (on geophysical well logs) which is distinct in virtually every part of the basin where Lower and Upper Cretaceous rocks are in contact. The Fish Shale Zone has no significant reflectance coefficient and thus has no prominent seismic signature associated with it. However, the two underlying widespread and uniform stratigraphic units, the lowest shale of the Colorado Gp and the Viking Fm and their lateral stratigraphic equivalents, commonly show a significant positive velocity contrast at their contact. The velosity contrast at the boundary between Lower and Upper Cretaceous is assumed to lie a few milliseconds above the Viking Fm event, which is normally a peak in the polarity convention utilized in this work. The Lower and Upper Cretaceous formations have similar seismic signatures and their lateral distribution is recognized as many exceptions occur. The seismic response to the boundary between the Lower and Upper Cretaceous is complicated by lateral changes in depositional style and character. This variability is demonstrated by the 17 incorporated examples of this chapter. The following specific adjustments are applied to the compilation of the Lower Cretaceous:

1) The informal term Silurian Group is utilized in preference to the informal term Basal Bow Island Fm equivalent is grouped with the Bow Island Fm, whereas to the south the Glauconitic Sandstone member contains both lacustrine sediments and channel sandstones.

2) The informal term Boundary Shale member of central Alberta and the Bluesky Fm of western Canada is preceded here by a description of the Mannville Gp and post-Mannville strata as they occur in central Alberta. In doing so, several areas of Lower Cretaceous strata (Fig. 8.1) can be related to depositional variations of their stratigraphic equivalents in central Alberta.

3) The informal term St. Marys Sandstone member is locally utilized in the description of the Mannville Gp and post-Mannville strata as they occur in central Alberta. In doing so, several areas of Lower Cretaceous strata (Fig. 8.1) can be related to depositional variations of their stratigraphic equivalents in central Alberta.

4) The informal term St. Marys Sandstone member is locally utilized in the description of the Mannville Gp and post-Mannville strata as they occur in central Alberta. In doing so, several areas of Lower Cretaceous strata (Fig. 8.1) can be related to depositional variations of their stratigraphic equivalents in central Alberta.

5) The informal term Taber Sandstone member is locally utilized in the description of the Mannville Gp and post-Mannville strata as they occur in central Alberta. In doing so, several areas of Lower Cretaceous strata (Fig. 8.1) can be related to depositional variations of their stratigraphic equivalents in central Alberta.

6) The informal term Glauconitic Sandstone member is utilized, consistent with the usage of Jackson (1985); 7) The informal term Ostracod member is utilized, and indicates the top of the lower Mannville, consists of the w. g. of Glaister (1985); and 8) The terminology of McLean (1982) is utilized in Figure 8.1 for the foothills areas of the basin.

DEPOSITION OF THE LOWER CRETACEOUS SEDIMENTS

A discussion of Lower Cretaceous clastic deposition in Western Canada is preceded here by a description of the Mannville Gp and post-Mannville strata as they occur in central Alberta. In doing so, several areas of Lower Cretaceous strata (Fig. 8.1) can be related to depositional variations of their stratigraphic equivalents in central Alberta.

LOWER MANNVILLE

The lower Mannville of central Alberta and indeed for much of Western Canada is comprised of predominantly non-marine clastics. The source of clastic material is dominantly from the west, however a stelid provenance (eastern source) is recognized for the eastern and northern portions of Western Canada. Stelid material from both eastern and western sources was carried to and deposited in a centralized drainage system which trended from south to north (Fig. 8.3). Paleotopography on the Canadian Cordillera allowed the Gulfian and Boreal seas to merge. This terminated the post-Mannville strata as they occur in central Alberta. In doing so, several areas of Lower Cretaceous strata (Fig. 8.1) can be related to depositional variations of their stratigraphic equivalents in central Alberta.

The following specific adjustments are applied to the compilation of Lower Cretaceous:

1) The informal term St. Marys Sandstone member is locally utilized in the description of the Mannville Gp and post-Mannville strata as they occur in central Alberta. In doing so, several areas of Lower Cretaceous strata (Fig. 8.1) can be related to depositional variations of their stratigraphic equivalents in central Alberta.

2) The informal term Glauconitic Sandstone member is utilized, consistent with the usage of Jackson (1985); 3) The informal term Ostracod member is utilized, and indicates the top of the lower Mannville, consists of the w. g. of Glaister (1985); and 8) The terminology of McLean (1982) is utilized in Figure 8.1 for the foothills areas of the basin.

The following specific adjustments are applied to the compilation of Lower Cretaceous:

1) The informal term St. Marys Sandstone member is locally utilized in the description of the Mannville Gp and post-Mannville strata as they occur in central Alberta. In doing so, several areas of Lower Cretaceous strata (Fig. 8.1) can be related to depositional variations of their stratigraphic equivalents in central Alberta.

2) The informal term Glauconitic Sandstone member is utilized, consistent with the usage of Jackson (1985); 3) The informal term Ostracod member is utilized, and indicates the top of the lower Mannville, consists of the w. g. of Glaister (1985); and 8) The terminology of McLean (1982) is utilized in Figure 8.1 for the foothills areas of the basin.

DEPOSITION OF THE LOWER CRETACEOUS SEDIMENTS

A discussion of Lower Cretaceous clastic deposition in Western Canada is preceded here by a description of the Mannville Gp and post-Mannville strata as they occur in central Alberta. In doing so, several areas of Lower Cretaceous strata (Fig. 8.1) can be related to depositional variations of their stratigraphic equivalents in central Alberta.

LOWER MANNVILLE

The lower Mannville of central Alberta and indeed for much of Western Canada is comprised of predominantly non-marine clastics. The source of clastic material is dominantly from the west, however a stelid provenance (eastern source) is recognized for the eastern and northern portions of Western Canada. Stelid material from both eastern and western sources was carried to and deposited in a centralized drainage system which trended from south to north (Fig. 8.3). Paleotopography on the Canadian Cordillera allowed the Gulfian and Boreal seas to merge. This terminated the post-Mannville strata as they occur in central Alberta. In doing so, several areas of Lower Cretaceous strata (Fig. 8.1) can be related to depositional variations of their stratigraphic equivalents in central Alberta.

LOWER MANNVILLE

The lower Mannville of central Alberta and indeed for much of Western Canada is comprised of predominantly non-marine clastics. The source of clastic material is dominantly from the west, however a stelid provenance (eastern source) is recognized for the eastern and northern portions of Western Canada. Stelid material from both eastern and western sources was carried to and deposited in a centralized drainage system which trended from south to north (Fig. 8.3). Paleotopography on the Canadian Cordillera allowed the Gulfian and Boreal seas to merge. This terminated the post-Mannville strata as they occur in central Alberta. In doing so, several areas of Lower Cretaceous strata (Fig. 8.1) can be related to depositional variations of their stratigraphic equivalents in central Alberta.

LOWER MANNVILLE

The lower Mannville of central Alberta and indeed for much of Western Canada is comprised of predominantly non-marine clastics. The source of clastic material is dominantly from the west, however a stelid provenance (eastern source) is recognized for the eastern and northern portions of Western Canada. Stelid material from both eastern and western sources was carried to and deposited in a centralized drainage system which trended from south to north (Fig. 8.3). Paleotopography on the Canadian Cordillera allowed the Gulfian and Boreal seas to merge. This terminated the post-Mannville strata as they occur in central Alberta. In doing so, several areas of Lower Cretaceous strata (Fig. 8.1) can be related to depositional variations of their stratigraphic equivalents in central Alberta.

3) The informal term Ostracod member is utilized, and indicates the top of the lower Mannville, consists of the w. g. of Glaister (1985); and 8) The terminology of McLean (1982) is utilized in Figure 8.1 for the foothills areas of the basin.

DEPOSITION OF THE LOWER CRETACEOUS SEDIMENTS

A discussion of Lower Cretaceous clastic deposition in Western Canada is preceded here by a description of the Mannville Gp and post-Mannville strata as they occur in central Alberta. In doing so, several areas of Lower Cretaceous strata (Fig. 8.1) can be related to depositional variations of their stratigraphic equivalents in central Alberta.

LOWER MANNVILLE

The lower Mannville of central Alberta and indeed for much of Western Canada is comprised of predominantly non-marine clastics. The source of clastic material is dominantly from the west, however a stelid provenance (eastern source) is recognized for the eastern and northern portions of Western Canada. Stelid material from both eastern and western sources was carried to and deposited in a centralized drainage system which trended from south to north (Fig. 8.3). Paleotopography on the Canadian Cordillera allowed the Gulfian and Boreal seas to merge. This terminated the post-Mannville strata as they occur in central Alberta. In doing so, several areas of Lower Cretaceous strata (Fig. 8.1) can be related to depositional variations of their stratigraphic equivalents in central Alberta.

The overlying Viking Fm of Sliper (1983) is a widespread coarsening upwards sandstone. Reinson (1985) defined the regional coarsening upwards sandstone. Reinson (1985) defined the regional coarsening upwards sandstone.
Figure 8.3. 8th order residual map of the base of Fish Scales to pre-Cretaceous unconformity showing basinl topography prior to deposition of the Lower Cretaceous strata.
muddy sandstone sequences. The uppermost cycle occasionally grades to a clean fine-grained shoreface bar sandstone. He interpreted the regional facies of the Viking Fm to be due to the progradation of nearshore sediments. The Viking Fm of central Alberta is correlated with the Bow Island Fm of southern Alberta (Workman et al., 1960). The Bow Island Fm, which includes the Joint Fm, grades westward into the Blairmore Gp (Fig. 8.3). To the north the Viking Fm is treated as a separate unit, the Stoney Gp.

The most significant recent advance in geophysical hydrocarbon exploration has been the application of seismic modelling techniques. Modelling allows the interpreter to set the geological dimensions and acoustic parameters of strata and to view their seismic response. The iterative process of modelling wellbore data to seismic response has provided a direct link between geology and geophysics, making the interpreter more effective at recognizing the seismic signature of various geological features. This technique has resulted in a better understanding of what can reasonably be defined with a seismic data set and aid in the modification of acquisition parameters accordingly.

Since the late 1960's the reserves of the average new oil and gas well drilled in Western Canada has fallen. This fact is primarily due to the maturity of carbonate plays. Reserves in major carbonate plays such as the Niobrara, Leduc, Clearwater, and Bow Island formations (which have sizeable per well reserves) are being replaced by lesser stratigraphic and reservoir improvement plays.

Depositional environments tend to fall within a range of meandering channel. The channel deposits are interpreted to be part of a braided river system fed by the Bow Island Glauconite A pool which is located approximately 230 km southeast of Calgary. Alberta; 2) heavy oil of Alberta and Saskatchewan; and 3) central and northern Alberta.

**Keswick member**

Lower Cretaceous reservoirs in Western Canada are almost exclusively sandstone in nature, with sandstone reservoirs being the major member of the lower Mannville. The Keswick member can be further subdivided into shallower sandstones and deeper siltstones. Grain size and composition normally occur only as a secondary cement or as lithic fragments in the lower Cretaceous.

**Upper Lower Cretaceous**

The most significant recent advance in geophysical hydrocarbon exploration has been the application of seismic modelling techniques. Modelling allows the interpreter to set the geological dimensions and acoustic parameters of strata and to view their seismic response. The iterative process of modelling wellbore data to seismic response has provided a direct link between geology and geophysics, making the interpreter more effective at recognizing the seismic signature of various geological features. This technique has resulted in a better understanding of what can reasonably be defined with a seismic data set and aid in the modification of acquisition parameters accordingly.

Since the late 1960's the reserves of the average new oil and gas well drilled in Western Canada has fallen. This fact is primarily due to the maturity of carbonate plays. Reserves in major carbonate plays such as the Niobrara, Leduc, Clearwater, and Bow Island formations (which have sizeable per well reserves) are being replaced by lesser stratigraphic and reservoir improvement plays.

Depositional environments tend to fall within a range of meandering channel. The channel deposits are interpreted to be part of a braided river system fed by the Bow Island Glauconite A pool which is located approximately 230 km southeast of Calgary. Alberta; 2) heavy oil of Alberta and Saskatchewan; and 3) central and northern Alberta.

**Figure 8.4. Location map, Bow Island Glauconite A pool** (courtesy, The Grove Company Ltd.)
Figure 8.6. Geological cross-section, Bow Island Glauconite A pool.
Figure 8.7. Seismic section, Bow Island Glauconite A pool.
pool in the Hays - Grand Forks - Bow Island trend which can be confidently delineated with seismic data. Glauconite Sandstone member reservoirs in the Grand Forks Field (T11-R13 W4M) and the Hays field (T12-R13 W4M) commonly have indistinct or weak seismic signatures (B. Sturt, pers. comm., 1987).

Glauconite Sandstone member reservoirs in this area typically have abrupt basal contacts with high angle cross-stratified sandstones, fining and shaling upward sequences, and an absence of both fauna and burrowing, all of which are suggestive of a terrestrial channel regime. The Glauconite A pool is classified as a channel deposit based on physical dimensions and well log signature and correlation. This is consistent with the description of the Glauconite Sandstone member of the Little Bow area (Hopkins et al., 1982) who note a diachronous relationship between the regional and channel facies of the Glauconite Sandstone member.

A threefold subdivision for the Glauconite Sandstone member is defined here to aid in the discussion of the seismic data related to the southern Alberta Mannville pool (subsections 8-1 to 8-5).

These generalized subdivisions are referred to as the: 1) regional facies; 2) channel facies; and 3) non-reservoir channel facies.

1) REGIONAL FACIES (Interchannel Facies)

The regional facies is relatively widespread and consists of a coarsening upward sequence of interbedded shales, siltstones and sandstones. These dominantly argillaceous strata are often horizontallly bedded and bioturbated. These strata are usually interpreted as shallow marine or coastal plain deposits (Jackson, 1985; Hopkins et al., 1982). The regional facies are shown in the 2-3 and 12-11 wells. The regional facies strata in the 14-2 and 8-10 wells mark the subcrop to the Lower Cretaceous, to the north. The Sawtooth Fm is the pre-Cretaceous unconformity and may represent a significant period of non-deposition or erosion (Jackson, 1985). Most or all of the lower Mannville strata (Ellerslie Fm) are absent in the area, presumably due to emergence of the area at that time. As a result, the Glauconite Sandstone member and Rierdon Fm are separated by only a few meters of strata. This interpretation is supported by the Hays field (T11-R13 W4M) who shows a thin Rierdon Fm and no lower Mannville sediments in the pool area (Fig. 8.29). Berry (1974) showed that the channel facies of the Glauconite Sandstone member (Grand Forks Field, T11-R13 W4M) can occur in direct contact with the Rierdon Fm or locally with the Sawtooth Fm. In some areas there is evidence that the reservoir sandstones are sourced from the erosion of predating Lower Mannville and or the Sawtooth Fm (B. Dick, pers. comm., 1988). The occurrence of a high velocity interval separating the channel facies sandstone from the Rierdon Fm may be of significance in the seismic detection of this reservoir. However, the major anomalous velocity contrast appears to be generated by the aggregate low velocity of the channel facies sandstones plus the Rierdon Fm to the higher velocity Sawtooth Fm sandstones (Fig. 8.4). In this example, the high velocity zone at the channel base is partially responsible for an extra peak, however, it is unclear as to whether this is due to the extra channel (laid deposit), or remnant lower Mannville strata (i.e. the Calcarenite member or Ostracoid member).

The pool trends southeast - northwest with paleostrome direction being to the north. Figure 8.4 indicates that the pool is approximately 500 m in width and 2.5 km in length, and is areate on a radius centered to the west of the pool. These characteristics are consistent with the modern point bar sequence of a meandering stream. The southernmost producing wells in the pool, particularly the 11-2-10 W4M, show a marked increase in shale content and may be correlative with the inside of a point bar sequence. Channel facies sandstones in excess of 20 m in thickness are noted in the 4-11-10-13 W4M well. These are interpreted as traceable deposit facies strata. The regional facies are shown in the 2-3 and 12-11 wells. The regional facies strata in the 14-2 and 8-10 wells mark the subcrop to the Lower Cretaceous, to the north. The Sawtooth Fm sandstones, generally thicker in pre-Jurassic erosional lows on the Mississippi unconformity.

