1

National Library
of Canada

Bibliothèque nationale
du Canada

Canadian Theses Service

Services des thèses canadiennes

Ottawa, Canada
K1A 0N4

CANADIAN THESES

THÈSES CANADIENNES

NOTICE

The quality of this microfiche is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy

Previously copyrighted materials (journal articles, published tests, etc.) are not filmed.

Reproduction in full or in part of this film is governed by the Canadian Copyright Act, R.S.C. 1970: c. C-30. Please read the authorization forms which accompany this thesis.

AVIS

La qualité de cette microfiche dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

Les documents qui font déjà l'objet d'un droit d'auteur (articles de revue, examens publiés, etc.) ne sont pas microfilmés.

La reproduction, même partielle, de ce microfilm est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30. Veuillez prendre connaissance des formules d'autorisation qui accompagnent cette thèse.

**THIS DISSERTATION
HAS BEEN MICROFILMED
EXACTLY AS RECEIVED**

**LA THÈSE A ÉTÉ
MICROFILMÉE TELLE QUE
NOUS L'AVONS REÇUE**

National Library
of Canada

Bibliothèque nationale
du Canada

0-315-22171-2

Canadian Theses Division

Division des thèses canadiennes

Ottawa, Canada
K1A 0N4

PERMISSION TO MICROFILM — AUTORISATION DE MICROFILMER

• Please print or type — Écrire en lettres moulées ou dactylographier

Full Name of Author — Nom complet de l'auteur

Jerry Joseph Sykora

Date of Birth — Date de naissance

Dec. 22/57

Country of Birth — Lieu de naissance

Canada

Permanent Address — Résidence fixe

173 Banning Rd. Kanata, Ont.
K2L-1C5

Title of Thesis — Titre de la thèse

Stratigraphy, sedimentology and diagenesis-porosity
relationships of the subsurface, Neocomian
Parsons Group, Mackenzie Delta area,
Northwest Territories, Canada.

University — Université

Carleton University

Degree for which thesis was presented — Grade pour lequel cette thèse fut présentée

M. Sc.

Year this degree conferred — Année d'obtention de ce grade

1984

Name of Supervisor — Nom du directeur de thèse

Dr. R. W. Vole

Permission is hereby granted to the NATIONAL LIBRARY OF
CANADA to microfilm this thesis and to lend or sell copies of
the film.

The author reserves other publication rights, and neither the
thesis nor extensive extracts from it may be printed or other-
wise reproduced without the author's written permission.

L'autorisation est, par la présente, accordée à la BIBLIOTHÈ-
QUE NATIONALE DU CANADA de microfilmer cette thèse et de
prêter ou de vendre des exemplaires du film.

L'auteur se réserve les autres droits de publication; ni la thèse
ni de longs extraits de celle-ci ne doivent être imprimés ou
autrement reproduits sans l'autorisation écrite de l'auteur.

Date

April 27/84

Signature

STRATIGRAPHY, SEDIMENTOLOGY AND DIAGENESIS-
POROSITY RELATIONSHIPS OF THE SUBSURFACE,
NEOCOMIAN PARSONS GROUP, MACKENZIE DELTA AREA,
NORTHWEST TERRITORIES, CANADA

by

© Jerry J. Sykora

A thesis submitted to the
Faculty of Science in the partial fulfillment
of the requirements for the degree of
Master of Science

Department of Geology
Carleton University

Ottawa, Ontario

April, 1984

The undersigned recommend to the Faculty of
Science acceptance of the thesis
" Sedimentology, stratigraphy and diagenesis-
porosity relationships of the subsurface,
Neocomian Parsons Group, Mackenzie Delta area,
Northwest Territories, Canada -"
submitted by Jerry J. Sykora in partial
fulfillment of the requirements for the degree
of Master of Science.

Thesis Supervisor

Chairman, Department of Geology

Carleton University

April, 1984

ABSTRACT

The Lower Cretaceous Parsons Group is a major hydrocarbon-bearing clastic sequence, consisting of the Martin Creek, McGuire and Kamik Formations. The Kamik Formation is informally subdivided into a sandstone-dominated lower non-marine member, a transitional member, and a shaly upper marine member. Subsurface mapping of the Parsons Group rocks is the most detailed and complete to date, distinguishing the three Kamik Formation members.

Log interpretation, petrography and stratigraphy are used to define a variety of depositional environments ranging from offshore in the McGuire Formation and the Kamik marine member through prograding barrier island in the Martin Creek Formation to high-energy braided-stream in the Kamik non-marine member. The sandstones studied are mostly quartz arenites, usually supermature, and show intragroup grain size differences related to depositional environments. Minor differences in feldspar abundances possibly are related to diagenetic alteration.

Compaction, cementation and dissolution are the major diagenetic processes which have affected the sandstones. Differences in diagenetic "assemblages" are related to grain size, composition and probably most importantly-burial depth. Silica is the predominant cement with carbonate, illite-montmorillonite and kaolinite cements present as well. Dissolution of carbonate, which has produced high secondary porosities, can be related to burial depth.

ACKNOWLEDGEMENTS

The bulk of the raw materials used in the fabrication of this thesis came from the research department and geological files of Gulf Canada Resources in Calgary. Without this generous access, this thesis would not have been possible. I would also like to express my gratification specifically to Ross Lennox and Doug Gardner of Gulf Canada for the time allotted me during the summer of 1983 to work on this thesis and to Bruce Hancock also of Gulf Canada for the discussions, time and physical contributions he made to the work. Special thanks go to all staff members of the research department of Gulf Canada and to Monti Lerand for their interest and assistance in this thesis.

I would like to thank James Dixon of the Geological Survey of Canada in Calgary for suggesting such an interesting, challenging and pertinent topic.

The AAPG grant-in aid program is acknowledged for their generous financial contribution assisting the research of this thesis. Energy, Mines and Resources is thanked for the financial assistance given me (research agreement #46-1983) during the course of this study.

Staff members of the core storage facility, Institute of Sedimentary and Petroleum Geology (GSC) in Calgary are mentioned in return for the prompt and friendly service given me during

the weeks spent there logging core.

Staff members of COGLA, especially Duncan Smith, are thanked for the easy access to files and patient treatment of my requests.

My peers at Carleton University, especially Dr. G. Ross, are much thanked for the endless geological discussions and support offered me during the investigation and writing of this thesis. Peter Jones is recognized for his assistance and opinions through-out the microprobe investigation of these rocks.

Thanks are given to Dr's J.A. Donaldson, T.J.S. Cole (Carleton University) and Dr. O.A. Dixon (Ottawa University) for agreeing to sit on my defense board, and for the many suggestions on improving the text.

Finally, special thanks are given to Dr. R.W. Yole in recognition for both having me as a graduate student and for the many hours of critical assessment, and numerous suggestions which greatly improved the quality and readability of the text.

TABLE OF CONTENTS

	page
TITLE PAGE.....	i
STATEMENT OF FACULTY APPROVAL.....	ii
ABSTRACT.....	iii
ACKNOWLEDGEMENTS.....	iv
TABLE OF CONTENTS.....	vi
LIST OF ILLUSTRATIONS.....	viii
LIST OF TABLES.....	viii
LIST OF FIGURES.....	viii
LIST OF PLATES.....	x
LIST OF APPENDICES.....	x
1. INTRODUCTION.....	1
1.1 Purpose.....	1
1.2 Methods.....	1
1.3 Geographic Setting.....	2
1.4 Selection of Boreholes.....	2
1.5 Previous Work.....	2
2. STRUCTURAL ELEMENTS OF THE MACKENZIE DELTA AREA.....	6
3. STRATIGRAPHY.....	9
3.1 General Introduction.....	9
3.2 Biostratigraphy.....	12
3.2.1 Surface.....	12
3.2.2 Subsurface.....	14
4. PETROGRAPHY.....	15
4.1 Methods of Study.....	15
4.1.1 Discussion of potential errors in composition.....	15
4.1.2 Method of grain size analysis.....	16
4.2 Sandstone Petrography.....	18
4.2.1 Framework composition.....	18
4.2.2 Quartz.....	24
4.2.3 Chert.....	25
4.2.4 Feldspars.....	26
4.2.5 Accessory minerals.....	26
4.2.6 Minor rock fragments.....	26
4.3 Compositional Differences Among Stratigraphic Units.....	27
4.4 Textural Differences.....	33
5. LITHOFACIES, DEPOSITIONAL PATTERNS, AND ENVIRONMENTS OF DEPOSITION.....	37
5.1 Parsons Group.....	37
5.2 Husky Formation Upper Member.....	40
5.2.1 Environmental interpretation.....	44
5.3 Martin Creek Formation.....	44
5.3.1 Depositional patterns.....	46
5.3.2 Environmental interpretation.....	49
5.4 McGuire Formation.....	51
5.4.1 Depositional patterns.....	52
5.4.2 Environmental interpretation.....	54
5.5 Kamik Formation.....	55

TABLE OF CONTENTS(continued)

	page
5.6 Non-marine Member.....	56
5.6.1 Depositional patterns.....	59
5.6.2 Environmental interpretation.....	61
5.7 Transitional Member.....	64
5.7.1 Depositional patterns.....	73
5.7.2 Environmental interpretation.....	73
5.8 Marine Member.....	76
5.8.1 Depositional patterns.....	81
5.8.2 Environmental interpretation.....	83
5.9 Sand Isoliths.....	84
6. DIAGENESIS.....	90
6.1 Compaction.....	90
6.2 Cementation.....	91
6.3 Silica Cement.....	91
6.4 Calcite Cement.....	93
6.5 Authigenic Clay Cement.....	94
6.5.1 Illite.....	94
6.5.2 Kaolinite.....	96
6.5.3 Other authigenic clays.....	97
6.6 Hematite Cement.....	97
6.7 Siderite Cement.....	97
6.8 Pyrite Cement.....	97
6.9 Glauconite.....	98
6.10 Replacement.....	98
6.11 Dissolution.....	99
6.12 Paragenesis of Cements and Authigenic Minerals...	100
6.13 Porosity.....	103
6.14 Diagenetic Association.....	104
7. DIAGENESIS, AND THE PURSUIT OF POROSITY.....	109
7.1 Predicting Reservoir Porosity.....	109
7.2 Diagenetic Facies and Depth.....	111
8. SUMMARY AND CONCLUSIONS.....	118
8.1 Summary.....	118
8.2 Conclusions.....	119
9. RECOMMENDATIONS FOR FURTHER STUDY.....	121
10. PLATES.....	122
11. REFERENCES.....	144
12. APPENDICES.....	149

LIST OF ILLUSTRATIONS

	page
LIST OF TABLES	
Table 1. Table of sandstone composition and grain size analyses.....	20-22
Table 2. Environments of deposition in the transitional member.....	75
Table 3. Diagenetic maturity as a function of depth in the Parsons Group rocks.....	114
LIST OF FIGURES	
Figure 1. General location map showing structural elements.....	3
Figure 2. Geographic location map showing well locations and cross-sections.....	4
Figure 3. Generalized structural contour map on top of Parsons Group strata.....	8
Figure 4. Comparison of subsurface and surface lithostratigraphic terminology for Lower Cretaceous Formations.....	10
Figure 5. Detailed cross-section along the basinward flank of the Eskimo Lakes Arch	in pocket
Figure 6. Detailed cross-section across the Kugmallit Trough	in pocket
Figure 7. Stratigraphic profile of the Parsons Group rocks along the basinward flank of the Eskimo Lakes Arch and across the Kugmallit Trough.....	13
Figure 8. Probable error with 300 point counts.....	17
Figure 9. Error range for grain size measurements...	19
Figure 10. Sandstone classification according to Folk (1968). Parsons Group.....	23
Figure 11. Ternary diagram of Martin Creek Formation sandstone compositions.....	28
Figure 12. Ternary diagram of non-marine member sandstone compositions.....	29
Figure 13. Ternary diagram of transitional member sandstone compositions.....	30
Figure 14. Ternary diagram of marine member sandstone compositions.....	31
Figure 15. Ternary diagram of sandstones from figures 11 to 14 with mean grain sizes between 0.10mm. and 0.20mm.....	32
Figure 16. Ternary diagram of sandstones from figures 11 to 14 with mean grain sizes between 0.10mm. and 0.20mm. and with oversized moldic porosity calculated as detrital feldspar.....	34
Figure 17. Distribution of mean grain size amongst sandstone-bearing units of the Parsons Group.....	36
Figure 18. Isopach map of the Parsons Group.....	38
Figure 19. Legend for graphic display of core.....	41

LIST OF ILLUSTRATIONS(continued)

page

LIST OF FIGURES(continued)

- Figure 20. Graphic display of core from the upper member, Husky Formation, Martin Creek Formation, and McGuire Formation... 42
- Figure 21. Isopach map of upper member, Husky Formation and Martin Creek Formation..... 47
- Figure 22. Isopach map of Martin Creek Formation.... 48
- Figure 23. Isopach map of McGuire Formation..... 53
- Figure 24. Graphic display of core from the non-marine member, Kamik Formation..... 57
- Figure 25. Isopach map of non-marine member..... 60
- Figure 26. Graphic display of core from the lower and middle transitional member, Kamik Formation..... 66
- Figure 27. Graphic display of core from the upper transitional member, Kamik Formation..... 67
- Figure 28. Isopach map of transitional member..... 72
- Figure 29. Graphic display of core from the marine member, Kamik Formation(E-21,G-04,P-41).. 77
- Figure 30. Graphic display of core from the marine member, Kamik Formation(L-43,F-18,E-54,A-12)..... 79
- Figure 31. Isopach map of marine member..... 82
- Figure 32. Sandstone isoliths for non-marine member. 86
- Figure 33. Sandstone isoliths for transitional member..... 88
- Figure 34. Sandstone isoliths for marine member.... 89
- Figure 35. Communality chart showing associations among various petrographic features in the Parsons N-10 well..... 105
- Figure 36. An association tree (based upon figure 35) with porosity at the base..... 108
- Figure 37. Graph of porosity variations as a function of grain size..... 110
- Figure 38. Diagenetic evolution (cycle) of sandstones..... 112
- Figure 39. Maximum porosity potential of Parsons Group sandstones (quartz arenites) versus depth of burial..... 115
- Figure 40. Estimated distribution of porosity development in the subsurface Parsons Group sandstones..... 116
- Figures 41 to 59. Detailed graphic display of core..In Pocket
- Figure 41. IOE Tuktu O-19 and Parsons N-10
- Figure 42. Tullugak K-31
- Figure 43. Parsons N-10
- Figure 44. Parsons N-10
- Figure 45. Parsons F-09
- Figure 46. Parsons N-10
- Figure 47. Parsons L-43

LIST OF ILLUSTRATIONS(continued)

page

LIST OF FIGURES(continued)

Figure 48. Wagnark C-23 and Ikhil I-37	
Figure 49. Siku E-21	
Figure 50. Parsons L-43 and Siku E-21	
Figure 51. Parsons F-09	
Figure 52. Siku A-12	
Figure 53. Ogruknang M-31 and Wagnark C-23	
Figure 54. Reindeer A-01 and IOE Tuk F-18	
Figure 55. Reindeer G-04	
Figure 56. Parsons P-41	
Figure 57. Siku A-12	
Figure 58. Parsons L-43	
Figure 59. IOE Tuk F-18, IOE Pikiolik E-54 and Siku E-21	

LIST OF PLATES

Plate 1. A 3.5 metre interval of core from the non-marine member in Ikhil I-37.....	122
Plate 2. A 4.5 metre interval of core from the transitional member in Siku E-21.....	124
Plate 3. A 4.4 metre interval of core from the transitional member in Siku A-12.....	126
Plate 4. Inorganic sedimentary structures and textures in cores.....	128
Plate 5. Trace fossils in cores.....	130
Plates 6 Scanning electron photomicrographs and to 11 thin section photomicrographs of constituents, textures, and porosities.....	132-143

LIST OF APPENDICES

Appendix 1. Stratigraphic tops used in study.....	149
Appendix 2. Biostratigraphic summary.....	160
Appendix 3. X-ray analyses.....	167

1. INTRODUCTION

1.1 Purpose

This study was undertaken to investigate the sedimentary petrology and stratigraphy of the Neocomian age Parsons Group based on boreholes in the Kugmallit Trough, southeastern Beaufort-Mackenzie Basin, and supplemented with outcrop data in the Richardson Mountains. By sedimentary petrography, and stratigraphic-sedimentological analysis the distribution and correlation of stratigraphic units, lithofacies, environments of deposition, diagenetic history, and associations were determined.

1.2 Methods

The Parsons Group was identified in the subsurface by well-to-well correlation using well logs, biostratigraphic data, and lithology where possible. Over one thousand feet of core were examined identifying sedimentary structures, lithological characteristics, and trace fossils (ichnology) based on comparison with illustrations in Chamberlain (1978). Over two hundred specially impregnated thin sections of both core and chip samples were studied using petrographic microscopy, and of these, forty-nine were investigated quantitatively. Selected samples were examined by scanning electron microscopy and X-ray analysis.

1.3 Geographic Setting

The Kugmallit Trough is situated in the southeastern Mackenzie Delta-Beaufort Sea area, east of the Yukon-Northwest Territories border (Figures 1 and 2). It is bound on the southeast by the Eskimo Lakes Arch and the Interior Plains and to the west by the Richardson Mountains. The area of detailed study is outlined in Figure 1.

1.4 Selection of Boreholes

Fifty boreholes, penetrating either Parsons Group strata or adjacent rocks (whose interpretation better define the petrology of the Parsons Group) were examined in the course of the study. These wells (listed in Appendix 1) provide the data for a comprehensive stratigraphic-sedimentological analysis.

1.5 Previous Work (summarized after Dixon, 1982)

Jeletzky (1958, 1960, 1961, 1967, 1974, 1975, 1980, in prep.) was the first investigator to study the stratigraphy of the Parsons Group lithostratigraphic equivalents in the Richardson Mountains, where he defined numerous units and proposed a geological history. Initial subsurface studies by Lerand (1973), Myhr and Gunther (1974), Côté et al. (1975), Myhr and Young (1975), and Brideaux and Myhr (1976), presented general or locally specific information on the nature of the Parsons Group. Research was encouraged by the major discovery of the Parsons Lake gas field in the early to mid seventies. Young et al. (1976) compiled a regional synthesis of surface and subsurface data which included the Parsons Group. The first comprehensive

Figure 1. General location map showing structural elements (from Dixon, 1982b, Figure 2)

Figure 2. Geographic location map showing well locations and cross-sections

stratigraphic-sedimentological study of the Parsons Group was attempted by Dixon (1982 a and b).

Little work has been published on the petrographic aspects of Parsons Group rocks. Schmidt and McDonald (1979) in their benchmark study of secondary porosity in sandstones used some Parsons Group rocks as examples. Dixon (1982a), described some petrographic characteristics of the sandstones. In both of these publications the quartz-rich nature of sandstones in the Parsons Group was recognized, but the mineralogy was not fully assessed.

2. STRUCTURAL ELEMENTS OF THE MACKENZIE DELTA AREA

The structural terminology used here (Figure 1) is from Dixon (1982b, Figure 2).

In the region studied, thickest Early Cretaceous deposits are in the Kugmallit Trough, a northeast - southwest trending depression flanked to the southeast by the Eskimo Lakes Arch, a positive feature throughout the deposition of the Parsons Group.

