# THE LOWER CRETACEOUS ELLERSLIE FORMATION

# OF

# SOUTHEAST TABER AND CHIN COULEE OIL FIELDS,

# SOUTHEASTERN ALBERTA

By

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## Abstract

Sandstones of the Lower Cretaceous Ellerslie Formation overlie a major unconformity in southeastern Alberta. Post-Jurassic erosion produced a subcrop pattern on which an extensive drainage system developed in Lower Cretaceous time. The Ellerslie sandstones were deposited in the river valleys, as point bars and as later channel fill with a rise in base level.

Within the study area, two morphologically distinct types of paleochannels are identified: a major meandering system and an incised channel of low sinuosity. These channels are filled with sandstones of different geometries.

The Ellerslie quartz arenites are responsible for a linear belt of oil fields extending from Montana to south-central Alberta. However, there have been production problems. Knowledge of the diagenetic history of these rocks allows recommendations aimed at optimizing oil recovery.

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## Work Schedule

During the summer and fall of 1983, 200 well logs from the study area were correlated and several cross-sections and maps were produced. This formed the basis of an independent study conducted by the author while employed at Mobil Oil. Before returning to Dalhousie University at Christmas time, eight cores were described, SEM photos were taken, and 26 thin sections were cut from the cores. During January 1984 the thin sections were described and the diagenetic history was worked out. Extensive reading was done throughout the course of the study. The thesis was written and typed in February 1984.

# Chapter 1

## Introduction

Sandstones lying above the Pre-Cretaceous unconformity form important oil reservoirs in Alberta and northern Montana. Although they have produced oil for several decades, there is still disagreement in the literature regarding correlations between individual fields and their depositional history. There has been little research done on the diagenesis of these rocks.

The nomenclature applied to the basal Cretaceous strata reflects the difficulty of regional correlation. Figure 1 shows some of the more common schemes adopted for Alberta. Several local names have been introduced for the reservoir sandstones of individual fields. Oil company geologists have called the producing sandstone near Taber, Alberta, the Taber sandstone, while the prolific sandstone of Cutbank, Montana, is called the Cutbank sandstone.

In order to give regional identification to the basal Cretaceous sandstone of southern Alberta, the nomenclature commonly used in central Alberta will be used for the purposes of this study. However, the Ellerslie Member of the Mannville Group will be elevated to formation status in order to recognize it as a mappable unit. The Calcareous Member (or "Ostracod Zone" of oilfield terminology) and Glauconitic Member will likewise be referred to as formations in agreement with Farshori, 1982.

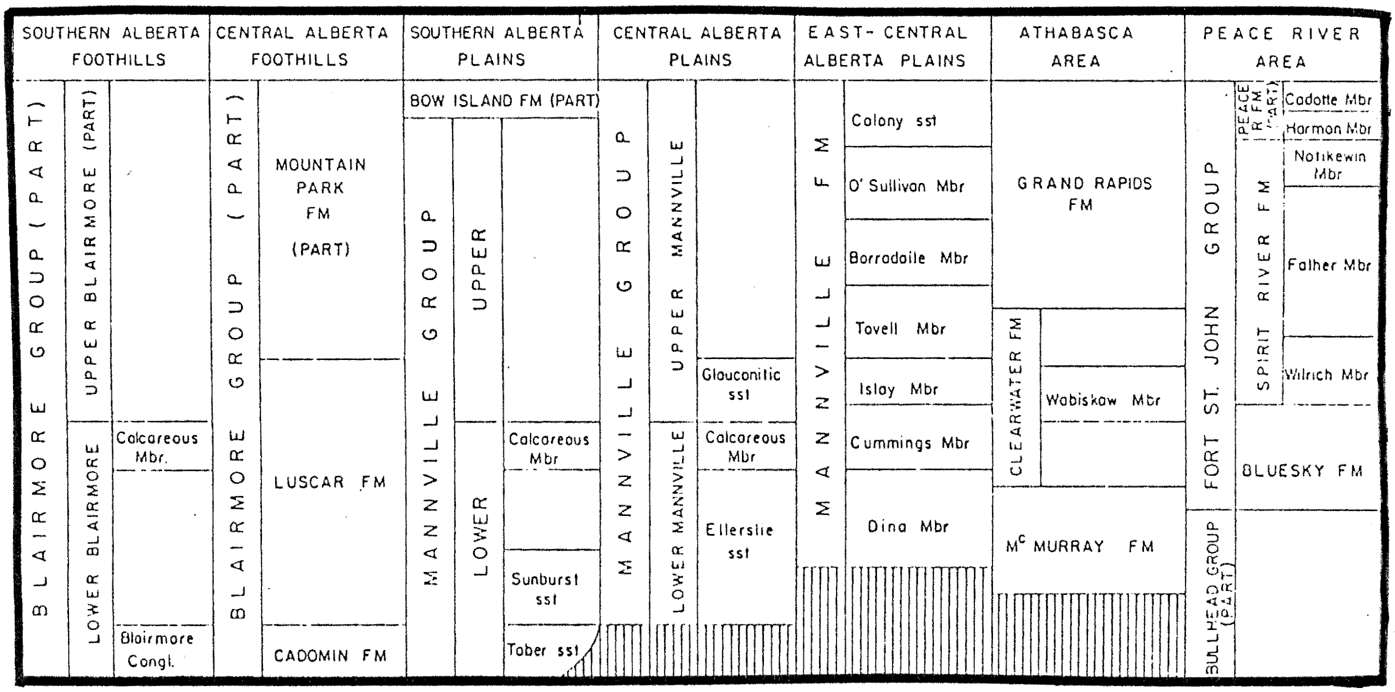



Figure 1: Nomenclature for basal Cretaceous strata in Alberta, after Glaister, 1959.

The purpose of this thesis is to formulate a model for the deposition and subsequent diagenesis of the Ellerslie sandstone within a small area of southern Alberta. The author is not aware of any previous work done on this specific area. The data base is entirely subsurface, consisting of 200 wire-line logs, 8 cores, and 26 thin sections.

The study area is located about 210 kilometers southeast of Calgary (Figure 2), and lies in townships 7 and 8, ranges 14, 15, and part of 16, west of the fourth meridian.

Figure 3 shows the location of wells drilled in the study area. Ellerslie oil fields are shown in green. Although these fields were discovered in the early 1960's, many of the wells are still in production and several recent oil wells have been drilled.

The Southeast Taber fields trend in a northerly direction consistent with other fields surrounding the study area. However, the Chin Coulee field is oriented in an anomalous, northwesterly direction. The Southeast Taber fields are irregularly-shaped and sporadic in distribution, whereas the Chin Coulee field is narrow, elongate and continuous. Any geologic model proposed for the study area must account for these differences.

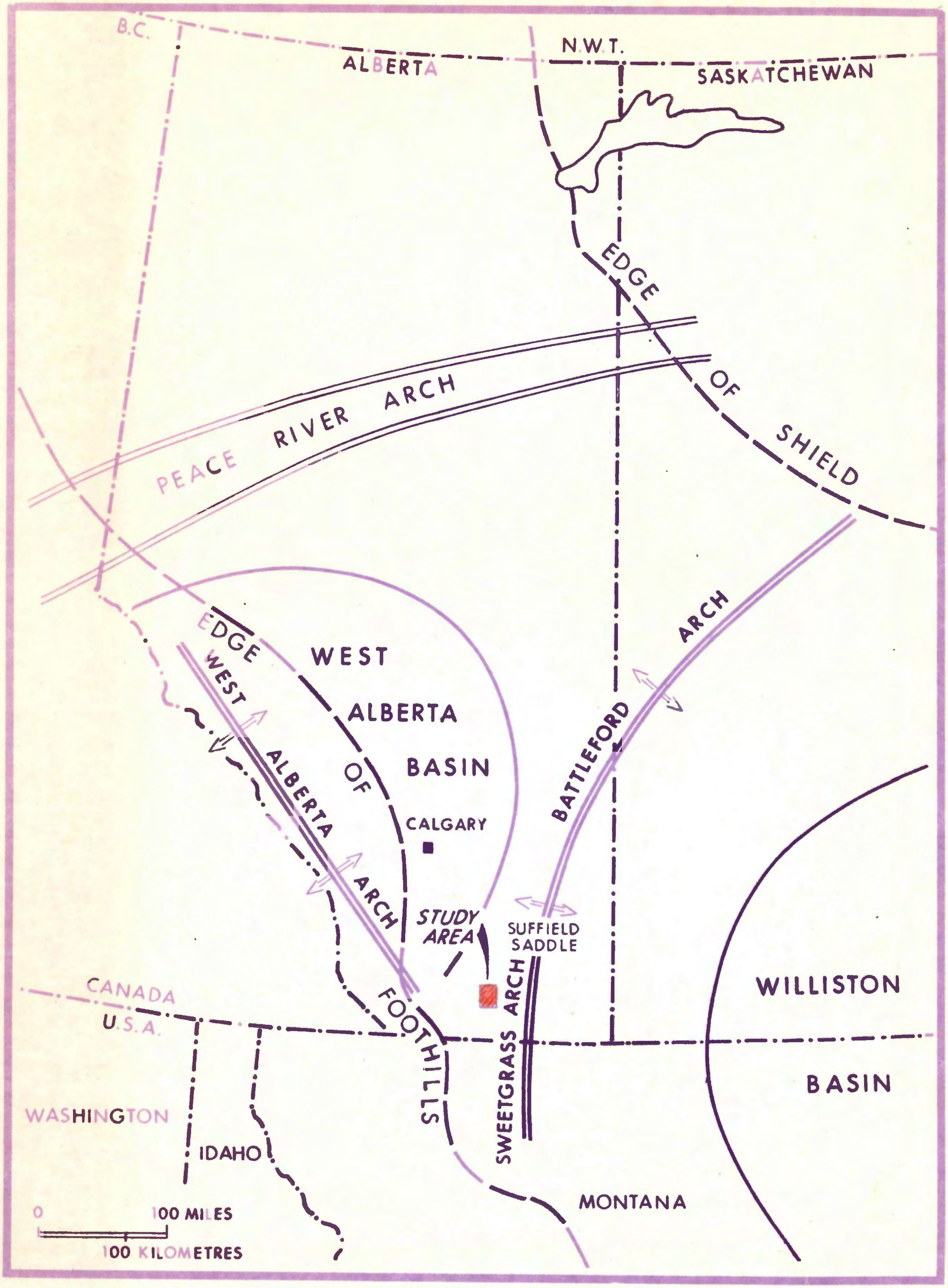



FIGURE 2: LOCATION OF STUDY AREA WITH RESPECT TO THE MAJOR STRUCTURAL FEATURES OF ALBERTA (after Stelk, 1975)

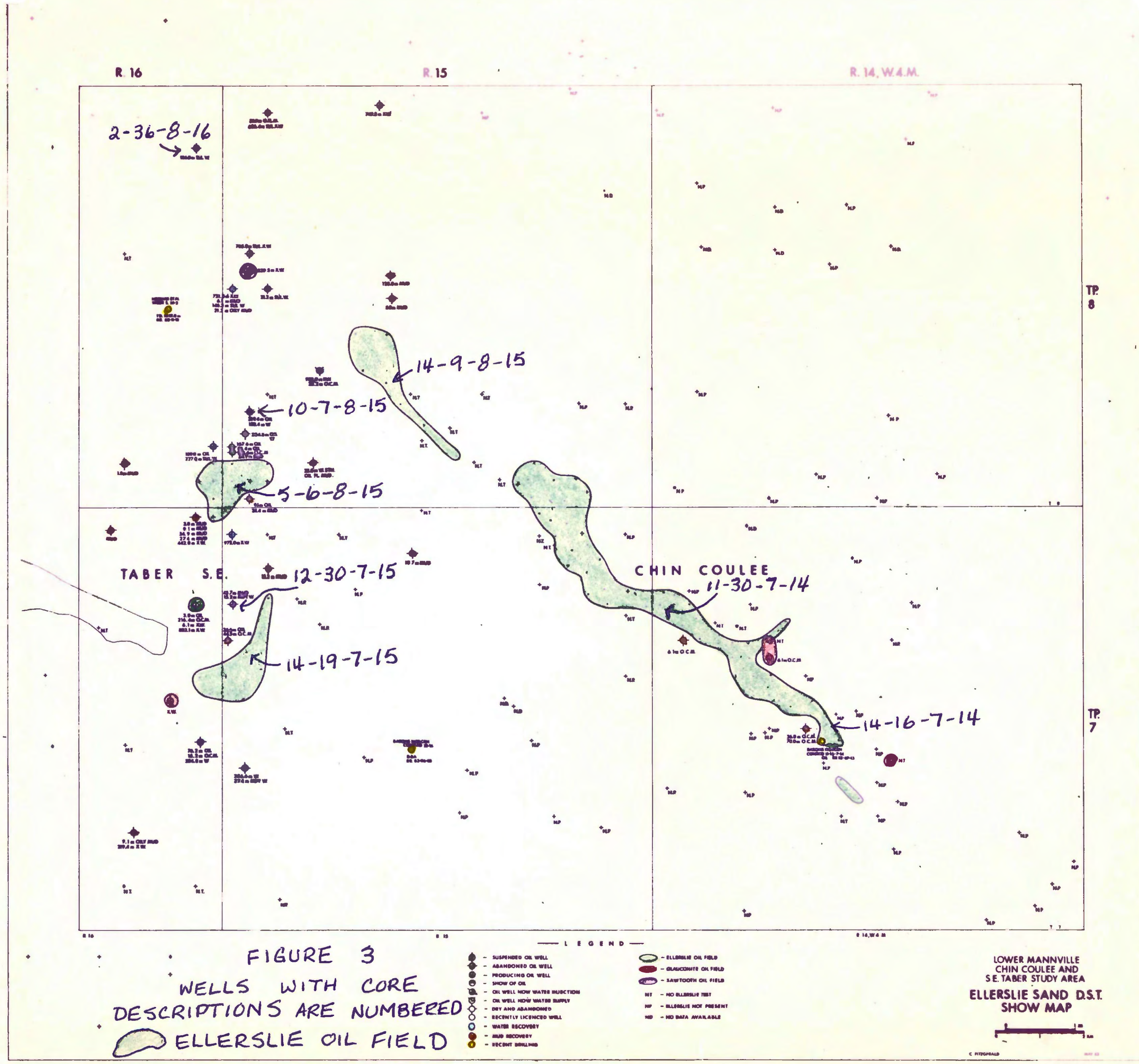



FIGURE 3
WELLS WITH CORE DESCRIPTIONS ARE NUMBERED

# Chapter 2

## Structural Setting

The broad stable platform in front of the main belt of Rocky Mountain disturbances is interrupted by a complex series of structures. The study area lies on the western flank of one of these features, the Sweetgrass Arch. It is a broad, gentle uplift that rises in Montana and plunges northward to meet the Battleford Arch at the Suffield Saddle. East of the Arch is the gently-sloping western flank of the Williston Basin; west of the Arch is the steeper eastern limb of the Alberta syncline (Figure 2).

Although it is generally agreed that the Sweetgrass Arch is primarily a Tertiary feature, Jurassic, Mississippian, and even early Paleozoic activation may have occurred (Webb, 1951; Herbaly, 1974; Thompson and Crockford, 1974; Stelck, 1975).

The dissolution of Paleozoic evaporites has been documented as a local structural control of Mannville sedimentation (Putnam, 1982). However, this phenomenon was not detected by mapping in the study area.

The resulting structure in the study area is relatively uncomplicated, with a regional dip of about 5 metres per kilometer to the northwest.

# Chapter 3

## Regional Geologic History

### Mississippian

During Mississippian time, the present Plains and Rocky Mountains region were submerged, as thick sequences of mainly limestone and calcareous shale were deposited. Post-Mississippian erosion on the Sweetgrass Arch and renewed subsidence in the Alberta syncline preserved most of the Mississippian rocks in a westerly direction so that subcrops of the various members are present in belts that parallel the axis of the Arch. Pennsylvanian, Permian, and Triassic strata are completely missing from the area of the Arch.

### Jurassic

While much of the Alberta shelf remained emergent in Middle Jurassic time, the western and southern portions were transgressed. The resulting marine sedimentation is termed the Ellis Group in southern Alberta. It consists of Sawtooth sandstones, overlain by Rierdon shales, and uppermost Swift sandstones.

Subsequent elevation of the northern portion of the Sweetgrass Arch caused erosion of the Jurassic strata so that members successively wedge-out northward. Erosion was most pronounced along the crest of the Arch, and thus the group thickens eastward and westward on its flanks, as well as southward. Figure 4 shows this subcrop pattern.

In the study area, the Swift Formation was completely eroded. The Rierdon and Sawtooth Formations overlie the irregular Mississippian unconformity, tending to smooth out the paleotopography.

Lower Cretaceous

A. Lower Mannville

During late Jurassic or early Cretaceous time, great orogenic movements associated with the Nevadian Orogeny produced the present-day Selkirk Mountains belt. The entire southern Alberta basin became emergent as the Jurassic sea was expelled. A major drainage pattern developed which flowed northward from Montana and cut through the various Jurassic units exposed along the Arch.

Clastics were supplied to this drainage system from the uplifted mountains to the west (Berry, 1967; Herbaly, 1974; Webb, 1954) or from the Precambrian craton to the northeast (Glaister, 1959; Hopkins, 1981; Hopkins, et al., 1982; Williams, 1963). Fluvial sands and shales were deposited in wide floodplains, forming the Lower Mannville Ellerslie Formation of southern Alberta.

In central and northern Alberta, some workers have proposed an estuarine valley interpretation (Horne, et al., 1982; Marion, 1982) or a combination of small estuarine, shoreline, and tidal

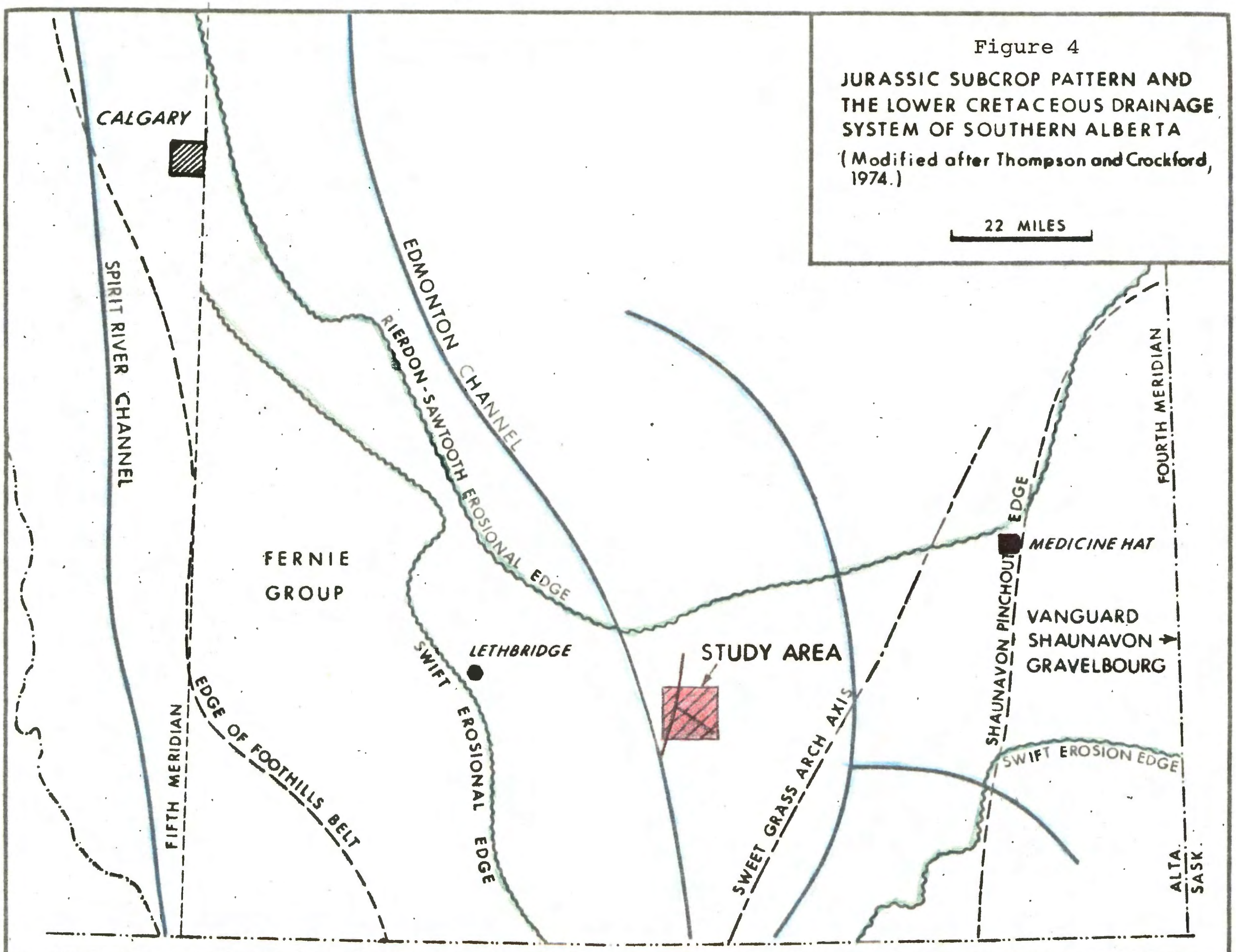



Figure 4

JURASSIC SUBCROP PATTERN AND THE LOWER CRETACEOUS DRAINAGE SYSTEM OF SOUTHERN ALBERTA

(Modified after Thompson and Crockford, 1974.)

deposit interpretations (Hopkins, 1982). These interpretations may all be compatible if contemporaneous facies transition is considered. Conditions were probably more fully marine in the north. Webb, 1954, has mapped thickened marine sequences of Lower Cretaceous age in the Peace River region.

An advance of the Clearwater Sea from the north is marked by the conformable deposition of the Calcareous Formation (or Ostracod Zone) over a major portion of southern and central Alberta. It consists of distinctive cream-coloured limestones interbedded with siltstones and mudstones, which grade upward into fine- to medium-grained white sandstone. Farshori, 1983, distinguished four lithostratigraphic units within this formation and correlated them to four stages of infilling of a large lake. The presence of freshwater gastropods, pelecypods and juvenile ostracods confirms a lacustrine origin.

B. Upper Mannville

With continued advance of the Clearwater Sea, accompanied by slow subsidence, the Glauconitic Formation was deposited over much of Alberta. It is generally agreed that the shoreline existed somewhere between Calgary and Edmonton (Herbaly, 1974). Broadly speaking, deposits to the northwest of this shoreline are marine and deposits to the southeast are continental.

However, there is considerable confusion in the literature as to the precise location of the shoreline and the origin of many of the deposits. Proximal Glauconitic sandstone sequences have been interpreted as marine bars by some authors and as fluvial deposits by others (Farshori, 1983; Herbaly, 1974; Hopkins, et al., 1982; Tilly, 1983).

It seems likely that the shallow sea had an irregular shoreline which fluctuated locally through Upper Mannville time. Therefore, marine, deltaic, and continental deposits would occur laterally and vertically in close proximity. Reworking of one sand body into another was probably common as well. This would account for the facies relations observed in the paleoshoreline region.

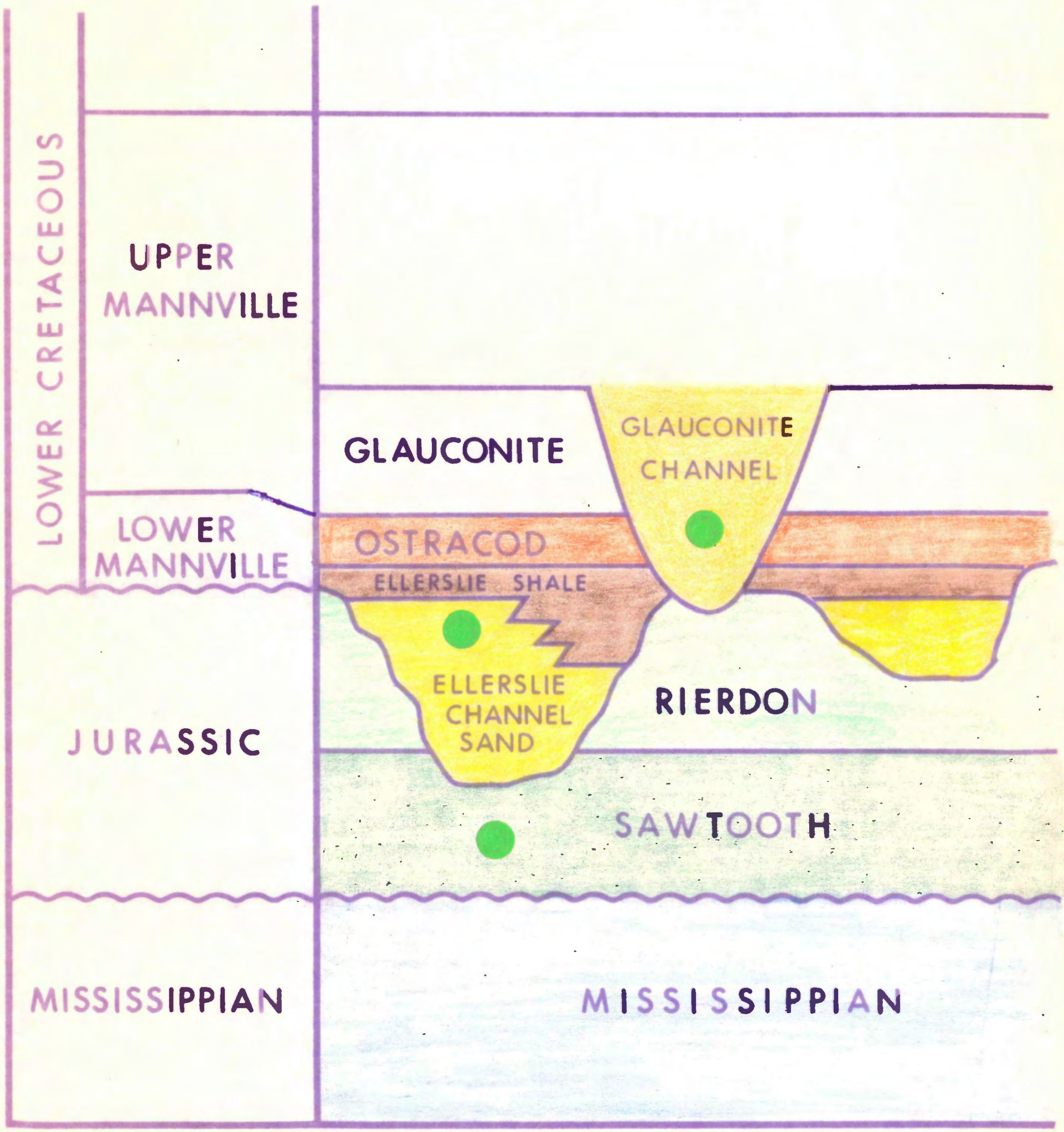
Within the study area, sedimentation was probably initiated by an influx of fine clastics into the Upper Mannville sea. Sandstones interbedded with mudstones are interpreted as crevase splay and mouth bar deposits that formed in interdistributary bays of a lower delta plain.

As positive tectonic movements in southern and central British Columbia increased the supply of detritus, the delta prograded. Distributary channels cut into the lower delta plain deposits, sometimes eroding through to the Ostracod, Rierdon highs, or Ellerslie Formation. These northwesterly-trending channels were filled with sand or shaley sand.

Figure 5 shows these stratigraphic relationships, as found in the study area. Figure 6 shows the correlations across the Sweetgrass Arch.