The overlying Glauconite Sandstone member shown on the cross-section in the 14-2 and 8-10 wells (Fig. 8.6) is interpreted as channel strata. These fluvial strata (the channel facies) are thought to have been deposited unconformably against the regional facies strata. The regional facies are shown to be productive. The boundary between the Glauconite Sandstone member and the Rierdon Fm is the pre-Cretaceous unconformity and may represent a significant period of non-deposition or erosion (Jackson, 1985). Most or all of the lower Mannville strata (Ellerslie Fm) are absent in the area, presumably due to emergence of the area at that time. As a result, the Glauconite Sandstone member and Rierdon Fm are separated by only a few meters of strata. This interpretation is supported by the Hays field (T11-R13 W4M) who shows a thin Rierdon Fm and no lower Mannville sediments in the pool area (Fig. 8.29). Berry (1974) showed that the channel facies of the Glauconite Sandstone member (Grand Forks Field, T11-R13 W4M) can occur in direct contact with the Rierdon Fm or locally with the Sawtooth Fm. In some areas there is evidence that the reservoir sandstones are sourced from the erosion of predating Lower Mannville and or the Sawtooth Fm (B. Dick, pers. comm., 1988). The occurrence of a high velocity interval separating the channel facies sandstone from the Rierdon Fm may be of significance in the seismic detection of this reservoir. However, the major anomalous velocity contrast appears to be generated by the aggregate low velocity of the channel facies sandstones plus the Rierdon Fm to the higher velocity Sawtooth Fm sandstones (Fig. 8.4). In this example, the high velocity zone at the channel base is partially responsible for an extra peak, however, it is unclear as to whether this is due to the extra channel (laid deposit), or remnant lower Mannville strata (i.e. the Calcarenite member or Ostracoid member).

The pool trends southeast - northwest with paleostrome direction being to the north. Figure 8.4 indicates that the pool is approximately 500 m in width and 2.5 km in length, and is areate on a radius centered to the west of the pool. These characteristics are consistent with the modern point bar sequence of a meandering stream. The southernmost producing wells in the pool, particularly the 11-2-10 W4M, show a marked increase in shale content and may be correlative with the inside of a point bar sequence. Channel facies sandstones in excess of 20 m in thickness are noted in the 4-11-10-13 W4M well. These are interpreted as traceable deposit facies strata. The regional facies are shown in the 2-3 and 12-11 wells. The regional facies strata in the 14-2 and 8-10 wells mark the subcrop to the Lower Cretaceous, to the north. The Sawtooth Fm sandstones, generally thicker in pre-Jurassic erosional lows on the Mississippi unconformity.

The overlying Glauconite Sandstone member shown on the cross-section in the 14-2 and 8-10 wells (Fig. 8.6) is interpreted as channel strata. These fluvial strata (the channel facies) are thought to have been deposited unconformably against the regional facies strata. The regional facies are shown to be productive. The boundary between the Glauconite Sandstone member and the Rierdon Fm is the pre-Cretaceous unconformity and may represent a significant period of non-deposition or erosion (Jackson, 1985). Most or all of the lower Mannville strata (Ellerslie Fm) are absent in the area, presumably due to emergence of the area at that time. As a result, the Glauconite Sandstone member and Rierdon Fm are separated by only a few meters of strata. This interpretation is supported by the Hays field (T11-R13 W4M) who shows a thin Rierdon Fm and no lower Mannville sediments in the pool area (Fig. 8.29). Berry (1974) showed that the channel facies of the Glauconite Sandstone member (Grand Forks Field, T11-R13 W4M) can occur in direct contact with the Rierdon Fm or locally with the Sawtooth Fm. In some areas there is evidence that the reservoir sandstones are sourced from the erosion of predating Lower Mannville and or the Sawtooth Fm (B. Dick, pers. comm., 1988). The occurrence of a high velocity interval separating the channel facies sandstone from the Rierdon Fm may be of significance in the seismic detection of this reservoir. However, the major anomalous velocity contrast appears to be generated by the aggregate low velocity of the channel facies sandstones plus the Rierdon Fm to the higher velocity Sawtooth Fm sandstones (Fig. 8.4). In this example, the high velocity zone at the channel base is partially responsible for an extra peak, however, it is unclear as to whether this is due to the extra channel (laid deposit), or remnant lower Mannville strata (i.e. the Calcarenite member or Ostracoid member).

The pool trends southeast - northwest with paleostrome direction being to the north. Figure 8.4 indicates that the pool is approximately 500 m in width and 2.5 km in length, and is areate on a radius centered to the west of the pool. These characteristics are consistent with the modern point bar sequence of a meandering stream. The southernmost producing wells in the pool, particularly the 11-2-10 W4M, show a marked increase in shale content and may be correlative with the inside of a point bar sequence. Channel facies sandstones in excess of 20 m in thickness are noted in the 4-11-10-13 W4M well. These are interpreted as traceable deposit facies strata. The regional facies are shown in the 2-3 and 12-11 wells. The regional facies strata in the 14-2 and 8-10 wells mark the subcrop to the Lower Cretaceous, to the north. The Sawtooth Fm sandstones, generally thicker in pre-Jurassic erosional lows on the Mississippi unconformity.

The overlying Glauconite Sandstone member shown on the cross-section in the 14-2 and 8-10 wells (Fig. 8.6) is interpreted as channel strata. These fluvial strata (the channel facies) are thought to have been deposited unconformably against the regional facies strata. The regional facies are shown to be productive. The boundary between the Glauconite Sandstone member and the Rierdon Fm is the pre-Cretaceous unconformity and may represent a significant period of non-deposition or ero...
The deepest reflection identified is the Wabamun event. This reflection shows an overall velocity contrast of clean low velocity sandstones with the underlying higher velocity pre-channel strata.

8-2: GRAND FORKS SAWTOOTH WW POOL

INTRODUCTION

The Grand Forks Sawtooth WW Pool is located 200 km southeast of Calgary, Alberta in T12-R13 W4M (Fig. 8.10). This prolific (heavy to medium gravity) oil producing area has been extensively developed under reduced well spacing and high volume 3D techniques. These techniques have led to high volumetric recoveries for moderate gravity crudes (Table 8.2).

The principal reservoir in the Grand Forks area is the Glauconitic Sandstone member. This horizon is the subject of this example, the sandstones of the WW pool are more important than the underlying higher velocity pre-channel strata. The observed signature of Figure 8.7.

The principal reservoir in the Grand Forks area is the Glauconitic Sandstone member. This horizon is the subject of this example, the sandstones of the WW pool are more important than the underlying higher velocity pre-channel strata. The observed signature of Figure 8.7.

The principal reservoir in the Grand Forks area is the Glauconitic Sandstone member. This horizon is the subject of this example, the sandstones of the WW pool are more important than the underlying higher velocity pre-channel strata. The observed signature of Figure 8.7.
Figure 8.12. Geological cross-section, Grand Forks Sawtooth WW pool.
Figure 8.13. Seismic section, Grand Forks Sawtooth WW pool.
Reserves and significant reservoir parameters of the Sawtooth WW pool are shown in Table 8.2. Production data for the pool are depicted in Figure 8.11.

Table 8.2: Reserves and significant reservoir parameters, Grand Forks Sawtooth WW pool (ERCB, 1987)

<table>
<thead>
<tr>
<th>Initial Oil in Place</th>
<th>3030 x 10^6bbl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Recovery Factor</td>
<td>25%</td>
</tr>
<tr>
<td>Additional Secondary Recovery Factor</td>
<td>25%</td>
</tr>
<tr>
<td>Initial Established Reserves</td>
<td>1,240 x 10^6bbl</td>
</tr>
<tr>
<td>Production To Date</td>
<td>555 x 10^6bbl</td>
</tr>
<tr>
<td>Remaining Reserves</td>
<td>704 x 10^6bbl</td>
</tr>
<tr>
<td>Area</td>
<td>560 ha</td>
</tr>
<tr>
<td>Average Pay</td>
<td>3.41 m</td>
</tr>
<tr>
<td>Average Water Saturation</td>
<td>25%</td>
</tr>
<tr>
<td>Oil Density</td>
<td>885 kg/m³</td>
</tr>
<tr>
<td>Average Depth</td>
<td>926.8 m</td>
</tr>
<tr>
<td>Discovery Year</td>
<td>1983</td>
</tr>
</tbody>
</table>

GEOLOGICAL CROSS-SECTION

The west to east geological cross-section Figure 8.12 depicts strata from the Mississippian-aged Peyto Fm through the Lower Cretaceous, Bow Island Fm. The cross-section more or less parallels the seismic section through sections 28 and 29-12-13 W4M and also covers the Grand Forks Upper Mannville B Pool to the west. The two slick water wells depict the relationship of the Glauconite Sandstone member channel facies in the Sawtooth Fm and could in fact share a common aquifer. Both of these wells display the bell shaped fining upward sequence of the Glauconitic Sandstone member channel facies in contrast to the coarsening upwards character of the Sawtooth Fm. A separation of the Sawtooth Fm between the 8-25 and the 9-29 locations is interpreted, based on independent oil-water contacts.

The Sawtooth Fm is laterally persistent up to the location of the 7-30-12-13 W4M well where the zone has been eroded and later replaced with lower Mannville strata. Two wells, 8-29, and 12-28-12-13 W4M are typical of oil wells in the WW pool, which averages 3.4 m of oil pay over water. No associated gas cap occurs with this Sawtooth Fm oil pool.

CONCLUSIONS

The Grand Forks Sawtooth WW pool is formed by a coarsening upwards sandstone which is likely of marine origin. On the assumption that the Sawtooth Fm sandstones are predominantly formed by a marine coarsening upwards sequence, in contrast to the dominantly fining upwards sandstones of the Glauconite Sandstone member channel facies, this pool is classified as a marine sandstone in age. The ERCB has recently reaccessed this and several other pools of the Grand Forks field to the Sawtooth Fm. Recognition of a coarsening upwards cycle as indicative of the marine Sawtooth Fm, and 2) fining upwards sequences in representative of Mannville strata permit a plausible interpretation of the geophysical and geological data.

The seismic signature of the Grand Forks Sawtooth WW pool is provided by a lateral character variation of the data in response to the lateral truncation of the Sawtooth Fm sandstones by lower Mannville erosion.

Figure 8.11. Production data, Grand Forks Sawtooth WW pool.

SEISMIC SECTIONS

The seismic data shown in Figure 8.13 were donated by Oakwood Petroleum Ltd., and are displayed under original processing. Identified on this west to east line are the Wabamun, Mississippian, Sawtooth, Mannville, and Bow Island sandstones. Of particular interest on this data is the lateral character change of the Sawtooth event near trace 50. This peak weakens and cannot be confidently correlated east of this point. This lateral character change correlates with the west to east truncation of the Sawtooth Fm illustrated in Figure 8.12 and thus the absence of the peak at 700 ms is thought to be indicative of pre-Cretaceous erosion of the Sawtooth Fm. As described for the geological section, little or no drape is detected associated with this feature and the seismic signature is principally one of lateral character variation. Identification for the events on this data are shown on Figure 8.14.

Figure 8.15 is a seismic model which was generated utilizing the sonic log from the 8-29 location plus a modification of this log which attempts to replace the stratigraphy of the 7-30 location. A reasonable comparison between the model of Figure 8.15 and the seismic section of Figure 8.13 is observed. Note, however, the diminished amplitude of the Mississippian event as the model where the Sawtooth Fm is absent.

Figure 8.12 and thus the absence of the peak at 700 ms is thought to be indicative of pre-Cretaceous erosion of the Sawtooth Fm. As described for the geological section, little or no drape is detected associated with this feature and the seismic signature is principally one of lateral character variation. Identification for the events on this data are shown on Figure 8.14.

Figure 8.15 is a seismic model which was generated utilizing the sonic log from the 8-29 location plus a modification of this log which attempts to replace the stratigraphy of the 7-30 location. A reasonable comparison between the model of Figure 8.15 and the seismic section of Figure 8.13 is observed. Note, however, the diminished amplitude of the Mississippian event as the model where the Sawtooth Fm is absent.

Figure 8.14. Single well synthetic seismic trace, Grand Forks Sawtooth WW pool.

CONCLUSIONS

The Grand Forks Sawtooth WW pool is formed by a coarsening upwards sandstone which is likely of marine origin. On the assumption that the Sawtooth Fm sandstones are predominantly formed by a marine coarsening upwards sequence, in contrast to the dominantly fining upwards sandstones of the Glauconite Sandstone member channel facies, this pool is classified as a marine sandstone in age. The ERCB has recently reaccessed this and several other pools of the Grand Forks field to the Sawtooth Fm. Recognition of a coarsening upwards cycle as indicative of the marine Sawtooth Fm, and 2) fining upwards sequences in representative of Mannville strata permit a plausible interpretation of the geophysical and geological data.

The seismic signature of the Grand Forks Sawtooth WW pool is provided by a lateral character variation of the data in response to the lateral truncation of the Sawtooth Fm sandstones by lower Mannville erosion.

S-3: THE COUNTESS UPPER MANNVILLE D POOL

INTRODUCTION

The Countess Upper Mannville D pool is located in T18 - R15 SSW, 145 km southeast of Calgary, Alberta, within the confines of the Countess field (Fig. 8.10). The ISMS discovery of this pool was the result of a major statistical well commitment to freehold licenses.
Mannville indicates that the Pekisko Fm was subaerially exposed during a portion of lower Mannville time. Present day dip of the pre-Cretaceous nonconformity is to the northeast, plunging away from the northwest flank of the Sweexglen Arch (Fig. 8.1).

Reserves and significant reservoir parameters for the Countess Upper Mannville D pool are shown in Table 8.3. Productivity data for the pool are shown in Figure 8.17.

Table 8.3: Reserves and significant reservoir parameters, Countess Upper Mannville D pool (ERCL, 1987)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Oil in Place</td>
<td>12000 x 10^3 m³</td>
</tr>
<tr>
<td>Primary Recovery Factor</td>
<td>10%</td>
</tr>
<tr>
<td>Additional Secondary Recovery</td>
<td>35%</td>
</tr>
<tr>
<td>Total Recoverable Reserves</td>
<td>5410 x 10^3 m³</td>
</tr>
<tr>
<td>Cumulative Production to Date</td>
<td>4899.8 x 10^3 m³</td>
</tr>
<tr>
<td>Remaining Recoverable</td>
<td>510 x 10^3 m³</td>
</tr>
<tr>
<td>Area</td>
<td>1538 ha</td>
</tr>
<tr>
<td>Average Pay</td>
<td>4.9 m</td>
</tr>
<tr>
<td>Average Porosity</td>
<td>25%</td>
</tr>
<tr>
<td>Average Water Saturation</td>
<td></td>
</tr>
<tr>
<td>Oil Density</td>
<td>994 kg/m³</td>
</tr>
<tr>
<td>Average Depth</td>
<td>1122 m</td>
</tr>
<tr>
<td>Discovery Year</td>
<td>1967</td>
</tr>
</tbody>
</table>

The geological cross-section (Fig. 8.18) parallels both the schematic section of McCoy and Moritz (1982) and the presented seismic section (Fig. 8.19). This cross-section across the Countess Upper Mannville D and O pools perpendicular to their depositional strike and to regional dip. Due to space restrictions the well logs have not been spaced directly over their respective locations along the seismic line.

The lowest identified formation on the cross-section is the Pekisko Fm. Lentic structural dip is ± 30 ° on the unconformity beneath parts of this pool and results in proportionate lower Mannville thinning. Regional mapping of the Mannville Gp thickness shows the pool to be located on a moderate thin of 130 m as opposed to areas of severe pre-Cretaceous erosion which show Mannville Gp isopachs approaching 190 m. Extreme lower Mannville thinning occurs at the 12-18 location where the Bantry shale lies almost directly on the Pekisko Fm.

Farshori (1983) used a fourfold subdivision of the Ostroaz (A.B.C.D) and a twofold subdivision of the channel facies sandstones to describe the pool and its setting. He described cycle A through D as representing a regressive sequence which resulted from the filling of an extensive "Ostracod" lake in southern Alberta. Cycle A is the Bantry shale, a benthonic, low velocity shale. Cycle B is a brown fossiliferous limestone, which is commonly referred to as the Ostroaz member, while cycles C and D are a bioturbated shale and white sandstone respectively. The units are interpreted as a regressive sequence of sedimentation: 1) below wave-base; 2) lower shoreface; 3) middle shore; and 4) upper shoreface. The C and D cycles of Farshori (1983) are considered to be part of the regional facies of the Glaucoclastic Sandstone member here.