The northwest, basinward margin of the Eskimo Lakes Arch is bounded sharply by a major fault zone referred to as the Tuktoyaktuk Fault-Flexure Zone (Lerand, 1973). The timing of this faulting in relation to the evolution of the Eskimo Lakes Arch is uncertain, but some contemporaneous movement during Parsons Group deposition is probable. Young *et al.* (1976, p.6) suggested that the Kugmallit Trough was a Jurassic Columbian element. Isopach trends of Jurassic strata, mapped by Dixon (1982), suggest that the Eskimo Lakes Arch was a positive feature throughout Jurassic time. Young *et al.* (1976, p.6) concurred that a Jurassic arch was present but were uncertain of its relationship to the Columbian Orogen. Configuration of the Kugmallit Trough is locally affected by the Tununuk High to the northwest and by the Napoiak High, Cache Creek Uplift and Canoe Depression to the southwest. Thinning of Parsons Group rocks in the western part of the study area implies a possible structural linkage between the Cache Creek Uplift and the Tununuk High (see

Young et al., 1976, Figure 2), expressed as a less negative saddle separating the Kugmallit Trough proper to the northeast from the Blow Trough to the southwest. Figure 3 is a grossly generalized structural contour map on the top of the Parsons Group strata. Dominating the structure is the Tuktoyaktuk Fault-Flexure Zone. The throw across this zone can be in excess of 1 kilometer. Côté et al. (1975, p. 616) suggested that throws up to 2400 metres exist across the fault zone.

The western Kugmallit Trough was most likely uplifted during the Late Cretaceous-Early Tertiary Laramide orogenic event in the Richardson Mountains, causing Parsons Group strata to dip to the northeast. The post-Parsons remnant of the Kugmallit Trough is recognized just west of Parsons Lake (Figure 3).

Structure maps in the Parsons Lake area (Figure 3) near the Tuktoyaktuk Fault-Flexure Zone, show numerous subsidiary faults of various displacements associated with the major fault zone. These faults may persist in abundance basinward.

Figure 3. Generalized structural contour on top of Parsons Group strata.

3. STRATIGRAPHY

3.1 General Introduction

Nomenclature for lithostratigraphic equivalents of Parsons Group strata exposed in the Richardson Mountains was developed by Jeletzky (1958, 1960, 1961, 1967, 1980, and in prep.). Correlations to the subsurface were first presented by Côté et al., (1975) who proposed "Parsons Sandstone" as a name for the sand-dominated unit now recognized as the Parsons Group. Young et al., (1976), and most recently Dixon (1982b) have further modified the nomenclature.

Figure 4 summarizes the lithostratigraphic nomenclature proposed by Dixon (op. cit.) for Lower Cretaceous rocks in the subsurface of the Mackenzie Delta region, and for the northern Richardson Mountains lithostratigraphic equivalents. Minor modifications are proposed for nomenclature of the subsurface Kamik Formation in this thesis.

Subsurface correlations used in this report are based on previous work by Dixon (1982b) in the subsurface of the Mackenzie Delta region. Stratigraphic tops in the wells used are given in Appendix 1. The present study involved mapping units within the Parsons Group that differ in three ways from those used by Dixon (1982). First, the upper member of the Husky Formation and the Martin Creek Formation of the Parsons Group have been mapped together in recognition of their depositional continuity and

resultant gradational contact. Secondly, the Kamik Formation has been divided into three members; a lower non-marine member, a transitional member, and an upper marine member.

Myhr and Young (1975) first noted that the Kamik Formation stratigraphic equivalent was divisible into marine and non-marine, laterally continuous units in the subsurface. Dixon (1982b, p.18) noted that the basal, non-marine section of the Kamik Formation can be vertically divided into two parts distinguishable by sandstone characteristics and overall sand percentages. He also recognized mappable horizons within the upper two thirds of the Kamik Formation, at least in the Parsons Lake area. Surface equivalent of the Kamik Formation can be similarly divided into three successive units corresponding to those seen in the subsurface (Dixon, 1982b, Figure 4). The Fault Creek Formation is lithologically equivalent to the non-marine member of the Kamik while the overlying Lower Canyon Formation can be divided into a lower coal-bearing sandstone-siltstone-shale part and a marine shale-dominated upper part. Dixon (1982b) considered subdivision of the Kamik Formation to be impractical. However, it is proposed here that recognition of the three members is possible over the entire subsurface extent of the Kamik Formation.

Thirdly, the basin margins have been conservatively re-interpreted to fit a depositional interpretation for the Parsons Group strata, which is more complete than was earlier available.

Correlations presented here are controlled by available biostratigraphic determinations, down-hole log responses to lithology, and petrography. They were extended throughout the study area by construction of stratigraphic cross-sections.

Figures 5 and 6 are detailed cross-sections along the short and long axes of the Kugmallit Trough. Figure 7 is a schematic representation of these cross-sections.

3.2 Biostratigraphy

3.2.1 Surface

Jeletzky (1958, 1960, 1961, 1975) has dated strata in the Richardson Mountains lithologically equivalent to Parsons Group using macro-fossils, as Neocomian in age.

Martin Creek-equivalents were dated Late Berriasian to Early Valanginian in Jeletzky's earlier work. Dixon (1982b, p.16) suggested that at this stage in Jeletzky's work, McGuire Formation equivalents had not been recognized. Jeletzky (1961) subsequent to the recognition of the McGuire Formation, assigned an Early to Late Berriasian age to Martin Creek equivalents.

Basing his conclusions on stratigraphic position and index fossils in the lower beds, Jeletzky assigned an early to Middle Valanginian age to equivalents of the McGuire Formation.

The lack of fossils in the Kamik equivalents forced Jeletzky (1960, 1961) to rely on stratigraphic position to date

Figure 7. Stratigraphic profile of the Parsons Group rocks along the basinward flank of the Eskimo Lakes Arch and across the Kugmallit Trough.

the Kamik as Middle or Late Valanginian to Middle Hauterivian in age. The upper member of the Coal-bearing Division, stratigraphically equivalent with the marine member of the Kamik, contains belemnites of possible Middle Hauterivian age (Jeletzky, 1960, p. 9).

3.2.2 Subsurface

Biostratigraphic information concerning the age of Parsons Group strata in the subsurface is drawn from - Barnes et al. 1974; Myhr and Gunther, 1974; Brideaux et al., 1975; Brideaux et al., 1976; Brideaux and Myhr, 1976 and unpublished biostratigraphic work by Gulf Canada Resources, Calgary.

Biostratigraphic information exists for sixteen wells, either penetrating Parsons Group strata, or occurring at basin margins where ages of contiguous strata are significant to the interpretation of basinal sediments.

The biostratigraphic information compiled in Appendix 2 in combination with log responses and petrographic data form the framework for the stratigraphic correlations of the subsurface Parsons Group strata. Biostratigraphic determinations have been adhered to unless clearly unreliable. Age estimates of subsurface Parsons Group rocks are very similar to those obtained from outcrop.

4. PETROGRAPHY

4.1 Methods of Study

Parsons Group sandstones were investigated using thin section petrography, scanning electron microscopy, X-ray diffraction, and microprobe analysis.

Approximately 315 metres (1030 feet) of core from 17 wells were examined. Of 200 thin sections from 11 wells in the Parsons Lake area, 57 were selected for detailed study and of these 49 examined thoroughly with quantitative techniques. Most thin sectioned samples were impregnated with blue epoxy to facilitate the recognition of porosity and to preserve of delicate authigenic clays during thin section preparation.

Mineral composition of authigenic clays was determined by petrographic microscope, SEM examination, X-ray diffraction and limited microprobe work.

Compositional analysis was achieved by recording 300 points on an approximate 2.5 x 1.5 cm. grid with an automatic point-count mechanical stage. Three hundred points were deemed sufficient based on the relative low compositional variability.

4.1.1 Discussion of potential errors in composition

Chayes (1956) deduced that for point count analyses true analytical error (σ_a) was a function of both counting error (σ_c) and sampling error (σ_s) (i.e. $\sigma_a = \sigma_c + \sigma_s$).

The sampling error can be kept to a minimum if a coarse - meshed grid is used (Chayes 1956, Hilliard and Cahn 1961) allowing that the distance between points exceeds the maximum grain size.

Counting error can be closely approximated by $(p(1-p/n))^{1/2}$ (Chayes, 1956, p.90) (p = calculated percentage, n =number of point counts).

$$\text{Since } \sigma_a = \sqrt{\sigma_s^2 + \sigma_c^2}, \quad \sigma_a = \sqrt{\sigma_s^2 + p(1-p)/n}$$

If σ_s can be assumed as zero then $\sigma_a = (p(1-p)/n)^{1/2}$

Figure 8 is a graphical representation of the probable minimal error as a function of calculated percentage, based upon a point count of 300.

4.1.2 Method of grain size analysis

The longest apparent grain dimension was measured to compensate for the variation in grain orientation within and between samples. Measurements were made using a micrometer eyepiece. Detrital components visibly modified by compaction were not measured. All measurements yield apparent grain sizes from thin sections.

A minimum of 50 grains were measured for each of the thin sections selected for detailed study. Samples exhibiting less

Figure 8. Probable error with 300 point counts.

thorough sorting (.75 standard deviation and greater) had a minimum of 75 grains measured. Fifty grain measurements were considered sufficient in most of the samples studied since a study of variance of the 50 grain count mean from a true mean (200 measurements) versus the degree of sorting (Figure 9) shows an error range generally less than 10 percent at the 95 percent confidence level. This level of accuracy obtained from a minimum of 50 grain counts translates into $\pm .02$ mm. for most of the samples studied.

4.2 Sandstone Petrography

4.2.1 Framework Composition

Percentages of the main detrital constituents of the sands are presented in Table 1. Quartz content (monocrystalline and metamorphic quartz) ranges from 78.2 to virtually 100 percent with an arithmetic mean of 96.1 percent for the 49 selected thin sections. Both dark and light coloured chert grains are present throughout the Parsons Group section, in quantities up to 16.9 percent. Feldspars are infrequently present in more than trace quantities, but locally exceed 5 percent. Accessory minerals such as zircon, and less commonly tourmaline and sphene, are usually present in minor amounts. Other minor detrital constituents include shale and siltstone grains, mafic rock fragments and woody particles. Using the sandstone classification scheme of Folk (1968) the rocks studied are mainly quartz arenites with minor sublitharenites and subarkoses (Figure 10).

RANGE OF ERROR IN MEAN GRAIN SIZE (for 50 count mean) versus DEGREE OF SORTING

95 PERCENT CONFIDENCE LEVEL

Figure 9. Error range for grain size measurements.

Well/ Depth (m)	Percentage Composition														Grain Size															
	Det	Qm	Qd	Cl	Sp	Fk	Feld	Dis	M	Sh	Slt	Ms	Ac	Oth	Mix	Sil	Car	Ill	Kao	Gl	Pys	Am	Py	Fe	Gr	Vg	Summary	Mean		
W 10/2850.7	83.5	95.8	1.2	0.0	0.3	0.4	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	12	2.7	5.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.05	0.17	1.5
W 10/2852.3	82.2	93.9	1.2	0.0	0.8	?	?	0.9	2.0	0.4	0.0	0.0	0.0	0.8	0.0	0.0	13	4.9	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2854.9	74.0	96.3	0.4	0.0	0.0	?	?	0.9	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5	1.7	3.3	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2856.7	77.8	94.0	0.4	0.0	0.4	?	?	0.0	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15	5.6	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2858.7	77.9	97.2	0.4	0.0	0.1	?	?	0.4	1.4	0.0	0.0	0.0	0.0	0.6	0.0	0.0	8	9.6	2.7	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2860.7	79.6	95.0	0.4	0.0	0.1	?	?	0.0	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15	3.7	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2864.7	84.2	95.4	0.4	0.0	0.0	?	?	0.2	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	18	2.3	7.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2875.5	87.6	96.2	0.8	0.0	0.4	?	?	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18	2.4	5.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2879.5	86.7	94.9	0.8	0.0	0.2	0.0	?	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10	1.4	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2885.2	92.4	92.4	0.5	0.2	?	?	?	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2891.7	81.0	96.0	0.8	0.5	1.3	?	?	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.0	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2893.1	84.6	92.5	1.6	0.2	0.3	0.2	?	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18	1.3	5.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2894.4	69.2	96.5	1.8	0.5	1.2	0.0	?	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8	0.2	4.4	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2897.5	84.8	93.9	1.8	3.1	0.4	?	?	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8	0.7	3.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2899.9	93.5	98.6	0.7	0.3	0.4	?	?	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23	2.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2903.2	89.9	97.9	0.0	0.0	0.1	?	?	0.0	1.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	22	1.0	3.1	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2906.6	70.5	90.0	1.0	0.5	0.9	0.0	?	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2913.7	93.7	90.4	4.3	4.2	1.1	0.0	?	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18	0.0	2.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W 10/2917.3	?	?	?	?	?	?	?	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10	0.0	0	0	0	0	0	0	0	0	0	0	0	0
W 10/2919.1	86.6	91.9	4.6	1.7	1.0	0.0	?	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

P Present Det Total percentage of non matrix detrital components (includes silica cement) # treated as a cement in text Qm Monocrystalline quartz (includes silica cement) Qd Metamorphic quartz = 200 point counts for grain size ac minor Cd Dark chert Cl light chert Fp Plagioclase feldspar Fk Potassium feldspar Fund Feldspar undifferentiated Fds Dissolving feldspar M Matrix Fragments Sh Shale Slt Siltstone Ms Muddy material Ac Accessory (zircon, tourmaline, sphene) Oth Other detrital components Mix Matrix Sil Silica, estimated Car Carbonate (calcite, siderite) Ill Illite dominated Kao Kaolinite Gl Glaucinite Py Pyrite Hm Hematite Mn Minerals Itl total Qdc Porosity from dissolution of carbonate cement Qfe Porosity after dissolution of original detritus, probably feldspar Qc Intrachert porosity Qf fracture porosity Qg Upper limit of size range in mm. lg lower limit of size range in mm. X Mean in mm. Qsd estimated phi standard deviation Mbr. Member fm formation ac Martin Creek formation na non marine member t transitional member w marine member.

Table 1. Table of sandstone composition and grain size data from analyses of thin sections.

Well/ Depth (m)	Percentage Composition																			Grain Size				Misc	
	Retained to 100 %																			Summary					
	Det	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Vg	g	g		g
	Det	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm	Qm
43/2939.8	?	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
41/22105.2	188.3	95.8	10.8	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41/2851.8	185.1	96.1	1.6	1.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
09/2840.7	?	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
09/2842.2	182.0	90.6	10.9	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
09/2845.9	174.3	84.1	11.5	1.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
09/2853.5	?	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
09/2854.8	180.3	94.5	10.0	1.3	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21/2950.7	171.3	97.2	11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21/2962.6	?	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
21/2965.7	183.0	91.8	12.9	0.8	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21/3048.5	193.2	96.8	11.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21/3049.8	176.6	88.2	13.9	1.4	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12/2807.7	170.1	97.7	10.0	1.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12/2807.9	174.3	97.8	11.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12/2808.1	168.4	97.1	11.5	0.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12/2810.2	162.2	93.1	12.2	0.9	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12/2811.5	181.1	87.2	12.8	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
06/2932.5	177.7	96.5	11.7	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

P Present Det total percentage of non matrix detrital components (includes silica cement) # treated as a cement in text Qm Monocrystalline quartz (includes silica cement) Qm Metamorphic quartz # 200 point counts for grain size # minor Cd Dark chert Cl light chert Fp Plagioclase feldspar Fk Potassium feldspar Fund Feldspar undifferentiated Fdis Dissolving feldspar M Mafic fragments Sh Shale Slt Siltstone M Woody material Ac Accessory (zircon, tourmaline, spene) Oth Other detrital components Mtx Matrix Sil Silica, estimated Car Carbonate (calcite, siderite) Ill Illite dominated Kao Kaolinite Gl Glaucinite Py Pyrite Mn Hematite Ttl Total Mde Porosity from dissolution of carbonate cement β Fe Porosity after dissolution of original detritus, probably feldspar β Fracture porosity β Fracture porosity Vg Vg Upper limit of size range in mm. lg Lower limit of size range in mm. $\bar{x}$ Mean in mm. σ Standard deviation Mbr. Member Fa. Formation ac Martin Creek formation nm non marine member t transitional member m marine member.

Table 1 (continued). Table of sandstone composition and grain size data from analyses of thin sections.

Well/ Depth(m)	Percentage Composition																				Grain Size										
	Detrital Component Recalculated to 100%										Authigenic Min.										Porosity										
	Det	Qm	Qcd	Cl	Sp	Fk	Und	Di	M	Sh	Silt	Ac	Orth	Mtx	Car	Ill	Kao	Gl	Py	Na	Min	Porosity	Summary								
43/2767.9	77.2	94.8	1.3	0.9	1.8	?	?	0.0	0.4	0.0	0.0	0.0	0.0	0.0	13	0.0	9.4	0.3	0.0	0.7	0.0	12.4	6.7	5.7	0.0	0.0	0.0	0.34	0.05	0.19	0.03
43/2769.1	?	P	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12	0.0	0.0	0.0	0.0	0.0	0.7	3.3	6.8	0.5	0.0	0.0	0.0	0.29	0.06	0.14	0.05
41/2961.0	84.9	94.6	13.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10	3.7	3.3	1.3	0.0	0.2	0.0	6.6	5.3	1.1	0.0	0.0	0.0	0.60	0.04	0.18	0.05
41/2966.5	93.7	94.6	1.7	0.7	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23	4.3	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.17	0.07	0.19	0.80
41/2971.7	76.6	97.3	10.0	1.3	0.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8	5.3	9.0	6.0	0.0	0.0	0.7	0.4	0.4	0.0	0.0	0.0	0.0	0.51	0.05	0.18	0.05
41/2973.2	70.4	97.6	10.0	1.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7	6.0	14.3	4.0	0.0	0.8	0.2	3.4	3.0	0.0	0.0	0.0	0.0	0.59	0.04	0.17	0.60
41/2976.3	88.0	98.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16	4.7	10.3	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.26	0.04	0.12	0.40
41/2976.5	62.0	86.4	10.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5	3.0	0.7	10.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.29	0.01	0.08	1.0
41/2977.0	?	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.21	0.02	0.12	0.70
41/2977.9	84.4	96.8	11.6	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12	0.0	15	2.0	7.6	1.0	0.0	0.3	2.7	2.7	0.0	0.0	0.0	0.29	0.01	0.13	0.10
41/2978.0	?	P	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.18	0.09	0.19	0.05
41/2978.8	78.0	95.5	2.9	0.4	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12	0.0	10.0	0.0	0.0	0.0	2.3	0.0	2.7	4.7	3.0	0.0	0.0	0.74	0.09	0.25	0.50
41/2979.1	32.2	78.2	1.0	1.0	7.9	?	?	0.0	2.0	0.0	0.0	0.0	0.0	0.0	2	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.74	0.06	0.18	0.05
41/2979.4	71.7	95.6	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.49	0.07	0.23	0.10
41/2979.5	78.3	99.4	10.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13	2.0	6.3	2.7	0.0	0.0	0.0	10.7	7.7	3.0	0.0	0.0	0.0	0.19	0.01	0.11	0.40
41/2979.6	71.6	96.5	11.5	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4	3.1	0.0	0.0	0.0	0.0	1.7	0.0	5.7	4.7	1.0	0.0	0.0	0.24	0.04	0.12	0.00
41/2979.8	81.1	87.7	7.6	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16	1.3	10.6	1.0	0.0	0.3	0.0	5.7	4.7	2.0	0.0	0.0	0.0	0.29	0.05	0.11	0.05
09/3000.2	34.6	89.6	11.2	2.3	5.8	?	?	1.3	0.0	0.0	0.0	0.0	0.0	0.0	6	3.2	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	1.23	0.01	0.21	0.60

P Present Det Total percentage of non matrix detrital components (includes silica cement) # treated as a cement in text Qm Monocrystalline quartz (includes silica cement) Qcd Metamorphic quartz # 200 point counts for grain size # minor Cd Dark chert Cl Light chert Fk Plagioclase feldspar Fk Potassium feldspar Fund feldspar undifferentiated Fdis Dissolving feldspar M Mafic fragments Sh Shale Silt Siltstone Na Woody material Ac Accessory (zircon, tourmaline, sphene) Oth Other detrital components Mtx Matrix Sil Silica, estimated Car Carbonate (calcite, siderite) Ill Illite dominated Kao Kaolinite Gl Glaucophane Py Pyrite Na Naevite Min Minerals Ill Total #dc Porosity from dissolution of carbonate cement #fe Porosity after dissolution of original detritus, probably feldspar #c Intrachert porosity #f fracture porosity Vg Upper limit of size range in mm. Lg Lower limit of size range in mm. X Mean in mm. #sd Estimated phi standard deviation Mbr. Member fa. Formation ac Martin Creek formation na non marine member t transitional member # marine member #q McGuire formation.