FIGURE 5

# TABLE OF FORMATIONS

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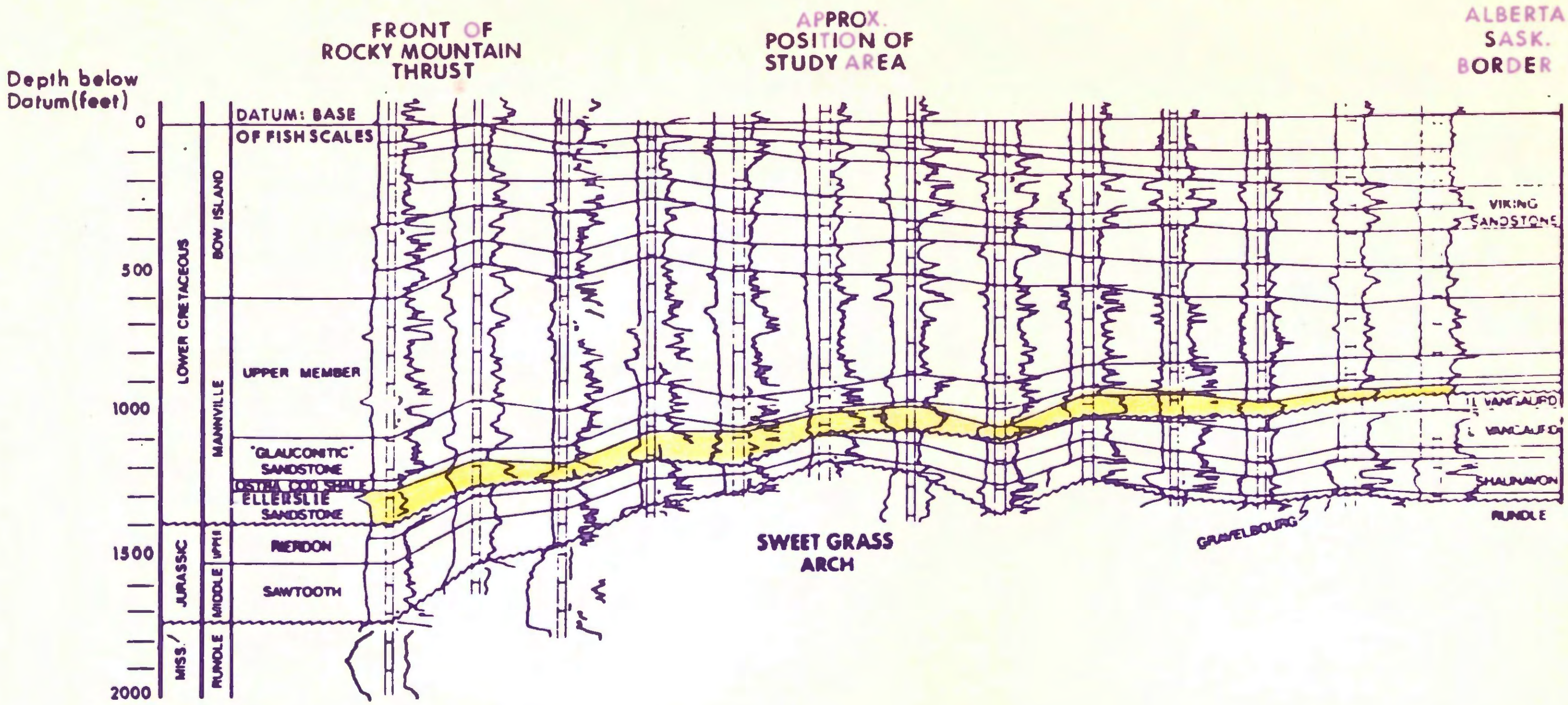


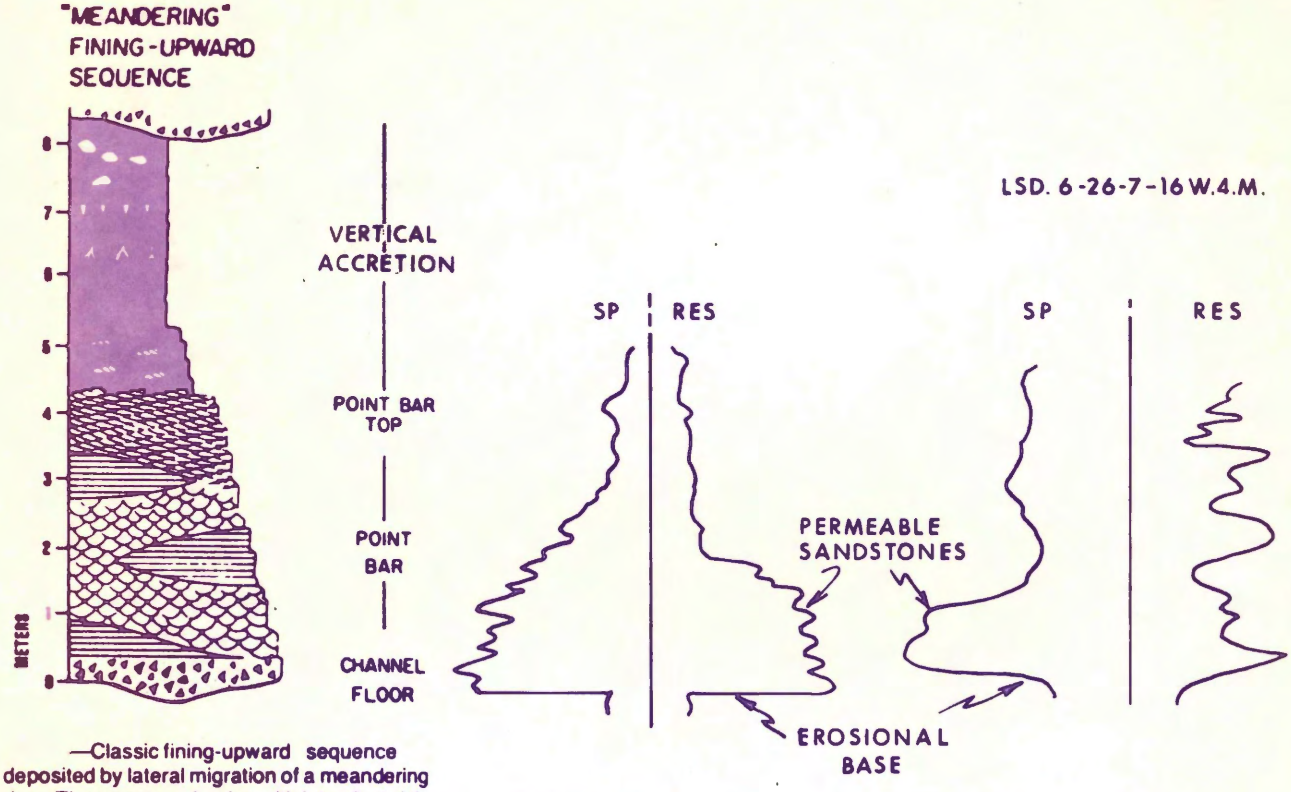

FIGURE 6. STRATIGRAPHIC CORRELATIONS OF THE LOWER CRETACEOUS AND JURASSIC FORMATIONS ACROSS THE SWEETGRASS ARCH NEAR THE INTERNATIONAL BORDER (Modified from Herbaly, 1974.)

# Chapter 4

## Correlation

Many of the formation boundaries were easily picked using a combination of electric, gamma ray, sonic, and neutron well logs. The base of the Fish Scale Sand, which marks the top of the Lower Cretaceous section, has a well-established, distinctive pattern on electric logs. Similarly, the top of the Mannville section is recognized by a marked change in average conductivity readings. The Bantry Shale of the Ostracod Zone has a fast sonic velocity, low density, and because of its high smectite content, a low gamma ray response; it is used extensively as a marker bed in southern Alberta. The Rierdon Shale is readily distinguished on electric logs from the Ellerslie and Sawtooth sandstones which lie above and below it. The high resistivity limestones of the Mississippian give a log signature which differs from those of the overlying clastics.

Problems with correlations are in distinguishing the sandstones of the Ellerslie and Glauconitic Formations. Both deposits can have upright bell-shaped curves, typical of fining upward point bar deposits (Figure 7). Furthermore, both can occur at approximately the same stratigraphic position. Therefore, it was necessary to study several core and chip samples. The distinctive mineralogies and textures of the sandstones were used to ascertain correlations.




—Classic fining-upward sequence deposited by lateral migration of a meandering river. The sequence begins with intraclast-rich conglomerate at the base, then trough crossbedded to parallel laminated sands, then finer rippled sands, and finally levee and overbank muds. (FROM CANT. 1982)

Idealized electric log profile of a fluvial point bar (from Klein, 1980)

Electric log from Southeast Taber Study Area

FIGURE 7: THE CLASSIC FINING-UPWARD PROFILE OF A POINT BAR AND THE IDEALIZED WIRE-LINE LOG PROFILE IT GENERATES. AN ELLERSLIE SANDSTONE LOG MOTIF FROM THE SOUTHEAST TABER AREA IS SHOWN FOR COMPARISON.

It was also noticed that gamma ray readings tended to be higher for Glauconitic sandstones than for Ellerslie sandstones of about the same grain size. This is attributed to the highly radioactive potassium content of the glauconite mineral and potassic feldspars of the Glauconitic Formation.

The regional stratigraphic cross-section A-A' (Appendix A), through the Southeast Taber and Chin Coulee fields, was constructed to show these initial correlations based on rock samples. It shows the characteristic downwardly convex nature of channel-fill sands. The paleochannels are clearly seen cutting into Jurassic strata of the Rierdon and Sawtooth Formations. The Southeast Taber channel is incised more deeply than the Chin Coulee channel. The Ellerslie Formation of both channels pinches out against Rierdon highs and the Ostracod Zone is found blanketing the Ellerslie or Rierdon Formations. Glauconitic channels are found where the Ostracod beds are absent, as well as in stratigraphically higher positions.

Several other stratigraphic and structural cross-sections were drawn at a more detailed scale (Appenix A). Many of these "picks" were also checked with rock samples, providing the necessary control to proceed with picking the rest of the tops of interest on the basis of log profiles. These data were used to generate a series of structural and isopachous maps.

Chapter 5

## Core Descriptions

Eight cores of Ellerslie sandstone were described in detail (Appendix B). Well locations for these cores are shown on Figure 3.

In general, each core has several fining-upward sandstone sequences. Basal conglomerate or coarse-grained sandstone has an erosional contact with the underlying Rierdon or Sawtooth Formations. Clasts of green, waxy, Rierdon shale, Sawtooth sandstone, or chert are common in this coarse unit. It is overlain by massive fine- to medium-grained porous sandstone which is overlain by fine- to very fine-grained, somewhat argillaceous, finely laminated sandstone. The fine sandstones often grade to shale or mudstone at the top. Carbonaceous and coaly fragments are most abundant towards the top.

In some sections of core the sequences are simply stacked one above the other. However, in many parts of the cores there are incomplete sequences and erosional contacts occur between the sandstone units.

Although some weak cross-bedding and planar laminations can be detected, much of the sandstone appears structureless. These units may be massive, or there may simply be a lack of mineral segregation or other inhomogeneities to outline the structures. Occasionally, blocks of sandy or muddy material were found in a framework of a different grain size. They appeared to be the products of slumping.

Compositionally and texturally the Ellerslie sandstones are very mature. Quartz is the most abundant detrital grain, comprising up to 100% of the framework near the top of the sequences. Dark-coloured chert and other sedimentary rock fragments are the remaining detrital grains, increasing in abundance towards the base of the sequences but averaging 20-40%. There is no depositional matrix. The grains are subrounded to subangular and generally well sorted.

The sandstones are orthoquartzites according to Folk's original classification scheme which was intended to reflect the source terrain. In this scheme, quartz and chert are at one apex of a triangular diagram and the sedimentary rock fragments are at another. This infers a sedimentary provenance for the Ellerslie sandstones. In his latest scheme, Folk groups chert with the sedimentary rock fragments. Most of the Ellerslie sandstones would therefore be classified as chert arenites, although a few quartz arenite units are present.

The percentage of porosity and cement was estimated at intervals throughout the cores. Although it is difficult to get accurate values using a light microscope, the relative percentages are meaningful. The more quartzose, finer-grained sandstones tend to have a greater percentage of silica cement (up to 20%). The distribution of clays and calcareous cement, however, seem more sporadic. The medium-grained units tend to have the greatest porosities (up to 22%).

# Chapter 6

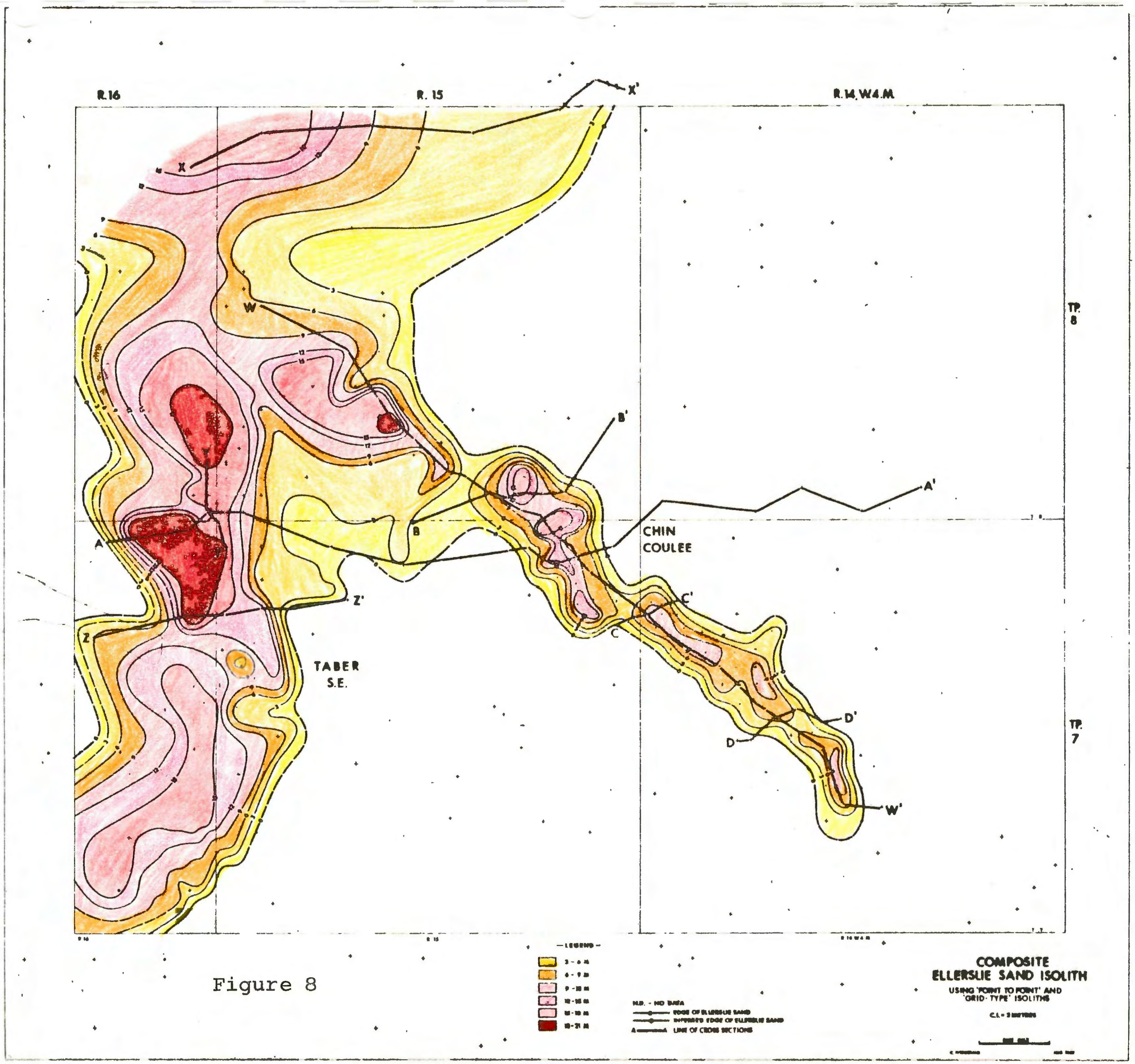
## Sand Body Geometry

Figure 8 is a composite Ellerslie sandstone isolith map showing the sand body geometry. Details of construction are given in Appendix D.

The Southeast Taber sandstone is 20 kilometers in length within the study area, trending northward; Chin Coulee sandstone spans 15 kilometers and is oriented to the northwest. The width of the sandstone distribution is greater in the Southeast Taber field, ranging from 4 - 7 kilometers as compared to 1 - 2 kilometers in the Chin Coulee field.

Sandstone thicknesses in the Southeast Taber field are variable across its width, reaching 18 - 21 metres in isolated, irregular pods, but averaging 11.4 metres. Sandstone thickness in the Chin Coulee field increases regularly towards the center of the paleochannel and towards the northwest where it reaches 18 - 21 metres near Southeast Taber. In general, the Chin Coulee sandstones are not as thick as in Southeast Taber, averaging 8.4 metres.

Figure 9 is a map of the Ellerslie sandstone structure. It shows that structurally highest points of the sandstone in Chin Coulee occur roughly along an axis through the center of the paleochannel. The structure contours have a more complex pattern in Southeast Taber.



R.16
R. 15
R.14 W.4.M.
X
X'
W
W'
A
A'
B
B'
C
C'
D
D'
Z
Z'
TP. 8
TP. 7
CHIN COULEE
TABER S.E.
— LEGEND —
N.D. - NO DATA
EDGE OF ELLERSLIE SAND
INFERRED EDGE OF ELLERSLIE SAND
LINE OF CROSS SECTIONS
COMPOSITE
ELLERSLIE SAND ISOLITH
USING 'POINT TO POINT' AND
'GRID- TYPE' ISOLITHS


Figure 8

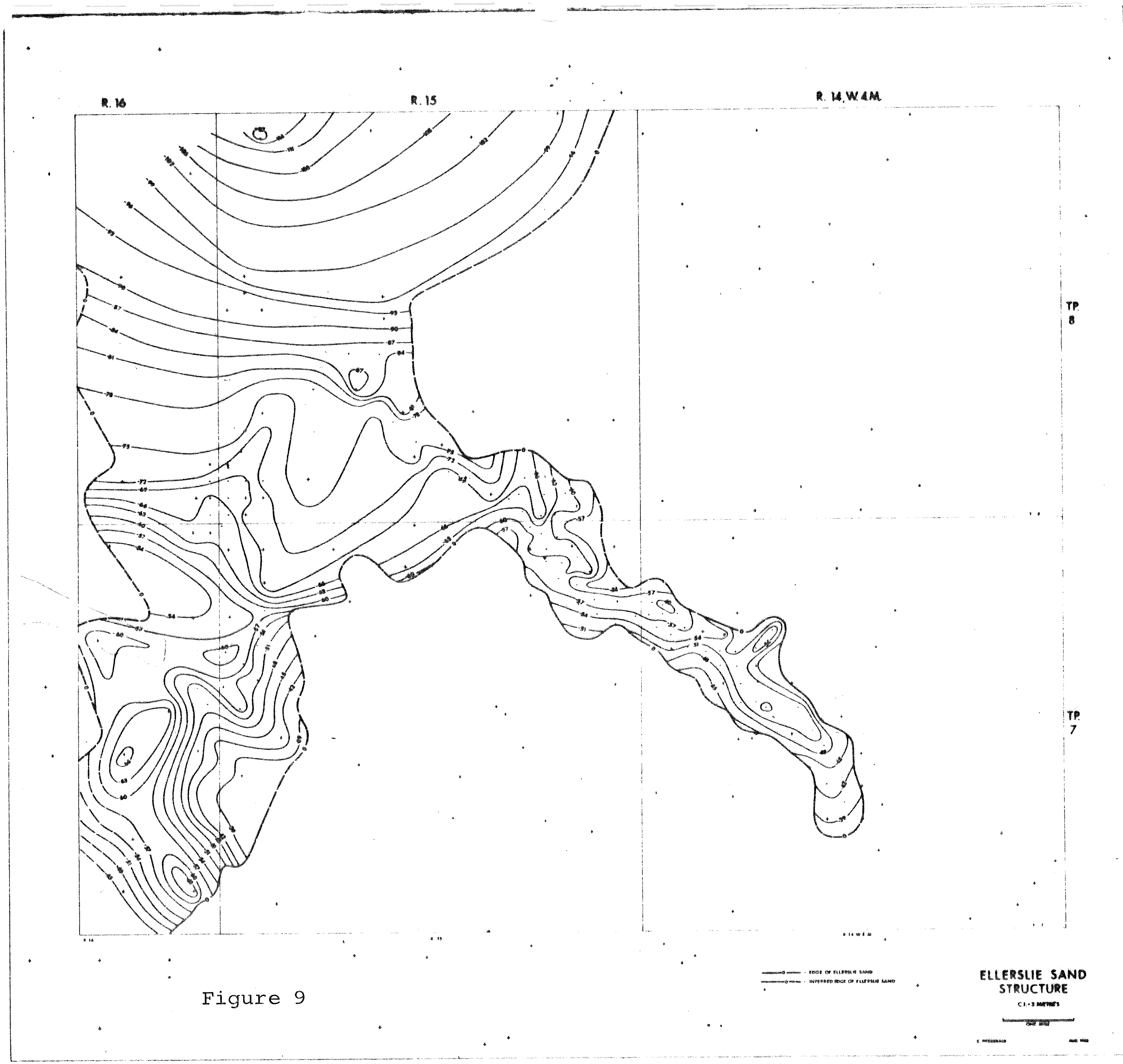

R. 16
R. 15
R. 14, W.4M.
TP. 8
TP. 7
EDGE OF ELLERSLIE SAND
INFERRED EDGE OF ELLERSLIE SAND
ELLERSLIE SAND
STRUCTURE
C.I.=3 METRES

Figure 9

# Chapter 7

## Paleodrainage Mapping

Two types of maps were used to define the paleodrainage pattern; both involve trend surface analysis. The methods used to construct these maps are described in Appendix D.

Figure 10 is a $4^{th}$ order residual of the Jurassic structure. Since the regional dip is subtracted from the present day structure, the map shows the actual relief on the Jurassic surface after river downcutting. Arrows were drawn through the points of maximum curvature of contour lines to show the river course. The paleoslope of the Chin Coulee valley is about 0.6 metres per kilometer and about 1.8 metres per kilometer for Southeast Taber.

A comparison with the Ellerslie sand isolith (Figure 8) reveals that the sand distribution is very closely controlled by the Jurassic structure for Chin Coulee. This is not true for Southeast Taber where the greatest sand thickness does not necessarily coincide with the channel axis. The thickest sands occur at the edges as well as within the river valley. The comparison also reveals that Jurassic highs correspond to areas of zero Ellerslie sand deposition.

The paleodrainage pattern was also mapped using the datum plane-valley floor isopach method of Andresen, 1961, and Bush, 1974. Figure 11 is the base of the Fish Scales to top of the Jurassic residual isopach. Since the channel sandstones thicken

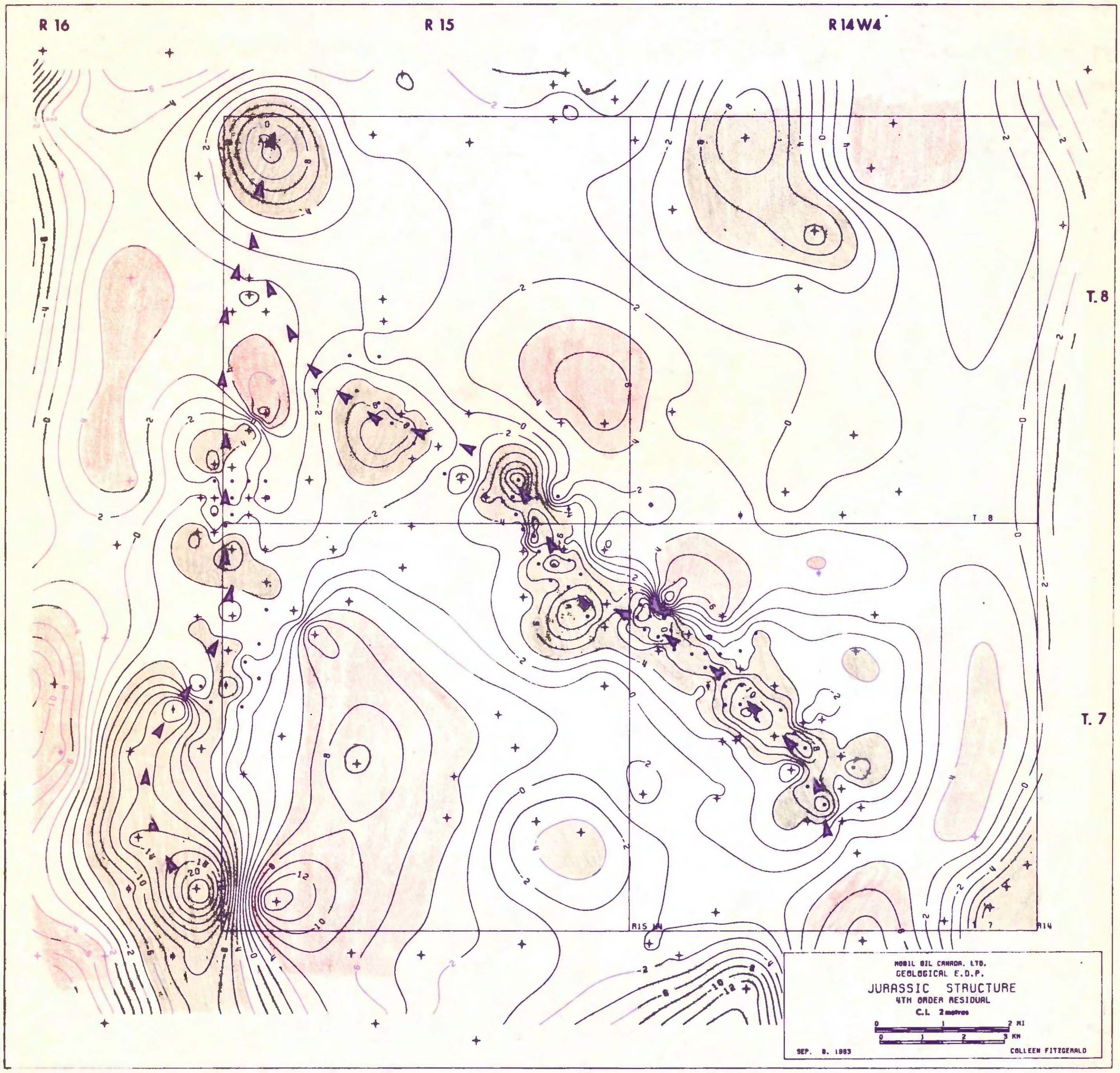

R 16
R 15
R14W4
T. 8
T. 7
MOBIL OIL CANADA, LTD.
GEOLOGICAL E.D.P.
JURASSIC STRUCTURE
4TH ORDER RESIDUAL
C.I. 2 metres
0 1 2 MI
0 1 2 3 KM
SEP. 8, 1983
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FIGURE 10

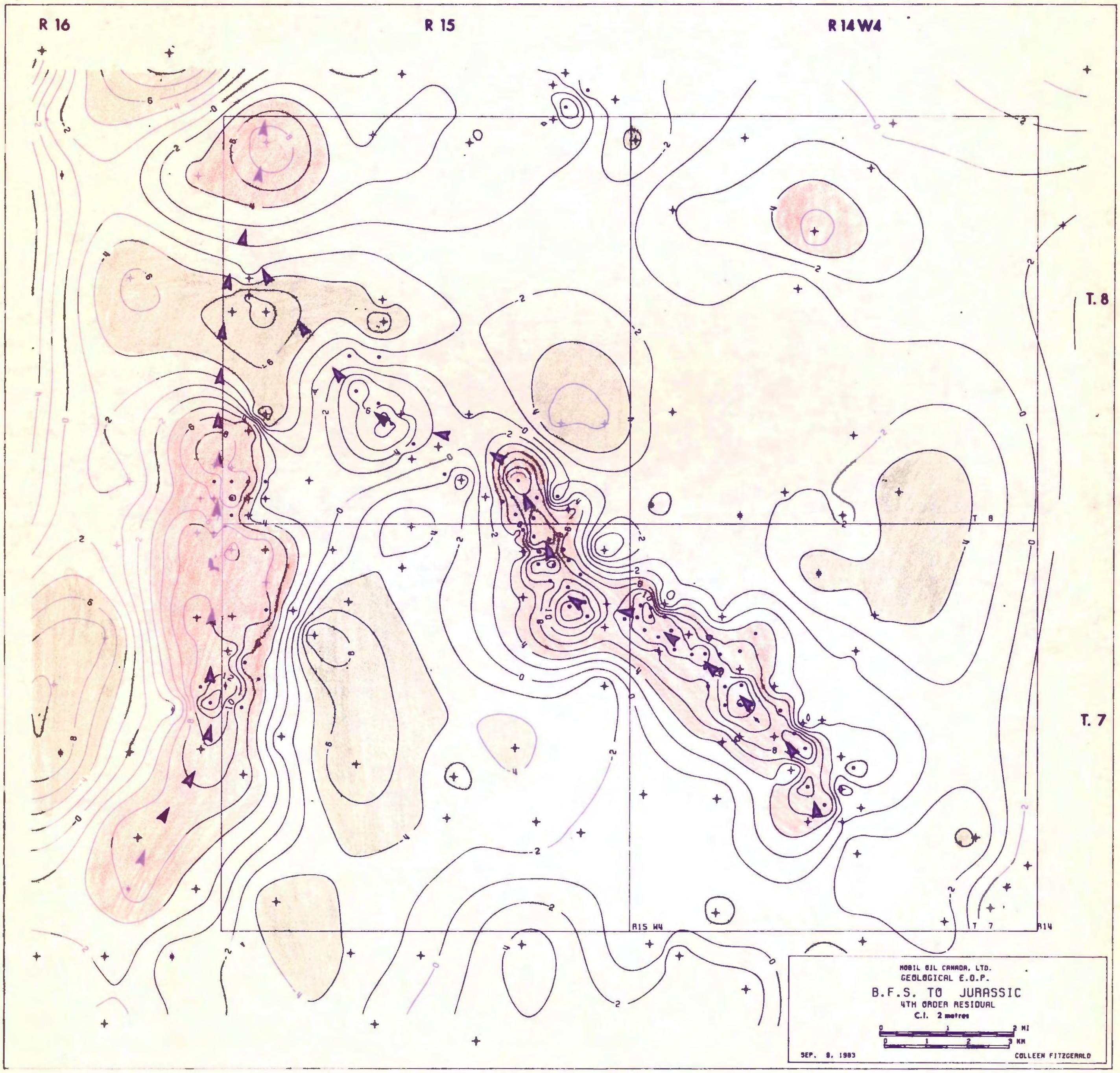
R 16
R 15
R 14 W4
T. 8
T. 7
R15 W4
T 8
T 7
R14
MOBIL OIL CANADA, LTD.
GEOLOGICAL E.O.P.
B.F.S. TO JURASSIC
4TH ORDER RESIDUAL
C.I. 2 metres
0 1 2 MI
0 1 2 3 KM
SEP. 8, 1983
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FIGURE 11

at the expense of the underlying strata, the red areas of thickest section depict the channels. The black areas of thinnest section correspond to areas of no channel sandstone.

This method seems to highlight the channels better than the unconformity structure method, probably because of the additional effect of differential compaction around the channel sandstones. There were several choices of data planes available for use in the study area, all producing very similar results. However, the top of the Jurassic to base of the Fish Scales Isopach was chosen for inclusion in the thesis because there were slightly more data points available for the stratigraphically higher base of the Fish Scales datum plane.

# Chapter 8

## Mapping the Mississippian Structure

Towards the Jurassic zero edge, some workers believe that the Mississippian erosional surface has strongly influenced the Jurassic paleotopography and, therefore, indirectly influenced Ellerslie sand deposition (Herbaly, 1974).

However, as the Jurassic cover thickens towards the south, the relationship becomes less obvious. In the study area, up to 50 metres of Jurassic marine sediments have smoothed out the paleotopography, apparently creating no areas of preference for stream erosion.

A $4^{th}$ order residual of the Mississippian structure was compared with the Jurassic structure residual. Only a vague correlation of highs and lows existed, mainly over Southeast Taber. This may be purely a function of Mississippian well control which is best in the deeper Southeast Taber wells. The Mississippian surface may undulate randomly over the entire study area.

Berry, 1967, observed a similar lack of relationship in his study of the Grand Forks oil field about 40 kilometers away, as did Hopkins, 1981, in the Medicine River area.