Farshori (1983) subdivided the Glaucoclastic Sandstone member into an upper and lower unit based on textural characteristics and paleontology. He described a distinct channel facies for both of the sandstone units, and suggested deposition occurred in a northwest draining channel system, approximately one kilometre wide and 3 to 12 m deep.

Due to lack of core study in this subsection the subdivisions suggested by Farshori (1983), cannot be replicated. However, the lowermost unit (A cycle or Bantry shale) is shown in all wells on the cross-section. The two off-channel wells are thought to represent a complete and uninterrupted A through D Ostracod sequence, whereas the three displayed channel wells represent the upper and lower Glaucoclastic Sandstone member channel facies sandstone units with an undetermined portion of the B, C and D Ostracod member units having eroded.

SEISMIC SECTION

The seismic data (Fig. 8.19) were donated by PanCanadian Petroleum Ltd. and reprocessed courtesy of Exploration Scientific Services Ltd. The line is oriented southwest to northeast, perpendicular to the strike of the Upper Mannville D pool (Fig. 8.18). Identification for the line is the location of a low-velocity structure in Figure 8.20. The lowest event indicated on the seismic section is the Pekisko Fm. Paleozoic strata in this area are exposed to the Mannville Gp rather than Jurassic strata. The top of the Pekisko event is identified as a peak, and is characterized by erosional relief. This event is 5 to 10 m time-structurally high in the vicinity of the D pool (traces 101-221) and occurs with coincident Mannville thinning.

Consistent with this relief there is a notable variation in the trough overlying the peak marking the Pekisko Fm.

The upper Mannville, Glaucoclastic Sandstone member of the D pool is described by Farshori (1983) and Herlany (1974) as channel facies sandstones, although McCoy and Moritz (1982) considered the deposition of reservoir strata and hydrocarbon entrapment.

In the immediate vicinity of the pool, cuesta like relief is formed in an area where geological studies had shown significant potential (McCoy and Moritz, 1982). Their study consisted of a 26 township area (2500 km²) containing about one well for every 16 sections. The authors state that geophysical methods available at that time were of little help in delineating the subtle elastic stratigraphic traps they envisioned.

The upper Mannville, Glauconitic Sandstone member of the D pool is described by Farshori (1983) and Herbaly (1974) as channel facies sandstones. Although McCoy and Moritz (1982) considered the deposition of reservoir strata and hydrocarbon entrapment, their study consisted of a 26 township area (2500 km²) containing about one well for every 16 sections. The authors state that geophysical methods available at that time were of little help in delineating the subtle elastic stratigraphic traps they envisioned.

The authors state that geophysical methods available at that time were of little help in delineating the subtle elastic stratigraphic traps they envisioned.

The upper Mannville, Glauconitic Sandstone member of the D pool is described by Farshori (1983) and Herbaly (1974) as channel facies sandstones. Although McCoy and Moritz (1982) considered the deposition of reservoir strata and hydrocarbon entrapment, their study consisted of a 26 township area (2500 km²) containing about one well for every 16 sections. The authors state that geophysical methods available at that time were of little help in delineating the subtle elastic stratigraphic traps they envisioned.

The upper Mannville, Glauconitic Sandstone member of the D pool is described by Farshori (1983) and Herbaly (1974) as channel facies sandstones. Although McCoy and Moritz (1982) considered the deposition of reservoir strata and hydrocarbon entrapment, their study consisted of a 26 township area (2500 km²) containing about one well for every 16 sections. The authors state that geophysical methods available at that time were of little help in delineating the subtle elastic stratigraphic traps they envisioned.

The upper Mannville, Glauconitic Sandstone member of the D pool is described by Farshori (1983) and Herbaly (1974) as channel facies sandstones. Although McCoy and Moritz (1982) considered the deposition of reservoir strata and hydrocarbon entrapment, their study consisted of a 26 township area (2500 km²) containing about one well for every 16 sections. The authors state that geophysical methods available at that time were of little help in delineating the subtle elastic stratigraphic traps they envisioned.

The upper Mannville, Glauconitic Sandstone member of the D pool is described by Farshori (1983) and Herbaly (1974) as channel facies sandstones. Although McCoy and Moritz (1982) considered the deposition of reservoir strata and hydrocarbon entrapment, their study consisted of a 26 township area (2500 km²) containing about one well for every 16 sections. The authors state that geophysical methods available at that time were of little help in delineating the subtle elastic stratigraphic traps they envisioned.

The upper Mannville, Glauconitic Sandstone member of the D pool is described by Farshori (1983) and Herbaly (1974) as channel facies sandstones. Although McCoy and Moritz (1982) considered the deposition of reservoir strata and hydrocarbon entrapment, their study consisted of a 26 township area (2500 km²) containing about one well for every 16 sections. The authors state that geophysical methods available at that time were of little help in delineating the subtle elastic stratigraphic traps they envisioned.

The upper Mannville, Glauconitic Sandstone member of the D pool is described by Farshori (1983) and Herbaly (1974) as channel facies sandstones. Although McCoy and Moritz (1982) considered the deposition of reservoir strata and hydrocarbon entrapment, their study consisted of a 26 township area (2500 km²) containing about one well for every 16 sections. The authors state that geophysical methods available at that time were of little help in delineating the subtle elastic stratigraphic traps they envisioned.

The upper Mannville, Glauconitic Sandstone member of the D pool is described by Farshori (1983) and Herbaly (1974) as channel facies sandstones. Although McCoy and Moritz (1982) considered the deposition of reservoir strata and hydrocarbon entrapment, their study consisted of a 26 township area (2500 km²) containing about one well for every 16 sections. The authors state that geophysical methods available at that time were of little help in delineating the subtle elastic stratigraphic traps they envisioned.

The upper Mannville, Glauconitic Sandstone member of the D pool is described by Farshori (1983) and Herbaly (1974) as channel facies sandstones. Although McCoy and Moritz (1982) considered the deposition of reservoir strata and hydrocarbon entrapment, their study consisted of a 26 township area (2500 km²) containing about one well for every 16 sections. The authors state that geophysical methods available at that time were of little help in delineating the subtle elastic stratigraphic traps they envisioned.

The upper Mannville, Glauconitic Sandstone member of the D pool is described by Farshori (1983) and Herbaly (1974) as channel facies sandstones. Although McCoy and Moritz (1982) considered the deposition of reservoir strata and hydrocarbon entrapment, their study consisted of a 26 township area (2500 km²) containing about one well for every 16 sections. The authors state that geophysical methods available at that time were of little help in delineating the subtle elastic stratigraphic traps they envisioned.
Figure 8.18. Geological cross-section, Countess Upper Mannville D pool.
Figure 8.19. Seismic section, Countess Upper Mannville D pool.
changes from a broad doublet to a single trough across the high, as a result of lower Mannville thinning. Unlike the Bow Island corresponding lower Mannville thinning, occurs from trace 330 to 440 on the seismic data. The time-structural low between traces 290 through 310 could be interpreted as non-reservoir channel fill. This sequence is diagrammatically represented in Figure 8.22. Several wells immediately west of the channel facies produce from the thin sandstones of the regional facies. It is uncertain as to whether these wells are in hydraulic communication with the channel facies or if the channel acts as a trap.

46.7 x 10^3 m^3

1114 m

273 ha

6.4 m

232

64,602

105

Figure 8.21. Location map, Badger Upper Mannville B pool (courtesy, The Geobase Company Ltd.).

Figure 8.23. Production data, Badger Upper Mannville B pool.

Figure 8.25. Location map, Little Bow and Retlaw pools (modified from T.16, Mannville Upper).
upper Mannville channeling. The Glauconitic Sandstone member in the non-reservoir channel facies does not exhibit the same porosity and permeability as the sandstones of the channel facies and are generally shaly and silty sandstones. No direct relationship is observed between pre-Cretaceous structure and the location of the channel facies. However, post-depositional structure at the Glauconitic Sandstone member level is controlled by compaction of the underlying lower Mannville strata across the pre-Cretaceous unconformity.

Further discussion of deposition of the Glauconitic Sandstone member is presented in Hopkins et al. (1982) and Hradsky and Griffin (1984).

SEISMIC SECTION

Seismic data for the Badger Upper Mannville B pool were donated by Bow Valley Industries Ltd. and are displayed in reprocessed format courtesy of Poco Petroleums Ltd. The seismic line (Fig. 8.25) is oriented west to east along the southern edge of section 24-16-18 W4M. This line crosses the regional facies, the channel facies, and possibly the non-reservoir channel facies of the Glauconitic Sandstone member. Identification of the seismic events are shown on Figures 8.26.

The regional facies which is characterized by the presence of the underlying Bantry shale, consists of thinly bedded marine sandstones and shales. The seismic signature of this unit is recognized to the west of trace 145 (at about 700 ms) and in descending order, consists of a weak peak (regional facies event), followed by a strong trough (lower Mannville event) and strong peak (Mississippian event).

The channel facies anomaly occurs between traces 145 and 57 and is characterized by both the absence of the regional facies event and a broad trough at the Glauconitic - Bantry - lower Mannville event. Both effects are due to the additive low velocities of the channel facies and the Bantry shale. East of trace 57 the signature of the non-reservoir channel facies is illustrated. This seismic signature is not distinguishable from the regional facies, and an absence of well control on this portion of the line leaves some uncertainty as to the existence of the non-reservoir channel facies at this location.

Time structural relief of 5 to 10 ms is observed along the Mannville Gp reflection, on the eastern portion of the line (Fig. 8.25). This structure is not coincident with the occurrence of the previously described channel facies anomaly. Time structural relief also occurs along the Pekisko Fin reflector (peak at 800 ms) coincident with the pool. This observed time relief occurs in conjunction with a character change along the Pekisko reflector and could be partially generated by tuning.

A seismic model utilizing sonic logs for wells in the regional facies, channel facies and non-reservoir channel facies is shown on Figure 8.26. This model replicates the anomalous feature observed on the seismic section (Fig. 8.25).

CONCLUSIONS

The Badger Upper Mannville B pool is formed by an upper Mannville channel sandstone which is detectable with seismic data. Recognition of the reservoir is dependent on the frequency content and more importantly proper phase correction of the seismic data. The seismic signature is due to the lateral contrast of low velocity channel facies sandstones with higher-velocity regional facies strata, and the constructive interference of the low-velocity channel facies and the low-velocity Bantry shale reflection.

8-5: TABER MANNVILLE A POOL

INTRODUCTION

The Taber Mannville A pool is located in T9 - R17 W4M, about 180 km southeast of Calgary, Alberta (Fig. 8.26) within a wide pre-Cretaceous erosional cut and illustrates the entrapment of oil in the lower Mannville, Taber Sandstone member channel. These sandstones fill a north to south trending pre-Cretaceous low termed the Cut Bank Valley (Hayes, 1986). This valley trends northward and could join the Spirit River valley of McLean (1977), as suggested by Jackson (1985, p. 45, Fig. 19). The informal term "Taber Sandstone"
Figure 8.24. Geological cross-section, Badger Upper Mannville B pool.
Figure 8.31. Geological cross-section, Taber Mannville A pool.
Figure 8.32. Seismic section, Taber Mannville A pool.
the Taber Sandstone member in this area. The first style, as illustrated by the A pool, is structural closure on the Taber Sandstone member which is post-depositional in age. Other economically significant reservoirs occur where the Taber Sandstone member is truncated in an updip position by the non-reservoir channel facies of the Glauconitic Sandstone member or are terminated by pinchout against the valley edge. Hradsky and Griffin (1984) also described trapping by lateral facies changes within the Taber Sandstone member due to late channeling and associated non-reservoir channel facies strata. The Taber Mannville A pool is positioned near the central axis of the Cut Bank Valley (Hayes, 1986). His mapping showed that the pool is located in an isopach thick where the lower Mannville and Taber Sandstone member isopachs are 40 and 25 m respectively (Fig. 8.29). Subcrop in the area of the pool is formed by the Blierdon Fm. The Swift Fm, which is present in the vicinity of the pool, is preserved to the east where it forms the edge of the Cut Bank Valley (Hayes, 1986).

Taylor (1984) described a significant Mississippian low and lower Mannville thick in this area which he termed the Taber Low. This low is slightly narrower than that described by Hayes (1986). Taylor’s data supports pre- and post-Tabor karsting of Mississippian limestone and lower Mississippian strata as a cause of the valley and source of local structure within the channel. This postulated trapping mechanism is schematically depicted in Figure 8.31.

Strata of the Taber Sandstone member are described by Hayes (1986) as “predominantly quartz and chert sandstone, most commonly medium-grained but ranging from very fine to coarse with conglomerate beds, a lack of marine fossils, locally abundant mudstones, rip up clasts, a predominance of massive bedding and planar cross-bedding, abundant sourcing and facing upward sequences” (Hradsky and Griffin, 1984). Proposed a braided stream environment for this unit. Reserves and significant reservoir parameters for the Taber Mannville A pool are shown in Table 8.5. Production data for the pool are shown in Figure 8.33.

Table 8.5: Reserves and significant reservoir parameters, Taber Mannville A pool (ERCB, 1987)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Oil in Place</td>
<td>1140 x 10^3 m³</td>
</tr>
<tr>
<td>Primary Recovery Factor</td>
<td>20%</td>
</tr>
<tr>
<td>Total Recovered Reserves</td>
<td>228 x 10^3 m³</td>
</tr>
<tr>
<td>Cumulative Production</td>
<td>2068 x 10^3 m³</td>
</tr>
<tr>
<td>Remaining Reserves</td>
<td>18.2 x 10^3 m³</td>
</tr>
<tr>
<td>Area</td>
<td>364 ha</td>
</tr>
<tr>
<td>Average Pay Thickness</td>
<td>3.37 m</td>
</tr>
<tr>
<td>Average Porosity</td>
<td>21%</td>
</tr>
<tr>
<td>Water Saturation</td>
<td>35%</td>
</tr>
<tr>
<td>Oil Density</td>
<td>921 kg/m³</td>
</tr>
<tr>
<td>Mean Function Thickness</td>
<td>965 m</td>
</tr>
<tr>
<td>Discovery Year</td>
<td>1944</td>
</tr>
</tbody>
</table>

Figure 8.28. Location map, Taber Mannville A pool (courtesy, The Geobase Company Ltd).

Figure 8.29. Isopach of the Taber Sandstone member in the vicinity of the Taber Mannville A pool (from Hayes, 1986).

Figure 8.30. Schematic geological cross-section of the Lower Cretaceous strata in the vicinity of the Taber Mannville A pool.

Figure 8.31. Schematic geological cross-section of the Lower Cretaceous strata in the vicinity of the Taber Mannville A pool.
8-6: WESTHAZEL G.P. SAND POOL

INTRODUCTION

The Westhazel G.P. Sand pool is located in T50 – R22 W3M approximately 75 km east of Lloydminster, Saskatchewan (Fig. 8.35). The pool illustrates the trapping of heavy oil where the normal monomictic south-west dip is locally reversed as a result of dissolution of the underlying Prairie Evaporite Fm salt. This pool is an excellent model in that it illustrates the relationship between the period of salt dissolution and the resultant lateral thickening of overlying strata.

The Westhazel pool, (specifically sections 33,34 and 35-50-22 W3M) produces from the sandstones of the General Petroleums (G.P.) and the Sparky members (Mannville Gp.). The G.P. member (Fig. 8.1) is placed in the informal middle Mannville Gp. subdivision of Vigneron (1977) and Puman (1982). Their subdivision which includes the Sparky, Rex, G.P., and Lloydminster members in the middle Mannville, is based on the conclusion that all of these strata share a dominantly marine genesis. This example is not an exception to this generalization.

CONCLUSIONS

The Taber Mannville A pool is located in a substantial north to south trending low termed the Cut Bank Valley (Hayes, 1986). This structural closure is mapped on the Taber Sandstone member across the pool. This closure is likely due to a remnant Mississippian high. The Geobase Company Ltd).