Table 1 (continued). Table of sandstone composition and grain size data from analyses of thin sections.

4.2.2 Quartz

Three types of quartz were recognized in the petrographic study.

Monocrystalline quartz is an ubiquitous mineral ranging from 70.5 to 99.5 percent of the detrital constituents , averaging 94.3 percent. These percentages include the syntaxial silica cement as framework grains, since the lack of evidence for original internal grain outlines precludes any possibility of quantitatively distinguishing between detrital and authigenic overgrowth silica. Commonly, the monocrystalline quartz contains fluid inclusions and less commonly microlites. The degree of undulose extinction varies widely, even within a single thin section, suggesting variable provenances for these detrital quartz constituents. The next most abundant type of quartz is commonly polycrystalline, schistose , exhibiting strongly undulose extinction, and intragrain sutured contacts ; it sometimes contains aligned micas. Such quartz , interpreted as metamorphic in origin, makes up to 10 percent of the detrital grains, averaging 1.8 percent.

Sedimentary quartz is identified , in this thesis by evidence of sedimentary re-cycling. Abraded overgrowths are the most reliable criteria for recognizing quartz of sedimentary provenance . In the arenites studied, diagenetic alteration by quartz and carbonate cements makes certain identification of such evidence near-impossible. The shale-dominated McGuire Formation (Plate 6a) was found in one thin section to contain

appreciable amounts of sedimentary quartz as a detrital constituent based on the presence of rounded and sometimes multiple overgrowths. Also, Plate 6a shows an overgrown broken round quartz clast attesting to recycling. The high degree of rounding of quartz clasts in the McGuire mudstone as well suggests recycling. Together with the presence of rounded zircon in most sandstones these data suggest that recycled sediments are a common constituent of most arenites studied.

4.2.3 Chert

Detrital chert fragments are, after quartz, the most common detrital constituent. Both light and dark-coloured chert grains occur throughout the stratigraphic section. The chert commonly contains visible sedimentary relict textures and minerals such as dolomite rhombs (Plate 6b), euhedral pyrite, void filling quartz, fossil, pellet ghosts (Plate 6c) oolitic ghosts and sometimes unaltered calcite. Partial dissolution of the cherty grains is not uncommon - a result of removal of remnant carbonate, expressed as intrachert moldic porosity (Plate 6d, see also Plate 6d).

The light-coloured chert is usually colourless and less commonly light yellow or green. Textures range from uniform microcrystalline to a combination of microquartz and megaquartz containing abundant relict textures. The light coloured chert constitutes from 0 to 15.9 percent of the detrital grains, averaging 1.5 percent.

The dark-coloured chert is light brown to dark brown,

sometimes varicoloured , and more rarely hematite-stained. Textures range from uniform microcrystalline (less common than in the light-coloured chert) to a combination of microquartz and megaquartz and a hybrid type of chert exhibiting chalcedonic textures. The dark coloured chert constitutes 0 to 8.5 percent of the detrital grains, averaging 1.1 percent .

4.2.4 Feldspars

The relative quantities of potassic and plagioclase feldspar types were not computed because of time considerations. Dissolution of feldspar is very common (Plate 6e), and the distinction between stable and corroded feldspars was made. Limited observations suggest that both the potassic and plagioclase feldspars are susceptible to dissolution.

4.2.5 Accessory minerals

Well-rounded zircon is the most abundant accessory mineral, locally occurring in measurable quantities, but usually recognizable only as a trace constituent. Tourmaline and sphene are also present locally in trace amounts.

4.2.6 Minor rock fragments

Shale, siltstone, mafic fragments (and minerals) and possibly minor detrital carbonate occur sporadically within the specimens studied usually only in trace quantities. Woody particles and associated carbonaceous material is present in quantities up to 12.4 percent.

4.3 Compositional Difference Among Stratigraphic Units

The stratigraphic distinction between the Martin Creek and the Kamik Formation sandstones as well as units within the Kamik Formation is supported by the compositional variations, despite the high degree of mineralogical maturity of the sandstones studied. As Figures 11,12,13 and 14 show, quartz, feldspar and rock fragments (chert) proportions are different for each member in the Kamik Formation and for the Martin Creek Formation, as compared with the Kamik as a whole.

Sandstones of the Martin Creek Formation (Figure 11) are typically more feldspar-rich than those of any other Parsons Group unit. The average feldspar content in the Martin Creek sandstones is 3.1 percent while the non-marine member of the Kamik Formation averages less than 0.5 percent feldspar as a detrital component (Figure 12). The transitional and marine members contain only trace quantities of detrital feldspar (Figures 13 and 14) .

Figures 12,13, and 14 also indicate that the non-marine and transitional members of the Kamik Formation have a higher chert (rock fragment) content than the overlying marine member.

Figure 15 is a triangular plot (from Folk,1968) for sandstones from Figures 11 to 14 with mean grain sizes between 0.10 and 0.20 mm. inclusive. Figure 15 shows little variation in

Figure 11. Ternary diagram of Martin Creek Formation sandstone compositions. Classification according to Folk (1968).

Figure 12. Ternary diagram of non-marine member sandstone compositions. Classification according to Folk (1968).

Figure 13. Ternary diagram of transitional member sandstone compositions. Classification according to Folk (1968).

Figure 14. Ternary diagram of marine member sandstone compositions. Classification according to Folk (1968).

Figure 15. Ternary diagram of sandstones from figures 11 to 14 with mean grain sizes between 0.10mm and 0.20mm. Classification according to Folk (1968).

chert content for the three members of the Kamik Formation (certainly between the transitional and marine member at least). The differences in chert content seen in Figures 12, 13 and 14 are a function of grain size, the coarser sandstones being more chert-rich. The feldspar variation is still recognizable in Figure 15.

Dissolution of feldspar has most likely caused an under-estimation of this component. Assuming that the uneven, moldic porosity (oversized pores) recognized in the sandstones is the result of the breakdown of detrital feldspar (observations support this), then the data can be re-plotted with this porosity type included with identified detrital feldspar. Figure 16 is such a plot and probably more closely resembles original composition. While Martin Creek sandstones still appear to be compositionally unique, the differences between these and other sandstones are not as great as before the feldspar correction. Such a porosity correction is probably a minimum value for feldspar since the secondary moldic porosity may have been partially destroyed by authigenic clays, cements, and late compaction.

4.4 Textural Differences

Accurate determination of the degree of rounding and sphericity was not possible because of the difficulty in determining original grain outline. Based on a few original grain outlines recognizable in almost every thin section studied (Plate 6f), the sandstones are estimated to have roundness values (based on

Figure 16. Ternary diagram of sandstones from figures 11 to 14 with mean grain sizes between 0.10mm and 0.20mm, with oversized moldic porosity calculated as detrital feldspar. Classification according to Folk (1968).

Powers, 1953) ranging from 0.4 to .0.85 (subrounded to very rounded Plate 6g). Sphericity is estimated to be generally moderate, but ranges from low to high in the specimens studied.

Sorting values were estimated using the comparison chart of Pettijohn, Potter and Siever (1972). Based on the verbal classification table of Folk (1959) the specimens studied range from very well-sorted to moderately well-sorted with the majority of sandstones being well-sorted (see Table 1). The marine sandstones of the Martin Creek Formation and marine member of the Kamik Formation are the best-sorted sandstones while the non-marine and transitional members exhibit, in general, somewhat poorer sorting. According to the criteria of Folk (1975), most of the Parsons Group rocks studied in this thesis are classified as texturally supermature.

Granulometric studies show significant size differences among the stratigraphic units. Figure 17 shows the range of apparent mean grain sizes in thin section for each of the four sandstone-bearing stratigraphic units in the Parsons Group. Although sample selection is far from random, and sample quantity is limited, Figure 17 probably illustrates a real intra-Parsons Group variability in grain size. Martin Creek sandstones have a small range in size (0.09 - 0.12 mm.) in the specimens studied. Since the Martin Creek Formation is a coarsening-up sequence the lower limit of grain size is a function of sample location. What is noteworthy is the fine-grained nature of the coarsest sandstone present in the upper

Figure 17. Distribution of apparent mean grain size amongst sandstone-bearing units of the Parsons Group. Size classes differ for representation purposes

part of the sequence.

The non-marine member of the Kamik Formation contains the coarsest sands of the Parsons Group. The transitional member is finer-grained and the marine member finer-grained still (see Figure 17). Such apparent differences in grain size may be attributed to different environments of deposition.

5. LITHOFACIES, DEPOSITIONAL PATTERNS, AND ENVIRONMENTS OF DEPOSITION

5.1 Parsons Group

The term "Parsons Sandstone" was first used by Côté et al. (1975) for a subsurface sandstone-dominated sequence consisting of the Martin Creek, McGuire, and Kamik Formations. Dixon (1982b, p. 14) proposed that the above formations be placed in the Parsons Group. The type locality for the Parsons Group is in well Gulf Mobil Parson F-09, 68°58', 34" N., 133°31' 33" W. In the present study the top of the Parsons Group in the F-09 well is set at 2,694 m. (8,838 feet), slightly higher than 2,698.1 m (8,852 ft.) the depth suggested by both Côté et al. (1975, p. 623) and Dixon (1982b, p. 14). The base of the Parsons Group is set at 3,055m (10,024 ft.), close to the Parsons Group base depth of Côté et al. (1975) 10,055 ft.) but significantly different from the 3,081.5 m (10,110 ft.) depth proposed by Dixon (1982b). Reasons for these amendments are discussed in detail in later sections of the text.

Figure 18. Isopach map of Parsons Group strata

The Parsons Group is present over the majority of the Mackenzie Delta region. Figure 18 is an interpretive isopach map of the Parsons Group. As with all the isopach maps included in this study, it reconstructs the original depositional thicknesses by estimating original values where partial penetration or removal of section by faulting or erosion has occurred.

A thickness of 1162 m (3812 ft.) of Parsons Group rocks in the Kipnik 0-20 well is the maximum penetrated to date. Significant Middle or Late Hauterivian erosion as well as depositional thinning has occurred just to the north on the Tununuk High (Figure 6). Deposition to the southeast was controlled by the emergent Eskimo Lakes Arch, near the crest of which basinward isopach changes are gradual and uniform, succeeded further basinward by rapid thickening, suggesting fault-related subsidence. The isopach patterns, although based upon limited information, suggest that the Tuktoyaktuk Fault-Flexure zone (Figure 1) was not the only structural feature affecting Parsons Group deposition. It is more likely that differential subsidence was influenced by a series of down-to-the-basin subsidiary faults. A narrow eastward trending embayment is suggested by isopachs in the Parsons Lake area. This feature is recognized in isopachs of both the transitional and marine members of the Kamik Formation (Figures 28 and 31). The anomaly may be related to faulting associated with the Tuktoyaktuk Fault-Flexure Zone, but its near orthogonal trend to the dominant NNE-SSW structure suggests the influence of a transverse fault system. Depositional encroachment onto the

arch was a result of changing water depths and thus depositional environments. The pinchout edge presented for the Parsons Group (Figure 18), approximately coincides with the depositional edge interpreted for the marine member of the Kamik Formation (Figure 31). To the west, limited subsurface information is supplemented by outcrop data from Jeletzky (1975). Parsons strata appear to thin towards the present-day Richardson Mountains, suggesting an influence from an approximately north-south trending "high". This "high" bears spatial and temporal resemblance to the Columbian (Young et al., 1976, p.4), Cache Creek Uplift proposed by Jeletzky (1975). Just to the west of Aklavik, thickening of the Parsons Group suggests an "embayment", which may well be an eastern extension of the Canoe Depression recognized by Jeletzky (1975) (see Figure 1).

The lack of subsurface information in the northern part of the Mackenzie Delta region prevents reliable definition of Kugmallit Trough, to the northeast. It is likely that it parallels the Eskimo Lakes Arch and ultimately joins up with the contemporaneous Beaufort-Mackenzie Basin to the north (Hea et al., 1980, Figure 17).

5.2 Husky Formation - Upper Member

Due to the gradational nature and probable depositional continuity of the contact between the upper member of the Husky Formation and the overlying Martin Creek Formation, the upper member is included in this study. The upper part of this unit

Figure 19. Legend for graphic display of core.

Applies to Figures 20, 24, 26, 27, 29, 30 and 41 to 59 inclusive

PARSONS F-09

McGuire
Formation

PARSONS N-10

9325
2843

TULLUGAK K-31

Martin
Creek
Formation

Figure 20. Graphic display of core from the upper member, Husky Formation, Martin Creek Formation and McGuire Formation. All depths corrected to log depths. For detailed core display see Figures 41to45 inc. (in pocket).

was cored in two wells - Parsons N-10 and Tuktu 0-19 (Figures 20 and 41-for legend see Figure 19). Lithology is typically siltstone-dominated with abundant interbedded dark-grey to brownish black shale and very fine-grained sandstone. The rock is characteristically heavily bioturbated with Terebellina cf. burrows recognizable in the Parsons N-10 well and both Teichichnus cf. and Asterosoma cf. burrows recognizable in the Tuktu 0-19 core. The rock cored in both wells exhibits a general coarsening-up trend easily recognizable from the well logs. The core cuts across the proposed contact between the upper member of the Husky Formation and the overlying Martin Creek Formation in both wells. Well-log response allows easy recognition of this contact, but actual lithologies change little.

In the Tuktu 0-19 well , slight upward coarsening of the strata occurs just above the base of the Martin Creek Formation, while in the Parsons N -10 well, bioturbation decreases in intensity and the strata are less argillaceous at the base of the Martin Creek Formation. As shown in Figure 20, the contact is interpreted as occurring within strata deposited in a middle shoreface environment. It is suggested that this contact between the Husky upper member and Martin Creek Formation, obtained from well logs and used throughout the subsurface, represents an approximate middle shoreface environment of deposition. According to Dixon (1982b), the lower part of the upper member is shale-dominated, with minor siltstone, sandstone and carbonate concretionary beds. The basal contact of the

upper member is defined by an abrupt contact with the sandstone of the lower member (see Figures 5 and 6).

5.2.1 Environmental Interpretation

Lithology and ichnology (environmental interpretations from trace fossils after Chamberlain, 1978) suggest offshore deposition changing upwards into a middle shoreface depositional environment for the Husky upper member. The sparsity of core in the lower part of the upper member prevents any definite interpretation of maximum water depth, but a shelf setting is likely.

5.3 Martin Creek Formation

The lower contact of the Martin Creek with the Husky Formation corresponds with the most recognizable gamma-ray signature available in this stratigraphic sequence and probably reflects a fundamental, environmentally controlled lithologic change which can be traced throughout the subsurface. Myhr and Young (1975) used this gamma-ray pick in their mapping of the Martin Creek Formation. The upper contact of the Martin Creek with the McGuire Formation is variable in the subsurface. Within the Kugmallit Trough, the contact is apparently gradational with the overlying McGuire Formation, and the contact is chosen at the point where shale content increases, sandstone beds thin and the sonic log response changes. Towards the Eskimo Lakes Arch, the upper contact is abrupt and most likely erosional (see Figure 20), an aspect probably typical of the contact near the Eskimo Lakes Arch.

Martin Creek strata have been cored in wells Tuktu 0-19, Tullugak K-31 and Parsons N-10 (Figures 20,42,43 and 44). The 2 metres cored at the base of the Martin Creek Formation in the Tuktu 0-19 well express a slight coarsening-up textural trend. The 31 metres cored through the full thickness of the formation in the Parsons N-10 (Figures 43 and 44) well is dominantly light grey to white, very fine to fine-grained quartzose sandstone, becoming progressively less argillaceous upwards in the section. Common sedimentary structures are horizontal bedding and low angle cross-bedding. Numerous reactivation and/or erosional surfaces occur throughout the section. The beds are locally burrowed, commonly pyritiferous and contain abundant zones of concave-down pelecypod shells.

In Tullugak K-31 (Figure 42), the 16 metres of Martin Creek Formation cored represent the only cores of this unit from the Kugmallit Trough. The lower section of the core is typically a light grey to white fine-grained, slightly argillaceous quartzose sandstone containing both low and high angle cross-beds and minor ripple cross-lamination. The beds are intermittently bioturbated and Asterosoma cf. burrows were recognized. Generally concave down pelecypod shell zones are common throughout the section. A slightly shalier section overlies this sandstone. This section is moderately to heavily burrowed, containing the burrows of Terebellina cf. and Chondrites sp.. Log response to upper? Martin Creek strata in the Tullugak K-31 well shows interbedded shale and sandstone

beds similar to those in the other Kugmallit Trough wells (Kipnik 0-20, Kugpik 0-13, Unak B-11), suggesting a gradational upper contact with the overlying deeper water McGuire Formation throughout the Kugmallit Trough (Figure 6).

5.3.1 Depositional Patterns

Figure 21 is an isopach map of the combined Husky upper member and the Martin Creek Formation. Thickness change is fairly uniform away from the Eskimo Lakes Arch and into the Kugmallit Trough. The Tununuk High apparently formed the northern flank of the Kugmallit Trough at this time. The thickest section of 404+ metres for this stratigraphic interval occurs at the Tullugak K-31 well, with log relationships indicating a faulted top. Isopachs indicate an opening of the trough towards the west. The Martin Creek Formation isopachs presented in Figure 22 shows the same overall trends as those in Figure 21, except for the following:

1. Contours no longer open to the west but either close in the Kugmallit Trough around the thickest section of 161 meters in the Kipnik 0-20 well, or open to the northeast.
2. Subsurface and outcrop data suggest the existence of the Napoiak High just east of Aklavik as well as the presence of an embayment just west of Aklavik called the Canoe Depression (Jeletzky, 1975). Some influence by the Cache Creek Uplift is also recognizable.
3. Thickness values in and north of the Parsons Lake area may indicate anomalous thinning approximately parallel to the Eskimo

Figure 21. Isopach map of upper member, Husky Formation and Martin Creek Formation (legend on Figure 18)

Figure 22. Isopach map of Martin Creek Formation
(legend on Figure 18)

Lakes Arch, suggesting possible contemporaneous fault movement along the west flank of the Arch .

5.3.2 Environmental Interpretation

The Martin Creek Formation is the sandstone-dominated upper part of the coarsening-upwards depositional cycle which begins with the underlying Husky Formation upper member. Core and log analysis suggests a shoreface to beach depositional environment in a basinward prograding system. Côté et al. (1975,p.623) suggested a beach-shoreface origin for the Martin Creek strata while Myhr and Young (1975,p.255), suggested a barrier-shoreline system with offshore shoals. Dixon (1982b,p.16) deduced a prograding barrier-island origin for the Martin Creek strata. The following points favour a prograding barrier island depositional system:

1. The vertical succession of strata and sedimentary structures combined with trace fossil evidence and petrography is indicative of a prograding nearshore depositional system.
2. Log response and stratigraphic succession in such wells as Reindeer G-04, Napartok M-01, and Ikhil I-37 suggests the possible presence of back-bar lagoonal deposits at these localities which escaped the minor pre-McGuire erosional episode that affected Martin Creek strata closer to the arch (see Figure 5).
3. Numerous reactivation and/or erosional surfaces are found

throughout the N-10 and K-31 cores. Hunter et al. (1979) stated that subhorizontal erosion surfaces probably occur in deposits formed from the slow progradation of most kinds of barred nearshore systems but should not occur in deposits formed from non-barred prograding shoreline systems.