# Chapter 9

## Porosity Mapping

Porosity values of Ellerslie sandstone were measured from sonic and neutron logs of the map area. Using a 10% porosity cut-off, the thicknesses of porous sandstone were totalled for each well. The isolith map for this porous sandstone (Figure 12) shows the thickest porous sandstone in red (18-21 m) and the thinnest porous sandstone in yellow (0-3 m).

This map differs from the previously-drawn isolith which contained porous and non-porous sandstone. For Chin Coulee, the thickest porous sand simply occurs in areas of thickest sandstone, towards the centre of the channel and especially near Southeast Taber where the channel is deepest. In Southeast Taber, areas of thickest porous sandstone do not necessarily coincide with the areas of thickest sandstone. Lenses of silty or non-porous sandstone cause differences in the two isopachs.

Average porosities were calculated for the porous sandstone of each well (Figure 13). The highest porosities (21-24%) are shown in yellow and the lowest porosity values are shown in brown ($<$12%). For Chin Coulee, the porosities increase regularly towards the center of the channel. For Southeast Taber, areas of highest porosity are found in isolated, irregular pods.

Values for the thickness and average porosity were multiplied for each well to produce a $\phi h$ map (Figure 14). The resulting pattern is once again very similar to that of the previous maps.

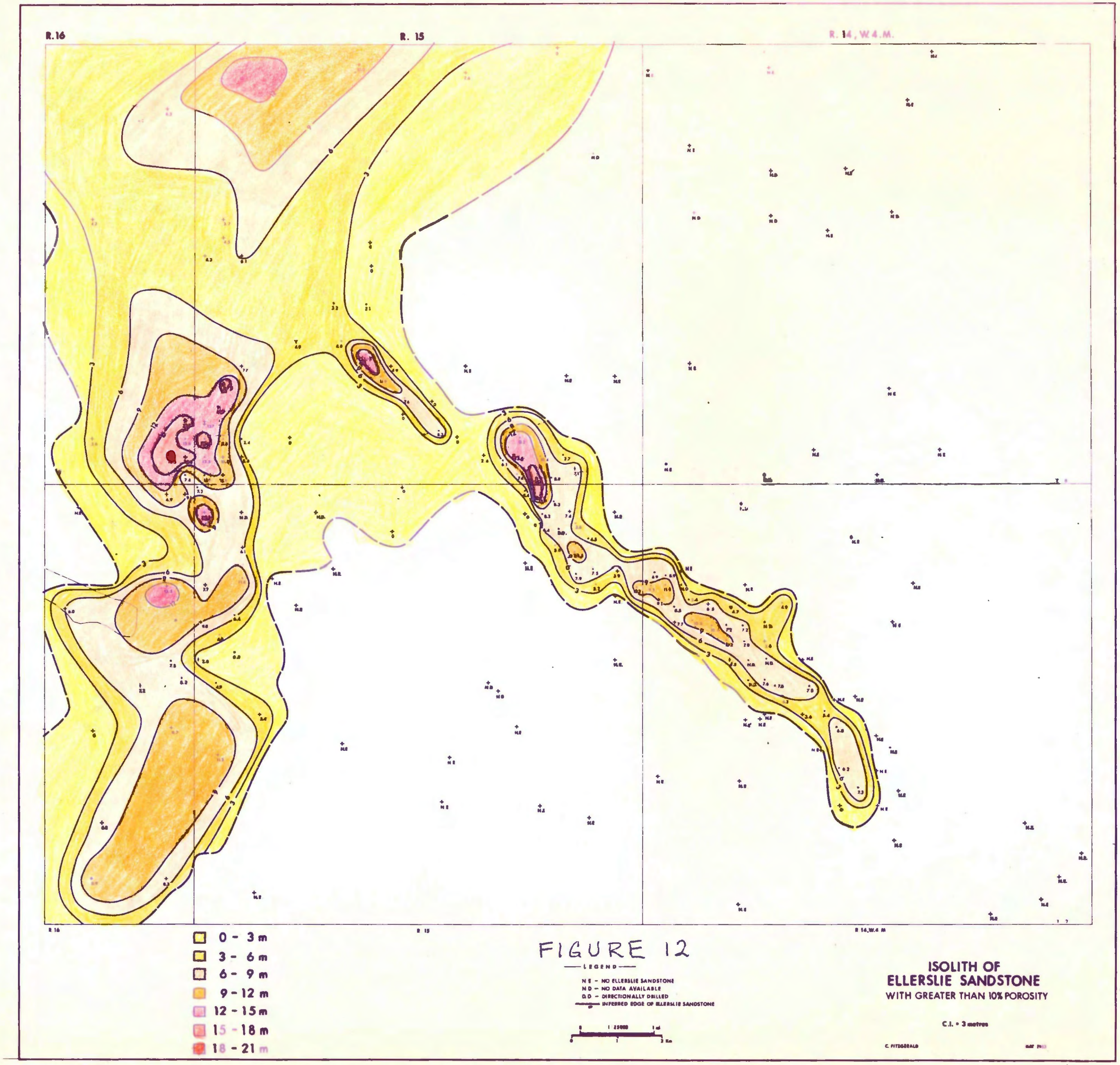

R.16
R. 15
R. 14, W.4.M.
0 - 3 m
3 - 6 m
6 - 9 m
9 - 12 m
12 - 15 m
15 - 18 m
18 - 21 m
LEGEND
N E - NO ELLERSLIE SANDSTONE
N D - NO DATA AVAILABLE
D.D - DIRECTIONALLY DRILLED
INFERRED EDGE OF ELLERSLIE SANDSTONE
ISOLITH OF
ELLERSLIE SANDSTONE
WITH GREATER THAN 10% POROSITY
C.I. = 3 metres
C. FITZGERALD

FIGURE 12

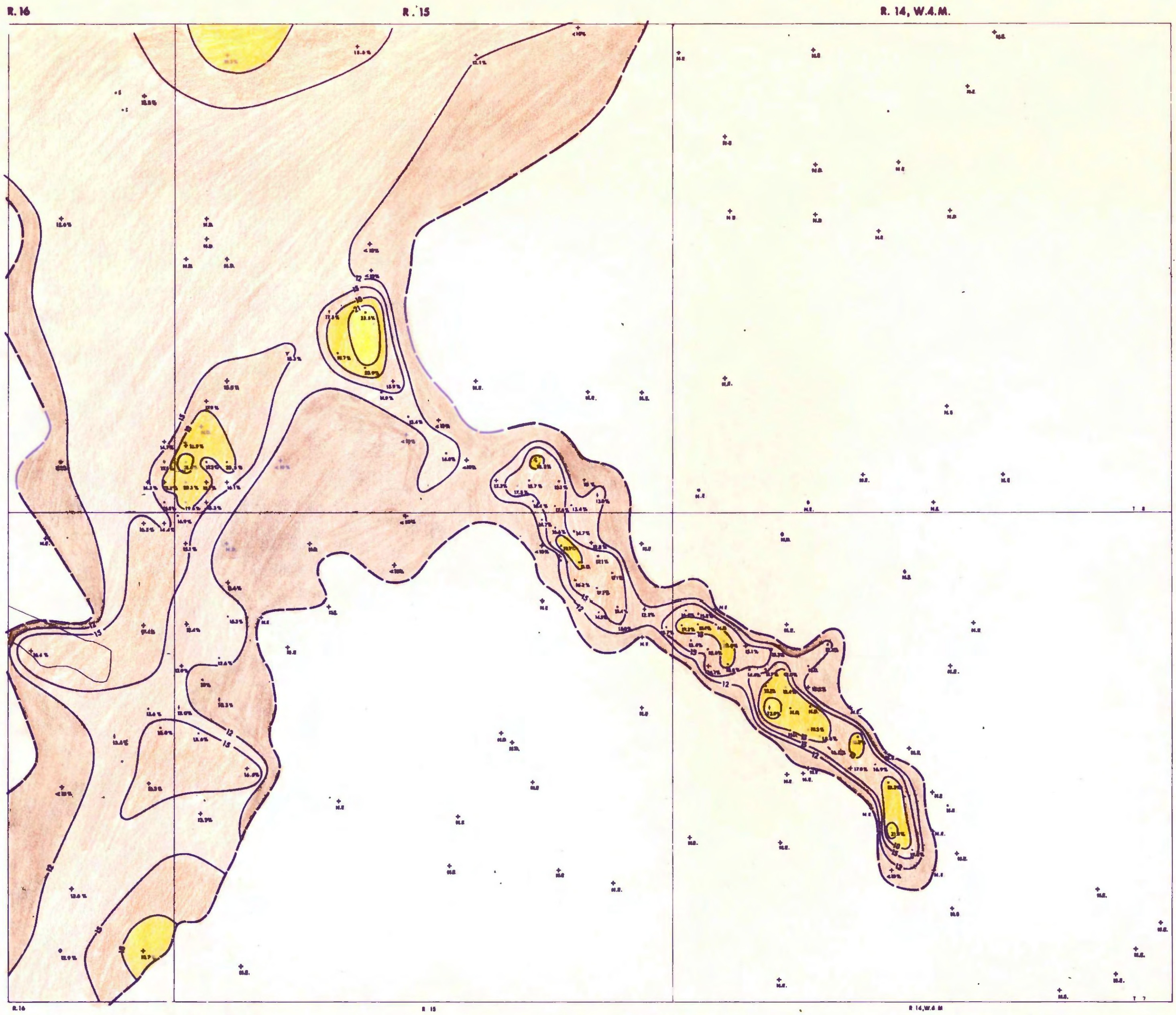



FIGURE 13

0 - 12 %
12 - 15 %
15 - 18 %
18 - 21 %
21 - 24 %

LEGEND

N.E - NO ELLERSLIE SANDSTONE
N.D. - NO DATA AVAILABLE
D.D - DIRECTIONALLY DRILLED
<10% - LESS THAN TEN PERCENT POROSITY
INFERRED EDGE OF ELLERSLIE SANDSTONE

1 : 25000

# AVERAGE POROSITY OF ELLERSLIE SANDSTONE

(INCLUDING ONLY THOSE UNITS GREATER THAN 10% POROSITY)

C.I. = 3 percent

C. FITZGERALD

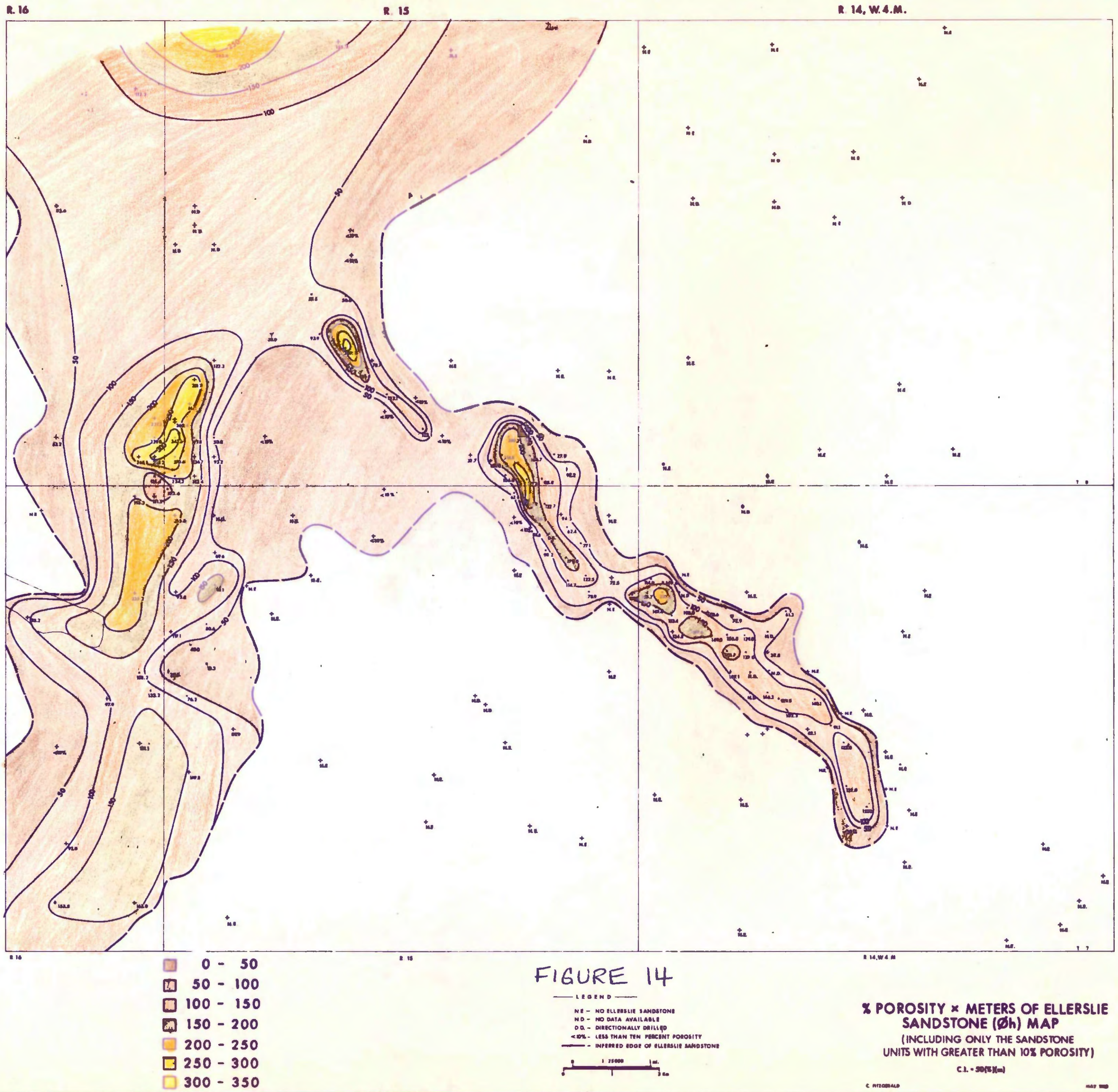



FIGURE 14

— LEGEND —

N.E. - NO ELLERSLIE SANDSTONE
N.D. - NO DATA AVAILABLE
D.D. - DIRECTIONALLY DRILLED
<10% - LESS THAN TEN PERCENT POROSITY
——— - INFERRED EDGE OF ELLERSLIE SANDSTONE

% POROSITY × METERS OF ELLERSLIE SANDSTONE (Øh) MAP
(INCLUDING ONLY THE SANDSTONE UNITS WITH GREATER THAN 10% POROSITY)

C.I. = 50(%)(m)

C. FITZGERALD

A comparison between these porosity maps and the show map (Figure 3) shows the effect of porosity on drill stem test recoveries. None of the oil wells drain sandstone with <10% porosity. Conversely, mud recoveries are almost always found in sandstones with <12% porosity.

Salt water is recovered from sandstones with thicknesses and porosities which are as good or better than in producing sandstones. Salt water is not recovered from sandstone with <10% porosity.

Sandstone thickness is not critical to oil production. There is an oil well in one metre of sandstone in the Southeast Taber field.

# Chapter 10

## Thin Section Descriptions

### Introduction

Ellerslie sandstones can be difficult to produce and there appear to be differences in reservoir quality between sandstones of various fields. Chin Coulee sandstones require acidizing and fracturing to bring 10% primary recovery to 15%. However, Southeast Taber sandstones yield 12% recovery without secondary techniques. Pay zones in other Ellerslie fields can have recoveries of less than 1% (E.R.C.B., 1982).

In order to investigate these production differences, 26 thin sections were described (Appendix C). Thin section locations are shown on the core descriptions of Appendix B.

### Methods and Problems

The thin sections were impregnated with a blue epoxy in order to differentiate the porosity more easily. However, not all pore space received the epoxy. This was more of an inconvenience than a problem, as it simply necessitated more careful observation.

The thin sections were stained with alizarin red-S and potassium ferricyanide after etching in dilute hydrochloric acid. Etching increases the clarity of fabrics and dissolves carbonates of different compositions by varying amounts. Staining with alizarin red-S differentiates carbonate minerals into two groups.

Aragonite, calcite, witherite, and cerussite, which dissolve rapidly in dilute hydrochloric acid, are stained, while dolomite, siderite, magnesite, and rhodochrosite, which react much more slowly with the acid, remain unstained. Staining with potassium ferricyanide will distinguish the ferrous iron distribution. Thus, pink-staining carbonates are calcite, purple to royale blue-staining carbonates are ferroan calcite, unstained carbonates are dolomite, and pale to deep turquoise carbonates are ferroan dolomite (Dickson, 1966).

Two of the thin sections were contaminated with drilling mud and so it was not possible to obtain reliable data. The contamination was caused by caving of the drilling mud into the friable sandstones. Had the author been more experienced, the problem might have been avoided by taking only inner core samples.

Plucking of grains from the slide during grinding was another problem encountered in a few thin sections. Plucked grains were distinguished from pore space by their "grain shape" and the absence of quartz overgrowths or other cements jutting into the cavities.

Since a thin section is not necessarily cut through the largest dimension of grains, a correction factor was applied to the measured values of grain size. Taylor, 1977, suggests that only about 70% of the actual grain size is seen in a thin section of fairly well-rounded, regularly packed grains. Accordingly, the figures for grain sizes, appearing in the descriptions, have been divided by 0.7.

Three hundred grains were point counted for 6 of the 26 thin sections. This provided an important check on the visual estimates of the other sections. Unfortunately, this method does not work for estimating the amount of cements; these percentages were visually estimated with the help of charts by Scholle, 1979, and Swanson, 1981.

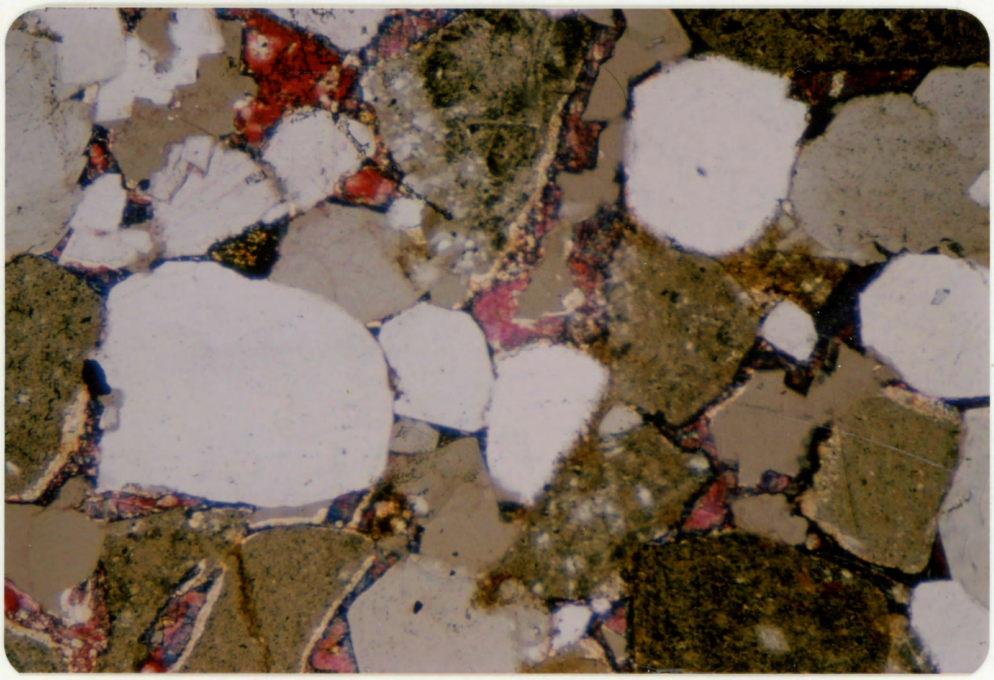
## General Description

### A. Grains

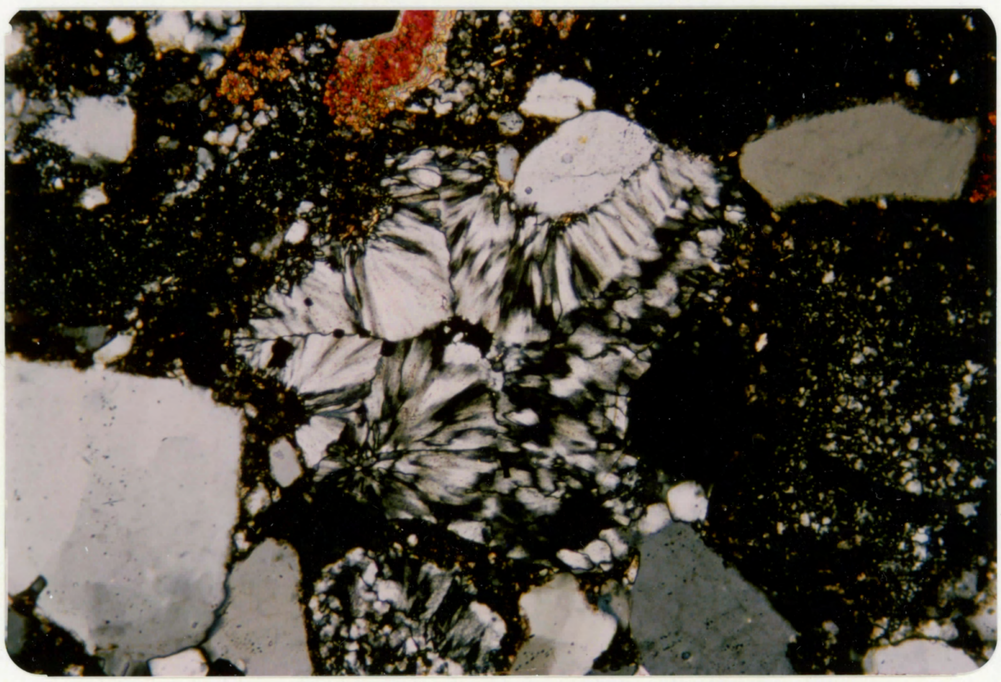
Quartz, chert, and sedimentary rock fragments (S.R.F.) compose the main detrital components of the Ellerslie sandstone. Quartz is the most common, averaging 70-85% of the clasts. There is no depositional matrix, and therefore they are classified as orthoquartzites or chert to quartz arenites (Figure 15A).

The quartz normally occurs as single grains with straight and undulose extinction equally common. About 20% of the quartz is polycrystalline. Chalcedony is found locally but is considered a sedimentary rock fragment (Figure 15B).

The sedimentary rock fragments generally compose less than 10% of the clasts and are very quartzose. Quartzite, quartzose sandstones, and shales are the most common. Rarely, a metamorphic fabric is seen; since it is randomly oriented, the foliation is considered to be a primary feature of the clasts.



A



B

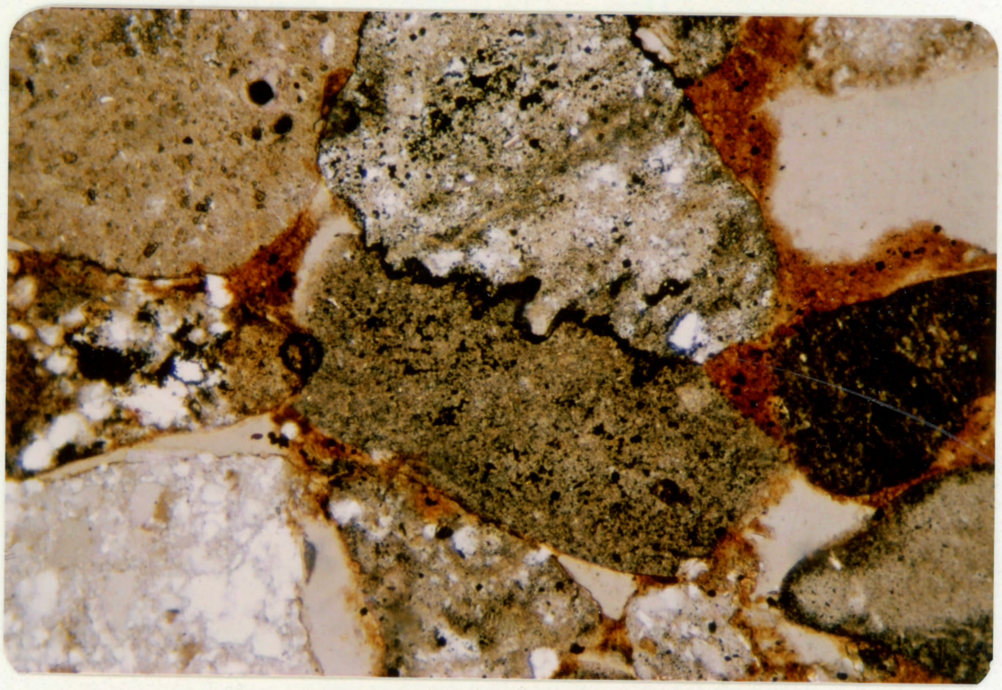
Figure 15: A. Photomicrograph of Ellerslie sandstone showing quartz grains (white), chert and sedimentary rock fragments (speckled brown), calcite cement (pink and red), ferroan calcite cement (blue), and porosity (tan). Partially crossed nicols, magnification=63x. B. Chalcedony, another detrital component. Crossed nicols, magnification=100x.

B. Grain Contacts

According to Taylor, 1950, the nature of the grain contacts in a sandstone is a visual measure of the result of sediment settling and compaction. However, grain contacts are high energy sites where cements are preferentially dissolved or precipitated. In the Ellerslie sandstones, the types of contacts are a function of chemical reactions as well as mechanical compaction.

"Floating grains" and tangential, straight, and embayed contacts are all common. "Floating grains" are found in pore space created by the dissolution of cement (although grains which appear floating in the two-dimensional thin section may have a contact in the third dimension). Tangential grain contacts are either caused by low degrees of mechanical compaction or by replacement then dissolution along most of the grain contact. Straight grain contacts may be caused by moderate mechanical compaction or by quartz overgrowths of two grains growing together. Embayed contacts can safely be attributed to compaction which causes quartz grains to become embedded in the softer sedimentary rock fragments. Also, microstylolites are commonly formed between two chert grains, causing a serrated boundary marked by an opaque line of insoluble impurities (Figure 16A).

Similarly, the number of grain contacts per grain is not just a measure of mechanical compaction. Taylor, 1950, contends



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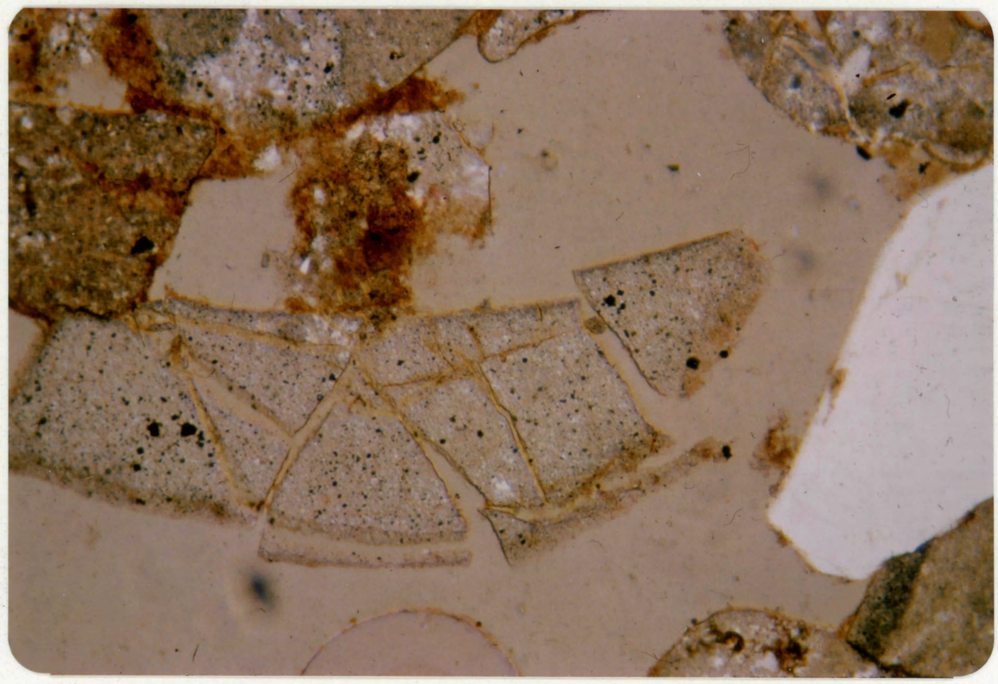


B

Figure 16: A. Chemical compaction effect-a micro-stylolite between two chert grains. Crossed nicols, magnification=100x. B. Mechanical compaction effect--a fractured chert grain. Crossed nicols, magnification=100x.

that the number of contacts per grain should increase with burial due to an increase in pressure. However, in Ellerslie sandstones, the number of contacts per grain also decreases with increasing replacement of detrital quartz with calcite cement. Therefore, there is no trend with depth in Ellerslie sandstones.

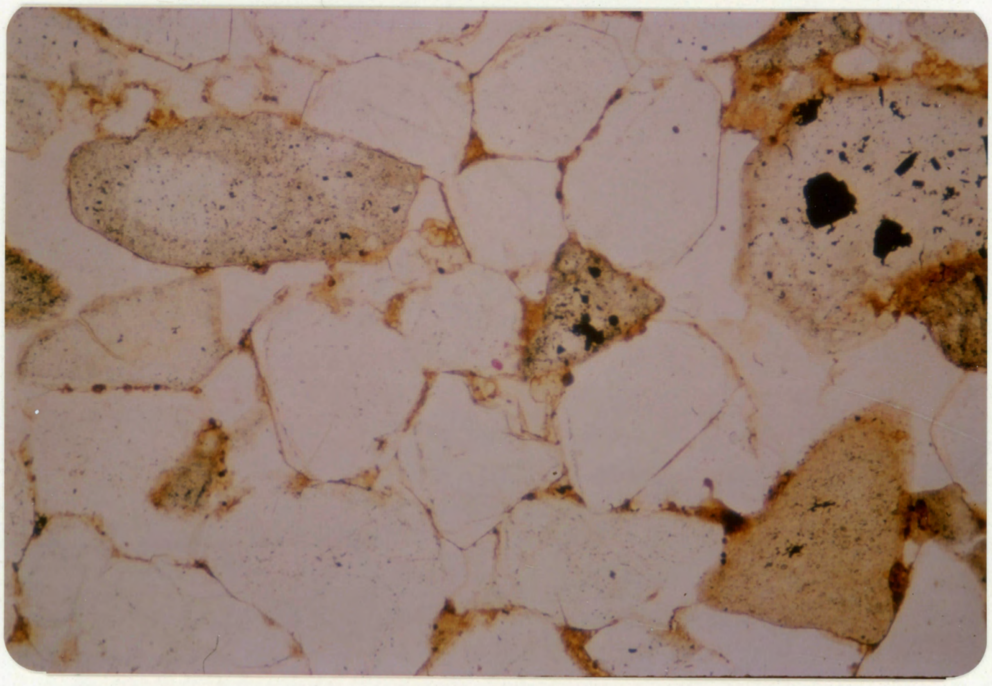
However, it is possible to gain a general understanding of the mechanical effects on these sandstones. Fracturing of grains is quite common (Figure 16B), as is the deformation of ductile grains. Also, many grains appear to have been rotated so that they obtain a higher degree of packing. The presence of at least some embayed contacts is also evidence of mechanical strain. Extensive cementation could not have been present before these mechanical effects because it would have inhibited strain on the grains.