While during the dissolution of the Prairie Evaporite Fm in this area it was observed that the structure is post-Mississippian and possibly Upper Cretaceous or later in origin. On this basis it was concluded that most of the oil entrapped in the G.P. member migrated into place in post-Mississippian time. Possible traps could therefore occur in other areas of Saskatchewan where porous Devonian and Mississippian strata cross this dissolutional edge. Broughton (1978) indicated that Paleocene coals are thickest over areas of salt dissolution and concluded that dissolution of the Prairie Evaporite Fm continued until at least post-Paleocene in southern Saskatchewan. A summary of the reserves and significant reservoir parameters for the Westhazel G.P. Sand pool are given in Table 8.6. Production data for this pool are displayed in Figure 8.37.

Figure 8.35. Location map, Westhazel G.P. Sand pool (courtesy, The Geobase Company Ltd.).

Original Oil in Place

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6,031</td>
<td>10^6 m^3</td>
</tr>
</tbody>
</table>

Estimated Primary Recovery

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1%</td>
<td></td>
</tr>
</tbody>
</table>

Initial Established Reserves

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>247</td>
<td>10^6 m^3</td>
</tr>
</tbody>
</table>

Production to Dec 31/85

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>10^6 m^3</td>
</tr>
</tbody>
</table>

Remaining Reserves

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>192</td>
<td>10^6 m^3</td>
</tr>
</tbody>
</table>

Developed Area

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>244</td>
<td>ha</td>
</tr>
</tbody>
</table>

Average Pay

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>8.0</td>
<td>m</td>
</tr>
</tbody>
</table>

Average Porosity

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>35%</td>
<td></td>
</tr>
</tbody>
</table>

Average Water Saturation

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>30%</td>
<td></td>
</tr>
</tbody>
</table>

Oil Density

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>977</td>
<td>kg/m^3</td>
</tr>
</tbody>
</table>

Average Depth

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>485</td>
<td>m</td>
</tr>
</tbody>
</table>

Discovery Year

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td></td>
</tr>
</tbody>
</table>

GEOLOGICAL CROSS-SECTION

Figure 8.36 is a west to east five well cross-section from the Westhazel G.P. Sand pool. A significant structural feature noted on the cross-section is the current dip of the Mannville Gp. strata which is in contrast to the general southwestern dip of the Western Canada Sedimentary Basin. This dip reversal is attributed to dissolution of the Prairie Evaporite Fm salt.

Sandstones of the G.P. member are uniformly thick on well logs except in the 32-34 location where they are replaced by a post-G.P. member shale filled channel, similar to that described by Vigrass (1977). This erosional feature is not essential to the trapping of
Figure 8.38. Geological cross-section, Westhazel G.P. Sand pool.
Figure 8.39. Seismic section, Westhazel G.P. Sand pool.
The seismic data for the Westhazel pool (Fig. 8.39) were donated by Husky Oil Operations Ltd. and reprocessed by Seistar Geophysical Ltd. This 5 km long line (24 fold, P-shooter energy source) was acquired in 1985 to aid in the exploration and development of the Westhazel pool. The line is divided into three portions on the basis of character patterns: 1) east portion; 2) west portion of the line (Prairieos); and 3) west portion of the line (Mesozoics). Event identifications are shown on the synthetic seismic trace of Figure 8.40.

A) EAST PORTION

The eastern portion of this line (traces 1-190) illustrates the total dissolution of the Prairie Evaporite Fm salts. The Prairie Evaporite event is absent on the right side of the line, but is present and labelled on the left hand side of Figure 8.39. The eastern portion of the line is typified by normal monoclinal dip to the southwest with no significant localized interval changes.

The uniformity of bed thickness and uniform depositional style noted in the Mannville Gp on this cross-section are evidence that these strata were deposited in a flat and relatively stable environment. On the basis of these observations it is concluded that present day structure is principally post-depositional in origin. Furthermore, the absence of interwell unit thickening at the Spinney Hill and St. Walburg intervals suggests that the structure probably postdates the deposition of these units.

B) WEST PORTION - PALEOZOIC

Paleozoic sediments on the west portion of the line (520 to 990 ms, traces 190-420) gradually thicken to the east. A 50 ms change in the total Paleozoic interval indicates the gradual westward thickening of the Prairie Evaporite Fm, and coincides with time-structural relief along the pre-Cretaceous unconformity events. The unconformity exhibits local undulating relief at the subcropping Beaverhill Lake Gp and dip reversal dip to the east over the larger area (traces 190-420, Fig. 8.39). This dip reversal is the structural element which provides closure for the Mesozoic horizons. The numerous rapidly changing events and diffractions in the 450 to 750 ms interval are associated with the partial dissolution of the Prairie Evaporite Fm salts and the resulting collapse features.

C) WEST PORTION - MESOZOIC

The Mesozoic interval on the western portion of this line (Fig. 8.39, above 520 ms and traces 420-200) shows dip reversal similar to that previously described for the Paleozoic. Of note is the absence of significant lateral thickening within the Mannville Gp interval along this line, suggesting that structure due to dissolution is post-Mannville in origin.

A minor feature is noted at the G.P. interval (traces 290-250 at 530 ms) which is coincident with the 12-34 well (Fig. 8.38). This feature is the seismic expression of a shale filled G.P. channel. The Mesozoic interval on the western portion of this line (Fig. 8.39) above 520 ms and traces 450-200) shows dip reversal similar to that previously described for the Paleozoic. Of note is the absence of significant lateral thickening within the Mannville Gp interval along this line, suggesting that structure due to dissolution is post-Mannville in origin.

CONCLUSIONS

The Westhazel G.P. Sand pool illustrates the structural trapping of hydrocarbons in Lower Cretaceous strata as a result of dip reversal due to salt dissolution. These data also illustrate the seismic gravity data.

Figure 8.42 is a gravity line covering the same area as the seismic section of Figure 8.39. These data whose location is shown in Figure 8.35 were donated by Wild Rose Gravity Exploration and were interpreted by Dr. J. Hulten and Young, 1984). Shown with the data of Figure 8.39 are regional gravity envelope interpretations for a full salt and a no salt section. Note the gradual change in the gravity response over the dissolutional area and the similarity of this slope to the dip measured by the seismic data. This style of dissolutional edge is very similar to that of Smith et al. (1984) shown in Figure 8.42.

Figure 8.41 is a gravity line covering the same area as the seismic section of Figure 8.39. These data whose location is shown in Figure 8.35 were donated by Wild Rose Gravity Exploration and were interpreted by Dr. J. Hulten and Young, 1984). Shown with the data of Figure 8.39 are regional gravity envelope interpretations for a full salt and a no salt section. Note the gradual change in the gravity response over the dissolutional area and the similarity of this slope to the dip measured by the seismic data. This style of dissolutional edge is very similar to that of Smith et al. (1984) shown in Figure 8.42.

Figure 8.42. Single well synthetic seismic trace, Westhazel G.P. Sand pool.

Figure 8.43 is a gravity line covering the same area as the seismic section of Figure 8.39. These data whose location is shown in Figure 8.35 were donated by Wild Rose Gravity Exploration and were interpreted by Dr. J. Hulten and Young, 1984). Shown with the data of Figure 8.39 are regional gravity envelope interpretations for a full salt and a no salt section. Note the gradual change in the gravity response over the dissolutional area and the similarity of this slope to the dip measured by the seismic data. This style of dissolutional edge is very similar to that of Smith et al. (1984) shown in Figure 8.42.
Seismic data is an aid in determining the dissolution history,ing the seismic signature of the pools of this subsection. They are:ground level gravity data is demonstrated, showing the applicabilityT38 R1 W4M. These strata, which are also known as the McLarenFigure 8.41. Gravity data, Westhazel G.P. Sand pool (courtesy,of Calgary, Alberta (Fig. 8.43). The pool is part of a channel faciesFigure 8.43. Location map, Provost Upper Mannville BB pool and otherexamples of this chapter. This subdivision should be regarded as anoversimplification of Wrightman et al. (1987) and Putnam and Oliver (1980).

8-7: PROVOST UPPER MANNVILLE BB POOL

INTRODUCTION

The Provost Upper Mannville BB pool is an upper Mannville channel facies reservoir located in T36 - R1 W4M, some 400 km east of Calgary, Alberta (Fig. 8.43). The pool is part of a channel facies trend which extends northward in T36, T37 and T38 R1 W4M. These strata, which are also known as the McLaren member (Gross, 1980), are part of the informal upper Mannville subdivision of Vigrass (1973) and Putnam (1982). Putnam and Oliver (1980) concluded that it is difficult to distinguish between the Cochrane, McLaren and Vigrass members of the upper Mannville on a regional basis due to their similarity and therefore a twofold subdivision of a singular upper Mannville unit is utilized in describing the seismic signature of the pools of this subsection. They are:

1) Regional facies sandstones - these strata are thought to be thecontemporaneous overbank, crevasse splay, swamp, marsh, lake, and mud deposits that accompanied the higher energy channel facies sandstones. These strata are exposed at depth in Provost and Oliver (1982) who denoted them as the B and C facies of the McLaren and Sparky members, respectively, and

2) Channel facies sandstones - these strata are the A facies ofProvost and Oliver (1982) and are generally thick, facing upward sandstones with abrupt basal contacts, rip up clasts and high angle cross-stratification. These strata are formed by the stacking of multiple paleochannels (Wrightman et al. 1987). Note however, that the subdivision presented herein is utilized in order to simplify the description of the seismic signature for Provost Upper Mannville BB pool and other examples of this chapter. This subdivision should be regarded as an oversimplification of Wrightman et al. (1987) and Putnam and Oliver (1980).

The Provost Upper Mannville B Pool is an upper Mannville sandstone facies reservoir located in T35 - R1 W4M, some 400 km east of Calgary, Alberta (Fig. 8.44). The pool is located at the northern end of an oil bearing channel trend that is mapped as a single channel facies (the Provost Upper Mannville B Pool) in T36 and T37 - R1 W4M (Gross, 1980). To the north this single channel sandstone splits into three separate, mappable channel facies deposits which form the Provost Upper Mannville BB, BB and PPP pools. This threefold separation of the channel deposited sandstones could indicate diversions as the channel flow slows on meeting the shoreline. These pools are all formed by elongated "shoe string" type deposits which are generally less than 1.5 km in width.

The three channel facies pools are located in an area of a Mannville Cip thin, marked by an absence of lower Mannville strata and the Nisku Fm subcrop. This area is referred to as the Bodo high and is accentuated to the north by the lower Mannville Edmonton Channel (Williams, 1963), where a full Dina member sandstone is deposited on subcrop which is eroded down to the Cretaceous and Cenozoic formations.

The upper Mannville sediments are separated from the middleMannville Sparky member by a laterally continuous shale unit and are overlain by the Joli Fou Fm. Laterally the three upper Mannville channel sandstone facies deposits are separated by a laterally continuous interbedded sandstones and shales of the regional facies. These upper Mannville channel deposits all show abrupt basal contacts and fining upwards sequences which grade upwards to non-reservoir strata. Reserves and significant reservoir parameters for the Provost Upper Mannville BB pool are listed in Table 8.7. Productivity data for this pool is illustrated in Figure 8.44.

<p>| Table 8.7: Reserves and significant reservoir parameters, Provost Upper Mannville BB pool (ERCB, 1987). |</p>
<table>
<thead>
<tr>
<th>Initial Oil in Place</th>
<th>Primary Recovery Factor</th>
<th>Total Established Recoverable Reserves</th>
<th>Cumulative Production</th>
<th>Remaining Established Reserves</th>
<th>Average Pay Thickness</th>
<th>Mass Formation Depth</th>
<th>Discovery Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>7,890 x 10^3 m³</td>
<td>10%</td>
<td>7,984 x 10^3 m³</td>
<td>263.7 x 10^3 m³</td>
<td>534.3 x 10^3 m³</td>
<td>8.53 m</td>
<td>755 m</td>
<td>1977</td>
</tr>
</tbody>
</table>

GEOLGICAL CROSS-SECTION

Figure 8.45 is a west to east geological cross-section which parallels the seismic line of Figure 8.46. This geological crosssection does not extend to the west to intersect the previously described lower Mannville Edmonton Channel complex, and thus is restricted to an area typified by the Nisku Fm subcrop and the absence of the Dina member. The upper Mannville channel complex is composed of three distinct vertical channel facies units which are offset by regional facies sediments. Gross (1980) suggests that these off-channel sediments predate the channel fill, noting that the channel of the more southerly B pool (T36 - R1 and T37 - R1 W4M) incises west into the middle Mannville sediments.

The channel facies outlined in wells of this cross-section (8-19, 1-20, T231) all show a characteristic abrupt channel base and evidence of a facing upward sequence on the SE curve. Gross (1980) described these reservoir sandstones as "fine to medium grained fairly well sorted with shale rip up clasts", and shows that both single and multiple, laterally accreting deposits occur in different parts of the pool. Note also that the wells of Figure 8.45 do not incise the middle Mannville strata as do some of the wells shown in Gross (1980). The rather cryptically "shallow" oil depth by depth channels illustrated in this subsection may indicate a lower energy regime in the channel complex northward from the area studied by Gross (1980).
Figure 8.45. Geological cross-section, Proven Upper Mannville
SSS, BB and PPP pools.
VELOCITY (Km/sec)

4.87 Single well synthetic seismic trace, Provost Upper Mannville SSS, BB and PPP pools.

no major time-structural or interval thickening features other than pre-Cretaceous erosional relief are noted. West of trace 287, the pre-Cretaceous subcrop is the Leduc Fm. Mannville interval time thickening here corresponds to the presence of the Dina member. To the east the thinning of the Mannville time interval coincides with the time structural high of the pre-Cretaceous unconformity and the Nisku Fm subcrop.

Three separate channel facies anomalies are observed between traces 237 to 261, 127 to 159 and 87 to 83, which are the seismic signatures of the SSS, BB and PPP pools respectively. These three areas exhibit an increase in both sharpness and amplitude in the trough to peak cycle directly under the Mannville Gp event. The increased amplitude on the peak is due to the velocity contrast between the low velocity channel facies sandstones and the strata which directly underlie the channel facies. Laterally, in the regional facies strata, this velocity contrast is much weaker. A slight upward convex shape occurs in the trough to peak sequence of the three anomalies. This effect could be due to differential compaction of channel facies to regional facies strata, with the latter showing a higher degree of compaction; however, this structure is not replicated at the Mannville event.

CONCLUSIONS

The Provost upper Mannville SSS, BB and PPP pools are typical of the upper Mannville channels of eastern Alberta described by Pottam and Oliver (1985) and Gross (1985). The seismic signature, however, is not consistent with that of the Colony member example of this test (Hair Hills Colony W pool) or the observations of Focht and Baker (1983). Three possible factors which could contribute to this difference are:

1) The channel facies sandstones of this subsection are capped by thicker upper Mannville strata, and are thinner than the previously cited examples. This fact may explain the absence of discernable drape along the Mannville event, (whereas drape is a noted characteristic of the data in Focht and Baker (1983));

2) The channel facies sandstones of this example are oil bearing whereas those of Focht and Baker (1985) are principally gas bearing reservoirs, a fact that could contribute to some character differences; and

3) Near surface geological conditions in the pool vicinity detracted from the data quality of this line and the application of an FK filter was required to clarify these anomalies.

8-8: HAYTER DINA B POOL

INTRODUCTION

The Hayter Dina B pool straddles the fourth meridian in T40 - R1 W4M, approximately 340 km east of Edmonton, Alberta (Fig. 8.48), and occurs within the confines of the Edmonton Channel complex of Williams (1963). The example depicts heavy oil entrapment in the Dina member sandstone of the Mannville Gp. The Dina member is typically a thick sequence of stacked channel facies sandstones whose east to west depositional axis are partially controlled by pre-Cretaceous structural relief. The fitting upwards characteristic of these sandstones can adversely effect oil production. Poresizes of 300 and pore-thickness commonly on the order of 15 µ lead to volumetrically large in place reserves of 37 630 x 10 3 m 3 of oil which are subject to a low recovery factor of 2% due to their high viscosity.