The gradational contact between the Martin Creek and McGuire Formations apparent in the Kugmallit Trough suggests that the shallower-water facies of the Martin Creek did not extend fully into the depocentre but was halted by transgressing conditions associated with McGuire Formation deposition. Supporting this hypothesis is the northwesterly shale-out trend of Martin Creek strata in the Richardson Mountains suggested by Jeletzky (1975) and Myhr and Young (1975).

The mineralogical and textural maturity of the Martin Creek sands (chapter 4) suggests high wave and/or tidal energy. Dixon (1982b) concluded that the lack of tidal channel - tidal inlet deposits encountered in the subsurface favours microtidal conditions. A high wave energy environment hypothesis is supported by the dominance of physical sedimentary structures as opposed to biogenic sedimentary structures (Elliot in Reading, 1983, p. 152; Heward, 1981, p. 238) and the presence of concave - down pelecypod shell zones throughout the Tullugak K-31 and Parsons N-10 cores. Salazar-Jiménez et al. (1982) suggested that concave-down valves in thin zones indicate stabilization under moderate to high-energy conditions, a conclusion reached by numerous authors in previous studies on bivalve orientaton.

Heward (1981) as well stated that most barrier islands occur on microtidal and mesotidal coasts.

Regressive shorelines, such as interpreted for Martin Creek deposition, are controlled to a large degree by persistently dropping sea level and/or increased sediment supply conducive to shoaling.

5.4 McGuire Formation

As described in the preceding section, the contact between the McGuire Formation and the underlying Martin Creek Formation can be abrupt suggesting erosion near to the Eskimo Lakes Arch or gradational, as within the Kugmallit Trough. Jeletzky (1980) suggested that McGuire strata may rest on rocks as old as those of the Husky Formation. This relationship is demonstrated by subsurface interpretation in this thesis for the Reindeer P-60 well, where McGuire Formation strata are shown as resting upon the upper member of the Husky Formation. Detailed stratigraphic analysis shows that this relationship is probably a result of Martin Creek non-deposition (see Figure 5).

The upper contact of the McGuire Formation with the overlying Kamik Formation is usually abrupt and erosional, probably a result of channelling at the base of the Kamik. However, transitional contacts are recognizable in numerous wells (Parsons N-10, N-17, L-37, Kamik D-58, F-38, Imnak J-29 and possibly Kugpik O-13 and Parson P-41) with the thickest

transition being 9m in the Parsons L-37 well.

McGuire Formation strata were cored in two holes - Parsons F-09 and Parsons N-10 (see Figures 20,44 and 45). In the Parsons N-10 well thin pyritic, coarse-grained erosional lag deposits directly overlie the Martin Creek Formation. McGuire Formation lithology is typically black shale with lenticular interbeds of light grey to blue-grey siltstone, commonly pyritic and moderately to heavily bioturbated. The shale is commonly waxy and fissile and is locally kerogenous. The Parsons F-09 section is typically pyritiferous, bioturbated, thin to lenticularly bedded greyish-brown mudstones, light-coloured siltstones and quartz wackes. The lower part of the core contains thin beds of medium to coarse-grained cross-bedded sandstones. Present here, as well, are zones of chert pebbles and glauconite.

Lithologies interpreted from well logs are shale-dominated, with thin interbeds of mainly coarsening-up sandstone bodies. Coal and carbonaceous shales have been reported from McGuire cuttings in the Kugpik 0-13 well (Canstrat Service Ltd; log number D-NWT-537) but stratigraphic interpretations indicate this carbonaceous material is from the lagoonal and back-bar facies of the underlying Martin Creek Formation.

5.4.1 Depositional Patterns

The thickest subsurface McGuire Formation section of 81 metres occurs in the Kipnik 0-20 well, near the depocentre interpreted from isopachs (Figure 23). The depositional edge

Figure 23. Isopach map of McGuire Formation
(legend on Figure 18)

onto the Eskimo Lakes Arch, reflects influences from the Canoe Depression and Cache-Creek High. Contours parallel the Eskimo Lakes Arch attesting to the major control exerted by that feature on depositional patterns. The Tununuk High is recognized by the thinner strata present in the Kugpik D-13 well.

5.4.2 Environmental Interpretation

Jeletzky (1975) interpreted the depositional environment of McGuire Formation lithostratigraphic equivalents in the Richardson Mountains as predominantly outer neritic to upper bathyal. Myhr and Young (1975, p. 249) interpreted the F-09 core as lagoonal and tidal flat deposits. Palynomorphs recovered from the same core indicated to Myhr and Gunther (1974) a lower coastal plain setting and to Brideaux (in Brideaux et al., 1975, p. 4) derivation from an upper coastal plain depositional environment. Dixon (1982b, p. 18) postulated a low-energy, nearshore, depositional environment for the McGuire in general.

Deposits of the McGuire Formation extend from mid-way up the Tuktoyaktuk Peninsula westward well into the Richardson Mountains. Throughout the subsurface the formation is interpreted by well logs to be a thin mudstone dominated unit. The stratigraphic and sedimentological consistency exhibited by the McGuire would only be expected in an extensive low-energy system. The intense bioturbation, mudstone dominated lithology, and the presence of glauconite all suggest a quiet marine

environment. A lagoon and/or shallow bay environment, such as that suggested by Côté et al. (1975, p. 627) may have been dominant close to the depositional edge of the Formation on the Eskimo Lakes Arch. The coarsening-up sandstone bodies, more common in the Kugmallit Trough may, represent short-lived, partially preserved barrier bars.

The McGuire Formation strata thus represent an extensive short-lived transgressive pulse. According to Reineck and Singh (1973, p. 308) the rate of shelf mud sedimentation ranges from 6 to 135 cm./100 years. Assuming deposition in an neritic setting and also assuming the slowest rate of deposition for the thickest section of 81m in the Kipnik 0-20 well in the Kugmallit Trough, a maximum depositional life span of about 135,000 years is assigned to the Formation.

5.5 Kamik Formation

The Kamik Formation (formally introduced by Dixon, 1982b, p. 18), the thickest unit in the Parsons Group, contains almost all the sandstone as well as nearly all the hydrocarbon reserves (1.8Tcf, $5.1 \times 10^{10} \text{ m}^3$ of gas-Langhus, 1980) at Parsons Lake. The type section of the Kamik Formation is present in the Kamik F-38 well (Dixon, 1982b, p.51) ($68^{\circ}57'25'' \text{ N}$; $133^{\circ}23'54'' \text{ W}$, from 3007m. to 3235m, 9864-10,613 feet). Vertically uniform, laterally persistent, lithologic units within the Kamik Formation have been recognized by Côté et al. (1975), Myhr and Young (1975) and Dixon (1982b) but mapping of possible

subsurface members has not before been attempted. In this thesis the Kamik is informally divided into three members based upon log response (gross lithology, overall sand percentage, nature of sand bodies), core studies (petrography, sedimentary structures, environmental interpretation), log correlations, and biostratigraphic information. These members, in ascending order, are the non-marine member, the transitional member and the marine member.

5.6 Non-Marine Member

The contact between the basal non-marine member of the sandstone-rich Kamik Formation and the underlying McGuire Formation is easily discernible on the basis of log response. As discussed in the previous section, the lower contact is locally erosional. The upper contact between the non-marine and overlying transitional member is everywhere gradational, but is arbitrarily placed at the top of the uppermost sand body in a sequence consisting of generally greater than 80% blocky, clean (as shown from gamma-log response), closely-spaced sands. Above the contact, strata are more shaly and carbonaceous (from sonic-log response and petrographic studies), and the sands are thinner, more widely spaced, and generally fine upwards. The non-marine member in the Kamik F-38 well is all clean sand, compared to an approximately 22 percent clean sand content in the overlying transitional member.

The non-marine member has been cored in the Parsons N-10, Parsons L-43, Wagnark C-23 and Ikhil I-37 wells (Figure 24).

Figure 24. Graphic display of core from the Formation. All depths corrected. For detailed core display see Fig

Figure 24. Graphical display of core from the non-marine member, Kamik Formation. All depths corrected to log depths.
For detailed core display see Figures 46 to 48 inc. (in pocket).

Two intervals totalling 23 metres were cored in the Parsons N-10' well (Figure 46). The interval from 2795 to 2804 metres consists of burrowed and bioturbated black shale and interbedded light-grey siltstone with thin coal seams and minor rippled and horizontally bedded fine-grained sandstone . It is overlain by a thin (1 to 2 metres) erosive fine to coarse-grained high-angle cross-bedded sandstone containing numerous shale rip-up clasts. The 14 metres cored from 2749 to 2763 metres contain medium to very coarse grained slightly fining-upwards sandstone , with at least five sand bodies containing abundant basal and interspersed pebbles and shale rip-up clasts. The dominant sedimentary structure is high angle cross-bedding. The sands are locally carbonaceous and commonly contain thin irregular (sometimes stylolitic) shale and carbonaceous shale stringers. Silty shale near the base of the core is extensively burrowed.

A 13 metre core in the Parsons L-43 well (Figure 47) crosses the boundary between the non-marine and transitional members. As defined here the lower part, (non-marine member) consists of thin , medium to very coarse-grained quartzose, slightly carbonaceous sandstones, characterized by high angle cross-bedding. Numerous pebble and/or shale rip-up clasts are present at the base of most beds. Two beds show very thin repetitive fining-up sequences and thin coal stringers and lenses. The upper part (transitional) is bioturbated, carbonaceous shale and siltstone exhibiting minor lenticular and convoluted-bedding.

Short cores from Ikhil I-37 (see Plate 1) and Wagnark C-23 (Figure 48) are carbonaceous medium to coarse-grained quartzose sandstones. The Ikhil I-37 core contains high angle cross-bedding and shale rip-up clasts, whereas the Wagnark C-23 core contains abundant scattered pebbles and woody fragments.

5.6.1 Depositional Patterns

Figure 25 shows subsurface isopachs of the non-marine member, Kamik Formation. The thickest known section (422 metres) is in the Kipnik 0-20 well. The 76 metre section measured by Jeletzky (1975) in the Richardson Mountains and assigned by him to the Martin Creek Formation lithostratigraphic equivalent has a typical lower Kamik lithology and is herein correlated in part with the non-marine member. The Eskimo Lakes Arch continued as a positive feature and the Cache Creek Uplift and Tununuk High were active, with significant thinning or absence of the non-marine member over these positive features. Although thickness information is lacking in the northeastern Richardson Mountains, from isopach trends it appears that the Cache Creek Uplift was an emergent feature throughout deposition of the non-marine member and the Kugmallit Trough was isolated from the Blow Trough to the west. Stratigraphic data from the Richardson Mountains collected by Jeletzky (1975) supports the presence of an areally limited Canoe Depression. The Napoiak High is not recognized. The depositional edge proposed in Figure 25 is based on the good well control on the western flank of the Eskimo Lakes Arch. The absence of the non-marine member on the Arch is mainly due to non-deposition and not erosion since

Figure 25 Isopach map of non-marine member, Kamik Formation (contour interval 25 metres in detailed area. Legend on Figure 18.)

deeper-water Kamik Formation strata (pre-Middle Hautrivian) are extensively on the west flank of the arch and on the Cache Creek Uplift. If any erosion of the non-marine member took place it was probably local and short-lived. Isopach values and depositional patterns of the Kamik Formation non-marine member provide insight as to the major contemporaneous tectonic features of the area at the time of deposition. The alluvial deposition postulated would have been influenced by topography far more than the deeper water sedimentation which preceded and followed this depositional interval. Besides revealing the larger structural features previously discussed, the isopachs also show significant local stratigraphic thinning in the Parsons Lake Area, and exceptional thickening in the Kugmallit Trough. Stratigraphic thinning in the Parsons Lake Area is interpreted as a response to contemporaneous fault movement associated with increased subsidence in the Kugmallit Trough. The circular thinning revealed in the Parsons Lake Area coincides remarkably well with the structural extent of the anticline associated with the North Parsons Lake gas pool.

5.6.2 Environmental Interpretation

A non-marine alluvial origin has been interpreted for this member by all previous authors. Myhr and Young (1975, Figure 42.8) proposed a delta plain origin for equivalent strata (basal third of Kamik Formation) Côté et al. (1975, p.627) suggested a non-marine cyclic fluvial environment.

Dixon (1982b) discriminated between fluvial channel,

crevasse splay or levee and flood plain deposits in his work on the lower Kamik.

Young (in Shawa, 1974) interpreted the N-10 core as distributary channel deposits of a delta plain environment.

Interpretation of core data, well-log responses and biostratigraphic work allow an evaluation of the depositional environment in the lower third of the Kamik Formation.

The lack of marine fossils and common carbonaceous content of the strata suggest a non-marine origin. Palynomorphs and foraminiferal studies by Gulf Canada Resources (unpublished data) in Calgary indicate a non-marine setting for lower Kamik strata (non-marine member) in the Parsons N-10 and Ikhil I-37 wells and a non-marine to coastal transition interpretation for equivalent rocks in the Parsons F-09, Reindeer G-04 and Beaverhouse Creek H-13 wells.

The alluvial deposits of the non-marine member are typically sandstone-rich. Minor fining - up trends can be detected in the core and from the well-logs. Erosional contacts, pebbles, shale rip-up clasts and high angle cross-bedding are typical. The wide extent and stratigraphic consistency of the sheet-like unit and the lack of flood-basin and channel - fill deposits suggests deposition was in a braidplain environment. The lack of debris flows, the

compositional and textural maturity of the sediments and lateral continuity of the strata discount an alluvial fan origin. Numerous general models of braidplain deposition have been developed (Miall, 1978), an important controlling parameter being the distance from source. At the base of the non-marine member in some wells (eg. Napartok M-01, Reindeer A-01, see Figure 5) the interval lacks mudstone and sands appear particularly blocky on logs. Such a vertical sequence is analogous to the source-proximal Bijou-Creek braidplain model (Rust in Miall, 1978). More typical of the non-marine member is a cyclical deposition of sandstones interbedded with thin mudstones (eg. Ikhil I-37, Reindeer G-04, Parsons N-10, see Figure 5). A possible analogue of such a depositional system is the source-distal South Saskatchewan River from which the South Saskatchewan braidplain model is derived (Miall, 1978).

Well-log data and core studies indicate that the South Saskatchewan River lithological succession (Cant in Miall, 1978) is analogous to the majority of the non-marine Kamik strata. Sedimentary structures similar to those of the South Saskatchewan model are present, but information is inconclusive due to limited core data. The lithologic and stratigraphic characteristics of the South Saskatchewan-type braidplain vary from lithologically homogenous proximal sediments to distal fining-up cycles with significant primary mud content (Rust, in Miall, 1978, and in Walker, 1979). These distal deposits may be transitional to those of a meandering fluvial system. The mudstones associated with braidplain deposition are limited to

deposition on levels or terraces above the active tract (Williams and Rust, 1969), which are usually vegetated.

It is likely that close to the eastern depositional limit shown in Figure 25, braidplain lithofacies and vertical profiles as in Reindeer A-01 and Napartok M-01, are of the Bijou Creek, Donjek, or even Scott type of braided stream deposit (cf. Miall, 1978). Basinward, meandering streams, or distal "muddy" South Saskatchewan type braided stream deposition would occur. Two Kugmallit Trough wells Kipnik 0-20 and Ikhil I-37 in fact, do contain noticeably fining-up sandstone bodies separated by significant thicknesses of mudstone (see Figures 5 and 6) - lithologies typical of the distal South Saskatchewan braidplain model.

An anomalous 120 metre thick sandstone body in the Kipnik 0-20 well at the base of the Kamik Formation is thought to represent delta front deposition whereas an equally anomalous 125 metre shale-dominated interval within the postulated braidplain sandstones near the base of the Kamik Formation in the Ikhil I-37 well has near-shore marine log characteristics. These two stratigraphic occurrences suggest that braidplain streams may have, at least locally, emptied directly into coastal waters.

5.7 Transitional Member

As discussed in the previous section, the contact between the transitional and non-marine members of the Kamik Formation

is placed at the top of the sandstones interpreted as braided channel deposits. The upper limit of the transitional member is placed at the top of a sand body (usually with barrier bar characteristics) approximately two-thirds up the Kamik section, above which the strata are noticeably more shaly, less carbonaceous and commonly contain one or more coarsening-up barrier bar sand sequences (see Figures 5 and 6). Transitional strata consist of numerous thin sands interbedded with locally carbonaceous mudstone, and thicker sands exhibiting either coarsening or fining-up trends. The upper contact of the transitional member coincides with the top of the informal B-zone (Gulf Canada files) and can be easily mapped throughout the subsurface in the Parsons Lake area. In the Kamik F-38 type section well - 22 percent of the transitional member is clean sand, while in the overlying marine member 6 percent is clean sand.

The transitional member has been cored in 8 wells - Siku E-21, Parsons L-43, Parsons F-09, Siku A-12, Ogruknang M-31, Wagnark C-23, IOE Tuk F-18 and Reindeer A-01. Two intervals totalling approximately 28 metres have been cored in Siku E-21 (see Figures 26, 27, 49 and 50 and Plate 2). The lower interval consists of fining-up sequences of fine to coarse-grained sandstones with abrupt, possibly erosional bases. Thin carbonaceous sandstone bodies in the centre of the core, interpreted as crevasse-splay deposits, show high angle cross-bedding, climbing-ripples, shale laminae, wavy and convoluted-bedding and

Figure 26. Graphic display of core from lower and middle transitional member, Kamik Formation. All depths corrected to log depths. For detailed core display see Figures 50, 51, 53, 54.

Figure 27. Graphic display of core from the upper transitional and lower Kamik formation. All core depths corrected to base of core. Figures 49, 50, 52 and 53 are also shown.

minor burrowing. Directly overlying the sandstones are silty carbonaceous shales. The sand bodies at the base and top of the core are examples of upper and lower channel bars respectively. The upper channel bar terminates in shale grading upwards from a fine-grained quartzose sandstone, containing numerous shale laminae, climbing-ripples, wavy-bedding and burrows. The lower channel bar is a pebbly, coarse-grained carbonaceous quartzose sandstone with subhorizontal bedding and low angle cross-bedding. The upper core is of a decidedly more marine nature. The sandstones typically contain numerous shale laminae and low angle cross-bedding (see Plate 4d), ripple marks, and wavy bedding. Chondrites cf. burrows are recognized (see Plate 5a), lower in the core, Helminthoida cf. may be present as well (Plate 5b). The overlying strata are relatively clean, fine-grained, quartzose sand with minor horizontal bedding and low angle cross-bedding. Chondrites cf. burrows are much more abundant and Skolithos cf. burrows may be present. A 3 metre fining-up erosional channel sand present near the bottom of the core contains numerous chert pebbles at the base and both high and low-angle cross-bedding dips at the top of the unit. The position of this channel sand amidst relative quiet water deposits suggests a possible delta-related submarine origin.

The lower core in Parsons L-43 (Figure 50) cuts the transitional - non-marine contact (Figure 26). The base of the transitional member consists of interbedded, burrowed, carbonaceous siltstone and shale containing lenticular and slumped bedding, minor coal and ripple marks, probably deposited

in a channel fill or flood basin environment. Overlying this shaly section, in an erosional manner, is the carbonaceous, medium to coarse-grained basal section of a quartzose channel sand containing numerous interspersed pebbles and low angle bedding dips as the only recognizable sedimentary structure. The 9 metres of core near the top of the transitional member is within a series of fine to coarse-grained cyclical fining-up quartzose sandstones. The strata contain numerous coal lenses and seams, shale rip-up clasts (mainly at the base of one major erosive channel), and both high and low angle cross-bedding.

Approximately 18 metres of core in the Parsons F-09 well (Figure 51) is cut from the transitional member (Figure 26). The beds are mainly very fine to fine-grained quartzose sandstone and generally featureless except for shale, laminae and contain zones of ripple marks, flaser bedding, shale rip-up clasts and one zone of high-angle bedding. Interbedded silty or sandy shale zones are present, usually irregularly or lenticularly bedded. Bioturbation is of a moderate to locally intense nature. The strata are interpreted as a coastal sand sequence consisting of a coaly shale zone at the base of the core thought to represent marsh deposition is overlain by dominantly intertidal and lagoonal deposits. Myhr and Young (1975, Figure 42.8) interpreted this core as delta plain to delta front/prodelta deposits. The uppermost sand is interpreted as a transgressive sand by Dixon (1982b) and this view is supported in this thesis.