C. Grain Size, Sorting, and Shape

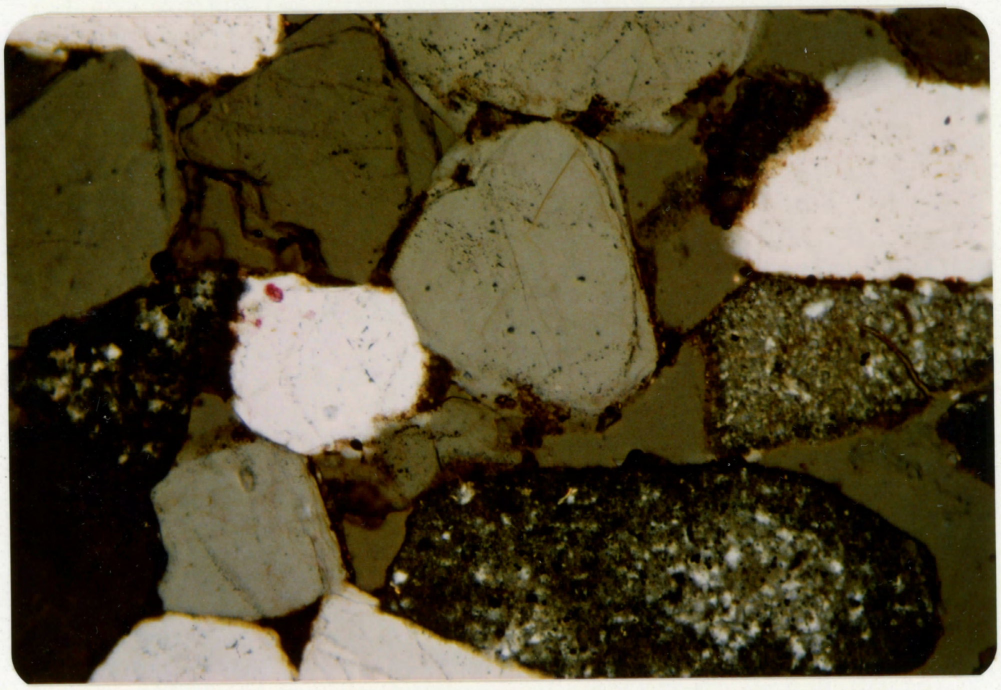
Grain sizes range from silt to pebble but most clasts are medium-grained sand. Within each thin section, the grains are usually moderately to well sorted. Although the clasts were originally well rounded, quartz overgrowths impart a pseudoangularity (Figure 17). The chert grains tend to be slightly larger and more angular than the quartz grains.

D. Cements

Quartz overgrowths, ferrous and non-ferrous calcite, dolomite, authigenic clay, and pyrite, are all found as cements.



A



B

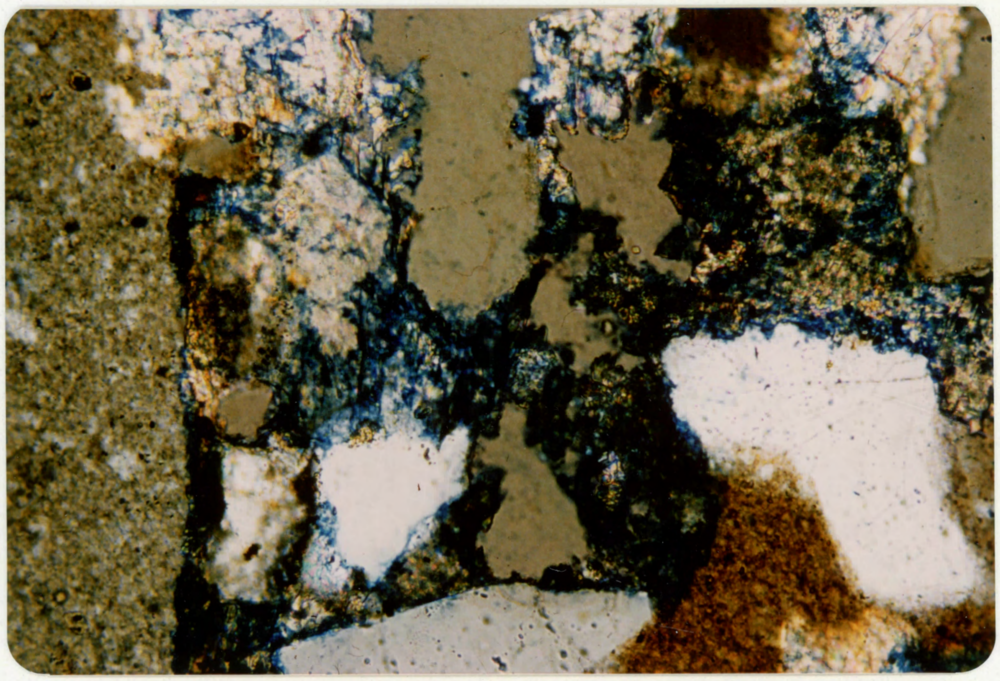
Figure 17: Quartz overgrowths in optical continuity with quartz grains, outlined by fine lines of impurities. A. Plane polarized light, magnification =63x. B. Crossed nicols, magnification=100x.

Between 1-8% quartz overgrowths are found either jutting into existing pore space or in contact with calcite cement. At least two phases of overgrowth precipitation are recognized by two lines of impurities within the siliceous cement of some grains.

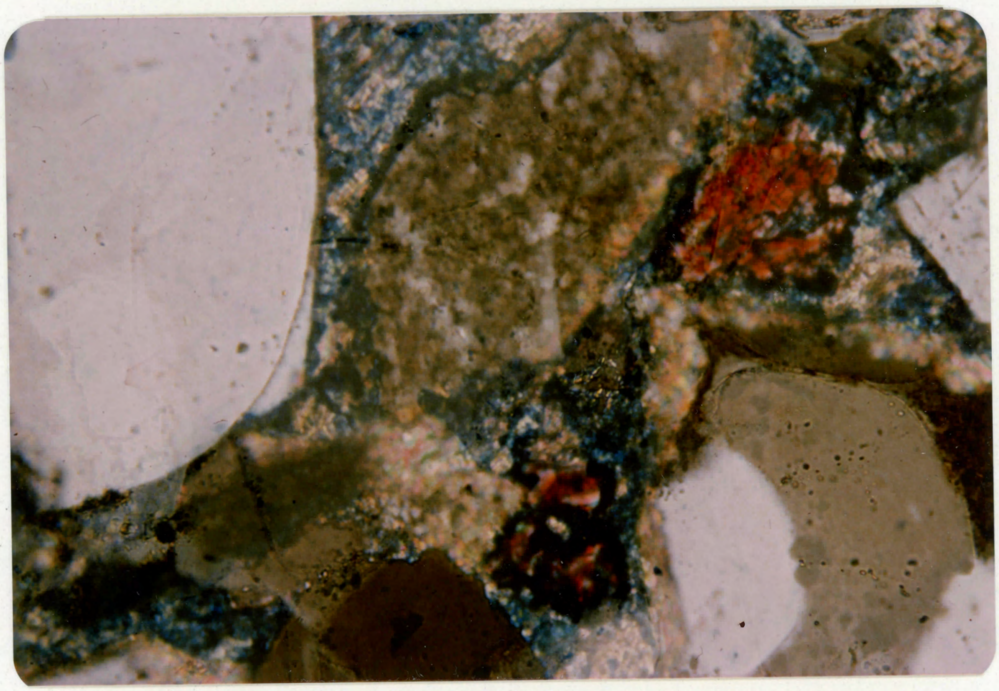
Some of the silica may have been derived from dissolution at microstylolites. This pressure solution silica is most common in the finer fraction of quartz arenites, according to Schmidt and McDonald, 1980. Alternatively, the silica may have been derived from extrastratal sources by the chemical compaction of adjacent, very fine-grained arenites, or as the product of clay diagenesis in adjacent shales. Replacement of quartz grains by carbonate may also have liberated silica to form overgrowths.

Figure 18 shows ferroan calcite cement. Only the surface grains are stained blue so some portions of calcite remain colourless. The ferroan calcite is found composing up to 5% of the rock. It preferentially corrodes quartz along fractures and irregular grain boundaries. Straight grain boundaries and quartz overgrowths are not favoured sites for silica replacement by calcite.

Non-ferrous calcite (stained pink or red) is often found associated with the ferrous variety. There is a reverse zoning pattern; ferrous calcite grows into the pores, followed by non-ferrous calcite at the the pore centers. Normally, the non-ferrous calcite would precipitate first; ferrous calcite would only form after the concentration or iron in solution becomes relatively



A



B

Figure 18: Ferroan calcite cement. A. Replacing quartz. Crossed nicols, magnification=250x. B. Surrounding quartz overgrowth. Shows reverse zoning with non-ferrous calcite. Crossed nicols, magnification=250x.

high. Iron is not preferentially incorporated into the calcite crystal lattice.

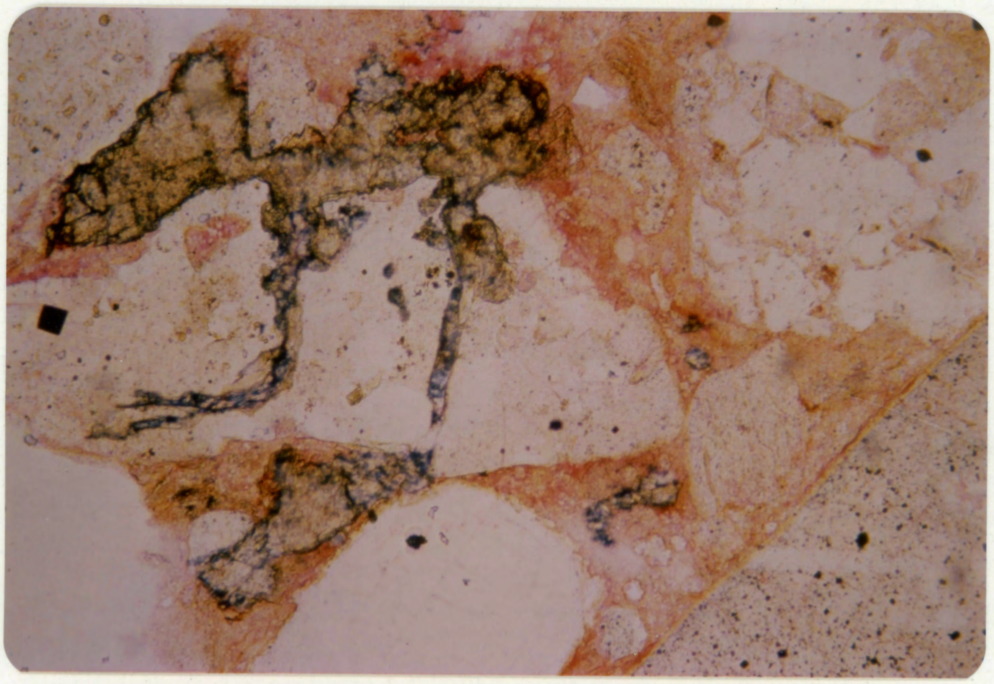
The reverse zoning may be explained by two phases of calcite cementation. Perhaps early ferrous pore fluids were followed by less ferrous solutions. Alternatively, the process of replacement may have provided conditions, such as increased temperature, which were favorable for iron substitution. Later, pore-filling calcite would not have this additional energy.

In some thin sections, non-ferrous calcite occupies up to 29% of the slide, completely eliminating the primary porosity.

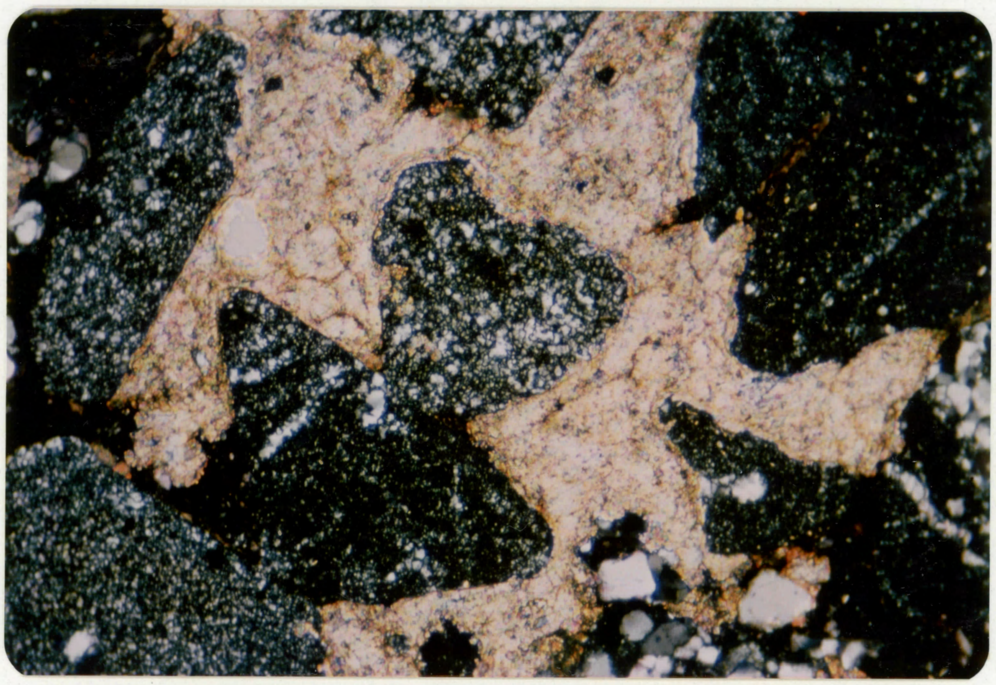
Dolomite cement (Figure 19) occurs in patches in a few thin sections, where it occupies less than 3% of the slide. It is most commonly found cementing chert grains or filling fractures in chert.

Clays are quite widespread, comprising up to 15% of the thin sections (Figures 19A and 20). They are found as thin films around grains and as pore fillers. The clays may be oil-stained and thus appear reddish-brown in colour.

Anhedral pyrite cement (Figure 20) is found in fractures and as patchy, pore-filling cement in several thin sections. It is often associated with carbonaceous material. Pyrite also occurs as inclusions within chert and in euhedral crystals within the cement.

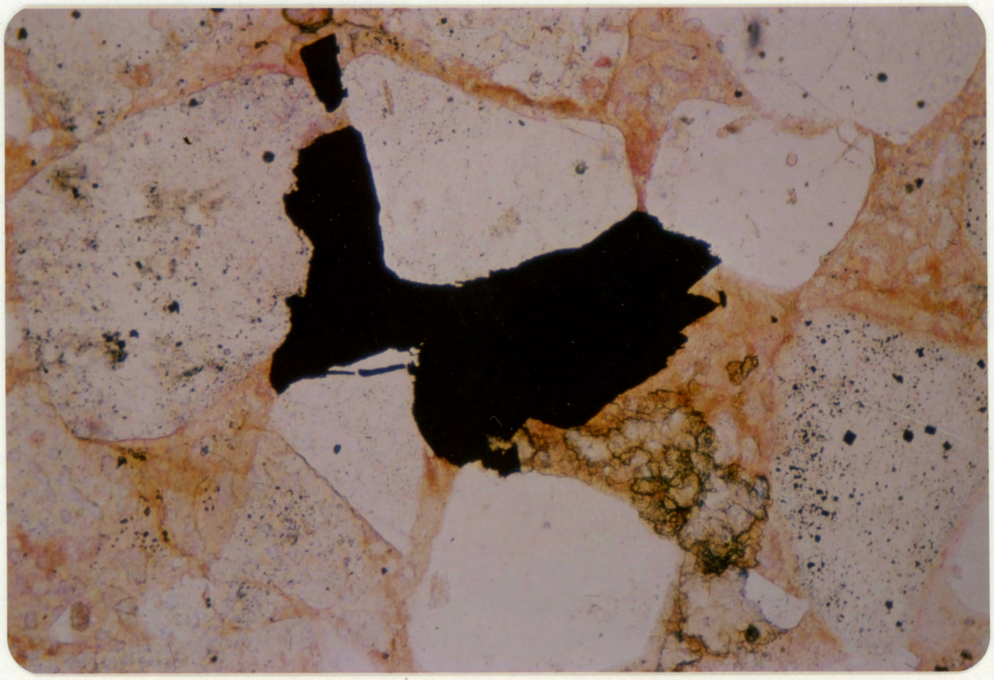


A

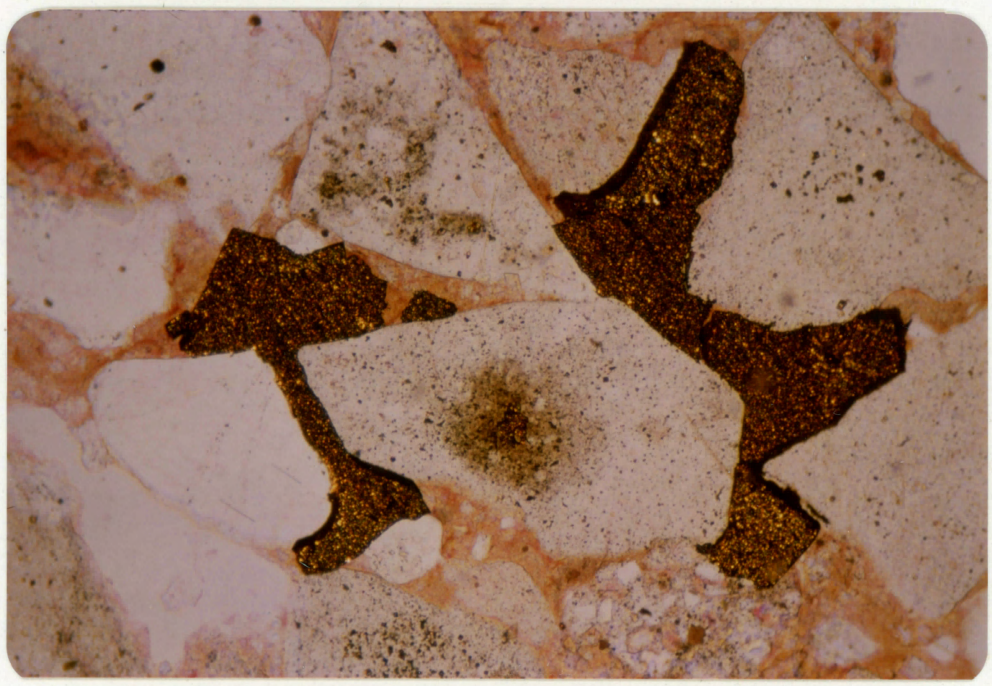


B

Figure 19: Dolomite cement. A. Filling fractures in chert. Surrounded by clay. Plane plarized light, magnification=100x. B. Cementing chert. Crossed nicols showing 4th order white birefringence, magnification=63x.



A



B

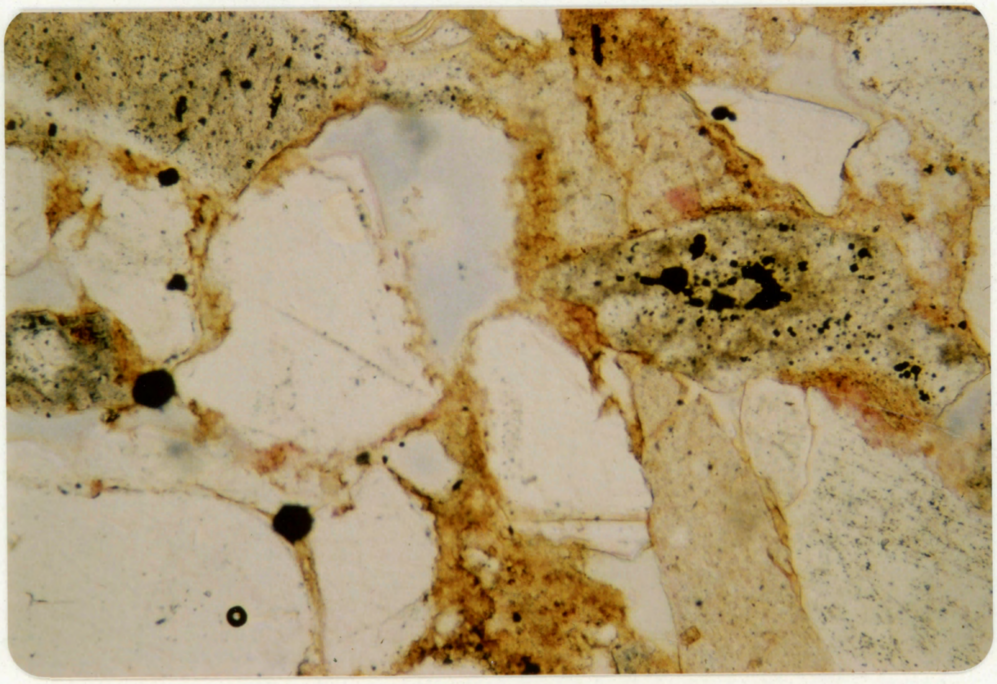
Figure 20: Pyrite cement. A. Fills a small fracture. Clay and dolomite are the other pore fillers. Plane polarized light, magnification=63x. B. Reflected light.

## E. Porosity

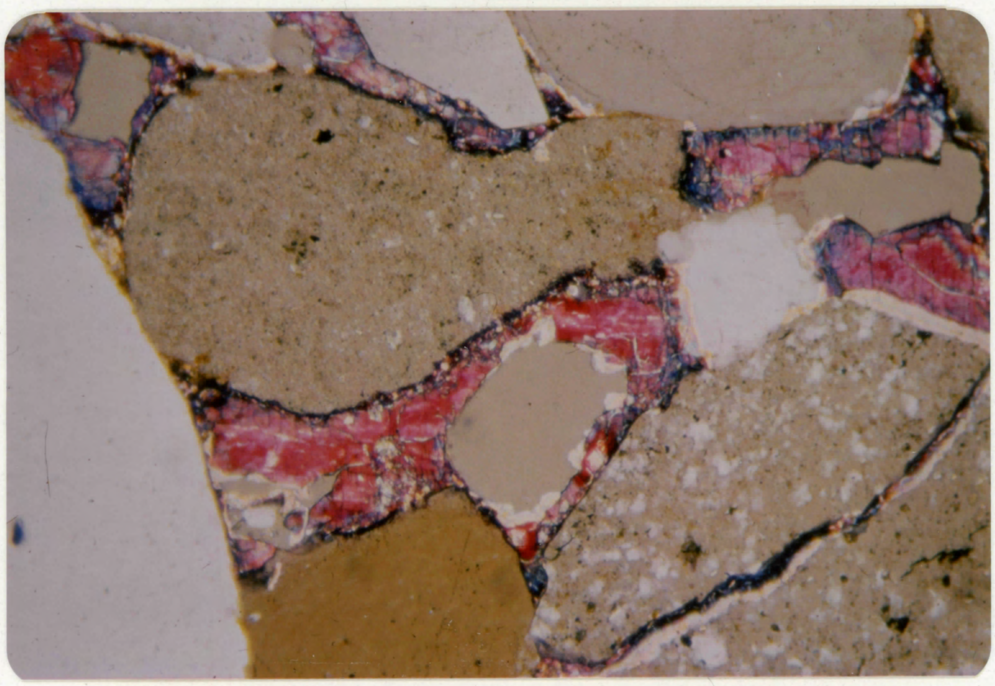
Porosity in the thin sections ranges from 0 - 22%. In some slides the porosity is completely eliminated by cements. In other slides, only minor amounts of quartz overgrowths or clays inhibit porosity.

Most of the porosity is intergranular, although minor intragranular porosity is created by fractured grains or is found within sedimentary rock fragments.

Several textural relations suggest that at least some porosity is secondary. Many of the pores are highly variable in shape and size. Some parts of thin sections have a higher percentage of porosity than others. Some pores are "oversized", that is they are too big to be primary in origin. Grains "floating" in porosity are fairly common, and pore space next to corroded quartz grains is typical. Molds of replacement along grain contacts was also observed. Traces of calcite cement are commonly seen within the porosity (Figure 21).



A



B

Figure 21: A. A quartz grain which was partially replaced and then surrounded by clay. The replacing carbonate was dissolved to create a pore space (blue). A quartz overgrowth is growing into the pore space. Plane polarized light, magnification=100x. B. Ferrous (blue) and non-ferrous (red) calcite, showing reverse zoning. Crossed nicols, magnification=100x.

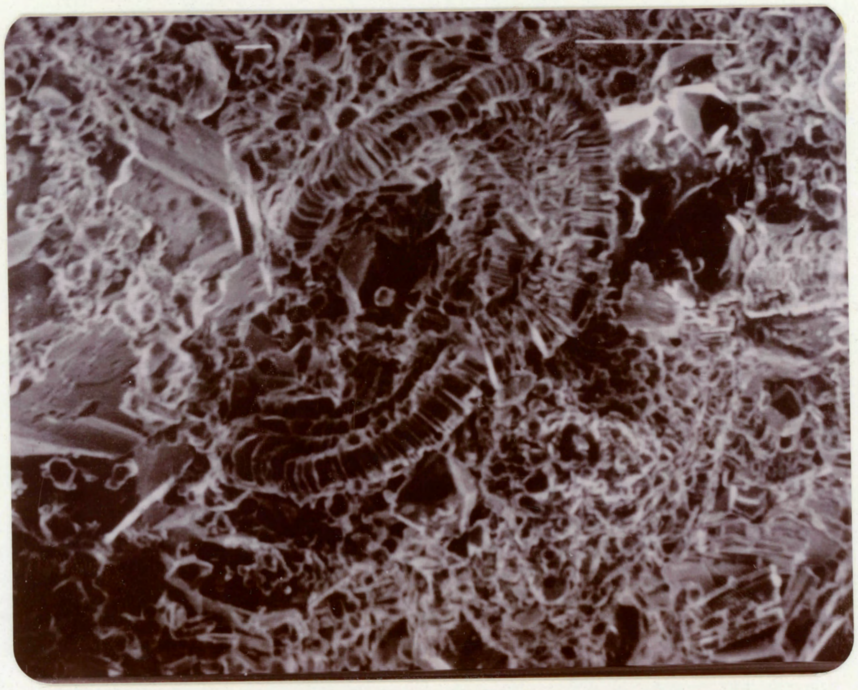
# Chapter 11

## Scanning Electron Micrographs

Samples of Ellerslie sandstone were viewed under a scanning electron microscope in order to identify the clays. Figures 22 and 23 are photomicrographs showing kaolinite clay. It occurs as pseudohexagonal plates which form booklets, and as vermicular growths characteristic of authigenic clay formed in a fluvial environment.

It is not surprising that kaolinite was found in these sandstones. This clay is typically found in quartz-rich sandstones with very little feldspar. It is often associated with quartz overgrowths and calcite cement, as in these sandstones (Carrigy and Mellon, 1964).

Although clays can be detrital or formed by *in situ* alteration, the clay viewed under the SEM probably precipitated from solution. Evidence for this is the large, well-formed crystals and the associated mineral assemblages. It is not derived from the alteration of feldspar because there is no feldspar in the Ellerslie sandstone and the clay is evenly distributed in the slides. The solution probably obtained the necessary aluminum from the nearby shales.



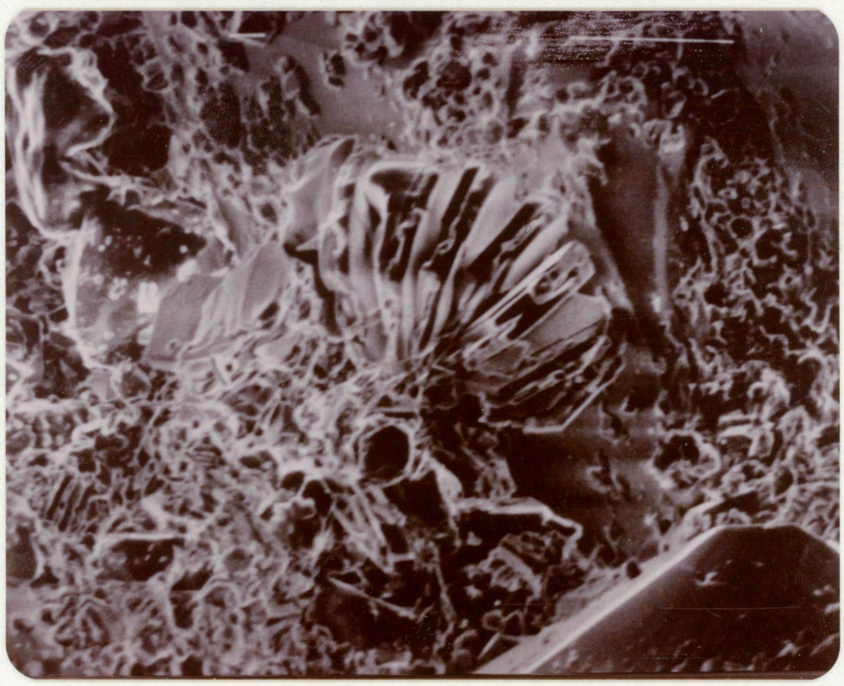


Figure 22: Kaolinite clay. The pseudohexagonal plates occur in booklets which form vermicular growths. Well LSD 2-36-8-16 W4, thin section 11. Magnification=3000x, scale bar is 10 µm.