One west to east cross-deption depicting the reservoir, the trapping mechanism and an adjacent pool to the east (the Eyehill Cummings Sand Pool) is shown. The two seismic sections, one east to west and one north to south, illustrate the seismic signatures of the Dina member and the pool trap. Productivity data for the Hayter Dina B pool are shown in Figure 8.49 and reserves and reservoir parameters are summarized in Table 8.8.
Table 8.8: Reserves and significant reservoir parameters, Hayter Dina B pool (ERCB, 1987)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Oil in Place</td>
<td>37,630 x 10^3 m³</td>
</tr>
<tr>
<td>Primary Recovery Factor</td>
<td>75%</td>
</tr>
<tr>
<td>Total Initial Established Reserves</td>
<td>755 x 10^3 m³</td>
</tr>
<tr>
<td>Cumulative Production</td>
<td>424.3 x 10^3 m³</td>
</tr>
<tr>
<td>Remaining Established Reserves</td>
<td>328.7 x 10^3 m³</td>
</tr>
<tr>
<td>Average Pay Thickness</td>
<td>11.24 m</td>
</tr>
<tr>
<td>Average Porosity</td>
<td>29%</td>
</tr>
<tr>
<td>Average Water Saturation</td>
<td>14</td>
</tr>
<tr>
<td>Oil Density</td>
<td>965 kg/m³</td>
</tr>
<tr>
<td>Mean Formation Depth</td>
<td>778.5 m</td>
</tr>
<tr>
<td>Discovery Year</td>
<td>1969</td>
</tr>
</tbody>
</table>

GEOLOGICAL CROSS-SECTION

Figure 8.50 is a west to east geological cross-section showing the relationships between the Dina member of the Hayter Dina B pool, the pool trapping mechanism and the Eyhill Cummings pool (Fig. 8.48). The lowest horizon identified is the subcropping Leduc Fm. Substantial erosional relief on the Leduc has a direct effect on the thickness and orientation of the Dina member sandstone, however this is not the sole controlling element on deposition of this unit.

Figure 8.50 shows four wells which intersect the Dina member at different depths. A hydraulic separation between the two oil pools is shown on this diagram, but is tenuous in that the oil-water contacts of the two pools are of similar structural elevations. Also note that the mapping of exact oil-water contacts in heavy oil areas is difficult due to the existence of long transition zones across these interfaces.

Two wells, 14-20 and 4-29 (Fig. 8.51) show a near maximum thickness of the Dina member sandstone. The 4-28 location shows a thin Dina sandstone which is capped by shale. The strata are laterally adjacent to thicker Dina sandstone in the east and west of this area and can create the lateral updip trapping mechanism. Additional closure is provided by differential compaction within the Dina member between strata which have contrasting volumes of shale, a mechanism that is thought to control the north and south limits of the pools as well as interwell structural changes. The westward limit of the pool is controlled by a contrasting volumes of shale, a mechanism thought to control the pool trapping mechanism and the Eyhill Cummings pool (Fig. 8.50). Production data, Hayter Dina B pool.

CONCLUSIONS

The Hayter Dina B pool illustrates heavy oil entrainment in the lower Mannville Dina member sandstone of the Edmonton Channel. The updip trapping mechanism (a seal formed by shale) is mapable with the presented seismic data. Vigrass (1977) has suggested that similar traps are due to the occurrence of intra-Mannville unconformities which the author certainly believes to exist.

A hydraulic separation between the two oil pools is shown on this line is a thickening of the Sparky Fm interval and corresponds on this line is a thickening of the Sparky Fm interval and corresponds to the peak to trough inflection at approximately 720 ms on Figure 8.51A.

SEISMIC SECTION

The two lines (Fig. 8.51) were donated by Hillcrest Resources Ltd.

1500 CDP data were acquired in 1984 using a Vibroseis energy source and a spread length of 900 m. Figure 8.51A is the west to east section and Figure 8.51B is the south to north. Identified on both lines are the Leduc, Dina, Sparky, Mannville, and Viking events. The west to east line of Figure 8.51A shows a thick Dina member interval to the west of trace 99. The Dina event correlation is shown on the synthetic seismic trace of Figure 8.52 and is placed at the peak to trough inflection at approximately 720 ms on Figure 8.51B. The seismic signature of the pool trap is shown to the east of trace 99. These strata are shown by the 4-28 location of the geological cross-section of Figure 8.50 and show the thin Dina member sandstone and thick overlying shale. Within this area (east of trace 99) the top of the Dina member is indicated at 750 ms. Note the lateral continuity of this area where the Dina member sandstone is "replaced" with shale. This lateral continuity is not the expected geometry of a post-depositional cut and fill structure as described for the Provost Basal Quartz C pool, and warrants further sedimentological examination.

A similar feature, indicating the partial lateral termination of the Dina member occurs north of trace 51 on Figure 8.51A. Also notable on this line is a thickening of the Sparky Fm interval and corresponds to the peak to trough inflection at approximately 720 ms on Figure 8.51A.

CONCLUSIONS

The Hayter Dina B pool illustrates heavy oil entrainment in the lower Mannville Dina member sandstone of the Edmonton Channel. The updip trapping mechanism (a seal formed by shale) is mapable with the presented seismic data. Vigrass (1977) has suggested that similar traps are due to the occurrence of intra-Mannville unconformities which the author certainly believes to exist.

A hydraulic separation between the two oil pools is shown on this line is a thickening of the Sparky Fm interval and corresponds to the peak to trough inflection at approximately 720 ms on Figure 8.51A. This time-structure, and thickening corresponds with Sparky member production and is interpreted as belonging to the shoaling of this marine middle Mannville unit and resultant better sorted sandstones as described for the following Hayter Sparky A pool.

CONCLUSIONS

The Hayter Dina B pool illustrates heavy oil entrainment in the lower Mannville Dina member sandstone of the Edmonton Channel. The updip trapping mechanism (a seal formed by shale) is mapable with the presented seismic data. Vigrass (1977) has suggested that similar traps are due to the occurrence of intra-Mannville unconformities which the author certainly believes to exist. However, the lateral continuity of the shale, suggested from the seismic data of this example, does not conform to a model of post-depositional erosional as an origin for the pool trap and it is unclear as to whether the shale predates, postdates or is concurrent with the deposition of the Dina member sandstone.

A thickening of the middle Mannville Sparky member which is interpreted as due to the occurrence of intra-Mannville unconformities is definable from the presented seismic data, similar to the Sparky member anomaly of the Hayter Sparky A pool (subsection 8-9).

8-9: HAYTER SPARKY A AND DINA A POOLS

INTRODUCTION

Two coincident reservoirs, the Hayter Sparky A and Dina A pools are illustrated in subsection 8-9 (Fig. 8.53). The pool, located in T41-R1 W4M approximately 340 km southeast of Edmonton, Alberta contains heavy gravity crude in the lower Cretaceous Mannville Gp at a depth of less than 1000 m. Relatively unrestricted production allowances for this area make these reservoirs attractive exploration targets. The lower Mannville pool of this subsection and those of the Hayter Dina B and Provost Basal Quartz C pools are similar in that all produce from the Dina member yet the inclusion of these data serves to contrast several different trapping mechanisms within the Edmonton Channel trend. Similar to the afore-
Figure 8.50. Geological cross-section, Hayter Dina B pool.
Figure 8.51. Seismic section, Hayter Dina B pool.
Figure 8.56. Geological cross-section, Hayter Sparky A and Dina A pools.
Figure 8.57. Seismic section, Hayter Sparky A and Dina A pools.
mentioned examples, the Hayter Dina A pool is located within an area of a lower Mannville thick. To the north and west of the pool pre-Cretaceous highs form as the Fortis Ridge and Bodo ridge are formed by the subscribing carbonate of the Nisku Fm. Subcrop in the area of the pool is formed by the Nisku Fm indicating erosion of both the Nisku and Leduc formations.

Structural closure and facies control of the Sparky member sandstone is provided by pre-existing structural closure on the Dina member. This structural control and the closure of the Sparky member shown here are similar to that of the Chauvin and Wainwright fields where the Sparky structure is provided by Devonian carbonates in the absence of the Dina member. Closure on the Sparky member at Hayter is due to differential compaction within the underlying Dina member. Coincident with the structure is a thickening of the Sparky member due to shoaling of the marine sandstone across this pre-existing high. Both the geological and geophysical sections document the thickening of the Sparky and structural closure on the Sparky and Dina members.

Figure 8.53: Location map, Hayter Sparky A and Dina A pools (courtesy, The Geobase Company Ltd.).

Oil recovery from the Dina A pool is substantially better (a total of 17%) than the previously documented Dina B pool (25%), due to lighter and less viscous oil, reduced well spacing, and a more uniform depth of the Sparky member. The Dina pool is at the interface of the Sparky and Dina members forming onlap style traps whereas the Sparky drapes over the Dina member across the pool. Thinning of the Mannville to Sparky sandstone is coincident with a distinct facies change from channel to regional representing the deeper marine environment of the area. In addition, the regional facies are often structurally and destratificationally controlled by pre-Cretaceous structure and or depositionally controlled by pre-Cretaceous facies and or differential compaction of the Lower Mannville.

Significant structural relief is observed along the Dina event between traces 210 and 320 (at 650 ms) and corresponds to an overall thickening of the Dina event. Coincident with this, there is an increase in the thickness of the Sparky member sandstone which is observed coincident with the structural relief along the Sparky member. As previously mentioned, the primary mechanism for initiating this shoaling is structural relief due to compaction within the underlying Dina member. This compactional relief is due to an extra thickness of Dina sandstone which is laterally offset by normal faults. A comparison of the 16-8 and 2-16 wells (Fig. 8.56) shows this relationship and corresponding structure. Similarly, at Chauvin, Wainwright and many other field locations throughout the Lloydminster area the Sparky member attains reservoir quality and closure coincident with underlying structure. This pre-existing structure is more commonly pre-Cretaceous highs with sandstones of the Lloydminster and G.P. members forming saucer type traps whereas the Sparky strata are thicker across the entire structural high. Smith et al. (1984) list four trapping mechanisms associated with the Sparky member as follows: A) Regional Facies” sandstones abutting against shale filled Channel Facies; B) Regional and Channel Facies sandstones trapped structurally, mainly due to dissolution of the Prairie Evaporite Fm; C) Sandstones locally developed within the Channel Facies; and D) Lateral pinchout of Regional Facies sandstones.

The Sparky member production of this example are best described by classification “D.” This classification could, however, be expanded to note that the regional facies are often structurally and destratificationally controlled by pre-Cretaceous structure and or differential compaction of the Lower Mannville.

GEOLeOLOGICAL CROSS-SECTION

Figure 8.56 is a west to east geological cross-section which portrays the reservoir sandstones and trapping mechanisms for the Sparky and Dina members (Fig. 8.55). The occurrence of heavy oil in the Sparky member sandstone is coincident with a distinct thickening of the underlying Dina member, which may be due to differential compaction. The Sparky member sandstone grades to a less shaly and more porous sandstone across this high as shown by the comparison of the producing and non-producing wells. This change is attributable to shoaling of the marine Sparky member across the Dina member structure with additional structure due to differential compaction of the Sparky member. Some thinning of the overlying Sparky shale is observed coincident with the structural relief along the Sparky member. As previously mentioned, the primary mechanism for initiating this shoaling is structural relief due to compaction within the underlying Dina member. This compactional relief is due to an extra thickness of Dina sandstone which is laterally offset by normal faults. A comparison of the 16-8 and 2-16 wells (Fig. 8.56) shows this relationship and corresponding structure. Similarly, at Chauvin, Wainwright and many other field locations throughout the Lloydminster area the Sparky member attains reservoir quality and closure coincident with underlying structure. This pre-existing structure is more commonly pre-Cretaceous highs with sandstones of the Lloydminster and G.P. members forming saucer type traps whereas the Sparky strata are thicker across the entire structural high. Smith et al. (1984) list four trapping mechanisms associated with the Sparky member as follows: A) Regional Facies” sandstones abutting against shale filled Channel Facies; B) Regional and Channel Facies sandstones trapped structurally, mainly due to dissolution of the Prairie Evaporite Fm; C) Sandstones locally developed within the Channel Facies; and D) Lateral pinchout of Regional Facies sandstones.

SEISMIC SECTION

The east to west seismic line of Figure 8.57 was donated by Murphy Oil, Canadian Occidental Petroleum, Texaco Canada Resources and Nexen Energy Ltd. and reprocessed by Seistar Geophysics Ltd. The two pools are located between traces 210 and 310 on the line and are separated by the Blackford and Sparky sandstones. The Sparky member sandstone produces oil and is trapped by significant time-structural relief and character changes.

Significant structural relief is observed along the Dina event between traces 210 and 320 (at 650 ms) and corresponds to an overall thickening of the Dina interval. Coincident with this, there is an increase in the thickness of the Sparky member sandstone which is observed coincident with the structural relief along the Sparky member. As previously mentioned, the primary mechanism for initiating this shoaling is structural relief due to compaction within the underlying Dina member. This compactional relief is due to an extra thickness of Dina sandstone which is laterally offset by normal faults. A comparison of the 16-8 and 2-16 wells (Fig. 8.56) shows this relationship and corresponding structure. Similarly, at Chauvin, Wainwright and many other field locations throughout the Lloydminster area the Sparky member attains reservoir quality and closure coincident with underlying structure. This pre-existing structure is more commonly pre-Cretaceous highs with sandstones of the Lloydminster and G.P. members forming saucer type traps whereas the Sparky strata are thicker across the entire structural high. Smith et al. (1984) list four trapping mechanisms associated with the Sparky member as follows: A) Regional Facies” sandstones abutting against shale filled Channel Facies; B) Regional and Channel Facies sandstones trapped structurally, mainly due to dissolution of the Prairie Evaporite Fm; C) Sandstones locally developed within the Channel Facies; and D) Lateral pinchout of Regional Facies sandstones.

The Sparky member production of this example are best described by classification “D.” This classification could, however, be expanded to note that the regional facies are often structurally and destratificationally controlled by pre-Cretaceous structure and or differential compaction of the Lower Mannville.
CONCLUSIONS

The Hayter Dina A and Sparky A pools are an example of stacked or "related" heavy oil reservoirs. The two pools are related in that closure on the Dina member forms the initial structure on which the Sparky member sandstone has developed. This mechanism would require some early stage differential compaction within the Dina member level (i.e. by sparky member time).

This leads to some confusion in that other upper Mannville strata of this area such as Colony member channels appear to be relatively uncompacted by pre-existing structures. However, note the local thinning of the Sparky member shale across the Sparky and Dina member highs of Figure 8.56 which may have levelled much of the preducing structure.

8-10: WAIGNWRIGHT

INTRODUCTION

The Wainwright subsection illustrates the relationships between the lower Mannville strata and the subcropping Paleozoic highs. Although the example is not specific to any particular pool, reserves are quoted to show the significance of subcropping traps, such as the Wainwright Nisku A pool. Subcrop traps, in this area, require a competent top seal which is generally formed by the middle Mannville strata. The data also show a Colony member channel whose characteristics are discussed in subsection 8-12 of this chapter. A schematic diagram (Fig. 8.59) depicts: 1) the geological setting of this seismic line; 2) several of the previously discussed trap types; and 2) the relationship of the Wainwright Ridge to the Edmonton Channel.

Reserves and significant reservoir parameters for the Wainwright Nisku A pool are shown in Table 8.10. Productivity data for the pool are illustrated in Figure 8.58. The Hayter Dina A and Sparky A pools are an example of stacked or "related" heavy oil reservoirs. The two pools are related in that closure on the Dina member forms the initial structure on which the Sparky member sandstone has developed. This mechanism would require some early stage differential compaction within the Dina member level (i.e. by sparky member time).

This leads to some confusion in that other upper Mannville strata of this area such as Colony member channels appear to be relatively uncompacted by pre-existing structures. However, note the local thinning of the Sparky member shale across the Sparky and Dina member highs of Figure 8.56 which may have levelled much of the preducing structure.