Approximately 20 metres were cored from near the top of the transitional member in the Siku A-12 (Figures 27 and 52 and Plate 3). The lower part of the core consists of a coarsening-up interbedded sequence of shale, siltstones and very fine-grained sandstones. Starved ripples, lenticular and irregular bedding and moderate to intense burrowing is common throughout the rock. Diplocraterion cf. and Teichichnus cf. burrows were recognized. Based on the lithologic sequence and sedimentary structures present, an intertidal mixed flat (both sand and mud, Reineck and Singh, 1973) or lagoon depositional setting is favoured. Overlying these beds is a 2 metre thick, dominantly medium-grained pebbly, carbonaceous and coal-bearing quartzose sand body (see Plates 4a and 4b). A moderately bioturbated, fine-grained sandstone body containing minor shale beds and common low angle bedding dips (Plate 4c) and cross-bedding overlies the channel sand in a somewhat erosional manner. Asterosoma cf. burrows may be present. Rocks in this core suggests a persistent intertidal coastal margin within which rapidly migrating tidal channels existed.

The approximately 10 metres of rock cored from the middle of the transitional member in Reindeer A-01 (Figures 26 and 54) is tentatively interpreted as having been deposited in an intertidal mixed flat. The strata are mainly, very fine-grained, locally rippled and cross-bedded, quartzose sandstones interbedded with numerous thin shale beds which contain siltstone and fine-grained zones. Bioturbation and burrowing is moderate throughout most of the core with possible Chondrites

cf. burrows recognized. Pyrite, glauconite and concretions are present.

Approximately 9 metres of core from the Ogruknang M-31 well (Figures 26 and 53) is located within the fining-upwards, mud-rich stream channel facies of the transitional member. The coarse channel clastics are fine to medium-grained, locally argillaceous, and exhibit ripple marks, low and high angle cross-bedding and common convoluted-bedding. These coarse clastics grade abruptly into a coal-bearing moderately bioturbated, shale dominated lithology interbedded with thin coarser clastic beds near the top of the core. Starved ripples are recognized in the coarser beds.

The 10 metres of rock cored from near the top of the transitional member in the Wagnark C-23 well (Figures 27 and 53) is dominantly a quartz wacke interbedded with thin siltstone and some coarser clastic zones. Three thin coal seams were noted, as well as common wavy and lenticular-bedding and (climbing)? ripple-lamination. Burrowing and bioturbation occurs sporadically throughout the core, with Rhizocorallium cf. burrows probably present.

The little more than 3 metres of silty and sandy slightly bioturbated woody shale cored from the IOE Tuk F-18 well shows lithological similarities to flood basin deposits (Figures 26 and 54), but this interpretation is tentative.

5.7.1 Depositional Patterns

Figure 28 is an isopach map of the transitional member in the Mackenzie Delta region. Depositional patterns are similar to those exhibited by other Parsons Group units. Both the Canoe Depression and the Cache Creek High were active during deposition. The thickest section of 270 metres was encountered in the Ikhil I-37 well. The depocentre appears to be located between the Kipnik 0-20 and Ikhil I-37 wells. Thickness values show that depositional connection between the Kugmallit and Blow Troughs was restored. Contours may open to the northeast.

A depositional arm extending towards the arch is recognized in the Parsons Lake area encompassing the Kamik D-48, D-58 and F-38 wells. As discussed earlier, the thickening present here may have been associated with contemporaneous fault movement, probably related to a transverse fault system oriented near-orthogonal to the dominant north-northwest structural trend.

Sandstone isolith thicks (Figure 33) mimic isopach thicks in the Parsons Lake area. Although control in the area is good it can only be postulated that associated with this zone of subsidence was a higher frequency of channelling probably associated with drainage off the Eskimo Lakes Arch.

5.7.2 Environmental Interpretation

The transitional member, a consistent vertical depositional succession, represents environments of deposition ranging from meandering river channel and flood basin (distributary in part)

to offshore. Both Côté et al. (1975) and Myhr and Young (1975) recognized the presence of non-marine rocks well into the middle Kamik Formation. These authors interpreted what is here called the transitional member as an interbedding of marine and non-marine rocks with little sedimentological consistency. Dixon (1982b, p.18) recognized a progressive depositional change throughout the Kamik, which expresses itself best in the transitional member.

Environmental interpretation of cores form the basis of the overall depositional model. Table 2 shows the location of the cores within the transitional member and the environmental interpretation. The lower transitional member cores are non-marine fluvial deposits whereas strata cored from the middle and upper transitional member are more marine .

Log responses suggest that this environmental succession is present throughout the subsurface (eg. Parsons F-09, Reindeer G-04, Reindeer A-01 , Imnak J-29, see Figure 5).

The sedimentological succession is thus interpreted as a response to transgressive conditions varying from non-marine meandering channel deposition to offshore marine. Fluvial deposition progressed from braidplain in the underlying non-marine member to a more meandering style due to either lessening regional gradient or sediment supply. Overlying these non-marine rocks are marginal and coastal sediments, characteristi-

Core Location	Environments of Deposition		
	lower transitional member	middle transitional member	upper transitional member

Siku E-21	channel bars crevasse splays natural levee		lower shoreface- upper offshore
Parsons L-43	channel fill- flood basin channel bar		coastal plain distributary channels
Parsons F-09		coastal sand sequence intertidal, marsh and lagoonal	
Siku A-12			intertidal sands and muds tidal channel
Reindeer A-01		intertidal mixed-flat	
Wagnark C-23			lagoonal
Ogruknang M-31	river channel facies		
IOE Tuk F-18		floodbasin?	

Table 2. Environments of deposition for the transitional member, Kamik Formation.

cally carbonaceous and more thinly interbedded. The spectrum of possible environments in the transitional member is the greatest of any Parsons Group unit.

With the continuing transgressive conditions, all coastal systems were drowned. Throughout the subsurface, the final deposits of this transgression are usually in the form of barrier bars. Ultimately this barrier bar system was drowned signalling the beginning of continuous marine deposition (see Figures 5 and 6).

5.8 Marine Member

The base of the marine member is placed at the transition to a shale-dominated sequence. The top of the marine member coincides with the top of the Parsons Group and is placed above the last sand underlying the shales of the Siku Formation.

The marine member has been cored in 7 wells - Reindeer G-04, Parsons P-41, Siku A-12, Parsons L-43, IOE Tuk F-18, IOE Pikiolik E-54, and Siku E-21. Approximately 18 metres were cored in the Reindeer G-04 well (Figures 29 and 55). The base of the core consists of bioturbated interbedded shale and siltstone containing minor horizontal-bedding and low angle cross-bedding. A thin, very fine-grained sand is present, its base being abrupt but not noticeably erosional and containing coarser clasts and shale rip-up clasts. The remainder of the lower core consists of thinly interbedded burrowed and bioturbated offshore shales and siltstones exhibiting local low angle cross-

bedding and containing woody fragments and siderite(?) concretions. The overlying core is siltstone - dominated, containing numerous shale laminae and thin beds. The siltstone commonly exhibits ripple cross-laminae and horizontal-bedding. Siderite(?) concretions are common. Beds here are extensively burrowed and bioturbated, with Terebellina cf. and Chondrites cf. burrows recognized.

Approximately 18 metres cored in the Parsons P-41 well (Figures 29 and 56), appear to be from a complex series of nearshore environments including lagoon, intertidal and subtidal sand flats, channel and backbeach and beach (based on ichnology and lithology). Plate 4f exhibits the conglomeratic channel base seen in the core. The rock is generally fine-grained. Lagoonal strata are shale-dominated and commonly contain thin coal seams and beds. Local bioturbation is common. Plates 5d,e and f exhibit burrows of Chondrites cf. and Teichichnus sp..

The 18 metres of Siku A-12 core also from a complex series of nearshore environments (Figures 30 and 57), consists of fine to medium-grained, carbonaceous, high and low angle cross-bedded, and rippled, laminated, coal-bearing rocks. The shale-dominated, bioturbated strata, interpreted as lagoonal deposits, are interbedded with coarser sands of tidal flat origin. A Teichichnus cf. burrow was recognized during core inspection at the top of the core (Plate 5c).

The 18 metres of core cut in Parsons L-43 represent, for the most part, a coarsening upwards barrier bar (Figures 30 and

58). The sediments range from very fine-grained horizontally-bedded and low angle cross-bedded sandstones of the upper shoreface environment, through the fine-grained high and low angle cross-bedded foreshore sands into a dominantly medium-grained generally sub-horizontally bedded sandstone of the backshore to foreshore depositional regime. The system appears to have been rapidly drowned, being overlain by shale-dominated offshore deposits.

Nearly 10 metres cored in the IOE Tuk F-18 well (Figures 30 and 59) are interpreted as a coastal sand sequence of uncertain origin. The rocks are dominantly fine-grained burrowed and bioturbated sandstones containing erosional and abrupt pebbly basal lags, ripple cross-laminae, and both low and high angle cross-bedding. Near the top of the core a thin, erosive, transgressive sand is present.

Rock cored in the IOE Pikiolik E-54 well (Figures 30 and 59) appears to be dominantly upper offshore (as shown by the lithological assemblages and presence of Chondrites cf. burrow - Chamberlain, 1978) and foreshore in origin. A thin erosive, pebbly, very coarse-grained sand body separates the upper offshore and foreshore deposits and may represent a tidal ridge deposit.

The 2 metres of burrowed shale and siltstone cored from the Siku E-21 well (Figures 30 and 59) are interpreted, through its

stratigraphic setting to be nearshore in origin. Plate 4e exhibits wavy-bedding present in the rock.

5.8.1 Depositional Patterns

Figure 31 is an interpretive isopach reconstructing original thicknesses in the marine member. It is postulated that the Tununuk High was still a prominent structural feature. Contours reflect this, showing thinning over this high. It is noteworthy that the marine member extends much further onto the Arch than older Kamik strata. The Cache Creek Uplift and the Canoe Depression are less obvious than in underlying Kamik rocks. The thickest section of 330 metres is in Ikhil VI-37, just northeast of the postulated depocentre. Contours appear to open to the northeast, whereas deposition was apparently still somewhat restricted to the west by the Cache Creek Uplift.

Anomalous thins in the isopach patterns near, and north of Parsons Lake, most likely reflect a combination of barrier bar deposition and sedimentological response to structural highs in the area. The prominent depositional thick to the east of Parsons Lake coincides with the embayment recognized in the transitional member isopach, and no doubt reflects continued local subsidence, probably within a local faulted zone. Sandstone isolith thicks (Figure 34) contrast markedly with isopach thicks in this area of local subsidence. Apparently, sand was deposited as a result of shoaling on highs, whereas low-lying areas were not conducive for coarse clastic sediment deposition in this dominantly offshore - nearshore environment.

Figure 31. Isopach map of marine member, Kamik Formation (legend on Figure 18)

5.8.2 Environmental Interpretation

The marine member of the Kamik Formation has been interpreted as marine by previous authors. Côté et al., (1975, p.627) recognized barrier island cycles, whereas Myhr and Young (1975) interpreted these same coarsening-upward sands as prodelta to delta front deposits. Dixon (1982b, p.23) interpreted the coarsening-upward sands of the marine member as barrier island deposits and associated deposits as lagoonal, tidal channel, shoreface and offshore, similar to the interpretation presented in this thesis.

Coarsening-upwards log responses of marine member strata proximal to the Eskimo Lakes Arch, such as in wells Reindeer A-01, Reindeer G-04 (see Figure 5), Parsons L-43, Parsons D-20, and Reindeer C-38 suggest strongly the presence of barrier islands, especially when combined with the core data obtained from Parsons L-43 and Reindeer G-04. The expected associated lagoonal, intertidal, nearshore and offshore deposits are confirmed by the data from available cores.

Conspicuously absent are barrier bars away from the Eskimo Lakes Arch. In wells Ikhil I-37, Kipnik O-20, Unak B-11 (see Figure 6), IOE Tuk F-18 and Wagnark C-23 the sands are generally thin and featureless and no barrier island deposits can be recognized with the degree of certainty which is possible in the Parsons Lake area.

2

The high net sand percentages near the Eskimo Lakes Arch (i.e. the coastline) probably indicate that barrier bar formation was limited to nearshore (Dickinson et al. 1972). The location of the depositional edge of the marine member in Figure 31 is in part based upon this relationship.

In the steadily deepening epeiric sea which likely existed in the Mackenzie Delta region at the time of the upper member deposition, barrier island sand bodies would have been stationary or landward migrating. Deposits basinward of the barrier island complexes would likely have been typical of a sandy shelf environment.

Coté et al. (1975) and Myhr and Young (1975) suggested that the boundaries between successive deposits analogous to the members proposed in this report are major diachronous facies boundaries. Dixon (1982b, p.23) suggested that only a slight diachroneity exists within the subsurface Parsons Group. The lack of any recognizable barrier bar/island sequences basinward in the marine member supports Dixon (op. cit.) and suggests rapid regional tectonic change since in a highly diachronous depositional regime, barrier sand bodies would have first formed in a more basinward location and migrated landward with deepening water levels.

5.9 Sand Isoliths

Semi-quantitative mapping of sands was achieved using gamma

ray response from down-hole logs. A "sand line" was drawn two-thirds of the way up from the common shale response to the cleanest sand response, a standard procedure in the petroleum industry. It is deduced through petrographic study that all gamma ray responses above this sand line represent clean and possibly reservoir quality sandstones and as such were included in the sand isoliths.

The sand isoliths show regional sand trends. In areas of high control, such as the Parsons Lake field, detailed variations are apparent.

Sand isoliths of the non-marine, transitional and marine members of the Kamik Formation were constructed to represent original depositional sand thicknesses. Figure 32 is the interpretive sand isolith map for the non-marine member. Sandstone thickness patterns are very similar to the isopach for the member, as would be expected in a braided stream depositional system. The sandiest section of 280 metres was encountered at the Kipnik 0-20 location. The arenaceous depocentre is just southeast of the Kipnik 0-20 location. The net sand percentage (see Figures 25 and 32) decreases noticeably toward and within the Kugmallit Trough. In the Parsons Lake area, nearly all the non-marine sediments are 75 percent or more sandstone, whereas net sand percentages in Ikhil I-37 and in Kipnik 0-20 are 63 and 66 percent respectively. This change in the abundances of sand substantiates the claim that the braided stream types graded basinward from the sandstone-rich, proximal

Figure 32. Sandstone isoliths for non-marine member, Kamik Formation (legend on Figure 18)

Bijou-Creek type into the "muddy" South Saskatchewan type of braid plain deposition.

Figure 33 is the sand isolith map for the transitional member. Sandstone thicknesses again mimic, to a large degree, the isopach for the member. The sandiest section of 142 metres was encountered at Ikhil I-37. The arenaceous depocentre is to the south and the west of the Ikhil I-37 location. Net sandstone percent is significantly less for the transitional member than in the underlying non-marine member. A noteworthy deviation of isolith contour patterns from the isopach of the member is in the Shallow Bay region. Based on information from Unak B-11 and Kipnik 0-20 wells (see Figure 6), sandstone appears to decrease in abundance to the northwest, indicating more muddy marine deposition that direction.

Figure 34 is the sand isolith for the marine member. Sand deposition was dominantly in the form of barrier islands/bars. The high control area of Parsons Lake reflects this depositional style. Over the rest of the subsurface, control is so limited that sand patterns can not be accurately discerned and generalized contouring of data is necessitated. The thickest sand section of 75 metres occurs in the Ikhil I-37 well. The arenaceous depocentre lies just to the southwest of the Ikhil I-37 location. Net sand percentages are the lowest of any Kamik Formation member.

Figure 33. Sandstone isoliths for transitional member, Kamik Formation (legend on Figure 18)

Figure 34. Sandstone isoliths for marine member, Kamik Formation (legend on Figure 18)

6. DIAGENESIS

Diagenetic changes affecting the sandstones of the Parsons Group are mechanical and chemical compaction, cementation, dissolution of silicates and carbonates and the authigenic formation of pore-filling clays.

The excess of free energy which provides the driving force for diagenesis is caused by (Berner, 1980):

1. thermodynamically unstable minerals and mineraloids such as aragonite, opaline silica, volcanic glass, semi-amorphous clay minerals - all less stable than corresponding authigenic minerals.
2. diagenetic change in pore water composition.

Authigenic precipitates may be derived from the dissolution of minerals within the sediment (diagenetic redistribution), or from outside. For quartzose sandstones, the bulk of excess free energy can only be brought about by a diagenetic change in the pore waters. Therefore chemical evolution of pore waters with burial depth will control the diagenetic sequence in such sands. The dewatering of interbedded, adjacent or subjacent shales may be the dominant process affecting the kind and amount of waters involved in the diagenesis of sandstones.

6.1 Compaction

Although the sandstones studied have diagenetically matured

beyond initial mechanical compaction, some early mechanical compaction effects can be observed. Petrographic studies also indicate that although some mechanical compaction has occurred, especially in the finer grained sandstones, most of the cement is allogenic, and the "pressure solution" visible is a product of impinging silica overgrowths (see silica cement, section 6.3 and Plate 6g).

The difficulty in differentiating between detrital quartz cores and syntaxial quartz overgrowths in the sandstones studied prevents any accurate evaluation of grain proximity, but the few samples where monocrystalline quartz grains show "dust lines" indicate a relatively low packing proximity due to the presence of early silica cement (Plate 6g).

6.2 Cementation

The precipitation of chemical cements is the most important diagenetic event affecting the reservoir potential of the Parsons Group sandstones. Three major cement types occur in the specimens studied: silica, calcite and authigenic clays. Siderite, pyrite and iron oxide cement occur locally, in minor amounts .

6.3 Silica Cement

Silica is the most common and abundant cement in the specimens studied (see Plates 6f,g and h). As discussed earlier, accurate estimation of amount of silica cement is not possible due to the difficulty in discriminating between detrital quartz

and authigenic silica overgrowths. Estimations of silica cement proportions based on the quantity of visible overgrowth crystal faces, recognition of overgrowths through variations in strain phenomenon and inclusions and "dust lines", when present, range from close to zero to near 25 percent. SEM examination shows the presence of silica overgrowths in the Parsons Group rocks and its effect on porosity (see Plates 7a,b and c).

The source of the silica may be:

1. silica derived from shales, from both initial waters at the time of burial and the smectite to illite transformation occurring at depth.

2. Dissolution of feldspars and quartz
3. Pressure solution
4. Meteoric waters.

Petrographic work suggests that pressure solution is not a major source for diagenetic quartz but merely serves to redistribute silica from zones of high lithostatic pressures to zones of lower hydrostatic pressures within the rock itself (see Plate 6g). Silica in mesogenetic and late cementing phases may be derived from the intrastratal dissolution of quartzose rocks (see Plate 1). Dissolution of feldspars and quartz is not

considered adequate to supply enough silica to form the amount of overgrowths in the sandstones examined. Eogenetic (surface influenced-early) and mesogenetic (below surface influences) silica overgrowths were therefore most likely derived either from circulating meteoric waters and/or from silica-bearing waters expelled from shales during burial, and probably deposited throughout the diagenetic history. Intrastratal dissolution may have contributed significant volumes of silica at depth.

6.4 Calcite Cement

Pore-filling calcite is present in at least minor quantities in most sandstones, but rarely in amounts more than 3 percent. Locally, calcite can constitute the dominant cement but such occurrences are rare. Calcite occurs as a fine mosaic of subequant clear crystals or in association with dark, probably illite-based clays (see Plates 7d and e). In samples with abundant calcite, the cement is coarse and poikilotopic, and is accompanied by partial to total replacement of detrital grains by calcite (see Plate 7f). In most samples, however, sparse calcite is scattered throughout the sample (see Plate 7g) apparently remnant after a major phase of mesogenetic dissolution. Most textural relationships observed in thin section suggest that calcite cementation succeeded the early silica cement.