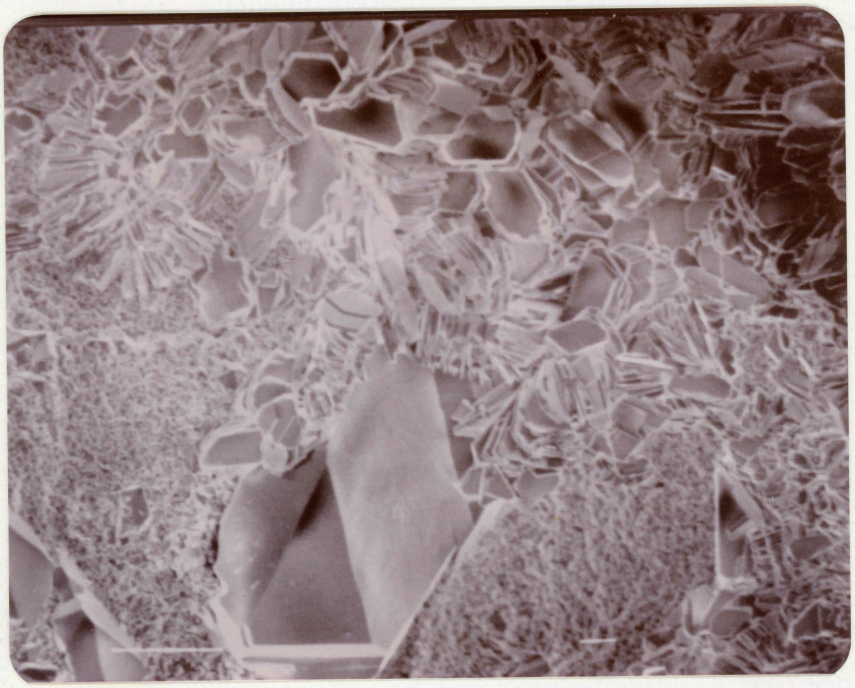


Figure 23: Booklets of kaolinite growing around a quartz overgrowth.
Well: LSD 14-16-7-14 W4, thin section 17.
Magnification=3000x, scale bar is 10 $\mu m$.

# Chapter 12

## Synthesis

### Depositional Model

The Ellerslie sandstones were deposited in fluvial paleochannels. Differences between the Chin Coulee and Southeast Taber fields are attributed to differing channel morphologies.

Southeast Taber sandstones are interpreted as deposits of a meandering river. The log profiles and cores indicate that point bars developed along the channel course. Stacking of these sequences, one above the other, generates repeated upright bell-shaped curves on some well logs. Channeling of one sand body into another causes a more complex curve on other well logs.

As the individual meanders become open loops, the point bars lose their crescent shapes and assume very irregular outlines. When meander loops are abandoned, they are filled with fine sediment which forms clay plugs within and at the edge of the river valleys. The resulting sand body of a composite point bar system, such as Southeast Taber, has an irregular shape and varying sand thicknesses. Wells spaced very close together can show extreme variation and the thickest part of the sandstone does not necessarily coincide with the true valley axis.

Chin Coulee sandstones are believed to be products of the infilling of an incised river valley. In response to a base level drop, the Chin Coulee channel was eroded straight through the Rierdon Formation, trying to establish equilibrium. The Chin Coulee river assumed a straighter course than Southeast Taber. This tributary did not cut the Jurassic strata as deeply as the main river, Southeast Taber. It experienced net erosion; therefore, no obvious point bars developed and no clay plugs filled abandoned meander loops of this low sinuosity river.

With a rise in base level, corresponding to an advance of the Clearwater Sea, the Cretaceous river valleys were filled with sand and capped by shale. Since the Chin Coulee tributary was at a higher elevation, it was one of the last channels to be filled. The resulting rock is a continuous, lenticular body of sandstone with thickest deposits corresponding to points of lowest relief on the Jurassic structure.

According to Cant, 1982, and Selley, 1978, this type of depositional model is quite common in the rock record. Leeder, 1978, pointed out that the narrower the alluvial plain, the greater tendency there will be for channel interconnections, culminating in the production of a multistorey, valley-fill deposit when the width of the alluvial plain approximates the width of the channel system.

Figure 24 shows the sand bodies generated by low sinuosity and high sinuosity rivers. This diagram, from Collinson, 1978, is thought to be representative of Chin Coulee (A), and Southeast Taber (B).

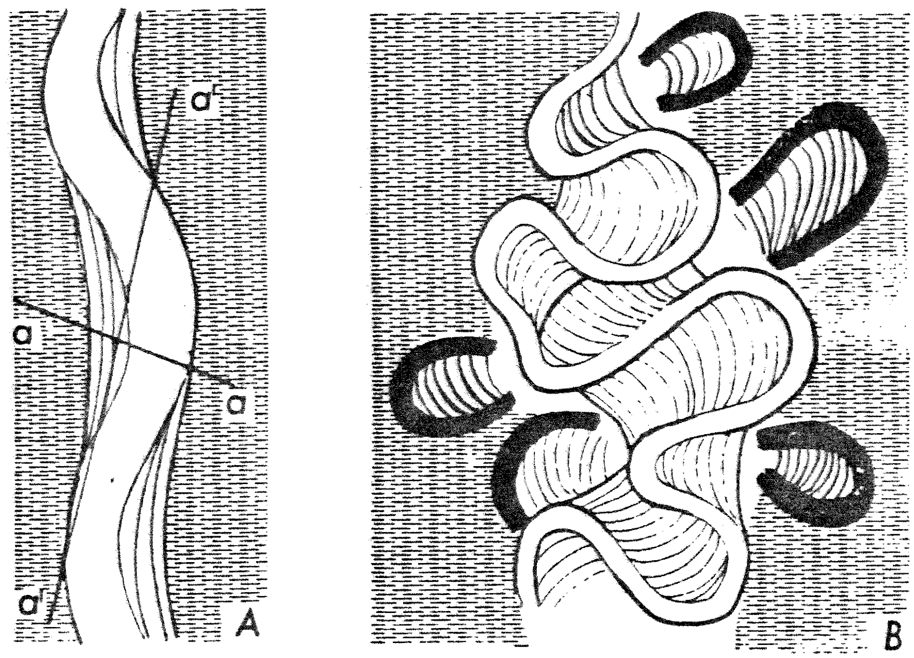



FIG. 24: Schematic plan views of the sand bodies generated by A) low sinuosity and B) high sinuosity streams. In A, if the channel is abandoned before sinuosity develops and the abandonment is gradual an elongate sand body with no internal erosion surfaces results. The lateral extent of such a sand body, seen in vertical section is clearly dependant upon the orientation of the section in relation to the current (cf. a-a and a'-a'). In B, the frequent cut-off of meander loops and the development of clay plugs (black) in abandoned channels leads to a series of restricted sand bodies separated either by erosion surfaces (heavy lines) or clay plugs. The final abandoned channel may be sand or clay filled. The orientation of a vertical section through such sand bodies has little influence on their observed lateral extent. **( from Collinson, 1978 )**

The porosity maps also reflect the differing morphologies. Chin Coulee has thickest, porous sandstone occurring in areas of thickest sand; non-porous lenses are distributed evenly throughout. The Chin Coulee channel was filled by rather homogenous sandy material. Southeast Taber sandstones, on the other hand, are most porous where point bars developed; the finer, non-porous material occurs in quieter-water parts of the channel. Therefore, the areas of thickest porous sand do not necessarily coincide with the areas of thickest sandstone.

The overall drainage pattern was probably dendritic, with tributaries that bifurcate at acute angles. Such a pattern is generally developed in homogenous rock that is rather uniformly resistant to weathering and erosion, such as the shales of the Rierdon Formation. Although there is a possibility that Chin Coulee is fault controlled, leading to a straight river, trending in an anomalous direction, there is no geologic evidence to support this.

The drainage system probably flowed from Montana to the north, as suggested by several authors and evidenced by the paleoslope in the study area. The provenance of Ellerslie sandstones is much less certain. It is generally agreed that the boundary between the lower and upper Mannville is marked by a change in source area from the eastern Precambrian shield to the uplifted mountains in the west (Glaister, 1959; Williams, 1963).

However, in Lower Mannville time, the source rocks in the east and west were very similar, consisting of clastics and carbonates. It is unclear if the transition of source rocks occurred as early as Ellerslie time. The chert and sedimentary rock fragments of the Ellerslie sandstone indicate a sedimentary source, of an undetermined location.

Diagenetic History

A diagenetic history of the Ellerslie sandstones is proposed on the basis of textural relations observed in the thin sections and SEM photographs. It is in general agreement with the four stages of diagenesis suggested by Schmidt and McDonald, 1980, for quartz arenites, and the three stages of diagenesis outlined by Dapples, 1972.

The first stage of diagenesis involved mainly mechanical compaction of the clean, uncemented sands with primary intergranular porosity. The compaction was accomplished by rotation of grains, deformation of ductile grains, and fracturing of grains. Tangential grain contacts decreased in number and straight or embayed contacts became more abundant. This stage reduced both the primary rock volume and the primary porosity. This stage must have occurred before significant cementation because many of the fractures are filled with cement and early cementation would have inhibited extensive mechanical compaction. This stage corresponds to the immature stage defined by Schmidt and McDonald, 1980.

The next stage was marked by the onset of pervasive chemical compaction, while the mechanical compaction of primary porosity became insignificant. It was accomplished first by pressure solution. The microstylolites and the first generation of quartz overgrowths probably formed at this time.

This was followed by carbonate cement which preferentially replaced quartz along irregular grain boundaries. Authigenic kaolinite probably grew at this time. The presence of clay is known to inhibit the growth of secondary quartz (Pittman, 1972). The percentage of clay and quartz overgrowths show no correlation when plotted on a graph. This lends support to the hypothesis that the overgrowths preceded the clay.

By this stage, the volume of remaining primary porosity was reduced almost to zero. The cementation would have halted any further mechanical compaction during this stage. This period of extensive cementation is termed the semi-mature stage by Schmidt and McDonald, 1980.

The next stage of diagenesis was marked by the decarbonatization of calcite and dolomite. This was probably caused by carbonic acid derived from the decarboxylation of maturing organic matter in intercalated shales. Pyrite cement would have formed also at this time. This would explain the association of pyrite and carbonaceous matter observed in the thin sections and cores. Some of the iron needed to form pyrite may have been liberated by the dissolution of ferroan calcite. This decarbonatization stage is called the mature stage A by Schmidt and McDonald, 1980.

In the final stage of diagenesis of the Ellerslie sandstones, a second generation of quartz overgrowths and carbonate cement formed. The non-ferrous variety of calcite probably grew over the remaining, earlier ferrous variety, producing reverse zoning. This corresponds to the mature stage B of Schmidt and McDonald, 1980.

The supermature stage of Schmidt and McDonald, 1980, was never attained in these sandstones. Secondary porosity would have been completely lost by mechanical compaction and much of the quartz would have recrystallized.

Several graphs were drawn in an effort to find correlations between the types and amounts of cements, depth, and grain size. However, the only pattern observed was a general increase in the amount of silica cement and a decrease in the percentage of porosity towards the tops of the sandstone sequences.

## Implications for Oil Production

These Ellerslie sandstones are not devoid of appreciable cementation as the literature often suggests and as commonly thought in the oil industry. These sandstones have had a complicated diagenetic history which ought to be well understood if production is to be maximized.

As Taylor, 1977, points out, grain size, permeability, and homogeneity decrease upward in fluvial sandstones. The oil accumulates at the top of the sandstone body, in the lowest quality sands.

It has therefore been common practice in the oil industry to fracture and acidize the producing Ellerslie Formation. This aids the permeability in the heavily silicified zones and dissolves the carbonate.

However, the carbonate contains appreciable amounts of iron. The acid used to dissolve the carbonate will liberate iron which forms another precipitate. This can be as detrimental as the carbonate itself. An iron complexing agent should be added to prevent this. Also, kaolinite booklets will dislodge with fluid flow and become trapped in the pore throats (Almon and Davies, 1981). Clay control agents should be added to minimize this problem.

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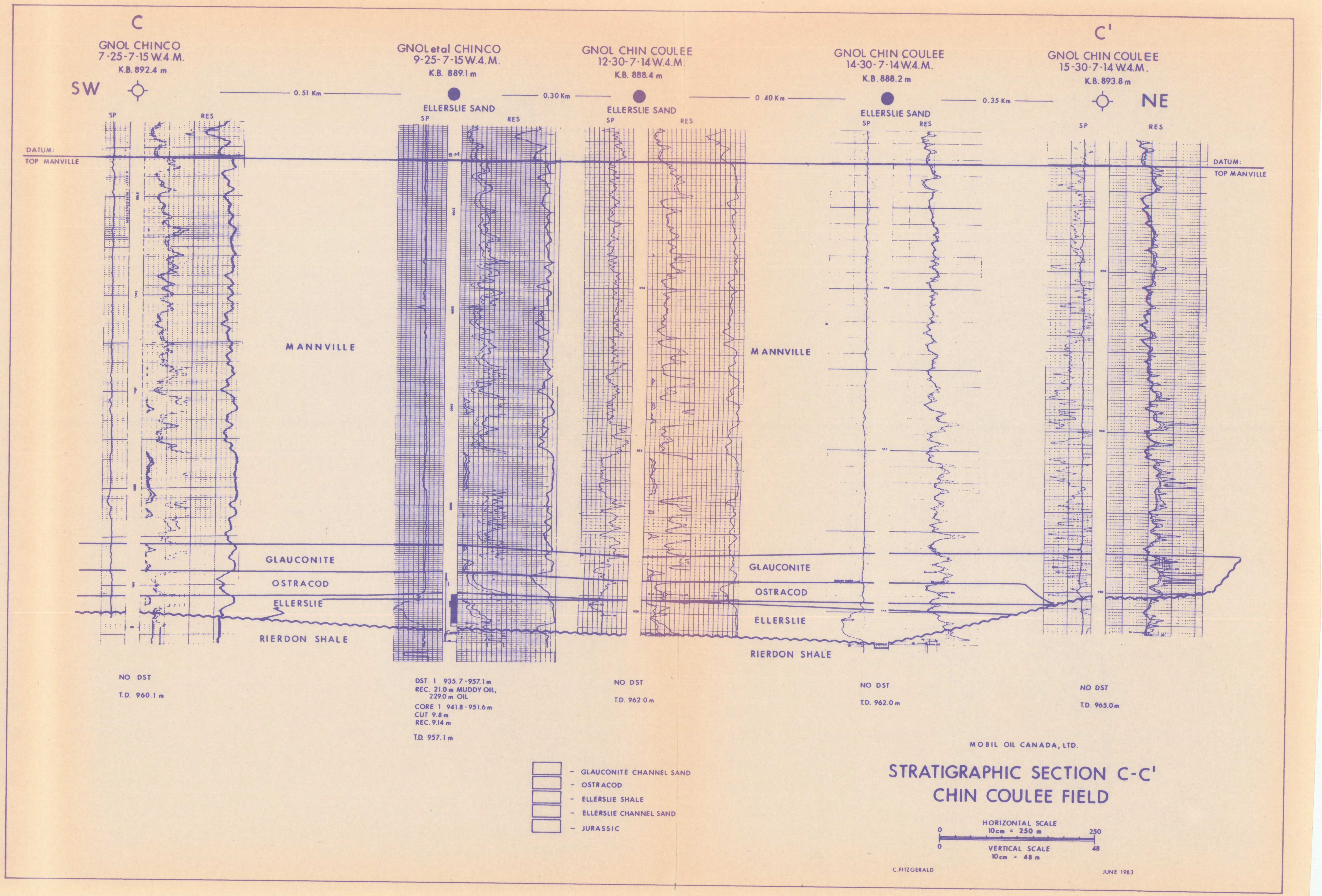
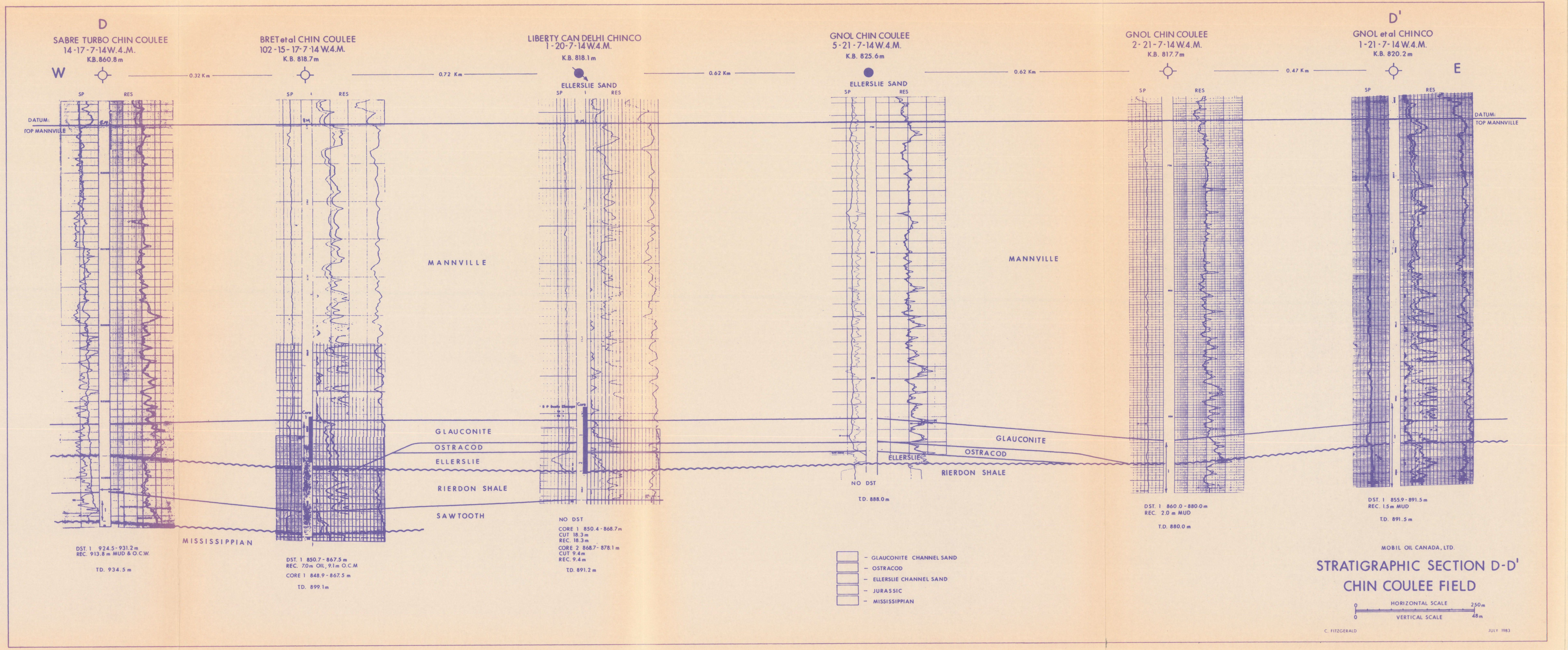
# Appendix A:

A
MID CONTINENT NO. 5
11-35-7-16W.4.M.
K.B. 904.9 m
W
1.95 km
EMPIRE ST. TABERSE
15-36-7-16W.4.M.
K.B. 904.3 m
0.6 km
CPOG TABER SE
1-1-8-16W.4.M.
K.B. 901.3 m
ELLERSLIE SAND
0.42 km
CPOG TABER SE
4-6-8-15W.4.M.
K.B. 997.6 m
ELLERSLIE SAND
0.4 km
CPOG TABER SE
3-6-8-15W.4.M.
K.B. 902.8 m
2.2 km
EMPIRE ST. TABER S.
10-32-7-15 W.4.M.
K.B. 909.5 m
1.72 km
BRASCAN GNOL CHINCO
7-33-7-15 W.4.M.
K.B. 984.2 m
2.94 km
GNOL CHINCO
11-35-7-15 W.4.M.
K.B. 898.0 m
0.47 km
GNOL CHINCO
7-35-7-15 W.4.M.
K.B. 897.3 m
ELLERSLIE SAND
0.37 km
GNOL CHINCO
8-35-7-15 W.4.M.
K.B. 895.8 m
ELLERSLIE SAND
0.37 km
GNOL CHINCO
5-36-7-15 W.4.M.
K.B. 892.4 m
ELLERSLIE SAND
0.9 km
EMPIRE ST. CHINCO
10-36-7-15 W.4.M.
K.B. 895.5 m
1.56 km
ASHLAND CONVNT CHINCO
6-6-8-14W.4.M.
K.B. 893.1 m
BOW ISLAND SAND
2.17 km
TECK LAMAQUE CPOG CHINCO
2-5-8-14W.4.M.
K.B. 885.1 m
BOW ISLAND SAND
1.2 km
ASHLAND CONVNT CHINCO
6-4-8-14W.4.M.
K.B. 887.7 m
1.5 km
CPOG CHINCO N.
4-3-8-14W.4.M.
K.B. 884.5 m
1.49 km
A'
POR et al N. CHINCO
8-3-8-14W.4.M.
K.B. 885.1 m
E
SP
RES
DATUM: BASE OF FISH SCALE SAND
VIKING
MANNVILLE
GLAUCONITE
OSTRACOD
ELLERSLIE
RIERDON SHALE
SAWTOOTH
MISSISSIPPIAN
NO DST.
T.D. 1006.7 m
DST. 1 982.7-994.9 m
REC. 442 m X.W., 274 m MUD
DST. 2 968.3-976.3 m
REC. 3 m MUD
DST. 3 967.7-980.2 m
REC. 9.1 m MUD
DST. 4 969.3-983.0 m
REC. 54.9 m MUD
T.D. 1008.2 m
DST. 1 976.0-979.0 m
REC. WATER
T.D. 1003.7 m
NO DST
T.D. 997.6 m
DST. 1 972.3-979.9 m
REC. 9.1 m OIL
24.4 m MUD
T.D. 998.5 m
DST. 1 993.8-1001.6 m
REC. 36.6 m MUDDY W.
908.3 m X.W.
DST. 2 786.4-851.6 m
REC. 670.6 m MUDDY X.W.
T.D. 1024.1 m
DST. 1 952.2-974.1 m
REC. 10.7 m MUD
T.D. 984.2 m
NO DST
T.D. 1011.9 m
NO DST
CORE 1 957.7-966.8 m
REC. 100%
T.D. 972.9 m
NO DST
T.D. 969.3 m
NO DST
T.D. 969.3 m
NO DST
T.D. 1001.3 m
DST. 1 653.8-699.8 m
NO RECOVERY
T.D. 1007.7 m
DST. 1 968.6-971.7 m
REC. 968.6 m X.W.
DST. 2 691.3-703.2 m
REC. 234.7 m W.
DST. 3 682.7-685.8 m
REC. NIL
T.D. 995.2 m
DST. 1 704.0-715.0 m
REC. 18 m MUD
105 m F.W.
105 m X.W.
DST. 2 978.0-985.0 m
REC. 18 m X.W.
72 m OIL FL. X.W.
T.D. 998 m
DST. 1 681.2-715.1 m
REC. 397.4 m MUDDY X.W.
DST. 2 937.3-952.5 m
REC. 9.1 m MUD
T.D. 996.7 m
NO DST
T.D. 1018.0 m
– GLAUCONITE CHANNEL SAND
– OSTRACOD
– ELLERSLIE CHANNEL SAND
– ELLERSLIE FORMATION
– JURASSIC
– MISSISSIPPIAN
MOBIL OIL CANADA, LTD.
REGIONAL
STRATIGRAPHIC SECTION A-A'
CHIN COULEE AND S.E. TABER
OIL FIELDS
HORIZONTAL SCALE
0 200 400 m
0 25 50 75 100 m
VERTICAL SCALE
C. FITZGERALD
MAY 1983


B
AEG GNOL BRASCAN CHINCO
16-33-7-15W.4.M.
K.B. 902.8m
SW
SP
RES
DATUM
TOP MANNVILLE
1.90 km
GNOL CHINCO
8-3-8-15W.4.M.
K.B. 898.9m
0.42 km
GNOL CHINCO
5-2-8-15W.4.M.
K.B. 900.1m
ELLERSLIE SAND
0.25 km
GNOL CHINCO
6-2-8-15W.4.M.
K.B. 897.9m
ELLERSLIE SAND
0.57 km
GNOL CHINCO
7-2-8-15W.4.M.
K.B. 891.5m
ELLERSLIE SAND.
0.50 km
GNOL CHIN COULEE
8-2-8-15W.4.M.
K.B. 891.2m
ELLERSLIE SAND
2.07 km
B'
PHOENIX ETAL CHIN COULEE
7-12-8-15W.4.M.
K.B. 888.5m
NE
DATUM:
TOP MANVILLE
MANNVILLE
GLAUCONITE
OSTRACOD
ELLERSLIE
RIERDON SHALE
SAWTOOTH
MISSISSIPPIAN
NO DST.
T.D. 1011.9 m
NO DST.
T.D. 982.7 m
DST. 1 967.4 - 979.6 m
REC. 45.7 m OILY MUD
(25-30% OIL)
T.D. 979.6 m
DST. 1 964.4 - 978.4 m
REC. 198.1 m CLEAN OIL
469.4 m OILY WATER
T.D. 978.4 m
NO DST
T.D. 969.3 m
NO DST.
T.D. 968.4 m
DST. 1 976.0 - 981.0 m
REC. 2.0 m CLEAN OIL
966.0 m WATER
T.D. 1007.0 m
- OSTRACOD
- ELLERSLIE CHANNEL SAND
- JURASSIC
- MISSISSIPPIAN
MOBIL OIL CANADA, LTD.
STRATIGRAPHIC SECTION B - B'
CHIN COULEE FIELD
HORIZONTAL SCALE
0
100
200
250m
0
24
48
VERTICAL SCALE
C. FITZGERALD
JUNE 1983



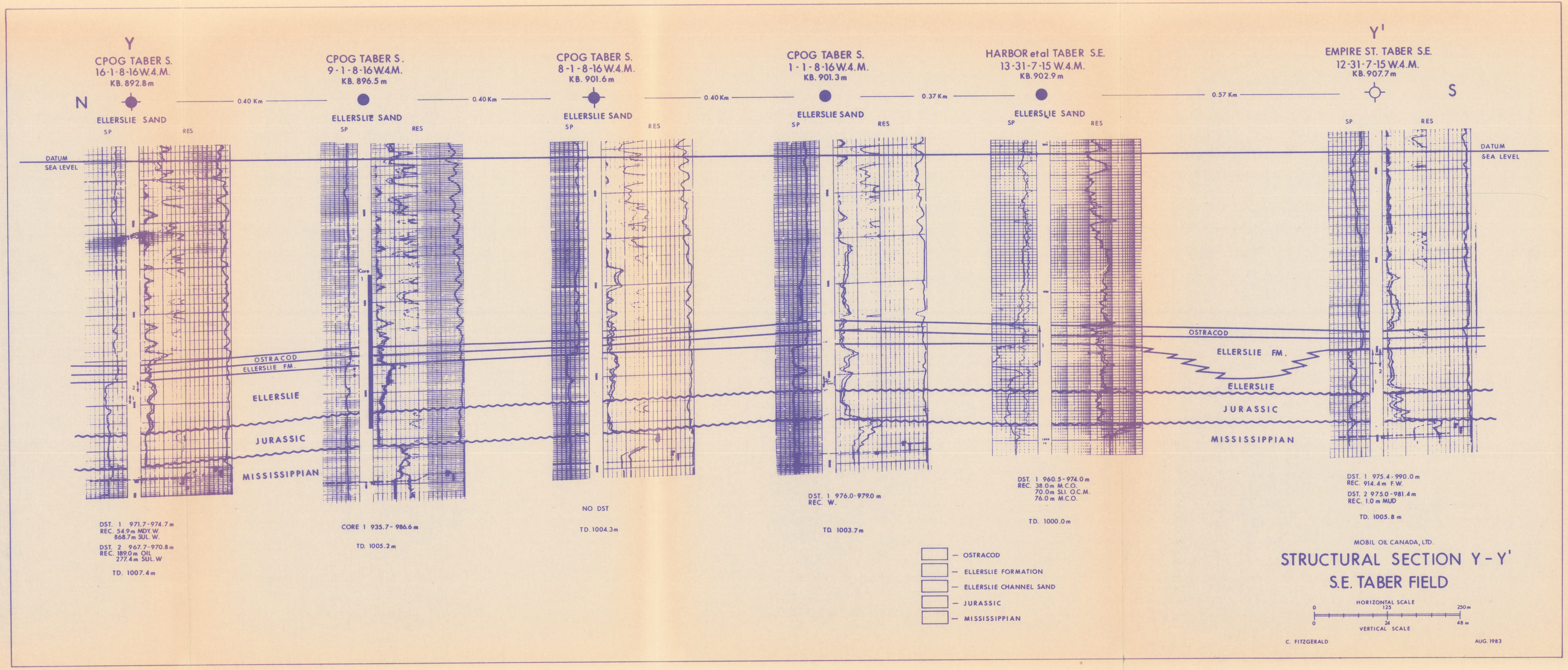
C
GNOL CHINCO 7-25-7-15 W.4 M.
K.B. 892.4 m
SW
0.51 Km
GNOLetal CHINCO 9-25-7-15 W.4.M.
K.B. 889.1 m
ELLERSLIE SAND
0.30 Km
GNOL CHIN COULEE 12-30-7-14 W.4.M.
K.B. 888.4 m
ELLERSLIE SAND
0.40 Km
GNOL CHIN COULEE 14-30-7-14 W.4.M.
K.B. 888.2 m
ELLERSLIE SAND
0.35 Km
C'
GNOL CHIN COULEE 15-30-7-14 W.4.M.
K.B. 893.8 m
NE
SP
RES
DATUM: TOP MANVILLE
MANNVILLE
GLAUCONITE
OSTRACOD
ELLERSLIE
RIERDON SHALE
NO DST
T.D. 960.1 m
DST 1 935.7-957.1 m
REC. 21.0 m MUDDY OIL, 229.0 m OIL
CORE 1 941.8-951.6 m
CUT 9.8 m
REC. 9.14 m
T.D. 957.1 m
NO DST
T.D. 962.0 m
NO DST
T.D. 962.0 m
NO DST
T.D. 965.0 m
- GLAUCONITE CHANNEL SAND
- OSTRACOD
- ELLERSLIE SHALE
- ELLERSLIE CHANNEL SAND
- JURASSIC
MOBIL OIL CANADA, LTD.
STRATIGRAPHIC SECTION C-C'
CHIN COULEE FIELD
HORIZONTAL SCALE
10cm = 250 m
0
250
VERTICAL SCALE
10cm = 48 m
0
48
C. FITZGERALD
JUNE 1983