GEOLGICAL CROSS-SECTION

The principal features of seismic section (Fig. 8.60) are schematically depicted on the geological cross-section (Fig. 8.59). This diagram also depicts trap types of the Provost Basal Quartz C pool, Hayter Dina A and B pools and the Hairy Hills Colony W pool. The left justified or southern portion represents the area of the Edmonton Channel, whereas the right justified portion represents the area of the Wainwright Ridge. Within the confines of the channel the pre-Mannville erosion has removed Paleozoic strata down to the Leduc Fm, resulting in deposition of a thick Mannville Gp as compared to the area of the ridge. On the ridge note that the Ireton and Nisku formations are preserved and the lower and some middle Mannville units onlap and truncate against the high providing potential hydrocarbon traps. The Nisku Fm is truncated updip by erosion and produces heavy oil (957 kglm 3 ) of the Wainwright Nisku A pool of T44 - R5 W4M. Here the Nisku Fm is capped by middle Mannville shales. Several other trap types such as intra-Mannville unconformities, Colony member channels, onlap of the Lloydminster member and shoaling of the Sparky member are depicted here and discussed further within this chapter (subsection 8-8, 8-9, 8-11). Thinning of the Lower Cretaceous strata as they onlap the Wainwright Ridge is shown on the 8th order residual map of Figure 8.61.

SEISMIC SECTION

The seismic line of Figure 8.60 is a south to north oriented 800% dynamite line acquired in 1983 and donated by Cabre Exploration Ltd., Bow Valley Industries and Coho Resources Limited. The left justified or southern portion represents the area of the Edmonton Channel, whereas the right justified portion represents the area of the Wainwright Ridge. Within the confines of the channel the pre-Mannville erosion has removed Paleozoic strata down to the Leduc Fm, resulting in deposition of a thick Mannville Gp as compared to the area of the ridge. On the ridge note that the Ireton and Nisku formations are preserved and the lower and some middle Mannville units onlap and truncate against the high providing potential hydrocarbon traps. The Nisku Fm is truncated updip by erosion and produces heavy oil (957 kglm 3 ) of the Wainwright Nisku A pool of T44 - R5 W4M. Here the Nisku Fm is capped by middle Mannville shales. Several other trap types such as intra-Mannville unconformities, Colony member channels, onlap of the Lloydminster member and shoaling of the Sparky member are depicted here and discussed further within this chapter (subsection 8-8, 8-9, 8-11). Thinning of the Lower Cretaceous strata as they onlap the Wainwright Ridge is shown on the 8th order residual map of Figure 8.61.
Figure 8.59. Schematic geological cross-section, Wainwright Ridge and Wainwright Nisku A pool.
Figure 8.60. Seismic data, Wainwright Ridge and Wainwright Nisku A pool.
and 204 and is typified by both a thin Mannville interval (640 to 710 ms) and a total absence of the Dina member. This extra trough to traces 36 and 156, is indicative of a Colony member channel. This event shows structural relief along the Mannville Gp and some thickening of the upper Mannville interval. Colony member type anomalies are discussed further in the Hairy Hills Colony W pool of this chapter.

CONCLUSION

Figure 8.60 shows the onlapping relationship between lower Mannville strata and pre-Cretaceous structures of the Wainwright Ridge. This relationship is common in the Western Canada Sedimentary Basin, and is a key to understanding both the deposition of the Lower Cretaceous strata and to explaining the occurrence of many Mannville and pre-Cretaceous seepage type traps. The seismic data also displays the signature of a Colony member channel facies sandstone.

S-11: PROVOST BASAL QUARTZ C POOL

INTRODUCTION

The Provost Basal Quartz C Pool is located in T40 - R8 W4M in central Alberta approximately 170 km east of Edmonton, Alberta (Fig. 8.42). This reservoir which is also referred to as the Sherrwood pool produces oil from the Ellerslie Fm. The pool, which measures approximately 1.5 km east to west by 1 km north to south, lies within the Edmonton Channel complex described by Williams (1963). The Provost Basal Quartz C Pool is similar to the Hayter Dina B pool in that both produce oil from the top of a thick, lower Mannville sandstone. The two examples, although genetically related, are different with respect to their trapping mechanisms. In the vicinity of this pool clean quartzose sandstones of the Ellerslie Fm consist of a series of stacked channels which may exceed 5% in gross thickness. An absence of good well-log markers within these sandstones prevent confident division of this unit into sequences and thus the presented subdivision of the Ellerslie Fm in Figure 8.65 should be used with caution. These sandstones are part of an east to west trending Lower Cretaceous valley fill sequence which is bounded to the north and south by Paleozoic escarpments. To the north, resistant carbonates and shales of the Nisku, Ireton and Leduc formations form a high termed the Wainwright ridge. Similarly to the south, Devonian strata form ridges termed the Hamilton Lake and Bodo highs (Fig. 8.3). The valley fill is variable in width, but is commonly on the order of 30 km across. It extends for several hundred kilometers from western Saskatchewan into eastcentral Alberta (Gross, 1980). The petrography of these sandstones (Williams, 1963) and their radiometric age based on contained feldspar (Williams et al., 1962) suggests an eastern source for these sediments. Likely sources are the Pre-Cambrian Shield or the Athabasca Sandstone of Saskatchewan.

This example is primarily stratigraphic in that the updip seal is formed by a very narrow, lower Mannville shale filled channel. This channel which lies to the north of the pool is of uncertain origin, but appears to be filled with sediments which postdate the Ellerslie Fm. Stale fill examined in core from a similar trap in T40-R26 W3M shows low energy characteristics (thin, horizontally laminated, and burrowed strata) in contrast to the channel facies of the Ellerslie Fm. This suggests that a rapid abandonment or marine transgression caused open channel systems and/or overbank lakes to be flooded and filled by overbank deposits or marine sediments, during late lower Mannville (Ostracod time).

At the Provost Basal Quartz C pool this cut and fill trend, southeast by northwest, perpendicular to regional dip, thinskimming a seal for downslope hydrocarbons. This style of trapping mechanism is discussed by Vigrass (1977), who suggested a post depositional model of erosion and filling, due to intra-Mannville unconformities.

The Basal Quartz C Pool produces 921 kg/m³ oil from an average pay of 13.4 m. The oil is underlain by a thick water zone which provides a drive mechanism in the absence of a gas cap or significant.

Figure 8.61. 8th order residual map Base of Fish Scales to peak cycle which occurs near the top of the Paleozoic strata over this area is due to the presence of the Nisku and Ireton formations which create deeper thickness of Paleozoic strata between traces 1 and 204 and is typified by both a thin Mannville interval (640 to 710 ms) and a total absence of the Dina member. This extra trough to traces 36 and 156, is indicative of a Colony member channel. This event shows structural relief along the Mannville Gp and some thickening of the upper Mannville interval. Colony member type anomalies are discussed further in the Hairy Hills Colony W pool of this chapter.

CONCLUSION

Figure 8.60 shows the onlapping relationship between lower Mannville strata and pre-Cretaceous structures of the Wainwright Ridge. This relationship is common in the Western Canada Sedimentary Basin, and is a key to understanding both the deposition of the Lower Cretaceous strata and to explaining the occurrence of many Mannville and pre-Cretaceous seepage type traps. The seismic data also displays the signature of a Colony member channel facies sandstone.

S-11: PROVOST BASAL QUARTZ C POOL

INTRODUCTION

The Provost Basal Quartz C Pool is located in T40 - R8 W4M in central Alberta approximately 170 km east of Edmonton, Alberta (Fig. 8.42). This reservoir which is also referred to as the Sherrwood pool produces oil from the Ellerslie Fm. The pool, which measures approximately 1.5 km east to west by 1 km north to south, lies within the Edmonton Channel complex described by Williams (1963).

CONCLUSION

Figure 8.60 shows the onlapping relationship between lower Mannville strata and pre-Cretaceous structures of the Wainwright Ridge. This relationship is common in the Western Canada Sedimentary Basin, and is a key to understanding both the deposition of the Lower Cretaceous strata and to explaining the occurrence of many Mannville and pre-Cretaceous seepage type traps. The seismic data also displays the signature of a Colony member channel facies sandstone.

S-11: PROVOST BASAL QUARTZ C POOL

INTRODUCTION

The Provost Basal Quartz C Pool is located in T40 - R8 W4M in central Alberta approximately 170 km east of Edmonton, Alberta (Fig. 8.42). This reservoir which is also referred to as the Sherrwood pool produces oil from the Ellerslie Fm. The pool, which measures approximately 1.5 km east to west by 1 km north to south, lies within the Edmonton Channel complex described by Williams (1963).
dissolved gas. The reservoir sandstones are relatively unconsolidated, and have average porosity of 30% and permeabilities of several Darcies. Specific reservoir parameters are presented in Table 8.11. Production data for the subject pool are shown in Figure 8.64.

### Table 8.11: Reservoir and significant parameters, Provost Quartz C pool (ERCB, 1987)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Oil in Place</td>
<td>5610 x 10^3 m^3</td>
</tr>
<tr>
<td>Primary Recovery Factor</td>
<td>393 x 10^3 m^3</td>
</tr>
<tr>
<td>Production to Date</td>
<td>2092 x 10^3 m^3</td>
</tr>
<tr>
<td>Remaining Recoverable Reserves</td>
<td>1383 x 10^3 m^3</td>
</tr>
<tr>
<td>Average Porosity</td>
<td>30%</td>
</tr>
<tr>
<td>Water Saturation</td>
<td>23%</td>
</tr>
<tr>
<td>Average Pay</td>
<td>12.4 kg/m^3</td>
</tr>
<tr>
<td>Oil Gravity</td>
<td>921 kg/m^3</td>
</tr>
<tr>
<td>Acres</td>
<td>192 ha</td>
</tr>
<tr>
<td>Discovery Year</td>
<td>1977</td>
</tr>
</tbody>
</table>

### GEOLOGICAL CROSS-SECTION

Five wells are presented in the west to east geological cross-section through the Provost Basal Quartz C Pool (Fig. 8.64), depicting: 1) regional Ellerslie Fm; 2) the reservoir; and, 3) the top. The section shows strata from the pre-Cretaceous unconformity to the base of the Fish Scales zone.

The lowest strata identified on Figure 8.64 are the sub-cropping Nisku Fm carbonates, which show local relief due to differential pre-Cretaceous erosion. Overlying this unconformity is the Ellerslie Fm which shows a lateral variation in thickness. This is overlain by the Nisku Fm which is the pre-Cretaceous subcrop in the vicinity of the pool. No salts are present in the Beaverhill Lake, Woodbend or Winterburn groups in the area and no evidence is found for dissolution of the Prairie Evaporite Fm salts.

#### SEISMIC SECTION

The seismic data shown in Figure 8.65 (loc. Fig. 8.62) were acquired in 1981 and in the development of the Provost Basal Quartz C pool. These proprietary data were donated by Cibio Resources Ltd., Bow Valley Industries Ltd. and Cobe Exploration Ltd., and were represented by Tektrac Resource Development Ltd. The twelvefold coverage, dynamic source data utilized 30 m group intervals along a 900 m by 960 m spread length with shotpoints spaced at 80 m intervals. The three kilometre long, west to east, line covers both the reservoir sandstone and the trap. Identification of the seismic events are shown on the synthetic seismic trace of Figure 8.66.

### CONCLUSIONS

Several different styles of hydrocarbon traps such as lateral pinchouts, differential compaction and post-depositional erosion with shale fill occur in the Elk Point Fm of the Edmonton Channel. The Provost Basal Quartz C Pool is an example of the latter type and has a discernable seismic signature, which consists of: 1) drape across the reservoir sandstone; 2) negative drape across the shale fill of the channel cut-out; and, 3) lateral time-structural and character variation of the Ellerslie event due to the variation in the Ellerslie Fm thickness.
Figure 8.64. Geological cross-section, Provost Basal Quartz C pool.
Figure 8.65. Seismic section, Provost Basal Quartz C pool.
INTRODUCTION

The channel sandstone reservoir of the Hairy Hills Colony W pool is typical of the prolific Colony member gas reservoirs of eastern Alberta which have been successfully exploited with the use of seismic data. The Colony member is the uppermost unit of the nine member informal subdivision of the Mannville Gp in the Lloydminster area and consists of silts, clays, coals and sandstones. The term Colony member sandstone has a strong genetic connotation as it is commonly associated with thick shoestring channel sandstones which trend south to north and northwest throughout much of east-central Alberta and Saskatchewan (Putnam and Oliver, 1980). In this subsection, usage of the term “Colony member” will infer the deposition of channel facies sandstones, whereas laterally equivalent non-channel facies are referred to as the regional facies. Work by Putnam and Oliver (1980) has lead to the proposal of contemporaneous deposition of the channel sandstones with associated levee, crevasse spays, overbank and other associated deposits. Significant drape across the Colony member channel sandstone anomalies of this example and many other examples of Focht and Baker (1985) suggest that most or all differential compaction of the upper Mannville postdates channel deposition. That much of the structural dome measured by the time-structural relief along the top of the Mannville event is “apparent” and caused by a change in the phase of the seismic response or “bright spot effect” (B. Diek, pers. comm., 1988). No distinction is made between “phase generated” and “drape generated” structures of the Colony member, channel sandstone anomalies.

The Colony member channel facies sandstones of this area occur as a zone of approximately 550 m and are unconsolidated to weakly consolidated quartz sandstones. The sandstones exhibit high angle cross-stratification, fining and shaling upward sequences, sharp bases, and occasionally rip up or slump clay clasts (Whitman et al. 1987). Permeabilities of several facies are common and porosities commonly average 30%. Reserves and reservoir parameters of the Hairy Hills Colony W pool are shown in Table 8.12. Production data for subsection 8-12 are illustrated in Figure 8.68.

Table 8-12A. Reserve sand significant reservoir parameters, Hairy Hills Colony W pool (ERCB, 1987)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Volume in place</td>
<td>1900 x 10^6 m³</td>
</tr>
<tr>
<td>Oil Recovery</td>
<td>72%</td>
</tr>
<tr>
<td>Surface Loss</td>
<td>5%</td>
</tr>
<tr>
<td>Initial Established Reserves</td>
<td>1300 x 10^6 m³</td>
</tr>
<tr>
<td>Net Cumulative Production</td>
<td>1194 x 10^6 m³</td>
</tr>
<tr>
<td>Remaining Established Reserves</td>
<td>118 x 10^6 m³</td>
</tr>
<tr>
<td>Average Spc. Thickness</td>
<td>0.262 m</td>
</tr>
<tr>
<td>Average Porosity</td>
<td>30%</td>
</tr>
<tr>
<td>Average Gas Saturation</td>
<td>75%</td>
</tr>
<tr>
<td>Mean Depth</td>
<td>238 m</td>
</tr>
<tr>
<td>Discovery Year</td>
<td>1954</td>
</tr>
</tbody>
</table>

**GEOLOGICAL CROSS-SECTION**

Five wells are shown in the geological cross-section of Figure 8.69. The two end wells (3-36 and 10-24) penetrate the Woodbend Gp, whereas the middle three wells penetrate less than 30 m into the Nisku Fm. The section is dated at sea level and includes the Lower Cretaceous Viking Fm at its top. Interwell distances are not to scale in this diagram in order to optimize the visual display.

The lowest strata shown are the Devonian Leduc Fm (Willingdon reef) and the off-reef Ireton and Duvernay formations. The sediments are overlain by the Nisku Fm which is the subcropping pre-Cretaceous reservoir in this area. The Nisku and Leduc formations contain gas reserves. Structural relief occurs on the pre-Cretaceous unconformity between the locations of this cross-section due to 1) differential erosion along the subcrop; and 2) differential compaction of the Ireton Fm. The area is thought to have been emergent during lower Mannville time as indicated by the absence of the lower Mannville strata.

The three central well logs (10-10, 10-2 and 7-33) show the development of the Colony member channel facies which approaches 40 m in the 10-10 well. All three wells show a sticky SP curve, with abrupt bases and shingling upward sandstones. Regional channel sands are represented by the two end wells 10-24 and 3-36. The channel facies wells are shown to be coalesced in a single channel event, however more detailed examination such as that of Whitman et al. (1987). p. 199 show the potential for hydraulic separation of closely spaced upper Mannville channels.

**SEISMIC SECTION**

The seismic section of Figure 8.70 was donated by Chevron Canada Resources Ltd. and reprocessed by Exploration Seismic Services Ltd. The line was part of a regional seismic acquisition program and is segmented to optimize the seismic signature of the pool. Identifications for the seismic events are shown on the synthetic seismic trace of Figure 8.71.