The proportions of calcite and silica cement may be attributed to the chemical instability of calcite. Quartz solubility is sensitive to pH only over 9, and is an order of

magnitude less than that of calcite in sea water quartz remains less soluble than calcite during a large range of conditions associated with diagenesis (Hayes, 1979).

6.5 Authigenic Clay Cement

Petrographic study, scanning electron microscopy and X-ray examination (see Appendix 3) reveal the presence of clay minerals of two main groups - illite-dominated and kaolinite.

6.5.1 Illite

Illite-based authigenic clays are shown from X-ray examination to be a mixed-layer illite (dominated) - montmorillonite. Illite is the dominant authigenic clay, present in almost all samples studied in quantities up to 27 percent. The illite occurs as:

1. Isolated or interconnected pore fillings. It may totally fill the pore space or be randomly scattered through an incompletely filled pore. Plate 7h shows this form of illite clay in thin section. Investigation of this form of pore-filling illite-montmorillonite by scanning electron microscopy reveals many morphologies, most probably related to slight variations in composition and diagenetic history. Plates 8a and b show illite-montmorillonite as partial to total pore-fillings. These same plates also show clay morphologies similar to those of illite/illite-montmorillonite as presented by Wilson and Pittman (1977). Plate 8c exhibits a very tightly packed laminated,

pore-filling authigenic clay. Although such morphologies resemble detrital chlorite (Wilson and Pittman, 1977, p.18), no detrital clay is recognized in thin section and no chlorite was detected by X-ray examination. The irregular flakes and lath-like projections characteristic of illite-dominated authigenic clay can be spotted upon closer examination. Morphologically less characteristic illite/illite-montmorillonite combinations are displayed in Plate 8d. Commonly, this form of illite-montmorillonite clay is present in large enough quantity to fill all or most of the porosity (see Plate 8e).

2. Thin pore linings, usually with associated congested pore throats in finer grained rocks. Plates 7e and 8f exhibit this form of illite distribution. Scanning electron microscopy reveals that this form of illite is similar to the irregular flakes and delicate growth habits depicted in authigenic illite and illite/montmorillonite clays in Wilson and Pittman (1977). Plates 8g and 8h show this form of clay at two different magnifications in two different rocks.

3. Thick pore linings, usually associated with random distribution of illite throughout the sample, pore throat congestion and abundant bridging of pore space (Plates 9a and 9b). It may be a coarser development of form 2. An illite morphology is recognizable in SEM photomicrographs (Plate 9c).

6.5.2 Kaolinite

According to Hoffman and Hower (1979, Figure 13), dickite is the higher temperature equivalent of kaolinite, forming at temperatures greater than approximately 100° C. The Parsons Group rocks studied with thin section and SEM are presently at temperatures below 100° C, suggesting that kaolinite should be the dominant phase present. X-ray examination of some specimens concurs with the above prognosis (Appendix 3). Kaolinite occurs mainly as a pore-filling authigenic clay in quantities up to 7 percent. In thin section it is recognizable as stacked plates or books with a sometimes recognizable pseudo-hexagonal crystal habit (Plate 9d). Kaolinite may also exhibit an interlocking very fine-grained mosaic habit difficult to distinguish from chert in thin section. Scanning electron microscopy reveals four forms of kaolinite. These are:

1. Scattered pore-filling stacked pseudo-hexagonal platelets aligned parallel to each other (Plate 9e). Most common form.
2. Vermicular growth, extending the length of the pore as a booklet-type morphology (see Plate 9f).
3. Pseudo-hexagonal plates coating quartz grains (see Plate 9g).
4. Least common, pore-filling stacked platelets with poorly defined, irregular plate edges (see Plate 9h). This kaolinite may have suffered some marginal corrosion.

Individual kaolinite plates range from 3 to 12 μm in length and 0.3 to 2.0 μm in thickness.

6.5.3 Other authigenic clays

No chlorite was recognized in thin sections but very minor amounts of the mineral were detected in X-ray examination (see Appendix 3). Minor authigenic muscovite was recognized in trace quantities in a few of the samples studied.

6.6 Hematite Cement

Although absent from the majority of specimens examined, red to reddish-brown hematite cement may be present in minor amounts.

6.7 Siderite Cement

Siderite occurs sporadically throughout the Parsons Group sands as scattered finely crystalline dark yellow-brown "beaded" flattened rhombs. Not more than 3 percent siderite is observed in the rocks studied, but Schmidt and McDonald (1979) suggest that siderite locally is a dominant cement in the Parsons Group. This disparity is probably a function of different sample locations.

Mineralogical associations indicate the siderite has undergone significant mesogenetic dissolution.

6.8 Pyrite Cement

Pyrite, the rarest cement, occurs either in a disseminated

lath-like pore-filling form (Plate 10a) or as patches in a few samples. Plate 10b shows pyrite cement replacing quartz in a typical occurrence of patchy pyrite. Finely crystalline pore-filling disseminated pyrite is also present (Plate 10c).

6.9 Glauconite

Green glauconite occurs as irregular fine grains usually in trace amounts throughout the Martin Creek and McGuire Formations and the upper marine rocks of the Kamik Formation.

6.10 Replacement

Carbonate partially replaces both feldspar and quartz grains in the rocks studied. Siderite or calcite may partially replace plagioclase or potassic feldspar. This phenomenon occurs sporadically within the stratigraphic section, indicating the variability of such controls as feldspar composition and local chemical conditions.

Defeldspathization is sometimes associated with the formation of illite (-montmorillonite?). This relationship is shown in Plates 9a and 10d and in the communality chart of Figure 35 (section 6.14). Possible reactions are (after Hutcheon, 1981):

Abundant carbonate cement is associated with minor to

extreme quartz corrosion and replacement (Plates 7e and f). Previous replacement of quartz by carbonate is inferred in a number of samples in which corroded quartz grains (Plate 7e) are seen but carbonate has been mostly dissolved.

As illustrated in Plate 10b, pyrite locally replaces quartz, and most likely any other detrital fragment which it surrounds.

6.11 Dissolution

Dissolution of detrital fragments and authigenic cements plays a major role in the diagenetic sequence, creating significant volumes of secondary porosity in the process. As exhibited in Plates 6e, 10d and 10e, abundant intrastratal feldspar dissolution has occurred and in at least some specimens is almost complete as evidenced by the sparse feldspar remnants accompanied by oversized , moldic pore spaces.

Mesogenetic dissolution of carbonate cement (both calcite and siderite) is recognizable by the erratic distribution of residual carbonate in the rocks, and the abundant corrosion of quartz grains where carbonate has been totally dissolved. Most porosity observed in thin section is, apparently a product of carbonate cement dissolution and is therefore secondary . Plate 10f shows isolated remnant carbonate cement, partially dissolved.

Intraparticle porosity is commonly observed in chert clasts.

(Plates 6c and d) and may reflect either partial dissolution of chert or the intrastratal dissolution of residual carbonate within the chert.

Leaching of feldspars is apparently a result of both acid diagenetic solutions (Almon 1981) and (for Ca-poor feldspars) solutions with high pH and rich in Ca^{2+} and CO_2 (Dapples, 1967, p.106). High pH fluids are undoubtedly responsible as well for dissolution of quartz in the Parson Group strata. According to Schmidt and McDonald (1979), most mesogenetic decarbonatization results from the decarboxylation of organic matter interbedded with the sandstone or in strata underlying the sandstone. The decarboxylation generates CO_2 combined with water produces carbonic acid capable of dissolving the carbonate. Other possible causes for decarbonatization are physico-chemical gradients at the boundaries of geopressure zones, the release of water from clay minerals and the generation of hydrogen sulphide (Schmidt and McDonald, 1979, p.198).

6.12 Paragenesis of Cements and Authigenic Minerals

Petrographic studies reveal spatial relationships of the diagenetic features and components from which a sequence of diagenetic events is proposed. When necessary, diagenetic theory and published examples are used to substantiate conclusions.

Of the minor authigenic minerals, glauconite and pyrite are thought to be mainly eogenetic. From the general ferric to

ferrous iron proportions in glauconite, it is deduced that glauconite is formed under moderately reducing conditions, probably associated with the action of sulphate-reducing bacteria on decaying organisms (Deer, Howie and Zussman, 1966). Pyrite is thought to form under reducing, neutral to weakly acidic conditions during early diagenesis (Wolf and Chilingarian, 1976). While most of the pyrite may be eogenetic, it is possible that mesogenetic pyrite is also present (Plate 10c). For late pyrite to form, the sulphur ions have to be held in some sulphur complex (sulphate etc.) until reducing conditions induce pyrite formation.

Petrographic study of the major cements suggests a sequence of authigenic minerals, reflecting in whole or in part a diagenetic history which may or may not be completely recorded. The following observations are pertinent to the Parsons Group rocks.

1. Syntaxial silica overgrowth was the first, and is the most pervasive of all cements. Plates 7a, 7b, 7c, 8b, 8d, 8g, 9c, 9e, 9f, 10g and 10h show that kaolinite, illite (-montmorillonite), and carbonate, occur after the quartz, deduced to be an early to intermediate (eogenetic to mesogenetic) diagenetic phenomenon. This observation concurs with that of Schmidt and McDonald (1979).

2. Carbonatization (including cements and replacement) is the next major diagenetic event, occurring alone or accompanied by authigenic clay cements (Plates 10d and 10e). Carbonatization is thought by Schmidt and McDonald (1979, p.196) to be an intermediate diagenetic stage, but their study of secondary porosity in the Parsons Group rocks, showed that siderite was at least in part, an eogenetic mineral.

3. Associated with carbonatization is the corrosion of quartz grains, and most likely the corrosion of feldspars since the high pH fluids that were responsible for silica dissolution should also be capable of destroying the feldspar lattice (Dapples, 1967, p.106).

4. In cases where decarbonatization does not occur and all pore space is filled, the diagenetic process terminates at this stage.

5. The process of decarbonatization (carbonate dissolution) may create abundant pore space, allowing further diagenesis. Abundant authigenic illite-rich mixed layer clay and kaolinite are then precipitated in these secondary pore spaces. Co-existence of illite and kaolinite is common (Plate 11a), suggesting overlapping conditions and times of precipitation.

6. A noticeable quantity of silica cement was deposited after decarbonatization, as indicated by the uncorroded crystalline silica overgrowths present in places where dissolution of

carbonate cement can be proven (assuming that corrosion of quartz is invariably associated with carbonate precipitation). Plates 6h and 11b show rocks with high secondary porosity and pristine quartz overgrowths after carbonate dissolution. Plate 11c shows an authigenic quartz crystal face riddled with kaolinite plates and deep impressions of plucked kaolinite booklets. It is likely that these silica overgrowths formed around an already nucleated mesogenetic kaolinite crystal.

7. After decarbonatization, further physical and chemical compaction and feldspar dissolution may continue .

6.13 Porosity

Original primary porosities in the sands studied were probably in the range of 40 percent (Pryor, 1968). Present porosities range from 0 to 25 percent and are virtually all of secondary origin, as determined from the criteria of Schmidt and McDonald (1979). Plates 7b, 7c, 7f, 8b and 8c show examples of the diagenetic loss of primary porosity accomplished by a combination of compaction and cementation processes.

Dissolution of cements - especially carbonate - and feldspars created secondary porosity (Plates 11b and d). Examples of high porosities through extreme and thorough dissolution, most likely of carbonate cement, is shown in Plate 11b. Most samples examined demonstrate secondary porosities reduced by silica and clay cements (Plates 7b, 8b, 9e, 10a and 11e). Pore and throat

sizes thus reduced result in a concomitant reduction of permeability. The high surface area typical of illite clay growth (Wilson and Pittman, 1977) is associated with abundant microporosity which will, in all likelihood, be totally ineffective as an hydrocarbon reservoir due to the small pore diameters present. Microporosity associated with kaolinite is intercrystalline in the form of interbooklet pores (Plate 11f). The microporosity associated with kaolinite crystals is coarser than that which is present in illite crystals of the same size, and as such is probably related to higher permeability.

6.14 Diagenetic Association

Observations of marked changes in the proportions of cements, feldspar and porosity observed over short vertical distances supported a study of associations amongst these features. Figure 35 is a communality chart of the variable diagenetic features based on closely spaced samples in the Parsons N-10 well. Associations revealed by Figure 35 are divided simply into weak and strong, and are presented in schematic form in Figure 36.

Many associations shown in Figure 35, such as the association between porosity and the degree of dissolution, and between porosity and silica overgrowths are as expected, but some strong associations apparent in Figure 35 could not have been demonstrated without detailed petrographic analysis. These include:

Figure 35. Communality chart showing associations among various petrographic features in the Parsons N-10 well.

1. Porosity variations are related to grain size.
2. Dissolution porosity (irregular, moldic porosity) can be directly related to the degree of feldspar dissolution
3. The quantity of illite (-montmorillonite) clay, observed to be authigenic in the most part, is proportional to the quantity of feldspar. Apparently, an abundance of residual feldspar indicates greater initial quantities of detrital feldspar and the illite present is, to some degree, a dissolution product of feldspar.

The most perplexing, yet economically important association exposed by Figure 35, is the direct relationship between porosity and grain size. Figure 37 expresses this association for all the samples studied. Previous investigators have related variations in diagenetic features to permeability differences. Wolf and Chilingarian (1976, p.173) stated that a permeable coarse-grained sandstone will be cemented faster than a finer-grained rock, if all other conditions are equal. Melon (1964) reached a similar conclusion in surmising that the extent of calcite and silicate cements is dependent upon the pore size (packing), which is slightly greater in coarser-grained rocks. In the Parsons Group, a greater permeability should then be associated with the coarser sandstones (see Table 1).

During and after eogenetic cementation by silica, the

relatively higher permeabilities of coarser Parsons Group rocks probably increased slightly with respect to finer-grained rocks. The relative porosities of coarse and fine-grained sandstones would remain unchanged. Subsequent mesogenetic cementation by carbonate would have been enhanced in the more permeable, coarser sandstones compared to that in the less permeable finer-grained sandstones. On a large scale, the process would have been self-limiting. Where carbonate cement was present, further porosity reduction through the pressure - solution of quartz or precipitation of allogenic silica would have been impeded or prevented, but where the carbonate cement is lacking, silica cementation would proceed according to the prevailing temperature, pressure and fluid conditions. The expected results of such texture-controlled processes would be tightly silica-cemented finer-grained rocks and coarser-grained rocks with a mixture of carbonate and silica cements. Subsequent dissolution of carbonate, while not affecting significantly the diagenetic state of the finer-grained sandstones, would result in abundant secondary porosity in coarser-grained sandstones.

* Such a model is supported by the association, albeit weak, of grain size and the amount of silica cementation. A stronger association may exist, but is not demonstrable because of difficulties mentioned earlier in accurate determination of the proportion of silica overgrowths. Figure 36 is a diagenetic association chart based on Figure 35, expressing the associations present as related to porosity. Such a chart

Figure 36. An association tree (based on Figure 35) with porosity at the base.

clearly shows the dependence of porosity on silica overgrowths, grain size and feldspar dissolution. Since the chart is based only upon observational measurements representing a specific time late in the diagenetic history, it does not reveal the past importance, nor the dissolution history of the carbonate cements. The carbonate proportions are those remaining after mesogenetic dissolution, showing an erratic distribution of a volumetrically unimportant mineral.

7. DIAGENESIS, AND THE PURSUIT OF POROSITY

7.1 Predicting Reservoir Porosity

The previous section outlined the apparent correlation between grain size, feldspar content and porosity, allowing a determination of reservoir quality based upon a synthesis of petrographic characteristics, including diagenetic features.

Assuming the described diagenetic phenomena are consistent throughout the subsurface, the sandstones of the non-marine member of the Kamik Formation should have the greatest porosity, being the coarsest unit in the Parsons Group. Winn et al. (1984) show that the coarser-grained non-marine sands of the Frontier sandstone in Wyoming have a higher porosity than finer-grained sands of the same unit. Porosity should generally lessen in the finer-grained transitional member sandstones and deteriorate further in the still finer-grained marine member. Such a relationship is suggested by the stratigraphically controlled porosity variations exhibited in Figure 37. Large positive

Figure 37. Graph of porosity variations as a function of grain size.

deviations from a linear porosity-grain size relationship probably reflect abundant feldspar dissolution porosity.

Martin Creek sandstones are typically fine-grained, well sorted and consistently contain more detrital feldspar than any other sandstone group examined. Empirical relationships suggest a significantly greater importance of grain size relative to feldspar dissolution (limited amount of moldic porosity), in the generation of secondary porosity. Potential subsurface porosities of the Martin Creek sandstones are only slightly greater than those of the transitional member of the Kamik.

7.2 Diagenetic Facies and Depth

The diagenetic mineral assemblages in any rock are a function of original mineralogy, time, geothermal gradient, depth and the nature of the diagenetic waters. Schmidt and McDonald (1979) have outlined these controls and the effects of these controls on the diagenetic cycle. They concluded that sandstones progress from the immature to supermature diagenetic stages with each intermediate phase characterized by certain diagenetic phenomena and resultant porosities (Figure 38). In any system of one age, exhibiting uniform mineralogical characteristics, and deposited in a basin with a relatively invariant geothermal gradient, diagenetic assemblages should be controlled solely by depth and the nature of the diagenetic waters.

Figure 38. Diagenetic evolution (cycle) of sandstones (from Schmidt and McDonald, 1979, figure 27).

The Parsons Group conforms to the above conditions, with most of the basin presently possessing a geothermal gradient ranging from 2.7° C/100m to 3.2° C/100m (bottom hole temperatures from logs). Slightly higher and lower geothermal gradients exist very near the Tuktoyaktuk Fault-Flexure Zone, but are local in extent. If the effects of diagenetic waters are disregarded diagenetic facies within the Parsons Group strata should be approximately a function of depth. Table 3 is a simplified categorization of the diagenetic stages represent in the wells studied based on the Schmidt and McDonald (1979, Figure 27) scheme. From this table the approximate depth, location and extent of the Mature A zone can be estimated. Extrapolation of associated diagenetic zones (Figure 38) as a function of real depth in the Kugmallit Trough, provides an approximation of the depths of these diagenetic zones in relationship to the Parsons Group. Figure 39 is a schematic maximum porosity plot redrawn after Schmidt and McDonald (1979, Figure 12) for the Parsons Group sandstones based on the depth-diagenetic-zone relationship. Based on Table 3, the transition from the semi-mature zone to the mature zone occurs at a depth of approximately 2.5 kilometers. Secondary porosity associated with the mature zone diminishes to near zero at about 7 kilometers depth. Choosing, arbitrarily, a 20 percent maximum porosity cut-off, the deepest potential reservoir is most likely above 6 kilometers. Figure 40 is a synthesis of Figures 3 (the generalized structural contour on the top of the Parsons Group) and 39, showing, qualitatively, relative reservoir potential at

Well	Approximate Depth (m)	Significant Diagenetic Occurrences	Diagenetic Maturity
Siku A-12	2715 - 2810	Good Porosity Moderate Silica Overgrowths Residual Carbonate	Intermediate Mature A
Parsons W-10	2750 - 2875	Good Porosity Moderate Silica Overgrowths Moderate to Residual Carbonate	Intermediate Mature A
Parsons U-43	2770 - 2940	Good Porosity Mod. to High Silica Overgrowths Residual or no Carbonate	Intermediate to Late Mature A
Kamuk D-58	2835 - 3080	Fair to Good Porosity Moderate Silica Overgrowths Scattered Decarbonatization	Early to Intermediate Mature A
Parsons F-09	2840 - 2950	Fair to Good Porosity Moderate Silica Overgrowths Scattered Decarbonatization	Early to Intermediate Mature A
Siku E-21	2950 - 3050	Fair to Good Porosity Mod. to High Silica Overgrowths Residual or no Carbonate	Intermediate to Late Mature A
Parsons P-41	2960 - 2975	Fair to Poor Porosity Mod. to High Silica Overgrowths Moderate Carbonate	Intermediate Mature A
Reindeer G-04	3010 - 3230	Fair to Poor Porosity Mod. to High Silica Overgrowths Residual Carbonate	Intermediate to Late Mature A
Nuna A-32	3230 - 3290	Good to Poor Porosity Mod. to High Silica Overgrowths Minor to Mod. Carbonate	Intermediate Mature A

Table 3. Diagenetic maturity as a function of depth in the Parsons Group. Maturity Index from Schmidt and McDonald (1979) and displayed in Figure 38. Subdivision of Mature A Zone introduced here

Figure 39. Maximum porosity potential of Parsons Group sandstones (quartz arenites) versus depth of burial (redrawn after Schmidt and McDonald, 1979, figure 12).