D
SABRE TURBO CHIN COULEE
14-17-7-14W.4.M.
K.B. 860.8 m
W
0.32 Km
BRET et al CHIN COULEE
102-15-17-7-14 W.4.M.
K.B. 818.7 m
0.72 Km
LIBERTY CAN DELHI CHINCO
1-20-7-14 W.4.M.
K.B. 818.1 m
ELLERSLIE SAND
0.62 Km
GNOL CHIN COULEE
5-21-7-14 W.4.M.
K.B. 825.6 m
ELLERSLIE SAND
0.62 Km
GNOL CHIN COULEE
2-21-7-14 W.4.M.
K.B. 817.7 m
0.47 Km
D'
GNOL et al CHINCO
1-21-7-14 W.4.M.
K.B. 820.2 m
E
SP
RES
DATUM:
TOP MANNVILLE
MANNVILLE
MANNVILLE
GLAUCONITE
OSTRACOD
ELLERSLIE
RIERDON SHALE
SAWTOOTH
MISSISSIPPIAN
GLAUCONITE
OSTRACOD
ELLERSLIE
RIERDON SHALE
DST. 1 924.5-931.2 m
REC. 913.8 m MUD & O.C.W.
T.D. 934.5 m
DST. 1 850.7-867.5 m
REC. 7.0 m OIL, 9.1 m O.C.M
CORE 1 848.9-867.5 m
T.D. 899.1 m
NO DST
CORE 1 850.4-868.7 m
CUT 18.3 m
REC. 18.3 m
CORE 2 868.7-878.1 m
CUT 9.4 m
REC. 9.4 m
T.D. 891.2 m
NO DST
T.D. 888.0 m
DST. 1 860.0-880.0 m
REC. 2.0 m MUD
T.D. 880.0 m
DST. 1 855.9-891.5 m
REC. 1.5 m MUD
T.D. 891.5 m
- GLAUCONITE CHANNEL SAND
- OSTRACOD
- ELLERSLIE CHANNEL SAND
- JURASSIC
- MISSISSIPPIAN
MOBIL OIL CANADA, LTD.
STRATIGRAPHIC SECTION D-D'
CHIN COULEE FIELD
0 HORIZONTAL SCALE 250 m
0 VERTICAL SCALE 48 m
C. FITZGERALD
JULY 1983


W
SEAVAN VAN-TOR ROYAL CAN
2-19-8-15 W.4.M.
KB. 872.9 m
N
2.22 Km
POR ET AL TABER S.E.
8-17-8-15 W.4.M.
KB. 876.0 m
ELLERSLIE SAND
1.92 Km
POR ET AL TABER S.E.
6-9-8-15 W.4.M.
KB. 889.4 m
ELLERSLIE SAND
1.77 Km
PETMT ET AL CHINCO
11-3-8-15 W.4.M.
KB. 899.4 m
ELLERSLIE SAND
1.12 Km
GNOL CHINCO
8-3-8-15 W.4.M.
KB. 898.9 m
1.27 Km
GNOL CHINCO
2-2-8-15 W.4.M.
KB. 891.2 m
ELLERSLIE SAND
1.75 Km
GNOL CHIN COULEE
6-36-7-15 W.4.M.
KB. 897.0 m
ELLERSLIE SAND
1.70 Km
GNOL CHIN COULEE
11-30-7-14 W.4.M.
KB. 888.4 m
ELLERSLIE SAND
2.05 Km
GNOL CHINCO
13-20-7-14 W.4.M.
KB. 890.6 m
ELLERSLIE SAND
1.47 Km
LIBERTY CAN DELHI CHINCO
8-20-7-14 W.4.M.
KB. 818.7 m
ELLERSLIE SAND
1.62 Km
GNOL ANDEX CHINCO
10-16-7-14 W.4.M.
KB. 817.2 m
ELLERSLIE SAND
1.42 Km
CARDINAL CHIN COULEE
16-9-7-14 W.4.M.
KB. 869.3 m
ELLERSLIE SAND
0.90 Km
W'
CARDINAL ETAL CHINCO
12-10-7-14 W.4.M.
KB. 878.1 m
S
SP
RES
DATUM +250 m
ABOVE SEA LEVEL
BASE FISH SCALE SAND
MANNVILLE
GLAUCONITE
OSTRACOD
ELLERSLIE
RIERDON SHALE
SAWTOOTH
MISSISSIPPIAN
T.D. 877.8 m
DST. 1 909.8 - 921.4 m
REC. 172.5 m SLI. GSY OIL
17.1 m O.C.M.
NO W
T.D. 961.6 m
- OSTRACOD
- ELLERSLIE CHANNEL SAND
- JURASSIC
- MISSISSIPPIAN
MOBIL OIL CANADA, LTD.
REGIONAL
STRUCTURAL SECTION W-W'
CHIN COULEE FIELD
HORIZONTAL SCALE
0 250 500 m
0 25 50 75 100 m
VERTICAL SCALE
Vertical Exageration = 5 Times
C. FITZGERALD
AUG. 1983

X
CPOG TABER SOUTH
2-36-8-16 W4M
KB 848.6 m
W
1.85 km
CPOG CLANCY
10-31-8-15 W4M
KB 841.2 m
2.57 km
BVX FINCASTLE
12-33-8-15 W4M
KB 853.4 m
2.35 km
CPOG SHERBURNE LAKE
10-34-8-15 W4M
KB 868.4 m
2.07 km
ANDARKO ET AL FINCASTLE
16-35-8-15 W4M
KB 876.2m
0.42 km
4-1-9-15 W4M
KB 877.8 m
0.67 km
6-1-9-15 W4M
KB 878.4m
0.70 km
X'
8-1-9-15 W4M
KB 882.1m
E
SP
RES
DATUM: SEA LEVEL
GLAUCONITE
OSTRACOD
ELLERSLIE
RIERDON SHALE
SAWTOOTH
MISSISSIPPIAN
DST. 1 954.0 - 960.1m
REC. 185.9m SUL XW
CORE 1 937.3 - 955.5m
CORE 2 955.5 - 973.8m
TD 993.0m
DST. 1 947.9 - 966.8m
REC. 54.9m OCM
626.4m SUL XW
TD 1057.0m
DST. 1 960.7 - 965.3m
REC. 749.8m XW
TD 999.7m
NO DST
TD 1022.9m
NO DST.
TD 1038.0m
DST. 1 970.0 - 994.0m
REC. 22.0m SL GSY OCM
TD 994.0m
DST. 1 974.7 - 984.5m
REC. 150.6m HVY OIL
18.3m OCM
DST. 2 1004.6 - 1009.5 m
(MISSISSIPPIAN)
REC. 237.7 m OCM
755.9 m FW
DST. 3 971.1 - 986.9m
REC. 292.6m GSY OIL
TD 1036.3m
DST. 1 972.3 - 986.0m
REC. 9.1m MUD
TD 986.0m
– OSTRACOD
– ELLERSLIE CHANNEL SAND
– JURASSIC
– MISSISSIPPIAN
MOBIL OIL CANADA, LTD.
STRUCTURAL SECTION X-X'
S.E. TABER FIELD
HORIZONTAL SCALE
0
250m
500m
0
24m
48m
VERTICAL SCALE
C.FITZGERALD
AUG. 1983

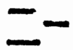

Y
CPOG TABER S.
16-1-8-16 W.4.M.
KB. 892.8 m
N
0.40 Km
ELLERSLIE SAND
SP
RES
DATUM
SEA LEVEL
CPOG TABER S.
9-1-8-16 W.4.M.
KB. 896.5 m
0.40 Km
ELLERSLIE SAND
SP
RES
Core
CPOG TABER S.
8-1-8-16 W.4.M.
KB. 901.6 m
0.40 Km
ELLERSLIE SAND
SP
RES
CPOG TABER S.
1-1-8-16 W.4.M.
KB. 901.3 m
0.37 Km
ELLERSLIE SAND
SP
RES
HARBOR et al TABER S.E.
13-31-7-15 W.4.M.
KB. 902.9 m
0.57 Km
ELLERSLIE SAND
SP
RES
Y'
EMPIRE ST. TABER S.E.
12-31-7-15 W.4.M.
KB. 907.7 m
S
SP
RES
DATUM
SEA LEVEL
OSTRACOD
ELLERSLIE FM.
ELLERSLIE
JURASSIC
MISSISSIPPIAN
OSTRACOD
ELLERSLIE FM.
ELLERSLIE
JURASSIC
MISSISSIPPIAN
DST. 1 971.7-974.7 m
REC. 54.9 m MDY. W.
868.7 m SUL. W.
DST. 2 967.7-970.8 m
REC. 189.0 m OIL
277.4 m SUL. W
TD. 1007.4 m
CORE 1 935.7-986.6 m
TD. 1005.2 m
NO DST
TD. 1004.3 m
DST. 1 976.0-979.0 m
REC. W.
TD. 1003.7 m
DST. 1 960.5-974.0 m
REC. 38.0 m M.C.O.
70.0 m SLI. O.C.M.
76.0 m M.C.O.
TD. 1000.0 m
DST. 1 975.4-990.0 m
REC. 914.4 m F.W.
DST. 2 975.0-981.4 m
REC. 1.0 m MUD
TD. 1005.8 m
— OSTRACOD
— ELLERSLIE FORMATION
— ELLERSLIE CHANNEL SAND
— JURASSIC
— MISSISSIPPIAN
MOBIL OIL CANADA, LTD.
STRUCTURAL SECTION Y - Y'
S.E. TABER FIELD
HORIZONTAL SCALE
0
125
250 m
0
24
48 m
VERTICAL SCALE
C. FITZGERALD
AUG. 1983

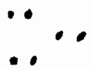
Z
HB TABER SE
6-26-7-16 W4M
KB 893.5m
W
2.5 km
EMPIRE ST. TABER SE
10-25-7-16 W4M
KB 915.3m
ELLERSLIE SAND
0.85 km
GNOL BRASCAN TABER SE
12-30-7-15 W4M
KB 915.0m
0.82 km
BRASCAN GNOL TABER SE
10-30-7-15 W4M
KB 915.9m
ELLERSLIE SAND
0.65 km
NORCEN ET AL TABER SE
12-29-7-15 W4M
KB 915.8m
1.35 km
Z'
BRASCAN TABER SE
16-29-7-15 W4M
KB 914.7m
E
SP
RES
DATUM : SEA LEVEL
GLAUCONITE
OSTRACOD
ELLERSLIE
RIERDON SHALE
SAWTOOTH
MISSISSIPPIAN
DST. 1 982.0 - 986.0m
(SAWTOOTH)
REC. 982.0m BRK. W
TD 1007.0m
DST. 1 967.7 - 981.4m
REC. 3.0m oil,
216.4m highly OCM,
6.1m XW
DST. 2 980.5 - 987.8m
REC. 803.1m XW
TD 1011.9m
DST. 1 965.3 - 974.1m
REC. 15.2m MDY W
DST. 2 975.7 - 989.7m
REC. 45.7m MUD
CORE 1 972.0 - 987.2m
CUT 15.2m
REC. 14.6m
CORE 2 987.2 - 989.7m
CUT 2.5m
REC. 2.4m
TD 989.7m
DST. 1 983.9 - 990.3m
REC. 210.3m GSY OIL
TD 990.6m
DST. 1 994.5 - 998.0m
(SAWTOOTH)
REC. 970.0m SL OIL
FLKD. GSY W
TD 1024.0m
NO DST
TD 998.2m
MOBIL OIL CANADA, LTD.
STRUCTURAL SECTION Z-Z'
S.E. TABER FIELD
- GLAUCONITE SAND
- OSTRACOD
- ELLERSLIE CHANNEL SAND
- ELLERSLIE FORMATION
- JURASSIC
- MISSISSIPPIAN
HORIZONTAL SCALE
0
250m
500m
0
24m
48m
VERTICAL SCALE
C. FITZGERALD
AUG 1983

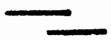
# Appendix B:

# LEGEND FOR CORE DESCRIPTIONS

## LITHOLOGY

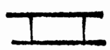
 Mudstone

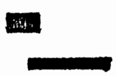
 Siltstone

 Shale

 Sandstone

 Conglomerate

 Limestone

 Carbonaceous/Coaly Plant Fragments

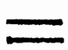
## FRAMEWORK COMPOSITION

Q Quartz

 Dark-Coloured Chert and Sedimentary Rock Fragments

## SEDIMENTARY STRUCTURES

 Massive Bedding

 Planar Laminations

 Small-Scale Cross-Stratification

 Large-Scale Cross-Stratification

## SHAPE

R Well-Rounded
r Subrounded
a Subangular
A Angular

## SORTING

W Well Sorted
M Moderately Sorted
P Poorly Sorted

## CEMENT

Λ Silica
⊥ Calcite
CL Clay

## OIL STAIN

 Heavy, Pervasive

 Light, Spotted

## ACCESSORIES

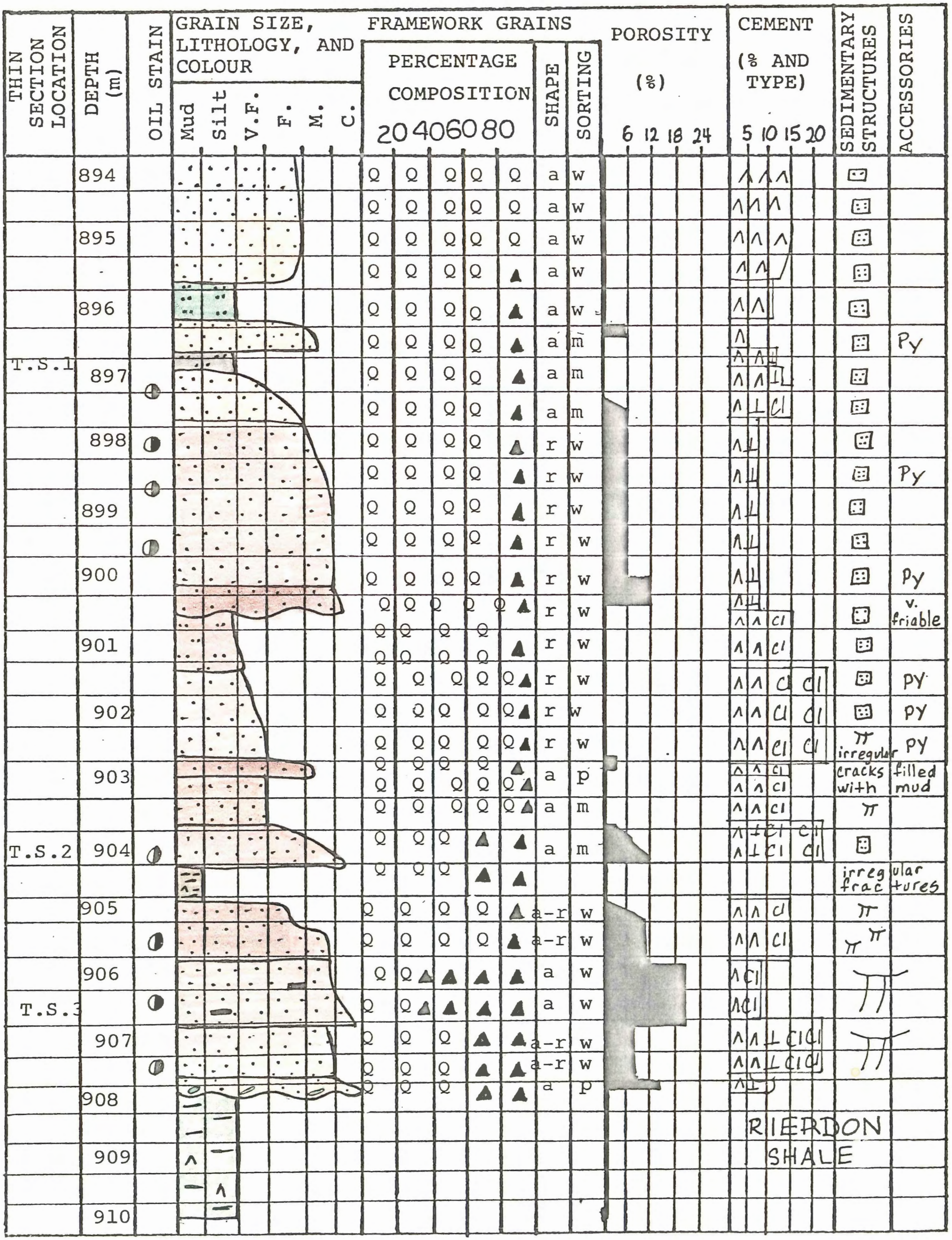
PY Pyrite

CORE DESCRIPTION--ELLERSLIE FORMATION

WELL LOCATION: LSD 14-19-7-15 W4 Southeast Taber

CORED INTERVAL: 894-903m, recovered 9m STATUS: Oil Well

903.5-912.5m, recovered 9m



CORE DESCRIPTION--ELLERSLIE FORMATION

WELL LOCATION: LSD 12-30-7-15 W4 — Southeast Taber

CORED INTERVAL: 972-987.2 m. rec. 14.6m. — STATUS: Dry

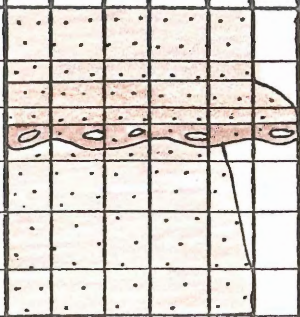
| THIN SECTION LOCATION | DEPTH (m) | OIL STAIN | FRAMEWORK GRAINS: PERCENTAGE COMPOSITION 20 | 40 | 60 | 80 | | SHAPE | SORTING | CEMENT (% AND TYPE) 5 10 15 20 | SEDIMENTARY STRUCTURES | ACCESSORIES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 972 | ◐ | Q | Q | Q | ▲ | ▲ | r | m | ∧ ⊥ ⊥ Cl | π | |
| T.S.4 | | ◐ | Q | Q | Q | ▲ | ▲ | r | m | ∧ ⊥ ⊥ Cl | π | |
| | 973 | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | 974 | | Q | Q | Q | ▲ | ▲ | r | w | ∧ ∧ ∧ ∧ ⊥ | | |
| | | | Q | Q | Q | ▲ | ▲ | r | w | ∧ ∧ ∧ ∧ ⊥ | | |
| | 975 | | Q | Q | Q | Q | ▲ | r | w | ∧ ∧ ∧ ∧ ∧ | | |
| | | | Q | Q | Q | Q | ▲ | r | w | ∧ ∧ ∧ ∧ ∧ | | |
| | 976 | | Q | Q | Q | Q | ▲ | r | w | ∧ ∧ ∧ ∧ ∧ | | |
| | | | Q | Q | Q | Q | ▲ | r | w | ∧ ∧ ∧ ∧ ∧ | | |
| | 977 | | Q | Q | Q | ▲ | ▲ | r | w | ∧ ∧ ∧ ∧ ∧ | | |
| | | | Q | Q | Q | ▲ | ▲ | a | w | ∧ ∧ ∧ ∧ ∧ / ∧ ∧ ⊥ Cl | | |
| | 978 | | Q | Q | Q | ▲ | ▲ | a | w | ∧∧ ⊥ Cl | | |
| | | | Q | Q | Q | ▲ | ▲ | a | w | ∧∧ ⊥ Cl | | |
| | 979 | | Q | Q | Q | ▲ | ▲ | a | w | ∧∧ ⊥ Cl | ⊡ | |
| | | | Q | Q | Q | ▲ | ▲ | a | w | ∧∧ ⊥ Cl | | |
| | 980 | | Q | Q | Q | ▲ | ▲ | a | w | ∧∧ ⊥ Cl | | |
| | | ◐ | Q | Q | Q | ▲ | ▲ | a | w | ∧ ∧ ⊥ Cl | | |
| | 981 | | Q | Q | Q | ▲ | ▲ | r | m | ∧ ∧ ⊥ Cl / ∧ ⊥ Cl | | |
| | | | Q | Q | Q | ▲ | ▲ | r | m | ∧ ⊥ Cl | | |
| | 982 | | Q | Q | Q | ▲ | ▲ | r | m | ∧ ⊥ Cl | | |
| | | | Q | Q | Q | ▲ | ▲ | r | m | ∧ ⊥ Cl | | |
| | 983 | | Q | Q | Q | ▲ | ▲ | r | m | ∧ ⊥ Cl | | |
| T.S.5 | | | Q | Q | Q | ▲ | ▲ | r | m | ∧ ⊥ Cl | ⊡ | |
| | 984 | | Q | Q | Q | ▲ | ▲ | r | m | ∧ ⊥ Cl | | |
| | | ● | Q | Q | Q | ▲ | ▲ | r | m | ∧ ⊥ Cl | | |
| | 985 | | Q | Q | Q | ▲ | ▲ | r | m | ∧ ⊥ Cl | | |
| | | | Q | Q | ▲ | ▲ | ▲ | r | w | ∧ ⊥ Cl | | |
| | 986 | | Q | Q | ▲ | ▲ | ▲ | r | w | ∧ ⊥ Cl | | tr. py |
| | | | Q | Q | ▲ | ▲ | ▲ | r | w | ∧ ⊥ Cl | | |
| | 987 | | Q | Q | ▲ | ▲ | ▲ | r | w | ∧ ⊥ Cl | | |
| T.S. 6 | | | Q | Q | ▲ | ▲ | ▲ | r | w | ∧ ⊥ Cl | | |
| | 988 | | Q | Q | ▲ | ▲ | ▲ | r | w | ∧ ⊥ Cl | | |

# CORE DESCRIPTION--ELLERSLIE FORMATION

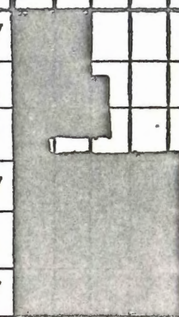
WELL LOCATION: LSD 2-36-8-16 W4 — Southeast Taber
CORED INTERVAL: 937.4-955.5 m.
955.5-973.8 m.
STATUS: Dry



Grain size, lithology, and colour (Mud, Silt, V.F., F., M., C.):



Porosity (%) (6, 12, 18, 24):



| THIN SECTION LOCATION | DEPTH (m) | OIL STAIN | FRAMEWORK GRAINS: PERCENTAGE COMPOSITION (20 40 60 80) | SHAPE | SORTING | CEMENT (% AND TYPE) (5 10 15 20) | SEDIMENTARY STRUCTURES | ACCESSORIES |
|---|---|---|---|---|---|---|---|---|
| | | ◐ | Q Q Q ▲ ▲ ▲ / Q Q Q ▲ ▲ ▲ | R | W | ∧ Cl / ∧ Cl | | |
| | 965 | | Q Q Q ▲ ▲ ▲ / Q Q Q ▲ ▲ ▲ | R / r | W / W | ∧ Cl | | |
| T.S.8 | | ◐ | Q Q ▲ ▲ ▲ | r | p | ∧ Cl / ∧ Cl | ← rip up clasts 2-50mm, clays + chert | |
| | 966 | | Q Q Q Q Q | r | W | ∧ | | |
| T.S.7 | | | Q Q Q Q Q | r | W | ∧ ∧ | SAWTOOTH | |
| | | | Q Q Q Q Q | r | W | ∧ | FORMATION | |

# CORE DESCRIPTION--ELLERSLIE FORMATION

**WELL LOCATION:** LSD 2-36-8-16 W4 — Southeast Taber
**CORED INTERVAL:** 937.3-955.5 m.
955.5-973.8 m.
**STATUS:** Dry

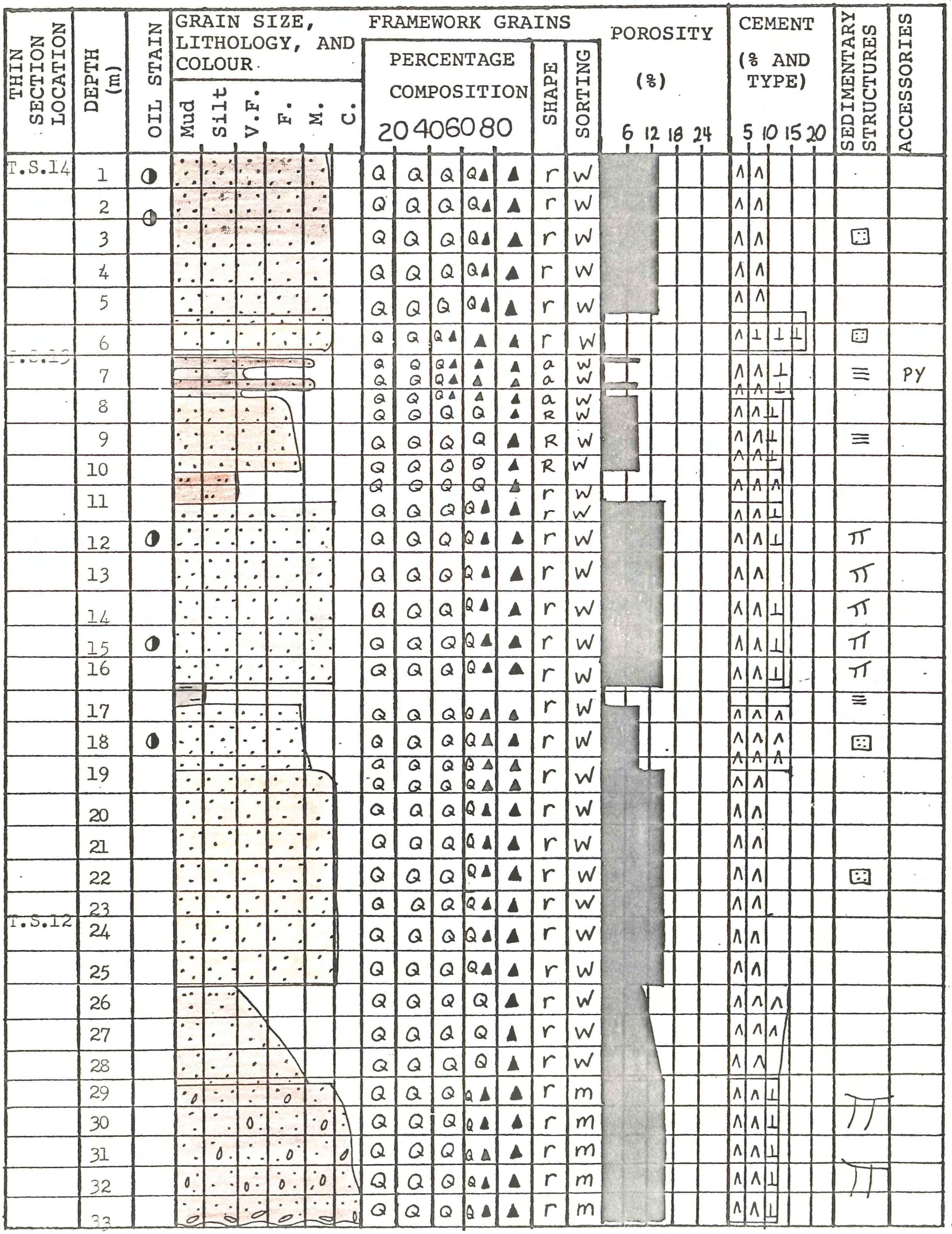
| THIN SECTION LOCATION | DEPTH (m) | OIL STAIN | GRAIN SIZE, LITHOLOGY, AND COLOUR (Mud, Silt, V.F., F., M., C.) | FRAMEWORK GRAINS: PERCENTAGE COMPOSITION (20 40 60 80) | SHAPE | SORTING | POROSITY (%) (6 12 18 24) | CEMENT (% AND TYPE) (5 10 15 20) | SEDIMENTARY STRUCTURES | ACCESSORIES |
|---|---|---|---|---|---|---|---|---|---|---|
| | 948 | | | OSTRACOD LMST. | | | | | | |
| | | | | | | | | | | |
| | 949 | | | | | | | | | |
| | | | | | | | | | | |
| | 950 | | | | | | | | | |
| | | | | | | | | | | |
| | 951 | | | | | | | | | |
| | | | | | | | | | | |
| | 952 | | | Q Q Q Q ▲ | r | W | | ∧ ∧ ∧ | | |
| | | | | Q Q Q Q ▲ | r | W | | ∧ ∧ ∧ | ⁙ | |
| | 953 | | | Q Q Q Q ▲ | r | W | | ∧ ∧ ∧ | | |
| | | | | Q Q Q Q ▲ | r | W | | ∧ ∧ ∧ | | |
| | 954 | | | | | | | | | |
| | | ◐ | | Q Q Q Q Q ▲ | R | W | | ∧ ∧ | ⁙ | |
| | | | | Q Q Q Q Q ▲ | R | W | | ∧ ∧ | | |
| | 955 | | | Q Q Q Q Q ▲ | R | W | | ∧ ∧ | | |
| T.S.11 | | | | Q Q Q Q ▲ | r | W | | ∧ Cl | ⁙ | |
| | 956 | ● | | Q Q Q Q ▲ | r | W | | ∧ Cl | | |
| | | | | | | | | | | |
| | 957 | | | Q Q Q Q ▲ | r | W | | ∧ ∧ Cl | ⁙ | |
| | | | | | | | | | | |
| | 958 | | | | | | | | | |
| | | | | Q Q Q Q ▲ | R | W | | ∧ Cl | ⁙ | |
| | 959 | | | | | | | | | |
| | | ◐ | | Q Q Q Q ▲ | R | W | | ∧ Cl | ≡ | |
| | 960 | ◐ | | Q Q Q Q ▲ | R | W | | ∧ Cl | ≡ | |
| | | | | Q Q Q Q ▲ | R | W | | ∧ Cl | ≡ | |
| | 961 | | | Q Q Q Q ▲ | R | W | | ∧ Cl | ≡ | |
| | | | | Q Q Q Q ▲ | R | W | | ∧ Cl | ≡ | |
| T.S.10 | 962 | ● | | Q Q Q Q ▲ | R | W | | ∧ Cl | | |
| | | | | Q Q Q Q Q ▲ | r | W | | ∧ ∧ ∧ | ≡ | |
| | 963 | | | Q Q Q Q Q ▲ | r | W | | ∧ ∧ ∧ | ≡ | |
| T.S. 9 | | | | | | | | ∧ ∧ ∧ | | |
| | 964 | ◐ | | Q Q ▲ ▲ ▲ | R | W | | ∧ Cl | homogenous ⁙ | |
| | | | | Q Q ▲ ▲ ▲ | R | W | | ∧ Cl | | |