The anomaly shown from trace 98 to 120, identified on Figure 8.69 at approximately 220 m is interpreted as a Colony member
The anomaly consists of time-structural relief of some 10 to 15 ms. Focht and Baker (1985) shows that differences between coal signatures of the Willingdon D3 and the Hairy Hills Colony W pool which trends north to south are discernable, and that seismic anomalies and channel sandstones are observable. Mannville thickening and a lateral amplitude anomaly are given in Chapter 4 (this volume). Most compaction of the Ireton Fm took place prior to the Mesozoic and these strata were erosionally removed. Further compaction did not recommence until the weight of the Cretaceous strata exceeded that of the eroded Paleozoic sediments. Additional discussion of the differential compaction process and the effects of erosion are given in O'Connor and Gretener (1974a, 1974b), and Labute and Gretener (1969).

The geological and seismic data in this subsection indicate that: 1) structural relief sufficient to trap hydrocarbons is present in the Ellerslie Fm across the rim of the underlying Leduc Fm reef; 2) significant thinning of the subcropping Paleozoic formations does not appear to occur coincident with the reef rim; and 3) the Ellerslie Fm does not appear to be depositional controlled by the reef. This would lead to the belief that the present structure on the Ellerslie Fm is largely post-depositional in origin.

CONCLUSIONS
Figure 8.69 illustrates the seismic signature of a Lower Cretaceous reef. Anomalous in its geological setting in that it is far removed from the major Leduc Fm reef trends of Alberta, Pullup of 40 ms and lateral truncation of Ireton Fm events are noted. Drapes of the Mesozoic strata across the Leduc Fm reef is re-erected in a significant degree that is consistent with the data. Figure 8.70 illustrates the superstructure of the crestal region for the Colony member channel facies. The time-relief which occurs across the Colony anomaly is seen in evidence that the Colony member channel facies sandstones were deposited contemporaneously with the laterally adjacent regional strata. Comparison of many upper Mannville ammonites by Fock and Baker (1965) shows that the ranges between reef anomalies and channel sandstones are discernable, and that seismic signatures can be used to estimate gross pay.

S-13: PEAVEY BLAIRMORE POOL
INTRODUCTION
The Peavey Blairmore pool, located approximately 45 km north of Edmonton, Alberta in T66-R24 W4M (Fig. 8.72), produces from the Ellerslie Fm and is of interest in that it overlies the edge of the Montisili Leduc Fm reef. Trapping in the Ellerslie Fm at Peavey is due to structural slope across an underlying reef. This structure is post-depositional and there is no discernable control on Ellerslie Fm sedimentation by the reef structures. The Montisili reef which is located on the northern portion of the Rimley-Leduc Fm reef chain shows a significant reef edge structure, analogous to the peripheral rim structure of the Redwater reef complex described by Mossop (1972).

Mossop (1972), Labute and Gretener (1969) and Gretener and Labute (1972) respectively, explain the occurrence of reef rim structures and drapes of post-reef strata. Their emulsions are used in explaining the occurrence of structural closure at the Ellerslie Fm interval in Chapter 4 (this volume). Most compaction of the Ireton Fm took place prior to the Mesozoic and these strata were eroded away. Subsequent Mesozoic deposition was salticlastic. The time-relief which occurs across the Colony anomaly is seen in evidence that the Colony member channel facies sandstones were deposited contemporaneously with the laterally adjacent regional strata. Comparison of many upper Mannville ammonites by Fock and Baker (1965) shows that the ranges between reef anomalies and channel sandstones are discernable, and that seismic signatures can be used to estimate gross pay.

CONCLUSIONS
Figure 8.69 illustrates the seismic signature of a Lower Cretaceous reef. Anomalous in its geological setting in that it is far removed from the major Leduc Fm reef trends of Alberta, Pullup of 40 ms and lateral truncation of Ireton Fm events are noted. Drapes of the Mesozoic strata across the Leduc Fm reef is re-erected in a significant degree that is consistent with the data. Figure 8.70 illustrates the superstructure of the crestal region for the Colony member channel facies. The time-relief which occurs across the Colony anomaly is seen in evidence that the Colony member channel facies sandstones were deposited contemporaneously with the laterally adjacent regional strata. Comparison of many upper Mannville ammonites by Fock and Baker (1965) shows that the ranges between reef anomalies and channel sandstones are discernable, and that seismic signatures can be used to estimate gross pay.

The deeper anomaly (at 620 ms) between traces 165 and 300 is the Ellerslie Fm. A downdip water interval is shown by the 6-30 well. The 2-30 location is common to the 8.74(2) section into two parts. A left justified portion illustrates the Mesozoic strata. The two wells which are stratigraphically continuous show the structural closure on the Ellerslie Fm across the rim of the underlying Leduc Fm reef, resulting in the origin of the peripheral rim structure of the Redwater Leduc Fm reef. He concluded that the rim structure is due to the greater compaction of the mottled near-reef lagomorph facies relative to the clean carbonates of the reef margins. No evidence was demonstrated for any primary rim structure on the reef edge. Labute and Gretener (1969) examined the degree and timing of the compaction of Ireton Fm shales encasing the Leduc Fm of the Wandering Lake Leduc Fm reef. They concluded that a significant thickness of pre-Cretaceous sediments was eroded from above these reefs. Their conclusion is supported by interval thickness data which show that compaction of the Ireton Fm was interrupted during the pre-Cretaceous hiatus due to the removal of overburden. Further compaction did not recommence until the weight of the Cretaceous strata exceeded that of the eroded Paleozoic sediments. Additional discussion of the differential compaction process and the effects of erosion are given in O'Connor and Gretener (1974a,1974b), and Labute and Gretener (1969).

The geological and seismic data in this subsection indicate that: 1) structural relief sufficient to trap hydrocarbons is present in the Ellerslie Fm across the rim of the underlying Leduc Fm reef; 2) significant thinning of the subcropping Paleozoic formations does not appear to occur coincident with the reef rim; and 3) the Ellerslie Fm does not appear to be depositional controlled by the reef. This would lead to the belief that the present structure on the Ellerslie Fm is largely post-depositional in origin.

A summary of the oil reserves and significant reservoir parameters for the Peavey Blairmore pool are shown in Table K.13. Productivity data for this pool are illustrated in Figure 8.75.

Table K.13: Reserves and significant reservoir parameters, Peavey Blairmore pool (ERCB, 1987)
Initial Oil in Place 1896 x 10^3 m^3
Primary Recovery Factor 20%
Additional Secondary Recovery Factor 5%
Additional Secondary Recoverable Reserves 37.0 x 10^3 m^3
Cumulative Production to Date 63.6 x 10^3 m^3
Remaining Establishe Reserves 373.8 x 10^3 m^3
Atta 272 ha
Average Pay 2.23 m
Average Formation Water Saturation 20.6%
Oil Density 876 kg/m^3
Average Depth Oil 1067 m
Discovery Year 1952

GEOLOGICAL CROSS-SECTION
The Peavey Blairmore pool geological cross-section is segmented into two parts. A left justified portion illustrates the Mesozoic strata and the right justified portion illustrates the Paleozoic strata.

Figure 8.74(1)
Figure 8.74(1) depicts the on-reef to off-reef stratigraphic relationships of the Woodbine Gp. The two wells which are stratigraphically continuous show the off-reef thickening of the Cambrian, Nisku and Ireton formations, and the off-reef occurrence of the Devonian Fm. The 2-30 location is common to the 8.74(2) section and illustrates a near maximum structural position along the reef rim.

Figure 8.74(2)
Figure 8.74(2) illustrates the Lower Cretaceous strata in the proximity of the reef rim. The horizon at 220 m below sea level shows the structural closure on the Ellerslie Fm. A downdip water interval is shown by the 6-30 well. An oil interval occurs between the 6-30 well and the interpreted gas cap.
Figure 8.69. Geological cross-section, Hairy Hills Colony W pool.
Figure 8.70. Seismic section, Hairy Hills Colony W pool.
Figure 8.74. Geological cross-section, Peavey Blairmore pool.
Figure 8.75. Seismic section, Peavey Blairmore pool.
which is penetrated in the 2-30 well. The continuity of this upper Ellerslie Fm sandstone is not conclusive but considered likely. Directly below the reservoir sandstone, the lower portion of the Ellerslie Fm appears to be in a fining upwards sequence, analogous to the Dino member (Mancosville Gp) and Ellerslie Fm channels of the Provo Basal Quartz C and Hayter examples of this chapter. The term Devil is applied here to the dolomite facies strata which lie directly on the pre-Cretaceous unconformity.

SEISMIC SECTION

The seismic section of Figure 8.75 was donated by Montney Resources Ltd. and is displayed under original processing. Well ties and the exact location of the line are undisclosed, however it is oriented perpendicular to the reef edge. A visual comparison of the data and the accompanying synthetic trace suggests that this data is slightly out of phase with log normal polarity. The data are twelve-fold Vf filmed source, acquired in 1983 using a 67-m source interval and 33.5-m group interval. Identifications for the seismic events are shown on the synthetic seismic trace of Figure 8.76.

Traces 1 through 30 (0.850 - 1.1 secs) of Figure 8.75 are the signatures of the Woodbasin Gp in an off-reef position. Traces 1 through 45 of approximately the same time-interval show the reef front, apex of the reef rim and the back-reef slope to the innerreef. The onshore occurs west of trace 75. Notable features on Figure 8.75, through this time interval, are the time-structure on the Leduc event and apparent pull-up of the deeper events that occur between the on-reef and off-reef positions. Maximum time-structure on the Leduc event and minimum pull-up of deeper events are observed at trace 54. This point is interpreted as the apex of the reef rim. A relative time-structure of 15 ms on the Leduc event is noted between the on-reef and off-reef positions. Similar time-structural relief is observable on much of the overlying strata and can be traced up to the differential compaction of on-reef to off-reef strata in the Woodbend Gp, rather than to compaction of the Woodbend Gp itself.

Figure 8.76. Single well synthetic trace, Peavey Blairmore pool.

Figure 8.77. Compressed seismic section, Peavey Blairmore pool.

CONCLUSIONS

The Peavey Blairmore pool is an Ellerslie Fm oil pool which occurs on the shelf. The ellerslie, Leduc Fm reef. The trapping of hydrocarbons is due to structural closure which is likely caused by the differential compaction of on-reef to off-reef strata in the Woodbend Gp. The uniformity of the Ellerslie Fm across the structure indicates that structural deformation postdates deposition of these strata. This is supported by the conclusions of (Mossop (1972), Labore and Guerrero (1969) and Guerrero and Labore (1972).
The Crystal Viking A pool is distinct from many Viking Fm pools of Western Canada in that anomalously thick sandstones and conglomerates were deposited in channel facies (Reinson et al., 1988). The anomalous reservoir thickness of the channel facies relative to other channel lateral regions is the principal determinant of the geophysical signature of the pool. However, this Viking Fm facies is known in only a few other areas and thus the model may have only minor application.

Reinson et al. (1988) subdivided the Viking Fm into three depositional facies based on core and well-log data. These are: 1) regional facies (inner shelf - lower shoreface sediments); 2) Estuarine bay fill (represented by the H pool); and, 3) Estuarine channel complex (with three stage subdivision).

Reinson et al. (1988) showed that regional facies consist of several funnel shaped upward coarsening cycles indicating deposition in a regressive marine environment. It was also demonstrated that the channel facies pinches and truncates the regional facies sequences. These channel sediments, in combination with the subtidal bay fill deposits were classified as an estuarine tidal channel facies complex.

The Crystal Viking A pool is defined by the ERCB (1987) extend northeast from the Viking Fm gas wells which were drilled prior to the discovery of Viking oil in T46 - R6 WSM. What is presently the updip gas cap of the A pool under existing boundary definitions includes the 11-33-46-3 W5M well, which tested gas from the Viking Fm in 1982. Discovery of the oil columns and active development of the pool did not occur until 1978. Discovery of the H pool is attributed to development drilling of the A pool in 1983.

As of January 1st, 1988 the A pool has produced some 1459.3 x 10^3 m^3 of 825 kg/m^3 oil or about 26.5 million barrels. Of note are both a local time-structural erosional low on the Banff event which occurs below the Viking A pool (traces 80-120), and a time-structural low along the lower Mannville event, identification of the seismic events are shown on the synthetic seismic trace of Figure 8.83. Computation of a lower Mannville thickness is thought to be a mechanism for focusing the channeling facies of the Crystal Viking sediments. This computation of the lower Mannville is thought to postdate the deposition of the regional Viking Fm strata but in mentioning predates the channel facies. This sequence is schematically shown in Figure 8.84. The Mannville event and Viking event are noted on Figures 8.82 at 1110 and 1130 ms respectively. The interval between these two events thickness by approximately 6 to 8 m from traces 70 to 170 with a maximum time thickness observed near trace 110. This time interval coincides with the thick channel facies of Figure 8.81 and is interpreted as Viking Fm thickening. This thickening is confirmed by the interpretation of Figure 8.88 which shows a thickening of the base of Fish Scales to Mannville interval across the pool. Note also that the Mannville Pr and some extent the Viking event appear to be time-structurally low across the anomalous area (traces 70 to 170). These data suggest that the Mannville-Jp, Joli Fou Fm and the regional Viking strata were all structurally low prior to channel incision and that the low was due to the differential compaction of lower Mannville strata between areas of variable lower Mannville thickness.
Figure 8.80: Geological cross-section, Crystal Viking A and H pools.

DRAFTING: K. GRIMSON
LOG PLOTS: 
AUTHOR: D. CEDERWALL (ADAPTED FROM REINSON 1985)
Figure 8.82. Seismic section, Crystal Viking A and H pools.
INTRODUCTION
The Pembina Ostracod E pool is located in T50-R4 W5M (Fig. 8.87), 80 km southwest of Edmonton, Alberta, and illustrates significant lateral facies variation within the Ostracod member which is coincident with localized structure on the pre-Cretaceous unconformity. Furthermore, the example is of interest in that the underlying Banff Fm which forms a structure beneath the Ostracod depositional sequence where: 1) the channel facies sandstones of subsections 8-10 and 8-12 were deposited concurrently with the regional facies strata and thus the dewatering of these sediments provided drape from differential compaction; and 2) the regional facies Viking Fm strata were relatively well compacted prior to channeling and redeposition of channel facies sediments thus negating the possibility of differential compaction.

A model of the seismic response of the Crystal Viking pool is shown in Figure 8.86. Note however, that these data were modified to include a uniform thickness in the Joli Fou to Mannville interval. This modification was deemed necessary as few of the available well logs penetrated the Mannville Gp. Note also that the well locations annotated above the seismic data of Figure 8.82 are those used in the model rather than those of the geological cross-section.

CONCLUSIONS
The Crystal Viking A pool is an estuarine channel fill, whereas the smaller H pool is set in a subsidiary facies of this complex. The channel is unconformable and eroded into regional Viking Fm strata. The seismic signature of this channel is characterized by an increase in Viking to Mannville interval time and a time-structural low on the Mannville event. An absence of detectable drape along the Viking Fm event suggests that compaction of the regional Viking facies predated the deposition of the channel facies.

8-15: PEMBINA OSTRACOD E POOL
After examination of the seismic data across other channel deposited reservoirs and noting the strong draping characteristics associated with these strata, a marked absence of dips across the channel facies is observed for the comparative analogous Viking Fm pool. This absence of dips is attributed to the differences in the
The subcroppping Banff Fm in this area is conformable on the Exshaw Fm. The Banff Fm consists of a lower micritic unit, a middle tight dolomite which normally forms the subcrop and occasionally the upper porus Clarke's Mbr. The Banff Fm, whose subcrop edge is roughly 40 km east of the pool location, dips to the southwest at approximately 5 m/km. Immediately west of the pool the Banff Fm is overlain by the Nedmay Fm. Clarke's Mbr highs appear to have an inner micritic facies which is typically a dolomite with vuggy porosity and a flanking facies of a cleaner crinoidal limestone with intercrystalline porosity.

The reservoir unit of this example is the Ostracod member of Glaisier (1993). He used the top of this member as the division between his informal upper and lower Mannville subdivisions. The Ostracod member generally occurs as a tight, non-reservoir facies immediately below a laterally extensive marine sheet sandstone of the Glaciomarine Sandstone member in this area. Within localized areas such as the Pembina Ostracod E pool the unit thickens and anastomizes with which this example averages 16%. The enhancement of the Ostracod member as a reservoir unit is likely due to wave action where it was structurally high due to both the relief on the under­

The Pembina Ostracod E pool covers approximately 3185 ha and contains some 3501 x 10³ m³ of oil in place, of which 1180 x 10³ m³ are estimated to be recoverable. An average pay thickness for the pool of 1.27 m is indicative of the thinness of the reservoir. Reserves and other significant reservoir parameters for the pool are shown in Table 8.15. Productivity data for the pool are illustrated in Figure 8.88.