Figure 40. Estimated distribution of the degree of porosity development in the subsurface Parsons Group sandstones

different depths. Contour trends from Figure 3 suggest limited reservoir potential to the north of Siku C-55, and west of Parsons Lake in the zone of thickest Parsons Group. Near-surface Parsons Group rocks proximal to the Richardson Mountains likely have a reduced reservoir potential due to chemical and/or biochemical degradation of any hydrocarbons present. Parsons Group sands in the remainder of the basin have fair to excellent reservoir potential. The zone of decreased potential near the Eskimo Lakes Arch correlates with the depositional edge of the best reservoir - the non-marine member. The Parsons Group isopach (Figure 18) reflects a more extensive depocentre than the structure map (Figure 3) would suggest. Apparently, the western half of the Kugmallit Trough was uplifted in the most part, probably during the Laramide orogenic event. If uplift preceded the burial of Parsons Group strata to depths where porosity was significantly reduced (as in the eastern Kugmallit Trough where late mature or supermature diagenetic facies probably exist), then porosity potential will be as outlined in Figure 40. This is likely the case, as the subsidence plot constructed by Langhus (1980, Figure 7) suggests that burial in the eastern Kugmallit Trough continued throughout the Tertiary to the present-day deepest point. In the less-likely case of subsidence being all pre-Laramide, western Kugmallit Trough strata would have the same reduction in porosity thought to exist in the eastern Trough.

8. SUMMARY AND CONCLUSIONS

8.1 Summary

This study has used available geophysical, petrographic, and biostratigraphic information from 50 wells to develop and present a better understanding of the sedimentary petrology and stratigraphy of the Parsons Group rocks. Despite the inherent limitations of such a study, the understanding and extrapolation of depositional patterns and environments in the Parsons Lake area to areas with less subsurface control allow a general, but geologically reasonable, interpretation for the whole basin.

An easily identifiable, progressively transgressive, basin-wide vertical succession of lithologies is recognized in the Kamik Formation, and permits a subdivision into three lithostratigraphic units. Such a division allows for a more complete understanding of sedimentological and tectonic histories of the best reservoir unit in this area of the subsurface.

The Parsons Group units are probably somewhat diachronous, but the sparse, vague and sometimes ambiguous biostratigraphic control does not permit an evaluation of the degree of diachronism. Stratigraphic interpretations and depositional patterns suggest that unit boundaries are only slightly diachronous, and reflect minor tectonic events which greatly affected basin-wide sedimentation patterns.

8.2 Conclusions

Petrological and stratigraphic studies on the subsurface Parsons Group have led to these conclusions.

a. Parsons Group sandstones studied are mostly quartz arenites, and are usually texturally supermature.

b. The Martin Creek Formation is richer in feldspar than sands in the Kamik Formation. This difference can be attributed, at least in part, to feldspar dissolution in the Kamik Formation.

c. The Kamik Formation can be divided into three informal members mappable over the whole subsurface extent of the Kamik Formation.

d. There are distinct differences in grain size among the four sandstone-bearing units-Martin Creek Formation and the non-marine, transitional, and marine members of the Kamik Formation. The non-marine member includes the coarsest sandstones, whereas the marine member and Martin Creek Formation are characterized by finer-grained sandstones.

e. Chert content is apparently a function of grain size. The coarser-grained lower Kamik sands contain more chert than the overlying finer-grained rocks.

f. The Kamik Formation shows a succession of depositional environments which change from high-energy fluvial at the base to offshore marine at the top. The changing environments of deposition closely coincide with the contacts between the proposed informal members.

g. Interpretive isopach maps show basin configuration controlled by the Eskimo Lakes Arch, Tununuk and Napoiak Highs, Cache Creek Uplift, and the Canoe Depression, but the degree of influence exerted by these structural features varied through Parsons Group time.

h. Limits of Parsons Group strata onto the Eskimo Lakes Arch are re-interpreted as being controlled more by depositional processes rather than by erosional processes.

i. Fault movement in the Parsons Lake area probably was contemporaneous with Parsons Group deposition.

j. Silica cementation occurs early and is widespread in the sandstones studied.

k. Porosity observed in the Parsons Lake area appears to be mostly secondary.

l. Association observed between secondary porosity and grain size, feldspar dissolution and moldic porosity, and authigenic illite and the quantity of feldspar appear to be strong.

m. The reservoir characteristics of each sandstone-bearing unit are defined by the response of the textural and mineralogical characteristics of the rocks to the diagenetic influences.

n. The type and quantity of porosity in the Parsons Lake area is closely related to the level of diagenetic maturity, which is related directly to present day depths of burial.

9. RECOMMENDATIONS FOR FURTHER STUDY

On the basis of this study, the authour recommends;

- a. Further mapping of diagenetic facies in deeper and shallower holes using chip samples. From this, a more accurate depth-controlled diagenetic maturity plot can be constructed.
- b. Detailed mapping of individual sand bodies in the Parsons Lake area where control is sufficient to merit such a study. Insights into the environments of deposition should be gained.
- c. Detailed documentation of the types and distribution of lithologies in the non-marine member of the Kamik Formation. The occurrence and nature of this sandstone unit represents an opportunity to draw analogies from such high-energy subsurface deposits to well-documented models and allow the creation of a subsurface model based mainly on log response.
- d. Investigation of the occurrence of stylolites in the Parsons Group sandstones. Stylolites may occur more frequently in deeper buried sandstones, and such intrastratal dissolution of quartz may be a major source of silica during late cementation.
- e. Formal introduction of names for the non-marine, transitional, and marine members of the Kamik Formation into the literature.

Plate 1

Core , 3909-3912.5 metre interval Ikhil 1-37 well.
Medium to coarse-grained quartzose sandstone
containing shale rip-up clasts with some high angle
cross-bedding. Arrows point towards stylolitic
horizons. Braided channel environment ,non-marine
member.

Plate 2

Core , 3041-3045.5 metre interval , Siku E-21 well. Interbedded fine to coarse-grained pebbly sandstones and silty mudstones, representing deposition in a relatively high- energy meandering river environment in the transitional member. A lower channel bar sandstone may be present at the top of the core, whereas the shaly rock is probably from a natural levee environment. Sandstone in box 3 is most-likely a crevasse-splay deposit. Scale in inches.

Plate 2

3311-3046 5M

BOX 3

CORE 3

BOX 1

BOX 2

0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

GULF MOBIL SIKU E-21

Plate 3

Core ,2806-2810.4 metre interval, Siku A-12 well. Fine to coarse-grained cross-bedded quartzose sandstone, **transitional member**. Arenites from the top of the core are interpreted as intertidal sands and are underlain by an erosive, pebbly, carbonaceous channel sand. Note that lower core box is upside-down. Scale in inches.

Plate 3

Plate 4

A. Coarse-grained quartzose sandstone , 2808.5 metre level , Siku A-12 well. Note the high porosity of which some is apparently moldic. Transitional member.

B. Erosional contact between the fine-grained sand flat and conglomeratic facies of the underlying channel sand, 2808 metres, Siku A-12 well. Transitional member.

C. High-angle bedding dip in the fine-grained quartzose sandstones, 2805.5 metres, Siku A-12 well. Transitional member.

D. Low-angle cross-bedding in the quartzose sandstones , 2954.5 metre level, Siku E-21 well. Transitional member.

E. Wavy bedding in nearshore sandstones, 2862 metre level, Siku A-12 well. Marine member.

F. A conglomeratic channel-base, 2967 metre level , Parsons P-41 well. Note the high porosities associated with the sandstone matrix. Marine member.

Plate 4

A

B

C

D

E

F

Plate 5

A. Sub-horizontal thinly bedded quartzose lower offshore sandstone, the upper part of which is thoroughly bioturbated ; Chondrites cf. and unidentifiable fauna. From 2949 metres, Siku E-21. Transitional member.

B. Thoroughly bioturbated fine-grained upper offshore rock showing both Helminthoida (h) and Chondrites (c) cf. burrows. From 2955 metres , Siku E-21. Transitional member.

C. Teichichnus cf. burrows (arrows) in a silty to very fine-grained lagoonal rock. From 2713.5 metres , Siku A-12. Marine member.

D. Probable Chondrites cf. burrows in the lagoonal rocks, 2974 metres, Parsons P-41. Marine member.

E. Possible Chondrites cf. burrows in the cross-bedded fine-grained quartzose beach sandstones, 2973 metres, Parsons P-41. Marine member.

F. Probable Teichichnus cf. burrows in thin horizontally-bedded lagoonal sandstones , 2975.5 metres, Parsons P-41. Marine member.

Plate 5

A

B

C

D

E

F

Plate 6

A. Rounded quartz overgrowth (defined by dust-line-arrow) around a broken rounded quartz grain implying a multi-cycle origin. Parsons F-09 well at 2997.4 metres, McGuire Formation. Thin section photomicrograph, XP light.

B. Intraparticle porosity (a) in a detrital chert grain, after the dissolution of a dolomite rhomb. Parsons P-41, 2974.4 m, marine member. Thin section photomicrograph, PP light.

C. Detrital chert (a) showing pellet ghosts and intraparticle porosity after dissolution of some pellets. Siku E-21, 3053.8 m, non-marine member. Thin section photomicrograph, PP light.

D. Significant intraparticle porosity (a) in a large polycrystalline quartz grain (b). Siku E-21, 3053.8 m, non-marine member. Thin section photomicrograph, PP light.

E. Excellent example of partially dissolved feldspar (a). Parsons N-10, 2760.5m, non-marine member. Thin section photomicrograph, PP light.

F. An example of silica overgrowth on a near-perfectly round quartz grain. The "dust line" coating the original detrital grain is unusually well-defined in this specimen. Parsons N-10, 2753.2m, non-marine member. Thin section photomicrograph, XP light.

G. Loosely-packed quartz grains showing silica-overgrowths coalescing. Porosity is dark grey. Parsons L-43, 2942.8m, non-marine member. Thin section photomicrograph, PP light.

H. Exceptionally well-developed crystalline quartz-overgrowths (a). Typically the detrital core is not recognizable. Parsons L-43, 2943.5m, non-marine member. Thin section photomicrograph, PP light.

Plate 6

A

0.1mm

B

0.2mm

C

0.2mm

D

0.2mm

E

0.1mm

F

0.2mm

G

0.5mm

H

0.5mm

Plate 7

A. Scanning electron photomicrograph of well-developed quartz overgrowths (a) partially filling pore space. The grains are incompletely coated with authigenic illite-dominated clay. Parsons N-10, 2760.6m, non-marine member.

B. Scanning electron photomicrograph of advanced quartz overgrowths. Porosity loss is more advanced than in Plate 7a. Later illite-dominated clay (a) is present. Parsons N-10, 2858.7m, Martin Creek Formation.

C. Extreme porosity loss due to quartz overgrowths nearly eliminating porosity. Late illite coats some of the grains. Parsons N-10, 2803.9m, non-marine member. Scanning electron photomicrograph

D. Scattered clear calcite cement (a) in a quartz arenite. Parsons F-09, 2850.3m, transitional member. Thin section photomicrograph, PP light.

E. Carbonate cement (a), probably calcite, in a quartz arenite. The slightly-dark shade of the carbonate is likely due to the presence of illite-dominated clays as impurities. Some quartz grains (b) show significant corrosion along their edges suggesting previous attack by now dissolved carbonate cement. A thin layer of dark illite now coats most grains. Siku E-21, 3052.6m, transitional member. Thin section photomicrograph, PP light.

F. Late pore-filling calcite cement (a) partially replacing a quartz grain (b). Parsons P-41, 2973.2m, marine member. Thin section photomicrograph, XP light.

G. Scattered calcite cement (a) within a loosely-packed quartz arenite. The calcite present is remnant after the dissolution event that removed the majority of the pore-filling calcite. Siku E-21 3047.4m, transitional member. Thin section photomicrograph, PP light.

H. Pore-filling illite (a) both totally and partially filling the pore spaces present (b). Siku A-12, 2720m, marine member. Thin section photomicrograph, PP light.

Plate 7

A

B

C

D

0.1mm

E

0.2mm

F

0.1mm

G

0.2mm

H

0.1mm

Plate 8

A. Authigenic illite-montmorillonite clay (a) partially infilling pore space (b). Note the lath-like projections of the illite-dominated clay. Parsons N-10, 2803.9m, non-marine member. Scanning electron photomicrograph.

B. Abundant pore-filling authigenic illite-dominated clay (a) eliminating interparticle porosity. Note that the clay is a post-silica-overgrowth (b) feature. Parsons N-10, 2752.0m, non-marine member. Scanning electron photomicrograph.

C. Pore space between quartz grains (a) totally filled with a tightly arranged, laminated, authigenic illite-dominated clay. Although the clay morphology resembles detrital chlorite, X-ray examination indicates otherwise. Reindeer G-04, 2937.1m, marine member. Scanning electron photomicrograph.

D. Pore space between quartz overgrowths (a) filled with morphologically indeterminable clay (b). X-ray analyses suggest this clay is illite-dominated. Parsons N-10, 2765.1m, non-marine member. Scanning electron photomicrograph.

E. Interparticle porosity between loosely-packed quartz grains (a) reduced to near-zero by the presence of abundant authigenic, illite-dominated clay (b). Reindeer G-04, 2921.5m, marine member. Scanning electron photomicrograph.

F. A thin layer of illite clay (a-very dark) coating most quartz grains. Note the loosely-packed and corroded nature of the quartz grains attesting to dissolution of previously existing carbonate cement. Parsons N-10, 2758.1m, non-marine member. Thin section photomicrograph, PP light.

G. Heavily overgrown quartz (a) covered by a thin layer of locally pore-bridging illite (b). Parsons N-10, 2765.2m, non-marine member. Scanning electron photomicrograph.

H. Close-up of a thin layer of illite (a) coating a quartz grain. Note the presence of abundant residual secondary pore space (b). Reindeer A-01, 2308.9m, transitional member. Scanning electron photomicrograph.

Plate 8

A

B

C

D

E

F

0.2mm

G

H

Banff Aquitaine-A.R.C.O. Rat Pass K-35

Stratigraphically and sedimentologically unfamiliar but Chamney micropaleontology (in Barnes et al., 1974) indicates Parson Group strata from at least 472.4 (1550) to 588.3 (1930).

Shell Kugpik L-24

Parsons Group not present probably due to erosion (may be faulted as well).

Gulf Mobil Parsons L-37 (taken from true vertical depth logs)

Parsons Group

Kamik Fm.	
marine mbr.	2709.7 (8890)
transitional mbr.	2844.7 (9333)
non-marine mbr.	2999.8 (9842)
McGuire Fm.	3047.1 (9997)
Martin Creek Fm.	3074.2 (10,086)
Husky Fm.	3134.0 (10,282)
lower mbr.	3218.7 (10,560)

10E Mayogiak L-39

Parsons Group not present due to non-deposition, erosion or faulting.

Gulf Mobil Parsons L-43

Parsons Group

Kamik Fm.	
marine mbr.	2697.5 (8850)
transitional mbr.	2836.5 (9306)
non-marine mbr.	2933.1 (9623)
McGuire Fm.	3018.7 (9904)
Martin Creek Fm.	3026.1 (9928)
Husky Fm.	3086.4 (10,126)
lower Fm.	3164.7 (10,383)

Gulf Mobil Kamik L-60

Parsons Group

Kamik Fm.	2958.7 (9707)
-----------	---------------

hole apparently TDs in Kamik Fm., but reports of depth are ambiguous

Plate 9

Plate 10

A. Opaque disseminated lath-like pore-filling pyrite patches (a). Note that the quartz grains are usually in corrosive contact with the pyrite. Pore-filling authigenic illite (b) is present also. Siku A-12, 2723.4m, marine member. Thin section photomicrograph, PP light.

B. A patch of pyrite cement (black) containing loosely-packed corroded quartz grains. Intact packing in the sandstone is observed in the right part of the photograph. Parsons N-10, 2850.2m, Martin Creek Formation. Thin section photomicrograph, PP light.

C. Finely crystalline, disseminated, pore-filling pyrite (a). Note that the pyrite has crystallized upon a well-developed quartz overgrowth (b), attesting to its later origin. Reindeer A-01, 2305.2m, transitional member. Scanning electron photomicrograph.

D. Moldic porosity created from the dissolution of feldspar (note the abundant feldspar remnants (a) in the pore space). A relatively higher authigenic illite content (b) is present in the pore as a dissolution product of the feldspar. Siku A-12, 2722.8m, marine member. Thin section photomicrograph, PP light.

E. Partially dissolved feldspar (a). Dissolution has proceeded along the near-orthogonal crystallographic axes. Reindeer A-01, 2308.9m, transitional member. Scanning electron photomicrograph.

F. Well-cleaved carbonate (calcite?) cement (a) showing partial dissolution (b). Parsons N-10, 2798.1m, non-marine member. Scanning electron photomicrograph.

G. Kaolinite booklets (a) filling interparticle pore space between silica cemented quartz grains. Crystal faces of overgrowths are on numerous grains and grain b shows the detrital quartz core. Parsons N-10, 2797.5m, non-marine member. Thin section photomicrograph, PP light.

H. Interparticle pore space between overgrown quartz (a) filled with calcite cement (b) and some indeterminable authigenic clays (c). Parsons N-10, 2803.9m, non-marine member. Scanning electron photomicrograph.

Plate 10

A

0.2mm

B

0.5mm

C

D

0.2mm

E

F

G

0.2mm

H

Plate 11

A. Authigenic kaolinite booklets (a) and illite-dominated clays (b), precipitated on an overgrown silica grain (c). The co-existence of kaolinite and illite attests to overlapping chemical conditions of stability and possibly formation. Parsons N-10, 2798.1m, non-marine member. Scanning electron photomicrograph.

B. Thin section photomicrograph showing interparticle porosity (dark) in a quartz arenite where abundant crystalline overgrowths are recognizable (a). The porosity is probably a result of mesogenetic carbonate dissolution. Parsons L-43, 2942.8m, non-marine member. PP light.

C. Pseudo-hexagonal kaolinite plates and deep impressions of kaolinite booklets (a) on a crystalline quartz overgrowth face (b). It is likely that the overgrowths grew around an already nucleated kaolinite crystal. Parsons N-10, 2799.0m, non-marine member. Scanning electron photomicrograph.

D. Large oversized moldic porosity (a). The occurrence of a relatively large quantity of illite clay (b) suggests dissolution of feldspar. Siku A-12, 2725.5m, marine member. Thin section photomicrograph, PP light.

E. Authigenic illite-dominated clay (a) and silica overgrowths causing an advanced loss of general pore space (c). Parsons N-10, 2798.1m, non-marine member. Scanning electron photomicrograph.

F. Close-up of plate 9e showing interbooklet microporosity in kaolinite. Parsons N-10, 2798.1m, non-marine member. Scanning electron photomicrograph.