CORE DESCRIPTION--ELLERSLIE FORMATION

WELL LOCATION: LSD 14-9-8-15 W4 Chin Coulee

CORED INTERVAL: 957.7-976.0 m. STATUS: Oil Well

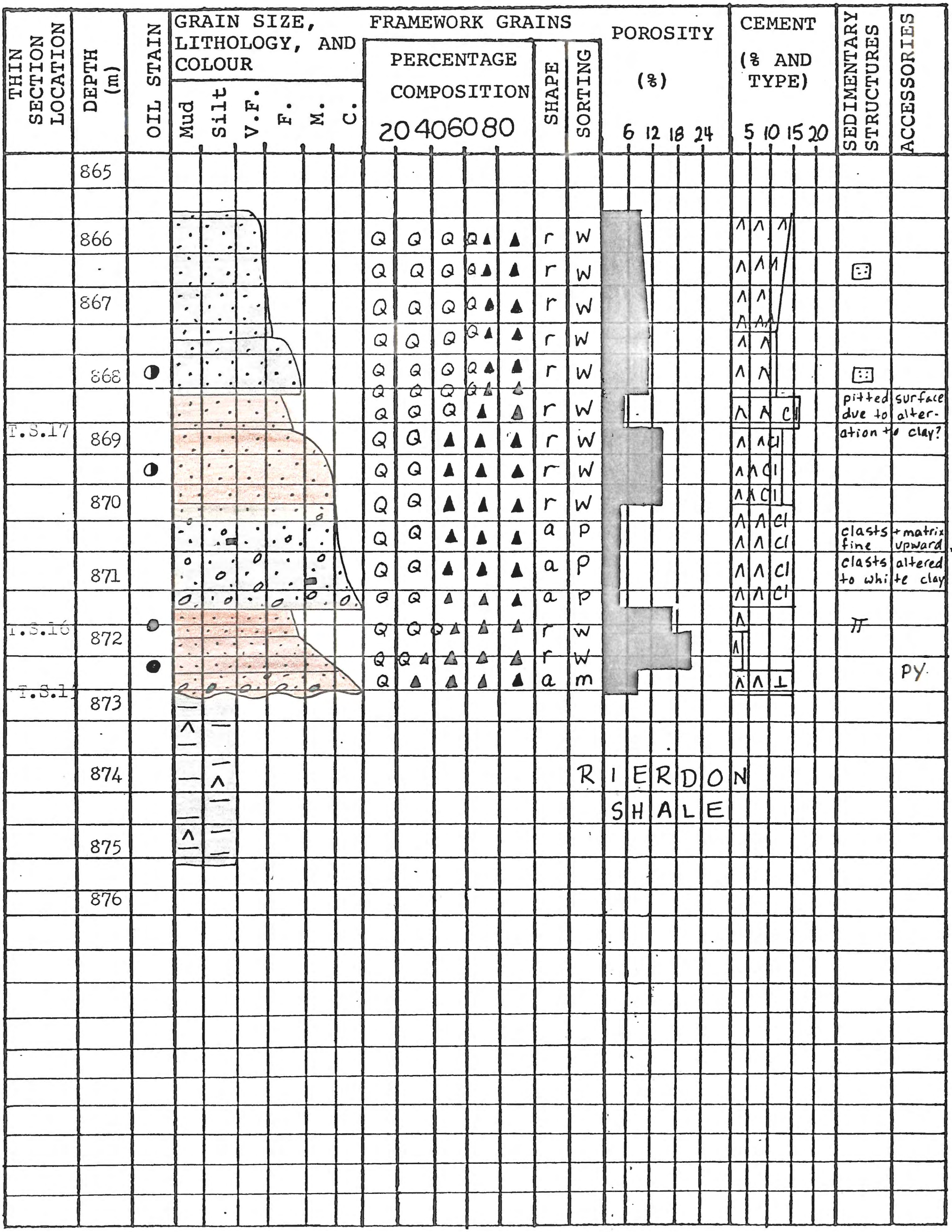
(cores not numbered by depth)



# CORE DESCRIPTION--ELLERSLIE FORMATION

WELL LOCATION: LSD 14-16-7-14 W4 Chin Coulee

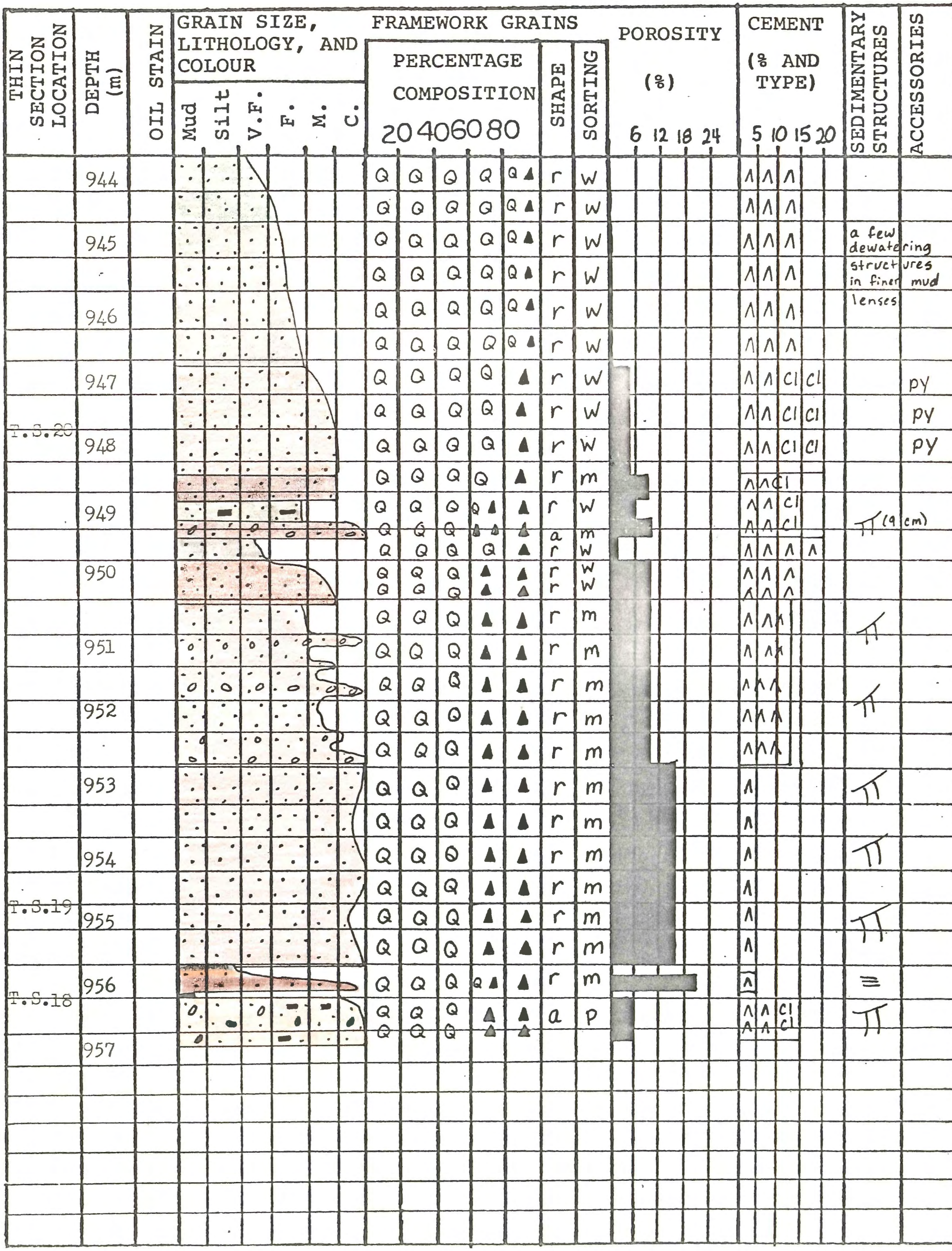
CORED INTERVAL: 865.9-875.7 m. STATUS: Oil Well



CORE DESCRIPTION--ELLERSLIE FORMATION

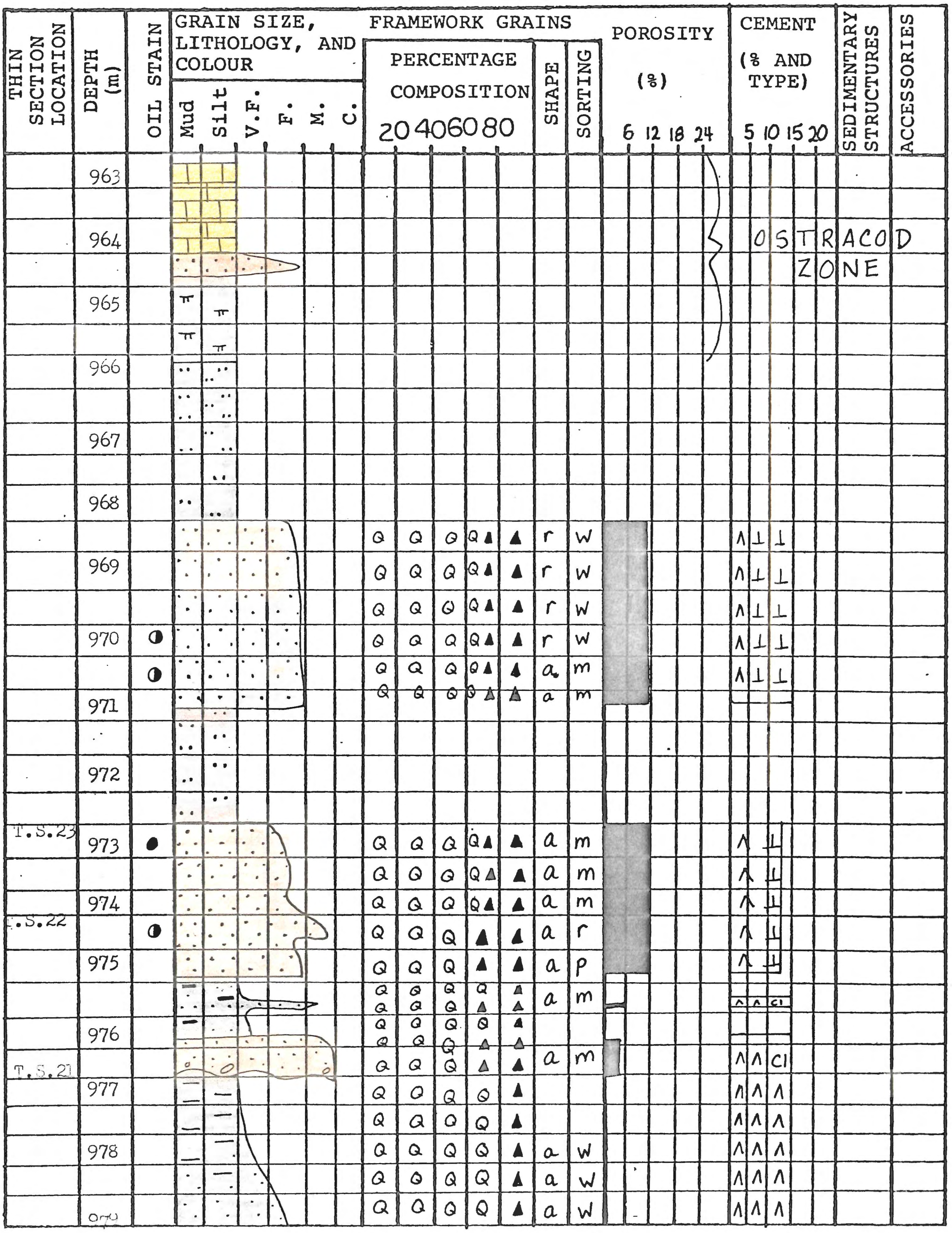
WELL LOCATION: LSD 11-30-7-14 W4 Chin Coulee

CORED INTERVAL: 944-957 m. STATUS: Oil Well



## CORE DESCRIPTION--ELLERSLIE FORMATION

**WELL LOCATION:** LSD 10-7-8-15 W4 Southeast Taber
**CORED INTERVAL:** 963.2-981.4 m. **STATUS:** Dry
rec. 18.3 m.



# CORE DESCRIPTION--ELLERSLIE FORMATION

**WELL LOCATION:** LSD 10-7-8-15 W4 Southeast Taber

**CORED INTERVAL:** 963.2-981.4 m. **STATUS:** Dry

Page 2

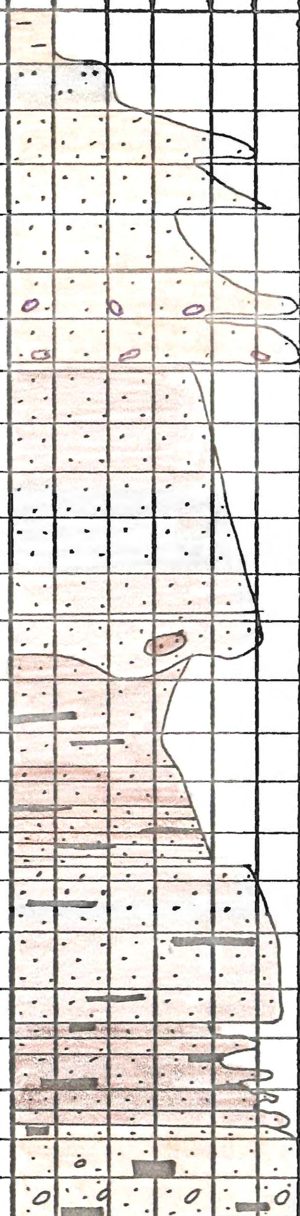
| THIN SECTION LOCATION | DEPTH (m) | OIL STAIN | GRAIN SIZE, LITHOLOGY, AND COLOUR: Mud | Silt | V.F. | F. | M. | C. | FRAMEWORK GRAINS: PERCENTAGE COMPOSITION 20 | 40 | 60 | 80 | | SHAPE | SORTING | POROSITY (%) 6 | 12 | 18 | 24 | CEMENT (% AND TYPE) 5 | 10 | 15 | 20 | SEDIMENTARY STRUCTURES | ACCESSORIES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Q | Q | Q | Q | ▲ | a | W | | | | | ʌ | ʌ | ʌ | | | |
| | 980 | | | | | | | | Q | Q | Q | Q | ▲ | a | W | | | | | ʌ | ʌ | ʌ | | | |
| | | | | | | | | | Q | Q | Q | Q | ▲ | a | W | | | | | ʌ | ʌ | ʌ | | | |
| | 981 | | | | | | | | Q | Q | Q | Q | ▲ | a | W | | | | | ʌ | ʌ | ʌ | | | |

# CORE DESCRIPTION--ELLERSLIE FORMATION

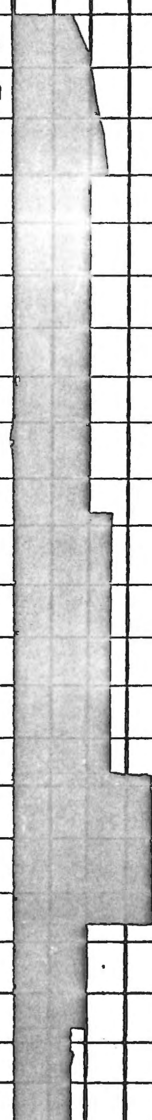
**WELL LOCATION:** LSD 5-6-8-15 W4 Southeast Taber
**CORED INTERVAL:** 963.2-980.2 m. **STATUS:** Oil Well

(core not numbered by depth)

GRAIN SIZE, LITHOLOGY, AND COLOUR (Mud, Silt, V.F., F., M., C.):



POROSITY (%) (6, 12, 18, 24):



| THIN SECTION LOCATION | DEPTH (m) | OIL STAIN | FRAMEWORK GRAINS: PERCENTAGE COMPOSITION (20 40 60 80) | | | | | SHAPE | SORTING | CEMENT (% AND TYPE) (5 10 15 20) | SEDIMENTARY STRUCTURES | ACCESSORIES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 24 | | | | | | | | | | | |
| | 23 | | | | | | | | | | | |
| | 22 | | Q | Q | Q▲ | ▲ | ▲ | r | m | ΛΛ | several local erosional features | |
| | 21 | ◐ | Q | Q | Q▲ | ▲ | ▲ | r | m | ΛΛ | | |
| | 20 | | Q | Q | Q | ▲ | ▲ | r | m | ΛΛ | | |
| | 19 | | Q | Q | Q▲ | ▲ | ▲ | a | p | ΛΛ | | |
| | 18 | | Q | Q | Q▲ | ▲ | ▲ | a | p | ΛΛ | | |
| | 17 | | Q | Q | Q | ▲ | ▲ | r | w | ΛΛ | π | |
| | 16 | | Q | Q | Q | ▲ | ▲ | r | w | ΛΛ | π | |
| | 15 | | Q | Q | Q | ▲ | ▲ | r | w | ΛΛ | π | |
| | 14 | | Q | Q | Q | ▲ | ▲ | r | w | ΛΛ | π π | |
| | 13 | | Q | Q | Q | ▲ | ▲ | r | w | ΛΛ | | |
| | 12 | | Q | Q | Q | ▲ | ▲ | r | w | ΛΛ | | |
| | 11 | | Q | Q | Q | ▲ | ▲ | r | w | ΛΛ | | |
| | 10 | | Q | Q | Q | ▲ | ▲ | r | w | ΛΛ | | |
| T.S.26 | 9 | | Q | Q | Q▲ | ▲ | ▲ | r | w | ΛΛ | ≡ | |
| | 8 | | Q | Q | Q▲ | ▲ | ▲ | r | w | ΛΛ | | |
| | 7 | ● | Q | Q | ▲ | ▲ | ▲ | a | w | Λ | | |
| T.S.25 | 6 | ● | Q | Q | ▲ | ▲ | ▲ | a | w | Λ Λ | | |
| | 5 | ● | Q | Q | ▲ | ▲ | ▲ | a | w | Λ | | |
| | 4 | ◐ | Q | Q | ▲ | ▲ | ▲ | a | p | ΛΛ | ≡ | |
| | 3 | | Q | Q | ▲ | ▲ | ▲ | a | p | ΛΛ | | |
| | 2 | | Q | Q | ▲ | ▲ | ▲ | a | p | ΛΛ⊥ | medium-on matrix | |
| | 1 | | Q | Q | ▲ | ▲ | ▲ | a | p | ΛΛ⊥ | | |
| T.S.24 | | | | | | | | | | | | |

# Appendix C:

THIN SECTION 1

DEPTH: 897.6 metres

WELL LOCATION: LSD 14-19-7-15 W4
Southeast Taber

STATUS: Oil Well

## COMPOSITION

GRAINS= 80%
POROSITY= 2%
CEMENT= 18%

## GRAIN COMPOSITION

QUARTZ= 76%
CHERT= 18%
S.R.F.= 6%
OTHER= 0%

## GRAIN CONTACTS

FLOATING= 2%
TANGENTIAL= 40%
STRAIGHT= 45%
EMBAYED= 13%
MOSAIC= 0%

NO. OF GRAIN CONTACTS PER GRAIN = 4

## GRAIN SIZE

RANGE: 0.14 mm TO 1.43 mm (fine to coarse)
AVERAGE: 0.23 mm (fine)

## SORTING

moderately sorted

## GRAIN SHAPE

subangular

## OTHER GRAIN FEATURES

S.R.F. are mainly shale (90%) although 10% is is quartzose, very fine-grained sandstone with occasional quartz veins. They contain abundant authigenic pyrite crystals. Some S.R.F. have been altered to clay. Some have many chalcedony crystals.
Quartz is corroded by calcite, occurs mainly as single grains, 70% straight, 30% undulose.

## CEMENT

5% QUARTZ OVERGROWTHS

5% CLAY occurs around qtz. overgr. (suggesting the silica cement came first). Clays esp. abundant near S.R.F.

5% FERROAN CALCITE stains royal blue, corrodes qtz. overgr. (suggesting overgr. came first), and often encloses red-staining:

1% WITHERITE?

2% DOLOMITE

very minor PYRITE

## POROSITY

2% porosity is disconnected hence the permeability is effectively 0. The pores are irregular in shape and size suggesting the porosity may be secondary. Quartz overgrowths jut into some pore space. Quartz has a ragged outline even adjacent to pore space, suggesting that some cement was dissolved. Pressure solution effects are not as apparent on this slide.

## COMMENTS:

THIN SECTION 2

DEPTH: 904.5 metres

WELL LOCATION: LSD 14-19-7-15W4
Southeast Taber

STATUS: Oil Well

## COMPOSITION

GRAINS=75%
POROSITY=5%
CEMENT=20%

## GRAIN SIZE

RANGE: 0.14 mm TO 0.51 mm (fine to medium)
AVERAGE: 0.41 mm (medium)

## SORTING

moderately sorted

## GRAIN COMPOSITION

QUARTZ=60%
CHERT=20%
S.R.F.=20%
OTHER=very minor amphibole (hornblende)

## GRAIN SHAPE

subangular

## GRAIN CONTACTS

FLOATING=20%
TANGENTIAL=30%
STRAIGHT=40%
EMBAYED=10%
MOSAIC=0%

NO. OF GRAIN CONTACTS PER GRAIN = 3

## OTHER GRAIN FEATURES

Qtz occurs almost exclusively as single grains. 65% has straight extinction; 35% has undulose extinction. It is corroded and surrounded by calcite cement.

S.R.F. are 75% sandstone and 25% shale. No metamorphic fabric was seen. Many contain abundant authigenic pyrite crystals.

## CEMENT

15% CLAY forms a thin film around grains and completely fills some pore space. It stains pink. (perhaps some is detrital and contains Ca++ which would react with the stain)

3% CALCITE cement is non-ferrous.

2% QUARTZ OVERGROWTHS are most commonly found jutting into pore space.

## POROSITY

The porosity is only about 5% and so the permeability is also poor. Clays constrict pore throats. Microporosity from grain fracturing is rare in this slide. There is some welding of grains and pressure solution seams.

COMMENTS: Much of this slide is drilling mud due to caving.

THIN SECTION 3

DEPTH: 906.6 metres

WELL LOCATION: LSD 14-19-7-15 W4
Southeast Taber

STATUS: Oil Well

## COMPOSITION

GRAINS= 76%
POROSITY= 15%
CEMENT= 9%

## GRAIN COMPOSITION

QUARTZ= 25%
CHERT= 43%
S.R.F.= 32%
OTHER= 0%

## GRAIN CONTACTS

FLOATING= 2%
TANGENTIAL=15%
STRAIGHT=63%
EMBAYED=20%
MOSAIC= 0%

NO. OF GRAIN CONTACTS PER GRAIN = 4

## GRAIN SIZE

RANGE: 0.25 mm TO 0.71 mm (medium to coarse)
AVERAGE: 0.35 mm (medium-grained)

## SORTING

well-sorted

## GRAIN SHAPE

subangular

## OTHER GRAIN FEATURES

S.R.F. are mainly sandstone (80%) with shale (17%) and chalcedony (3%) found within rock fragments and alone. Many grains exhibit metamorphic fabrics. The orientation is random and therefore primary.

Quartz occurs mainly as single grains; straight and undulose extinction are equally common.

## CEMENT

5% CLAY forms a thin film around grains and completely fills some pore space. Clay distribution is not uniform; clay is most abundant around the chert grains. Oil is absorbed by the clays, imparting a reddish-brown colour.

4% QUARTZ OVERGROWTHS jut into pore space, cause rounded quartz grains to have a pseudoangularity with rectangular outlines.

minor authigenic PYRITE occurs in one large patch, almost completely filling pore space

## POROSITY

Although the porosity is 15%, the permeability is poor. The triangular-shaped pore throats are blocked by grain contacts or clay. Some of the irregularly-shaped pores appear secondary, although the evidence is not convincing. Several grains are fractured, creating minor secondary porosity. The fractures are not filled by cement.

COMMENTS: There are microscopic lenses of finer quartz-rich layers and coarser chert and S.R.F.-rich layers. Clay cement is more abundant in the chert and S.R.F. lenses. Quartz overgrowths are more common in the quartzose lenses.

THIN SECTION 4 DEPTH: 972.7 metres

WELL LOCATION: LSD 12-30-7-15 W4 STATUS: Dry

Southeast Taber

COMPOSITION

GRAINS=
POROSITY=
CEMENT=

GRAIN SIZE

RANGE: mm TO mm (
AVERAGE: mm (

SORTING

GRAIN COMPOSITION

QUARTZ=
CHERT=
S.R.F.=
OTHER=

GRAIN SHAPE

GRAIN CONTACTS

FLOATING=
TANGENTIAL=
STRAIGHT=
EMBAYED=
MOSAIC=

NO. OF GRAIN CONTACTS
PER GRAIN =

OTHER GRAIN FEATURES

CEMENT

POROSITY

COMMENTS: This slide is contaminated by drilling mud and therefore it is not possible to obtain reliable data.

THIN SECTION 5

DEPTH: 983.7 metres

WELL LOCATION: LSD 12-30-7-15 W4
Southeast Taber

STATUS: Dry

## COMPOSITION

GRAINS= 80%
POROSITY= 4%
CEMENT= 16%

## GRAIN SIZE

RANGE: 0.14 mm TO 1.14 mm (fine to v. coarse)
AVERAGE: 0.57 mm (coarse-grained)

## GRAIN COMPOSITION

QUARTZ= 60%
CHERT=25%
S.R.F.=15%
OTHER= 0%

## SORTING

moderately-sorted

## GRAIN SHAPE

subrounded to well rounded

## GRAIN CONTACTS

FLOATING= 5%
TANGENTIAL= 10%
STRAIGHT= 60%
EMBAYED= 25%
MOSAIC= 0%

NO. OF GRAIN CONTACTS PER GRAIN = 4

## OTHER GRAIN FEATURES

S.R.F. are very quartzose; it is somewhat arbitrary as to when they should be called chert. If clays or laminations are present they are called S.R.F. In some, a metamorphic fabric is defined by muscovite. Most S.R.F. are very fine sandstone.

Quartz grains have 80% straight, 20% undulose extinction.

## CEMENT

6% CALCITE cement is clearly 2° (corrodes qtz, oversized pores, floating grains, elongate pores, inhomogenous packing). Half is iron-rich (staining blue, coarser), half is iron-free (staining pink). Reverse zoning sometimes present.

6% CLAY plugs pore throats, assoc. with v. small qtz grains (breakdown of chert?), forms film around some grains.

4% QUARTZ OVERGROWTHS

## POROSITY

4% porosity is irregularly-shaped, some pores are elongate, of different sizes, at least some is 2°, porosity is probably not effective. Only minor pressure solution effects.

COMMENTS:

THIN SECTION 6

DEPTH: 987.7 metres

WELL LOCATION: LSD 12-30-7-15 W4
Southeast Taber

STATUS: Dry

**COMPOSITION**

GRAINS= 70%
POROSITY= 15%
CEMENT=15%

**GRAIN SIZE**

RANGE: 0.29 mm TO 1.0 mm (medium to coarse)
AVERAGE: 0.57 mm (coarse)

**GRAIN COMPOSITION**

QUARTZ= 40%
CHERT= 55%
S.R.F.= 5%
OTHER= 0%

**SORTING**

well-sorted

**GRAIN SHAPE**

wellrounded

**GRAIN CONTACTS**

FLOATING=10%
TANGENTIAL= 25%
STRAIGHT= 60%
EMBAYED= 5%
MOSAIC= 0%

NO. OF GRAIN CONTACTS
PER GRAIN = 3

**OTHER GRAIN FEATURES**

S.R.F. are very quartzose (quartzite fragments), some have a mosaic texture.

Quartz grains have 80% straight extinction and 20% undulose extinction.

**CEMENT**

9% CLAY sometimes occurs around embayed quartz (perhaps it came after the dissolution of calcite).

4% DOLOMITE cement has traces of iron.

2% QUARTZ OVERGROWTHS

trace of PYRITE cement fills some fractures and pores.

**POROSITY**

15% porosity, most is secondary (elongate, floating grains, very irregular shape and size). Permeability is poor, clays block pore throats.

COMMENTS: Quartz overgrowths are relatively uncommon in this slide. This probably why this slide looks so well rounded.

THIN SECTION 7 (Sawtooth Sandstone) DEPTH: 966.8 metres

WELL LOCATION: LSD 2-36-8-16 W4 STATUS: Dry
Southeast Taber

COMPOSITION

GRAINS= 72%
POROSITY= 24%
CEMENT= 4%

GRAIN SIZE

RANGE: 0.07 mm TO 0.57mm (v. fine to coarse)
AVERAGE: 0.25 mm (medium-grained)

SORTING

very well sorted

GRAIN COMPOSITION

QUARTZ= 98%
CHERT= 0%
S.R.F.= 2%
OTHER= v. minor green amphibole (hornblende)

GRAIN SHAPE

corroded edges but high sphericity

GRAIN CONTACTS

FLOATING= 7%
TANGENTIAL= 13%
STRAIGHT= 65%
EMBAYED= 15%
MOSAIC= 0%

NO. OF GRAIN CONTACTS PER GRAIN = 4

OTHER GRAIN FEATURES

S.R.F. are shale and quartzite; they contain abundant pyrite

CEMENT

2% QUARTZ OVERGROWTHS: not as abundant as in Ellerslie sandstones, though overgrowths may have been dissolved)

2% CLAYS: form a thin film around some grains

POROSITY

24% porosity: at least some appear secondary (enlarged pores, irregular shape and size of pores)

COMMENTS: These Sawtooth Sandstones are much more mature (texturally and mineralogically) than Ellerslie Sandstones.