<table>
<thead>
<tr>
<th>Summary of Reserves</th>
<th>Pembina Ostracod E pool (ERCB, 1987)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remaining Established Reserves</td>
<td>785.3 x 10³ m³</td>
</tr>
<tr>
<td>Average Pay Thickness</td>
<td>1.27 m</td>
</tr>
<tr>
<td>Average Pore Volume</td>
<td>16%</td>
</tr>
<tr>
<td>Average Water Saturation</td>
<td>25%</td>
</tr>
<tr>
<td>Oil Density</td>
<td>840 kg/m³</td>
</tr>
<tr>
<td>Average Depth</td>
<td>1579 m</td>
</tr>
<tr>
<td>Discovery Year</td>
<td>1980</td>
</tr>
</tbody>
</table>

**GEOLOGICAL CROSS-SECTION**

The Pembina Ostracod E pool geological cross-section (Fig. 8.89) shows strata from the Banff to Viking formations. The Ostracod member is situated between the upper Mannville Glaciomarine Sand­

The interval at approximately 50 m subsea and labeled as the Ostracod member (Fig. 8.89) is the reservoir facies. This unit thickens and has enhanced reservoir characteristics coincident with the underlying pre-Cretaceous structure. Immediately above this at 800 m subsea is the coarsening upwards Glaciomarine Sandstone member which locally has been termed the Pembina Barrier by Smith and Meekal (1983). The 7-28 well represents the southern limit of the Pembina Barrier.

**SEISMIC SECTION**

The seismic data for the Pembina Ostracod E pool were donated by Chevron Canada Resources Ltd. and reprocessed by Exploration Seismic Services Ltd. The line (Fig. 8.90) is approximately 20 km long and is part of a regional twofold dynamics survey with 200-m shotpoint intervals and 50-m group intervals. The line shows the flank of the pre-Cretaceous Clarke's Mbr high and the corresponding lower Mannville and Mannville Gp thinning on the western portion of the pool.

A time window of 200 to 800 ms was selected in order to optimize the display of this pool. Shallow reflectors, particularly those below the Viking event at approximately 980 ms, show poor response primarily due to both the use of a heavy charge as an energy source and the wide spread lengths. The data, however, show excellent response over the Lower Cretaceous interval from 980 to 1100 ms.

The eastern end of the line which is in the productive area of the pool shows the Lower Cretaceous unit to be some 120 m in time­

West of trace 300 the following observations can be made: 1) lower time-structure relief on the Lower Cretaceous; 2) thickening of the lower Mannville; and 3) a thinning of the Banff to Wabamun.
Figure 8.89. Geological cross-section, Pembina Ostracod E pool.
Figure 8.90. Seismic section, Pembina Ostracod E pool.

**WELLS PLOTTED TO STRATIGRAPHICALLY SIMILAR LOCATION (IMPROPER SURFACE LOCATION)**

VIKING MANNVILLE OSTRACOD-LWR. BANFF MNVL. WABAMUN
Gp time interval. These features are due to the absence of the Clarke's Mbr porosity within this area, but is not demonstrated with this specific data. The dimensions of a sharp erosional feature corresponds to the localized erosional low which occurs in the 3-31 well (Fig. 8.91).

The observed lower Mannville thinning and time-structural relief on the data form a close approximation to the limits of the field, however note that this relationship is indirect as the Ostracod zone has no directly observable seismic response (Fig. 8.91).

The seismic data fails to show a direct response to the Clarke's Mbr porosity (which sometimes causes the pre-Cretaceous event to change from a single peak to a doublet peak across the porous beds). Presumably the thickness of Clarke's Mbr porosity is insufficient and/or the frequency content of this data is too low to respond to the two positive reflection coefficients which occur at the: 1) lower Mannville to Clarke's Mbr interface; and 2) Clarke's Mbr to tight Banff Fm interface.

CONCLUSIONS

The Pembina Ostracod E pool is a Lower Cretaceous pool which is not directly detectable with seismic data. However, development of a reservoir facies in the Ostracod member is coincident with pre-Cretaceous structure which is mappable with seismic data. Features which are diagnostic of this pool are: 1) lower Mannville and Mannville Gp thinning; 2) pre-Cretaceous unconformity to Wabamun Gp thickening; and 3) time-structural relief of the Mississippian and Lower Cretaceous.

A lateral character change along the unconformity reflector can be diagnostic of Clark's Mbr porosity within this area, but is not demonstrable with this specific data. The dimensions of a sharp erosion feature stop at the Banff Fm high are shown via well control and the observed diffractions pattern on the seismic data. The occurrence of this pool and several other central Alberta pools are schematically depicted in Figure 8.92.

8-16: PEMBINA-LOBSTICK GLAUCONITE E POOL

INTRODUCTION

The Pembina-Lobstick Glauconite E pool (Fig. 8.93) is located in T49-R6LSW5M approximately 125 km southwest of Edmonton, Alberta. The example shows significant gas reserves trapped in the marine upper Mannville Glauconitic Sandstone member. Post-depositional erosion of an existing marine sandstone unit and shale infill is postulated as a trapping mechanism for the pool.

The Lobstick Glauconitic Sandstone member pools are located just south of an extensive east to west trending zero edge of the depression. A uniformly thick, coarsening upwards sandstone that is laterally pervasive over several hundred square kilometres termed the Pembina Barrier. Smith and Meekel (1983) notes north of the zero edge. In this area the Glauconitic Sandstone member is commonly water bearing with rare gas entrapment where it is draped over pre-Cretaceous highs such as those formed by the Clarke's Mbr at the Glenevis and Alexis pools. South of this edge, and north of the Hoadley Barrier complex, (Chiang, 1985) the Glauconitic Sandstone member is gas bearing. However, at Lobstick it is gas bearing and very similar in log signature to the northern lying wet Glauconitic Sandstone member. Neither stratigraphic nor structural position explain the trapping mechanisms of gas in this pool, however an examination of wells.
such as the location 6-2-56-64W5M suggests that there was post-depositional erosion of the reservoir sandstone and a replacement of the interval with a shale. Separation of the Lobstick pools (from a once continuous marlstone sandstone) by post-depositional erosion is suggested as the trapping mechanism for the Pembina-Lobstick A, E, G, J and D pools. Reserves and significant reservoir parameters for the two larger pools (E and G) are given in Table 8.16. Production data for this subsection are illustrated in Figure 8.94.

Table 8.16: Reserves and significant reservoir parameters, Pembina-Lobstick Glauconite E and G pools (ERCB, 1987)

<table>
<thead>
<tr>
<th>Pool</th>
<th>Initial Volume in Place</th>
<th>Surface Logs</th>
<th>Initial Established Reserves for the Pembina Lobstick Glauconite E pool</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>5000 x 10^6 m^3</td>
<td>5%</td>
<td>3800 x 10^6 m^3</td>
</tr>
<tr>
<td>G</td>
<td>1758 ha</td>
<td></td>
<td>3000 x 10^6 m^3</td>
</tr>
<tr>
<td>E+G</td>
<td>6758 ha</td>
<td>5%</td>
<td>6800 x 10^6 m^3</td>
</tr>
<tr>
<td>E+G</td>
<td>1758 ha</td>
<td></td>
<td>3800 x 10^6 m^3</td>
</tr>
</tbody>
</table>

**SEISMIC SECTION**

Seismic data for the Pembina-Lobstick Glauconite E pool were donated by Chevron Canada Ltd. and reproduced by Exploration Seismic Services Ltd. These data are part of a regional east west line whose location is shown on Figure 8.93. Annotated on Figure 8.96 are the Wabamun, Banff, lower Mannville, Glauconitic Sandstone, Mannville and Viking events. To the west of trace 180 some Nordegg Fm and possibly some Pelkie Fm may occur but are not distinguished within what is labelled as the Banff interval. Identification of the seismic events are shown on the synthetic seismic trace of Figure 8.97.

Noteworthy on the data is a local change in the signature of the Mannville interval (traces 180-340 from 1.140 - 1.180 secs), which coincides with the shaled out Glauconitic Sandstone member interval shown in the 11-16 and 11-18 locations of Figure 8.95. To the east of wells 8-5 and 6-4, Figure 8.96, the data shows the signature of the regionally uniform and wet Glauconitic Sandstone or "Pembina Barrier". To the west of trace 340 the Mannville signature is similar to that of the "Pembina Barrier" area. This area is represented on the cross-section by the 6-1 and 6-2 wells which have produced 13 and 18 BCF of gas respectively. The seismic data of Figure 8.96 and the data shown on the geological cross-section (Fig. 8.97) suggest that these reserves are trapped against the updip feature shown from traces 180 to 340. Notable features of this interval are lateral weakening of the lower Mannville event and the discontinuity of events with the Glauconitic Sandstone to pre-Cretaceous interval. A local, pre-Cretaceous high of approximately 10 ms and weakening of the unconformity event is also noted over this area. Negative dips due to compaction of the shaled out Glauconitic member interval is suggested by the structural lows along the Mannville event at 1050 ms, (traces 190-200). The time-structural lows are of both borehole reflections is coincident with the previously described pre-Cretaceous high.

**CONCLUSIONS**

Reservoir sandstones of the Pembina-Lobstick Glauconite E pool have geological and geophysical characteristics which are very similar to those of the Pembina Barrier. The trapping mechanism of this pool has a geophysical and geological signature which contrasts with the Pembina Barrier. Furthermore, these data allow the conjecture that this trap is a shale filled channel comparable to that of the Provost Basalt Quartz C pool and to those described by Vigrass (1977).

8-17: MARTEN HILLS/WABISKAW A AND WABAMUN A POOLS

**INTRODUCTION**

The Marten Hills field (Fig. 8.98) lies within T74 through T76, R23 W4M through R2 W5M, approximately 250 km north of Edmonton, Alberta, and contains significant gas reserves (920 BCF recoverable) in the Lower Cretaceous Wabiskaw Mbr and Devonian Wabamun Gp (Table 8.17).

Gas entrapment in the Wabiskaw Mbr is primarily structural and is attributed to the differential compaction of the lower Mannville strata across pre-Cretaceous Devonian highs. In the area the Wabiskaw A pools (courtesy, The Geobase Company Ltd).
Figure 8.95: Geological cross-section, Pembina-Lobstick Glauconite E pool.

DRAFTING: K. GRIMSON  
LOG PLOTS:  
AUTHOR: D. CEDERWALL
Figure 8.96. Seismic section, Pembina- Lobstick Glauconite E pool.
Figure 8.100. Geological cross-section, Marten Hills Wabamun A and Wabiskaw A pools.
Figure 8.101. Seismic section, Marten Hills A and Wabiskaw A pools.
communication with the aquifer and thus have poorer production. This effect is of similar magnitude and character to velocity pull-up of the deeper events. The Wabiskaw Mbr is a widespread 12 to 18 m thick, coarsening upwards, marine sheet sandstone and is mapped in an extensive southwest to northeast trending belt some 50 km wide. Wabiskaw Mbr deposition occurred in a stable environment with little primary structure, as the unit shows a uniform palaeovalley thickness. Draining of the marine sandstone is observed in only the highest palaeotopographic locations, where the lower Mannville is absent due to emergence in pre-Wabiskaw times. Updip of the field, the Wabiskaw Mbr sandstone contains heavy oil, whereas downdip both isolated gas bearing closures and an extensive water leg occur. Structure values on the top of the sandstone indicate monoclinal regional dip to the southwest of 2.5 m/km which is locally interrupted by basin closures that mirror structure on the pre-Cretaceous erosional surface. The Paleocene strata at the subcrop were differentially eroded prior to deposition of the Lower Cretaceous, leaving remnant Wabamun Gp curvices which are now gas bearing. Compaction of the laterally adjacent lower Mannville strata has caused gas to be structurally trapped in the Wabiskaw Mbr. Occasionally gas is trapped in other draping Lower Cretaceous sandstones.

Table 8.17. Reserves and significant reservoir parameters, Marle Sophie Hills Wabiskaw and Wabamun pools (ERCB, 1987).

<table>
<thead>
<tr>
<th>Area</th>
<th>Initial Volume in Pipe</th>
<th>Initial Reserves</th>
<th>Net Cumulative Production</th>
<th>Remaining Est. Reserves</th>
<th>Discovery Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25.55 x 10^6 m^3</td>
<td>19.61 x 10^6 m^3</td>
<td>32.42 x 10^6 m^3</td>
<td>8.17 x 10^6 m^3</td>
<td>1980</td>
</tr>
<tr>
<td>Pool Recovery Factor</td>
<td>80%</td>
<td>65%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Loss</td>
<td>3%</td>
<td>5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Initial Rate, Reserves</td>
<td>19.70 x 10^6 m^3</td>
<td>5600 x 10^6 m^3</td>
<td>25.50 x 10^6 m^3</td>
<td>8.17 x 10^6 m^3</td>
<td></td>
</tr>
<tr>
<td>Net Cumulative Production</td>
<td>15.36 x 10^6 m^3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remaining Est. Reserves</td>
<td>8.13 x 10^6 m^3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area</td>
<td>82,374</td>
<td>32,374</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Pay Thickness</td>
<td>5.23 m</td>
<td>11.59 m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Porosity</td>
<td>27.8%</td>
<td>15.8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas Saturation</td>
<td>65%</td>
<td>55%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Formation Depth</td>
<td>685.8 m</td>
<td>772.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discovery Year</td>
<td>1961</td>
<td>1961</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RESERVES AND SIGNIFICANT RESERVOIR CHARACTERISTICS

**GEOLOGICAL CROSS-SECTION**

The cross-section of Figure 8.101 is oriented east to west and shows strata from the Wabamun Gp to the Viking Fm. Note how the different major beds are labelled in ascending order as the Wabamun Gp, lower Mannville, Wabiskaw Mbr, Mannville Gp, Joli Fou Fm and Viking Fm. Of interest is the fact that the Marten Hills section shows the apparent structural pull-up of the deeper events.

The Wabiskaw Mbr, as shown in Figure 100, is a relatively uniform widespread coarsening upwards unit that has a striking resemblance to the Glauconitic Sandstone members of the Pembina-Lobstick Glauconite pool. Notable features of this section are the thickening of the Wabiskaw to Wabamun interval in structurally low and wet wells (ie. 2-52 and 6-19). Some depositional control of the Wabiskaw Fm is suggested in the structurally highest wells, (ie. 8-61) where it is in direct contact with the subcrop. The seismic data (Fig. 8.101) for the Marten Hills example were acquired in 1977 and is a 2D seismic data line using 134-m shot point intervals and a 20 m seismic trace showing the identification of the events is shown in Figure 8.102. The Wabiskaw Mbr gas is not demonstrated here, but the extent of the pool is coincident with Wabiskaw to Wabamun interval changes of 5 to 8 ms.

**CONCLUSIONS**

Substantial gas reserves are trapped in the Wabiskaw Mbr and Wabamun Gp in the Marle Sophie Hills field. Little, is an apparent time-structural pull-up of the deeper events. This is due to the lateral contrast of the high-velocity Wabamun Gp carbonates to the lower-velocity lower Mannville strata which occur offsetting these highs. Time-structural relief on the order of 10 to 15 ms occurs between the highs and lows of the unconformity event and is coincident with Wabiskaw to Wabamun interval changes of 5 to 8 ms.
SUMMARY

Lower Cretaceous reservoirs of the Western Canadian sedimentary basin occur in a wide variety of depositional environments and are, therefore, a show a wide variation in their geometry, making geophysical exploration largely dependent on an understanding of the local geology. However, the detection of: 1) drapes due to differential compaction; 2) outlap; and 3) specific lateral character variations, are the main elements of the seismic expression of many of these chapters examples.

REFERENCES

Benson, A.L. and James, A.C. 1974. Merten Hills sites wildcat play. The Oil and Gas Journal, v. 72, no. 4, p. 53-56.


Smith, D. and Meekel, I.D. 1983. Recent sand models applied to Alberta basin exploration. Published by I.D. Meekel and Co.