THIN SECTION 8 (Conglomeratic base of Ellerslie Sandstone) DEPTH: 966.0 metres

WELL LOCATION: LSD 2-36-8-16 W4 STATUS: Dry

Southeast Taber

COMPOSITION

GRAINS= 94%
POROSITY= 1%
CEMENT= 5%

GRAIN SIZE

RANGE: 0.14mm TO 28.6 mm (fine sand to pebble)
AVERAGE: -- mm (conglomerate)

GRAIN COMPOSITION

QUARTZ= 75% (mostly smaller grains)
CHERT= 10% (mostly larger grains)
S.R.F.= 15% (mostly larger grains)
OTHER= 0%

SORTING

very poorly sorted

GRAIN SHAPE

well rounded to angular where embayed

GRAIN CONTACTS

FLOATING= 0%
TANGENTIAL= 2%
STRAIGHT= 33%
EMBAYED= 65%
MOSAIC=0%

NO. OF GRAIN CONTACTS PER GRAIN = 6

OTHER GRAIN FEATURES

The largest clasts are chert and S.R.F. The S.R.F. are: poorly sorted quartzose sandstone; well sorted sandstone with 55% quartz, 20% shale as clasts, 25% shale matrix; shale with a lineation which "flows" around harder quartz grains (muscovite defines the foliation); it forms solution seams.

CEMENT

4% CLAYS: some may be deformed clasts, some may be detrital. They almost completely fill the porosity.

1% QUARTZ OVERGROWTHS are much less common than in other slides. Many may have been dissolved at contacts.

POROSITY

1% porosity mainly due to the microporosity generated by intra-granular porosity of a S.R.F. within a S.R.F. Some apparent porosity is caused by plucking.

COMMENTS: Microsylolites are very common; elongate, stretched-out grains are common⟶ sediment was subjected to severe mechanical and chemical compaction.

THIN SECTION 9

DEPTH: 963.7 metres

WELL LOCATION: LSD 2-36-8-16 W4
Southeast Taber

STATUS: Dry

COMPOSITION

GRAINS= 88%
POROSITY= 1%
CEMENT= 11%

GRAIN SIZE

RANGE: 0.03 mm TO 0.57 mm (medium silt to coarse)
AVERAGE: 0.14 mm (fine sandstone)

GRAIN COMPOSITION

QUARTZ= 70%
CHERT= 20%
S.R.F.= 10%
OTHER= v. minor hornblende

SORTING

poorly sorted

GRAIN SHAPE

well rounded to corroded

GRAIN CONTACTS

FLOATING= 20% (in clay & pyrite)
TANGENTIAL= 40%
STRAIGHT= 35%
EMBAYED= 5%
MOSAIC= 0%

NO. OF GRAIN CONTACTS PER GRAIN = 2 to 3

OTHER GRAIN FEATURES

Quartz occurs as mianly single crystals, 60% straight extinuishing, 40% with undulose extinction. Some are mosaic, polycrystalline. Quartz is corroded by pyrite.

S.R.F. are sandstones with a clay matrix and quartzite

CEMENT

5% PYRITE CEMENT: anhedral, in patches, replacing something-- very corroded floating grains within it; some pyrite is evenly distributed within the clay as smaller, rounded crystals.

5% CLAYS: some is reddish, pore filling, some may be detrital or from the breakdown of S.R.F.

1% QUARTZ OVERGROWTHS

v. minor DOLOMITE CEMENT

POROSITY

1% porosity is secondary (pores are larger than grains, irregular size and shape of pores, only one main patch of porosity and one very thin, very long streak of porosity).

COMMENTS: There is quite alot of fractured grains.

THIN SECTION 10

DEPTH: 962.1 metres

WELL LOCATION: LSD 2-36-8-16 W4
Southeast Taber

STATUS: Dry

COMPOSITION

GRAINS= 70%
POROSITY= 22%
CEMENT= 8%

GRAIN SIZE

RANGE: 0.14 mm TO 0.86mm (fine to coarse sand)
AVERAGE: 0.43 mm (medium sandstone)

SORTING

well sorted

GRAIN COMPOSITION

QUARTZ= 80%
CHERT= 15%
S.R.F.= 5%
OTHER= 0%

GRAIN SHAPE

well rounded, though quartz overgrowths and corroded quartz grains make them appear subangular

GRAIN CONTACTS

FLOATING= 10%
TANGENTIAL= 5%
STRAIGHT= 35%
EMBAYED= 50%
MOSAIC= 0%

NO. OF GRAIN CONTACTS PER GRAIN = highly variable, average = 5

OTHER GRAIN FEATURES

Quartz is highly fractured though no porosity is generated (mechanical compaction occured before the inhibiting effect of cements). 75% straight, 25% strongly undulose extinction. Most are single grains, few are polycrystalline.

S.R.F. are maily siltstone, a few are fine grained sandstone.

CEMENT

8% QUARTZ OVERGROWTHS: weld many of the quartz grains together

v. minor PYRITE

POROSITY

Excellent (22%) porosity, at least some is secondary (irregular shape and size of porosity, oversized pores, floating grains), very good permeability

COMMENTS: This is a fery poor thin section; there are many air bubbles around grinding grit.

THIN SECTION 11

DEPTH: 955.8 metres

WELL LOCATION: LSD 2-36-8-16 W4
Southeast Taber

STATUS: Dry

COMPOSITION

GRAINS= 87%
POROSITY= 6%
CEMENT= 7%

GRAIN SIZE

RANGE: 0.07mm TO 0.86mm (v. fine to coarse)
AVERAGE: 0.29 mm (medium sandstone)

SORTING

moderately sorted

GRAIN COMPOSITION

QUARTZ= 70%
CHERT= 20%
S.R.F.= 10%
OTHER= v. minor green hornblende

GRAIN SHAPE

moderately to well rounded

GRAIN CONTACTS

FLOATING= 0%
TANGENTIAL= 25%
STRAIGHT= 45%
EMBAYED= 30%
MOSAIC= 0%

NO. OF GRAIN CONTACTS PER GRAIN = 6

OTHER GRAIN FEATURES

Quartz grains are quite fractured, although no microporosity is created; occurs in single grains with straight to slightly undulose extinction.

S.R.F. are maily v. fine sandstone or siltstone, some have a metamorphic foliation.

CEMENT

5% CLAYS: line pores and completely fill porosity around smaller grains.

2% QUARTZ OVERGROWTHS

v. minor PYRITE replacement

POROSITY

6% porosity: the small pores are fairly evenly distributed. They are triangular to irregular in shape. Some is probably secondary since there are molds of replacement along grain contacts.

COMMENTS: There is a long, thin, reddish, organic plant fragment.

There is a high degree of mechanical compaction.

THIN SECTION 12

DEPTH: see core description

WELL LOCATION: LSD 14-9-8-15 W4
Chin Coulee

STATUS: Oil Well

## COMPOSITION

GRAINS= 84%
POROSITY= 10%
CEMENT= 6%

## GRAIN SIZE

RANGE: 0.14 mm TO 0.57 mm (fine to coarse)
AVERAGE: 0.28 mm (medium sandstone)

## GRAIN COMPOSITION

QUARTZ= 80%
CHERT=15%
S.R.F.= 5%
OTHER= 0%

## SORTING

well sorted

## GRAIN SHAPE

subrounded

## GRAIN CONTACTS

FLOATING= 2%
TANGENTIAL= 35%
STRAIGHT= 53%
EMBAYED= 10%
MOSAIC= 0%

NO. OF GRAIN CONTACTS
PER GRAIN = 5

## OTHER GRAIN FEATURES

Quartz is slightly corroded in places, most is slightly undulose, most is monocrystalline, some polycrystalline.

S.R.F. are v. fine quartzose sandstones and shale.

## CEMENT

5% CLAYS are distributed evenly throughout, occuring around grains and in pore throats.

1% QUARTZ OVERGROWTHS: not conspicuous

v. minor FERROUS CALCITE

## POROSITY

10% porosity, some is secondary (molds of rim cement); it was probably generated by the dissolution of ferrous calcite cement, remnants of calcite seen.

COMMENTS: Some of this thin section is drilling mud due to caving.

THIN SECTION 13

DEPTH: see core description

WELL LOCATION: LSD 14-9-8-15 W4
Chin Coulee

STATUS: Oil Well

COMPOSITION

GRAINS=
POROSITY=
CEMENT=

GRAIN SIZE

RANGE: mm TO mm (
AVERAGE: mm (

SORTING

GRAIN COMPOSITION

QUARTZ=
CHERT=
S.R.F.=
OTHER=

GRAIN SHAPE

GRAIN CONTACTS

FLOATING=
TANGENTIAL=
STRAIGHT=
EMBAYED=
MOSAIC=

NO. OF GRAIN CONTACTS
PER GRAIN =

OTHER GRAIN FEATURES

CEMENT

POROSITY

COMMENTS: This sample is contaminated with drilling mud from caving. Therefore, it is not possible to get an accurate description.

THIN SECTION 14

DEPTH: see core description

WELL LOCATION: LSD 14-9-8-15 W4
Chin Coulee

STATUS: Oil Well

**COMPOSITION**

GRAINS= 69%
POROSITY= 20%
CEMENT= 11%

**GRAIN SIZE**

RANGE: 0.14mm TO 0.57mm (fine to coarse)
AVERAGE: 0.28 mm (medium-grained sandstone)

**SORTING**

well sorted

**GRAIN COMPOSITION**

QUARTZ= 70%
CHERT= 10%
S.R.F.= 20%
OTHER= 0%

**GRAIN SHAPE**

subrounded

**GRAIN CONTACTS**

FLOATING= 2%
TANGENTIAL= 40%
STRAIGHT= 48%
EMBAYED= 10%
MOSAIC= 0%

NO. OF GRAIN CONTACTS
PER GRAIN = 3

**OTHER GRAIN FEATURES**

Quartz is corroded in places, both next to pores and next to calcite. 40% is polycrystalline, 60% slightly undulose single grains.

S.R.F. are fine-grained sandstone, some contain muscovite.

**CEMENT**

3% CALCITE CEMENT: occurs in patches throughout the slide.

4% CLAY: outlines some pore space as if it came before the generation of secondary porosity. It is hydrocarbon stained.

4% QUARTZ OVERGROWTHS: some v. spectacular

**POROSITY**

Porosity appears secondary (over-sized pores, irregular shape and size of pores, clay outlines pores)

Permeability is fairly good as well.

COMMENTS:

THIN SECTION 15

DEPTH: 872.6 metres

WELL LOCATION: LSD 14-16-7-14 W4
Chin Coulee

STATUS: Oil Well

**COMPOSITION**

GRAINS= 70%
POROSITY=0%
CEMENT= 30%

**GRAIN SIZE**

RANGE: 0.28 mm TO 2.14 mm (med. sand to granule)
AVERAGE: 0.71 mm (coarse sandstone)

**GRAIN COMPOSITION**

QUARTZ= 20%
CHERT= 75%
S.R.F.= 5%
OTHER= 0%

**SORTING**

poor to moderate

**GRAIN SHAPE**

subangular

**GRAIN CONTACTS**

FLOATING= 10%
TANGENTIAL=25%
STRAIGHT= 50%
EMBAYED= 15%
MOSAIC=0%

NO. OF GRAIN CONTACTS PER GRAIN = 3

**OTHER GRAIN FEATURES**

Chert is almost quartzite, some has re-crystalized patches, some is in veins.

S.R.F. are v. quartzose sandstones and shale with some metamorphic fabric.

Quartz has straight to slightly undulose extinction.

**CEMENT**

28% CALCITE CEMENT: in large, anhedral patches

2% QUARTZ OVERGROWTHS

**POROSITY**

No porosity

COMMENTS: Minor amounts of calcite-filled fractures.

THIN SECTION 16

DEPTH: 872.0 metres

WELL LOCATION: LSD 14-16-7-14 W4
Chin Coulee

STATUS: Oil Well

COMPOSITION

GRAINS= 82%
POROSITY= 6%
CEMENT= 12%

GRAIN SIZE

RANGE: 0.14 mm TO 0.57mm (fine to coarse)
AVERAGE: 0.21 mm (fine-grained sandstone)

GRAIN COMPOSITION

QUARTZ= 87%
CHERT= 7%
S.R.F.= 3%
OTHER= 3% carbonaceous material defines laminations

SORTING

well sorted

GRAIN SHAPE

subrounded

GRAIN CONTACTS

FLOATING= 15%
TANGENTIAL= 30%
STRAIGHT= 50%
EMBAYED= 5%
MOSAIC= 0%

NO. OF GRAIN CONTACTS PER GRAIN = 2

OTHER GRAIN FEATURES

Quartz is quite corroded; most has straight to slightly undulose extinction, some is polycrystalline.

S.R.F. are shale and very quartzose sandstone.

CEMENT

8% CLAY: completely fills the pore space in parts of the thin section

4% QUARTZ OVERGROWTHS

trace FERROUS CALCITE

v. minor PYRITE

POROSITY

6% porosity occurs mostly around quartz overgrowths. It is not very evenly distributed. Traces of calcite cement are found near pores. The porosity is probably secondary, from the dissolution of ferrous calcite.

COMMENTS:

THIN SECTION 17

DEPTH: 869.0 metres

WELL LOCATION: LSD 14-16-7-14 W4
Chin Coulee

STATUS: Oil Well

## COMPOSITION

GRAINS= 82%
POROSITY= 5%
CEMENT= 13%

## GRAIN SIZE

RANGE: 0.14 mm TO 0.57 mm (fine to coarse)
AVERAGE: 0.28 mm (medium-grained sandstone)

## SORTING

well sorted

## GRAIN COMPOSITION

QUARTZ= 85%
CHERT=12%
S.R.F.= 3%
OTHER= 0%

## GRAIN SHAPE

subrounded

## GRAIN CONTACTS

FLOATING= 15%
TANGENTIAL= 30%
STRAIGHT= 50%
EMBAYED=5%
MOSAIC= 0%

NO. OF GRAIN CONTACTS PER GRAIN = 2

## OTHER GRAIN FEATURES

Quartz is corroded in places, it occurs mostly as single grains with straight to slightly undulose extinction, some is polycrystalline.

S.R.F. are shale and very quartzose sandstone.

## CEMENT

8% CLAY: completely fills the pore space in parts of the slide.

4% QUARTZ OVERGROWTHS

1% FERROUS CALCITE clearly corrodes some quartz.

## POROSITY

5% porosity is probably secondary (oversized pores, variable size and shape of pores, some elongate pores, traces of calcite found around pores)

COMMENTS: This is a poor slide--plucking of grains is common and there is some caving. This thin section is very similar to thin section 16, except that there is slightly more calcite cement and hence less porosity.

THIN SECTION 18 (conglomerate)  DEPTH: 956.2 metres

WELL LOCATION: LSD 11-30-7-14 W4  STATUS: Oil Well
Chin Coulee

COMPOSITION of matrix:

GRAINS= 79%
POROSITY= 10%
CEMENT= 11%

GRAIN SIZE

RANGE: 0.28mm TO 35.7 mm (medium sand to pebble)
AVERAGE: 1.57 mm (v. coarse sandstone)

SORTING

very poorly sorted

GRAIN COMPOSITION

QUARTZ= 55%
CHERT= 40%
S.R.F.= 5%
OTHER= minor carbonaceous fragments, ductilely deformed.

GRAIN SHAPE

subangular

GRAIN CONTACTS

FLOATING= 5%
TANGENTIAL= 35%
STRAIGHT= 55%
EMBAYED= 5%
MOSAIC= 0%

NO. OF GRAIN CONTACTS PER GRAIN = 4

OTHER GRAIN FEATURES

Quartz occurs maily as single grains, 60% has undulose, 40% has straight extinction.

Chert tends to be larger and more angular than quartz.

S.R.F. are shale.

CEMENT

9% CLAY: some is probably detrital or from the breakdown of chert or shale--two colours of clay are present.

2% QUARTZ OVERGROWTHS

POROSITY

10% porosity within cements, could be primary or secondary. Also, very minor microporosity found within clasts. No effective porosity.

COMMENTS: Grain fracturing is quite common. Conglomeratic clasts are: altered chert with pink-staining clays; lithic sandstone (wacke).

THIN SECTION 19

DEPTH: 955.0 metres

WELL LOCATION: LSD 11-30-7-14 W4
Chin Coulee

STATUS: Oil Well

COMPOSITION

GRAINS= 73%
POROSITY=15%
CEMENT= 12%

GRAIN SIZE

RANGE: 0.28 mm TO 1.14mm (medium to v. coarse)
AVERAGE: 0.71 mm (coarse sandstone)

GRAIN COMPOSITION

QUARTZ= 25%
CHERT= 70%
S.R.F.= 5%
OTHER= pyrite associated with carbonaceous fragments

SORTING

moderately sorted

GRAIN SHAPE

subangular

GRAIN CONTACTS

FLOATING= 0%
TANGENTIAL= 25%
STRAIGHT=60%
EMBAYED= 15%
MOSAIC= 0%

NO. OF GRAIN CONTACTS PER GRAIN = 4

OTHER GRAIN FEATURES

Quartz grains are more rounded than chert grains. Most quartz occurs as single grains with straight to slightly undulose extinction. It is corroded.

S.R.F. are very quartzose sandstone (or quartzite) and shale.

CEMENT

10% CLAYS: oil stained, line pore space and completely fill the porosity in places.

2% QUARTZ OVERGROWTHS

POROSITY

15% porosity is both primary and secondary. Secondary porosity is evidenced by partial replacement of quartz, followed by dissolution of the calcite.

COMMENTS: Grains are fractured.

THIN SECTION 20

DEPTH: 948.0 metres

WELL LOCATION: LSD 11-30-7-14 W4
Chin Coulee

STATUS: Oil Well

COMPOSITION

GRAINS= 75%
POROSITY= 10%
CEMENT= 15%

GRAIN SIZE

RANGE: 0.14 mm TO 1.00 mm (fine to coarse)
AVERAGE: 0.57 mm (coarse sandstone)

GRAIN COMPOSITION

QUARTZ= 55%
CHERT= 40%
S.R.F.= 5%
OTHER= 0%

SORTING

well sorted

GRAIN SHAPE

subrounded

GRAIN CONTACTS

FLOATING= 10%
TANGENTIAL= 50%
STRAIGHT= 35%
EMBAYED= 5%
MOSAIC= 0%

NO. OF GRAIN CONTACTS PER GRAIN = 3

OTHER GRAIN FEATURES

Quartz grains are more rounded than chert grains.

S.R.F. are shale.

Chert grains contain abundant pyrite.

CEMENT

10% CLAYS: oil stained, completely fill porosity in much of the slide.

2% QUARTZ OVERGROWTHS

3% CALCITE CEMENT: both ferrous and non-ferrous, clearly replacing quartz, reverse zoning.

POROSITY

Secondary porosity is clearly created by the dissolution of calcite cement. Evidence: elongate pores, partially replaced quartz, remnant calcite cement "floating" in pores, oversized pores, irregular size and shape of pores.

Some microporosity is created by fractured quartz grains.

COMMENTS: Grain fracturing is quite common.

THIN SECTION 21 (Basal Conglomerate) DEPTH: 976.9 metres

WELL LOCATION: LSD 10-7-8-15 W4 STATUS: Dry

Southeast Taber

COMPOSITION of matrix:

GRAINS= 84%
POROSITY= 1%
CEMENT= 15%

GRAIN SIZE

RANGE: 0.07 mm TO 0.86 mm (v. fine to coarse)
AVERAGE: 0.43 mm (medium-grained sandstone)

GRAIN COMPOSITION

QUARTZ= 80%
CHERT= 15%
S.R.F.= 5%
OTHER= 0%

SORTING

very poorly sorted
(bimodal)

GRAIN SHAPE

subangular (pseudoangularity due to corrosion and quartz overgrowths)

GRAIN CONTACTS

FLOATING= 10%
TANGENTIAL= 15%
STRAIGHT=30%
EMBAYED=30%
MOSAIC=15%

NO. OF GRAIN CONTACTS PER GRAIN = 6

OTHER GRAIN FEATURES

Quartz occurs in two size fractions-bimodal. The smaller quartz grains are v. much smaller than the chert. Most quartz has undulose extinction.

Chert contains abundant pyrite.

CEMENT

8% CLAY

3% CALCITE CEMENT: non-ferrous, corrodes quartz, rather unevenly distributed.

4% QUARTZ OVERGROWTHS

POROSITY

This is a tight sandstone, although some microporosity is found within large clasts and there is very minor irreducible lamellar porosity.

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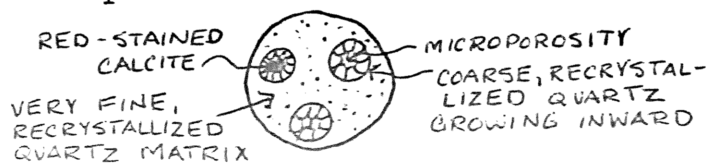
A separate thin section of a larger (~1 cm) clast shows it is a very quartzose, recrystallized, metamorphosed sandstone.




COMMENTS: Porosity is not all blue--it was not successfully impregnated with epoxy. These holes looked like they were plucked.

THIN SECTION 22

DEPTH: 974.7 metres

WELL LOCATION: LSD 10-7-8-15 W4
Southeast Taber

STATUS: Dry

COMPOSITION

GRAINS= 60%
POROSITY= 3%
CEMENT= 37%

GRAIN SIZE

RANGE: 0.14 mm TO 0.85 mm (fine to coarse)
AVERAGE: 0.43 mm (medium-grained sandstone)

GRAIN COMPOSITION

QUARTZ= 80%
CHERT= 14%
S.R.F.= 6%
OTHER= 0%

SORTING

moderately sorted

GRAIN SHAPE

subrounded

GRAIN CONTACTS

FLOATING=10%
TANGENTIAL=40%
STRAIGHT=45%
EMBAYED= 5%
MOSAIC=0%

NO. OF GRAIN CONTACTS PER GRAIN = 4

OTHER GRAIN FEATURES

S.R.F. are mostly shale and quartzite.

Quartz occurs mainly in single grains with 80% straight, 20% slightly undulose extinction.

CEMENT

5% QUARTZ OVERGROWTHS

3% CLAYS

29% CALCITE CEMENT: large portions are optically continuous, clearly replacing quartz in places.

POROSITY

3% porosity found within partially calcite-cemented pores.

COMMENTS:

THIN SECTION 23

DEPTH: 973.2 metres

WELL LOCATION: LSD 10-7-8-15 W4
Southeast Taber

STATUS: Dry

## COMPOSITION

GRAINS= 73%
POROSITY= 7%
CEMENT= 20%

## GRAIN SIZE

RANGE: 0.01 mm TO 0.13mm (medium silt to fine sandstone)
AVERAGE: 0.04 mm (coarse silt)

## GRAIN COMPOSITION

QUARTZ= 93%
CHERT= 5%
S.R.F.= 2%
OTHER= v. minor green amphibole (hornblende)

## SORTING

moderately sorted

## GRAIN SHAPE

corroded, subangular

## GRAIN CONTACTS

FLOATING= 0%
TANGENTIAL=5%
STRAIGHT= 50%
EMBAYED= 25%
MOSAIC= 20%

NO. OF GRAIN CONTACTS PER GRAIN = 6

## OTHER GRAIN FEATURES

The very fine quartz appears recrystallized but probably is not because: some sand-sized quartz shows no sign of strain; polygonal grain boundaries are not present; quartz overgrowths occur on some rounded (detrital) grains.

## CEMENT

10% CALCITE CEMENT: both ferrous and non-ferrous, occurs in patches.

4% CLAYS

6% QUARTZ OVERGROWTHS

minor authigenic PYRITE

## POROSITY

7% porosity. Individual pores are so small they would not constitute effective porosity. Porosity is probably secondary because: pores have an irregular size and shape, they are unevenly distributed just as calcite cement is.

COMMENTS:

THIN SECTION 24

DEPTH: 980.2 metres

WELL LOCATION: LSD 5-6-8-15 W4
Southeast Taber

STATUS: Oil Well

COMPOSITION

GRAINS= 87 %
POROSITY= 2%
CEMENT= 11%

GRAIN SIZE

RANGE: 0.07 mm TO 1.14mm (v. fine to v. coarse)
AVERAGE: 0.28 mm (medium-grained sandstone)

SORTING

very poorly sorted

GRAIN COMPOSITION

QUARTZ= 90%
CHERT= 5%
S.R.F.= 5%
OTHER= abundant carbonaceous/coaly plant fragments often assoc. with pyrite (10%)

GRAIN SHAPE

subangular

GRAIN CONTACTS

FLOATING= 25%
TANGENTIAL= 20%
STRAIGHT= 25%
EMBAYED= 30%
MOSAIC= 0%

NO. OF GRAIN CONTACTS PER GRAIN = variable, ~4

OTHER GRAIN FEATURES

Quartz is very fractured, most are straight extinguishing single grains.

S.R.F. are very quartzose (almost quartzite) and quartz wacke.

CEMENT

7% CLAY

2% QUARTZ OVERGROWTHS

2% NON-FERROUS CALCITE CEMENT: replacing quartz and cementing some pore space and replacing some plant fragments.

POROSITY

2% porosity, no permeability. Porosity occurs along edges of red, carbonaceous plant fragments and is created by dissolution of calcite cement.

COMMENTS: Slumping of finer material and carbonaceous matter into coarser bedload material probably occured.

THIN SECTION 25

DEPTH: see core description

WELL LOCATION: LSD 5-6-8-15 W4
Southeast Taber

STATUS: Oil Well

## COMPOSITION

GRAINS= 78%
POROSITY= 12%
CEMENT= 10%

## GRAIN COMPOSITION

QUARTZ= 60%
CHERT=30%
S.R.F.=10%
OTHER= 0%

## GRAIN CONTACTS

FLOATING=0%
TANGENTIAL=20%
STRAIGHT= 60%
EMBAYED= 20%
MOSAIC=0%

NO. OF GRAIN CONTACTS
PER GRAIN = 4

## GRAIN SIZE

RANGE: 0.14mm TO 0.71mm ( fine to coarse)
AVERAGE: 0.43mm (medium-grained sandstone)

## SORTING

well sorted

## GRAIN SHAPE

subangular

## OTHER GRAIN FEATURES

S.R.F. are shale and quartzite and quartzose wackes and rare chalcedony

Quartz occurs mostly as single grains with slightly undulose extinction.

## CEMENT

6% CLAYS are oil-stained

4% QUARTZ OVERGROWTHS

## POROSITY

12% porosity and probably fairly good permeability. Much of the porosity occurs next to corroded quartz grains and is probably secondary.

COMMENTS: Rare microsylolites, rotation of grains, deformation of the more ductile grains, and fractured quartz is evidence of severe mechanical compaction.

THIN SECTION 26

DEPTH: see core description

WELL LOCATION: LSD 5-6-8-15 W4
Southeast Taber

STATUS: Oil Well

## COMPOSITION

GRAINS=70%
POROSITY=20%
CEMENT= 10%

## GRAIN SIZE

RANGE: 0.14 mm TO 0.9 mm (fine to coarse)
AVERAGE: 0.47 mm (medium-grained sandstone)

## GRAIN COMPOSITION

QUARTZ=90%
CHERT= 4%
S.R.F.= 6%
OTHER= 0%

## SORTING

well sorted

## GRAIN SHAPE

subrounded

## GRAIN CONTACTS

FLOATING= 0%
TANGENTIAL=20%
STRAIGHT=55% (mainly due to qtz. overgrowths)
EMBAYED=25%
MOSAIC=0%

NO. OF GRAIN CONTACTS PER GRAIN = 4

## OTHER GRAIN FEATURES

S.R.F. are shale and quartzose sandstone.

Quartz occurs mainly as single grains with straight to slightly undulose extinction. About 15% is polycrystalline.

## CEMENT

7% QUARTZ OVERGROWTHS: 2 phases

3% CLAY

## POROSITY

Excellent porosity and permeability. At least some of the porosity is secondary. Some quartz grains and overgrowths are corroded (quartz is preferentially corroded as opposed to overgrowths). A second generation of overgrowths masks much of the dissolution.

COMMENTS: Quartz is slightly fractured.

# Appendix D:

## Appendix D

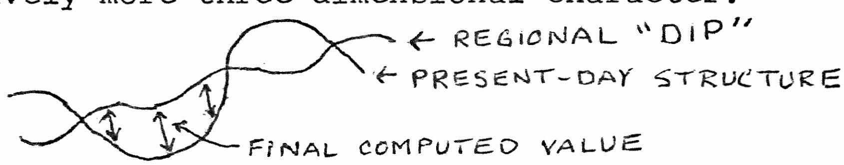
## Mapping Methods

1. Composite Ellerslie Sand Isolith
(Figure 8)

The hand-contoured Ellerslie Sandstone Isolith was generated using a combination of two types of isolith maps. The first was drawn by contouring the individual thicknesses of sandstone found in each well. The second was constructed by overlaying hand-drawn Jurassic and Ellerslie sandstone structural maps. Where the contours intersected, the sand thickness was calculated by taking the difference of contour line values. This provided additional data points so that the combination of the two maps is as accurate as possible with existing well control.

2. Fourth Order Residuals
(Figures 10 and 11)

The two residual maps were produced by a computer utilizing trend surface analysis equations. The regional "dip" or surface is subtracted from the present-day structure to arrive at the map. With increasingly higher order residuals the regional "dip" varies from a plane to a surface with successively more three dimensional character.




In this way, the paleogeography of Jurassic time (Figure 10) is seen before the regional tilt was imposed by post-Jurassic movement on the Sweetgrass Arch.

For isopach construction (Figure 11), the regional dip is subtracted from both the Ellerslie sandstone structure and the Jurassic structure. Then the isopach is computed from the differences between the two surfaces.