Plate 11

A

B

0.5 mm

C

D

0.1 mm

E

F

REFERENCES

- Almon, W.R., 1981. Depositional environment and diagenesis of Permian Rotliegendes sandstones in the Dutch sector of the Southern North Sea : in *Clays and the Resource Geologist*, F.J. Longstaffe (ed.); Mineralogical Association of Canada, Shortcourse Handbook 7, Calgary, p. 119-147.
- Barnes, C.R., Brideaux, W.W., Chamney, T.P., Clowser, D.R., Dunay, R.E., Fisher, M.J., Fritz, W.H., Hopkins, W.S. Jr., Jeletzky, J.A., McGregor, D.C., Norford, B.S., Norris, A.W., Pedder, A.E.H., Rauwerda, P.J., Sherrington, P.F., Sliter, W.V., Tozer, E.T., Uyeno, T.T., and Waterhouse, J.B., 1974. Biostratigraphic determinations of fossils from the subsurface of the Northwest and Yukon Territories; Geological Survey of Canada, Paper 74-11.
- Berner, R.A., 1980. Early diagenesis: A theoretical approach. Princeton Press, 250 pp..
- Brideaux, W.W., Chamney, T.P., Dunay, R.E., Fritz, W.H., Hopkins, W.S. Jr., Jeletzky, J.A., McGregor, D.C., Norford, B.S., Norris, A.W., Pedder, A.E.H., Sherrington, P.F., Sliter, W.V., Sweet, A.R., Uyeno, T.T., and Waterhouse, J.B., 1975. Biostratigraphic determinations for fossils from the subsurface of the Districts of Franklin and Mackenzie; Geological Survey of Canada, Paper 74-39.
- Brideaux, W.W., Clowser, D.R., Copeland, M.J., Jeletzky, J.A., Norford, B.S., Norris, A.W., Pedder, A.E.H., Sweet, A.R., Thorsteinsson, R., Uyeno, T.T., and Wall, J., 1976. Biostratigraphic determinations from the subsurface of the Districts of Franklin and Mackenzie and the Yukon Territory; Geological Survey of Canada, Paper 75-10.
- Brideaux, W.W., and Myhr, D.W., 1976. Lithostratigraphy and dinoflagellate cyst succession in the Gulf Mobil Parsons N-10 well, District of Mackenzie; Geological Survey of Canada, Paper 76-1B, p. 235-249.
- Cant, D.J., 1978. Development of a facies model for sandy braided river sedimentation: Comparison of the South Saskatchewan River and the Battery Point Formation: in *Fluvial Sedimentology*, A.D. Miall (ed.); Canadian Society of Petroleum Geologists, Memoir 5, p. 627-640.
- Chamberlain, C.K., 1978. Recognition of trace fossils in cores: in *Trace Fossil Concepts*; Society of Economic Paleontologists and Mineralogists, Short Course No. 5, p. 119-166.
- Chayes, F., 1956. Petrographic Modal Analysis: An elementary statistical appraisal. John Wiley and Sons, Inc., New York, 113pp..

- Côte, R.P., Lerand, M.M., and Rector, R.J., 1975. Geology of the Lower Cretaceous Parsons Lake gas field, MacKenzie Delta, Northwest Territories: in *Canada's Continental Margins*, C.J. Yorath, E.R. Parker, and D.J. Glass (eds.); Canadian Society of Petroleum Geologists, Memoir 4, p.613-632.
- Dapples, E.C., 1967. Diagenesis of Sandstones; in *Diagenesis in Sediments. Developments in Sedimentology 8*, Chapter 3. G. Larsons and G.V. Chilingar (eds.), Elsevier, p. 91-126.
- Deer, W.A., Howie, R.A., Zussman, J., 1966. *An Introduction to the Rock-forming Minerals*. John Wiley and Sons, New York. 207 pp..
- Dickinson, K.A., Berryhill, H.L.Jr., and Holmes, C.W., 1972. Criteria for recognizing ancient barrier coastlines; in *Recognition of Ancient Sedimentary Environments*, J.K. Rigby and Wm. K. Hamblin (eds.); Society of Economic Paleontologists and Mineralogists, Special Publication 16, p.192-214.
- Dixon J., 1982a. Sedimentology of the Neocomian Parsons Group in the subsurface of the Mackenzie Delta area, Arctic Canada; *Bulletin of Canadian Petroleum Geology*, Vol. 30, No. 1, p.9-28.
- , 1982b. Jurassic and Lower Cretaceous subsurface stratigraphy of the MacKenzie Delta-Tuktoyaktuk Peninsula, N.W.T.; *Geological Survey of Canada, Bulletin 359*.
- Elliot, T., 1983. Clastic shorelines; in *Sedimentary Environments and Facies*, H.G. Reading (ed.); Elsevier, New York, p.143-177.
- Folk, R.L., 1959. *Petrology of Sedimentary Rocks*. Hemphill Publishing Co., 154 pp..
- , 1968. *Petrology of Sedimentary Rocks*. Hemphill Publishing Co., 170 pp..
- 1975. *Petrology of Sedimentary Rocks*. Hemphill Publishing Co., 170 pp..
- Gulf Canada Resources Inc. , Calgary. Unpublished data.
- Hayes, J.B., 1979. Sandstone diagenesis-the hole truth: in *Aspects of Diagenesis*; Society of Economic Paleontologists and Mineralogists, Special Publication No. 26, p.127-139.
- Hea, J.P., Arcuri, J., Campbell, G.R., Fraser, I., Fuglem, M.O., O'Bertos, J.J., Smith, D.R., and Zayat, M., 1980. Post-Ellesmerian basins of Arctic Canada: Their depocentres, rates of sedimentation and petroleum potential, in A.D. Miall, (ed.), *Facts and Principles of World Petroleum Occurrences*; Canadian Society of Petroleum Geologists, Memoir 6, p.447-488.

Heward, A.P., 1981. A review of wave-dominated clastic shoreline deposits; *Earth Science Reviews*, 17, p.223-276.

Hilliard, J.E. and Cahn, J.W., 1961. An evaluation of procedures in quantitative metallography for volume-fraction analysis. *Transactions of the Metallurgical Society of AIME*, p.344-352.

Hoffman, J. and Hower, J., 1979. Clay mineral assemblages as low grade metamorphic geothermometers: Application to the thrust faulted disturbed belt of Montana, U.S.A.: in *Aspects of Diagenesis*; Society of Economic Paleontologists and Mineralogists, Special Publication No. 26, p.55-79.

Hunter, R.E., Clifton, H.E., and Phillips, R.L., 1979. Depositional processes, sedimentary structures, and predicted vertical sequences in barred nearshore systems, Southern Oregon coast; *Journal of Sedimentary Petrology*, Vol.49, No.3, p.711-726.

Hutcheon, I., 1981. Applications of thermodynamics to clay minerals and authigenic mineral equilibria: in *Clays and the Resource Geologist*, F.J.Longstaffe (ed.); Mineralogical Association of Canada, Short Course Handbook 7, Calgary, p.169-191.

Jeletzky, J.A., 1958. Uppermost Jurassic and Cretaceous rocks of Aklavik Range, northeastern Richardson Mountains, Northwest Territories; Geological Survey of Canada, Paper 58-2.

----- 1960. Uppermost Jurassic and Cretaceous rocks, east flank of Richardson Mountains between Stoney Creek and lower Donna River, Northwest Territories; Geological Survey of Canada, Paper 59-14.

----- 1961. Eastern slope, Richardson Mountains; Cretaceous and Tertiary structural and regional significance: in *Geology of the Arctic*, G.O.Raasch (ed.); Proceedings 1st International Symposium on Arctic Geology, University of Toronto Press, Vol.1, p.532-583.

----- 1967. Jurassic and (?) Triassic rocks of the eastern slope of Richardson Mountains, northwestern District of Mackenzie; Geological Survey of Canada, Paper 66-50.

----- 1974. Contribution to the Jurassic and Cretaceous geology of northern Yukon and District of Mackenzie, Northwest Territories; Geological Survey of Canada, Paper 74-10.

----- 1975. Jurassic and Lower Cretaceous paleogeography and depositional tectonics of Porcupine Plateau, adjacent areas of north Yukon and those of Mackenzie District; Geological Survey of Canada, Paper 74-16.

- 1980. Lower Cretaceous and Jurassic rocks of McDougall Pass area and some adjacent areas of north-central Richardson Mountains, northern Yukon Territory and northwestern District of Mackenzie, N.W.T. (NTS 116P/9 and 116P/10). A reappraisal; Geological Survey of Canada, Paper 78-22.
- in prep. Six new Lower Cretaceous Formations in Richardson Mountains, northern Yukon and District of Mackenzie, Northwest Territories (NTS 106,107,116,117). Geological Survey of Canada.
- Langhus, B.G., 1980. Generation and migration of hydrocarbons in the Parsons Lake area, N.W.T., Canada: in Facts and Principles of World Petroleum Occurrence, A.D. Miall (ed.); Canadian Society of Petroleum Geologists, Memoir 6, p.523-534.
- Lerand, M.M., 1973. Beaufort Sea: in The Future Petroleum Provinces of Canada, R.G.M. McGrossman (ed.); Canadian Society of Petroleum Geologists, Memoir 1, p.315-386.
- Mellon, G.B., 1964. Discriminatory analysis of calcite and silicate cemented phases of the Mountain Park sandstone: Journal of Geology, Vol.72, No.6, p.786-809.
- Miall, A.D., 1978. Lithofacies types and vertical profile models in braided river deposits: a summary: in Fluvial Sedimentology, A.D. Miall (ed.); Canadian Society of Petroleum Geologists, Memoir 5, p.597-604.
- Myhr, D.W., and Gunther P.R., 1974. Lithostratigraphy and coal reflectance of a Lower Cretaceous deltaic succession in the Gulf Mobil Parsons F-09 borehole, N.W.T.; Geological Survey of Canada, Paper 74-1B, p.24-28.
- Myhr, D.W., and Young F.G., 1975. Lower Cretaceous (Neocomian) sandstone sequence of Mackenzie Delta and Richardson Mountains area; Geological Survey of Canada, Paper 75-1C, p.247-266.
- Pettijohn, F.J., Potter, P.E., and Siever, R., 1972. Sand and Sandstone. Berlin-Heidelberg, New York: Springer, 618 pp..
- Powers, M.C., 1953. A new roundness scale for sedimentary particles: Journal of Sedimentary Petrology, Vol.23, p.117-119.
- Pryor, W.A., 1968. Reservoir inhomogeneities of Recent sandbodies. Final Report, American Petroleum Institute Research Project 91-B. American Petroleum Institute.

- Reineck, H.E., and Singh, I.B., 1973. Depositional Sedimentary Environments-With Reference to Terrigenous Clastics; Springer-Verlag, Berlin, 439 pp..
- Rust, B.R., 1978. Depositional models for braided alluvium: in Fluvial Sedimentology, A.D.Miall (ed.); Canadian Society of Petroleum Geologists, Memoir 5 p.605-626.
- Rust, B.R., 1979. Coarse alluvial deposits: in Facies Models, R.G.Walker (ed.); Geoscience Canada, Reprint Series 1, p.9-21.
- Salazar-Jimenez, A., Frey, R.W., and Howard, J.D., 1982. Concavity orientations of bivalve shells in estuarine and nearshore shelf sediments, Georgia: Journal of Sedimentary Petrology, Vol.52, No.2, p.565-586.
- Schmidt, V. and McDonald, D.A., 1979. The role of secondary porosity in the course of sandstone diagenesis: in Aspects of Diagenesis; Society of Economic Paleontologists and Mineralogists, Special Publication 26, p.175-207.
- Williams, P.F., and Rust, B.R., 1969. The sedimentology of a braided river: Journal of Sedimentary Petrology, Vol.39, p.649-679.
- Wilson, M.D., and Pittman, E.D., 1977. Authigenic clays in sandstones: Recognition and influence on reservoir properties and paleoenvironment analysis: Journal of Sedimentary Petrology, Vol.47, No.1, p.3-31.
- Winn, R.D., Jr., Stonecipher, S.A., Bishop, M.G., 1984. Sorting and wave abrasion: Controls on composition and diagenesis in lower Frontier sandstones, Southwestern Wyoming: American Association of Petroleum Geologists Bulletin, Vol. 68, No. 3, p.269-284.
- Wolf, K.H., and Chilingarian, G.V., 1976. Diagenesis of sandstones, and compaction: in Compaction of Coarse-Grained Sediments, II. Developments in Sedimentology 18B, G.V.Chilingarian and K.H. Wolf (eds.). Elsevier, p.69-444.
- Young, F.G., 1974. Use of sedimentary structures for recognition of clastic environments, M.S.Shaw (ed.); Canadian Society of Petroleum Geologists, 66 pp..
- Young, F.G., Myhr, D.W. and Yorath, C.J., 1976. Geology of the Beaufort-Mackenzie Basin; Geological Survey of Canada, Paper 76-11.

Appendix 1

Stratigraphic Tops

Tops of the formations and members of the Parsons Group and Husky Formation are given. These values form the basis of the isopach maps presented in this thesis. Contacts were picked from gamma ray/sonic logs, gamma ray/neutron or density logs, SP/DIL logs or sample logs (Canstrat) in descending order of preference. Information was augmented with core data where possible. Depths are given in metres and feet (in parenthesis). A question mark appearing beside a value indicates a questionable pick.

Gulf East Reindeer A-01

Parsons Group	
Kamik Formation	
marine member	2080.6(6826)
transitional member	2238.8(7345)
non-marine member	2366.5(7765)
McGuire Formation	2505.5(8220)
Martin Creek Formation	2529.8(8300)
Husky Formation	2560.9(8402)
lower member	2642.0(8668)

Gulf Mobil Siku A-12

Parsons Group	
Kamik Fm.	
marine mbr.	2658.5(8722)
transitional mbr.	2788.6(9149)
non-marine mbr.	2880.4(9450)
McGuire Fm.	2971.8(9750)
Martin Creek Fm.	2993.1(9820)
Husky Fm.	2560.9(9957)
lower mbr.	3109.0(10,200)

Nuna A-32 (from Canstrat)

Parsons Group	
Kamik Fm.	
marine mbr.	3237.0(10,620)?
transitional mbr.	3264.4(10,710)?
non-marine mbr.	3291.8(10,800)?
McGuire Fm.	3322.2(10,900)?
Martin Creek Fm.	3334.5(10,940)?
Husky Fm.	3401.6(11,160)?

Ula A-35

Parsons Group not present due to either faulting or erosion

Aklaavik A-37

Parsons Group

Kamik Fm.	
marine mbr.	887.0(2910)
transitional mbr.	993.7(3260)
non-marine mbr.	not present
McGuire Fm.	1017.1(3337)
Martin Creek Fm.	1024.7(3362)
Husky Fm.	1094.2(3590)
lower mbr.	1212.5(3978)

Gulf Mobil Parsons A-44

Parsons Group

Kamik Fm.	
marine mbr.	2905.7(9533)
transitional mbr.	3031.0(9944)
non-marine mbr.	3116.9(9944)
McGuire Fm.	3198.0(10,492)
Martin Creek Fm.	3209.5(10,530)
Husky Fm.	3264.1(10,709)
lower mbr.	3357.4(11,015)

Shell Unak B-11

Parsons Group

Kamik Fm.	
marine mbr.	1179.6(3870)
transitional mbr.	1324.4(4345)
non-marine mbr.	1541.7(5058)?
McGuire Fm.	1607.8(5275)?
Martin Creek Fm.	1670.3(5480)?
Husky Fm.	1802.0(5912)
lower mbr.	2008.6(6580)?

Gulf Mobil Siku C-11

Parsons Group

Kamik Fm.	
marine mbr.	2792.6(9162)
transitional mbr.	2890.7(9484)
non-marine mbr.	2981.0(9780)
McGuire Fm.	3015.1(9892)
Martin Creek Fm.	3037.6(9966)
Husky Fm. (probable fault)	3017.2(10,076)
lower mbr.	3180.0(10,433)

Imperial Wagnark C-23

Parsons Group

Kamik Fm.	
marine mbr.	3569.5(11,711)
transitional mbr.	3744.5(12,285)
non-marine mbr.	3842.0(12,605)
McGuire Fm.	3914.6(12,843)
Martin Creek Fm.	3929.8(12,893)
Husky Fm.	3969.1(13,022)
lower mbr.	4045.3(13,272)

Gulf East Reindeer C-38

Parsons Group

Kamik Fm.	
marine mbr.	1116.2(3662)
transitional mbr.	not present
non-marine mbr.	not present
McGuire Fm.	1170.7(3841)
Martin Creek Fm.	1176.5(3860)
Husky Fm.	1188.7(3900)
lower mbr.	1257.0(4124)

Gulf Mobil Siku C-55

Parsons Group

Kamik Fm.	
marine mbr.	4143.8(13,595)
transitional mbr.	4270.6(14,011)
hole TDs in transitional mbr. at	4506.5(14,785)

Gulf Mobil Parsons D-20 (depths taken from true vertical depth log)

Parsons Group

Kamik Fm.	
marine mbr.	2729.8(8956)
transitional mbr.	2838.0(9311)
non-marine mbr.	2949.6(9677)
McGuire Fm.	2955.3(9696)
Martin Creek Fm.	2981.6(9782)
Husky Fm.	3045.0(9990)
lower mbr.	3150.4(10,336)

Gulf Mobil Kamik D-48

Esso Pex Napartok M-01

Parsons Group

Kamik Fm.	
non-marine mbr.	fault contact at 1320.0(4331)
McGuire Fm.	1448.0(4751)
Martin Creek mbr.	1458.0(4784)
Husky Fm.	1523.0(4997)
lower mbr.	1618.0(5309)

IOE Pikiolik M-26

Parsons Group not present probably due to non-deposition and/or erosion.

Gulf Mobil Ogruknang M-31

Parsons Group

Kamik Fm.	
marine mbr.	3903.3(12,806)?
transitional mbr.	fault contact at 3950.8(12,962). Lower extent defined by fault at 4081.3(13,390).

Gulf Mobil Parsons N-10

Parsons Group

Kamik Fm.	
marine mbr.	2614.6(8578)
transitional mbr.	2682.6(8801)
non-marine mbr.	2746.9(9012)
McGuire Fm.	2827.9(9278)
Martin Creek Fm.	2848.1(9344)
Husky Fm.	2878.6(9444)
lower mbr.	2943.2(9656)

Gulf Mobil Parsons N-17 (taken from true vertical depth logs)

Parsons Group

Kamik Fm.	
marine mbr.	2871.5(9421)
transitional mbr.	2962.7(9720)
non-marine mbr.	3074.8(10,088)
McGuire Fm.	3152.9(10,344)
Martin Creek Fm.	3179.7(10,432)
hole TDs in Martin Creek Fm.	at 3208.3(10,526)

Gulf Mobil Parsons F-09

Parsons Group

Kamik Fm.	
marine mbr.	2693.8(8838)
transitional mbr.	2818.8(9248)
non-marine mbr.	2906.9(9537)
McGuire Fm.	2980.3(9778)
Martin Creek Fm.	3005.0(9859)
Husky Fm.	3055.3(10,024)
lower mbr.	3140.1(10,302)

Union Aklavik F-17

Parsons Group probably not present due to erosion and/or non-deposition

IOE Tuk F-18

Parsons Group

Kamik Fm.	
marine mbr.	3018.4(9903)
transitional mbr.	3045.6(9992)
non-marine mbr.	3099.2(10,168)
McGuire Fm.	3129.1(10,266)
hole TDs in McGuire Fm. at	3146.1(10,322)

Shell Napoiak F-31

Parsons Group

Kamik Fm.	
marine mbr.	759.0(2490)
transitional mbr.	824.2(2704)
non-marine mbr.	867.5(2846)
McGuire Fm.	893.1(2930)
Martin Creek Fm.	901.9(2959)
Husky Fm.	913.2(2996)
lower mbr.	981.2(3219)

Gulf Mobil Kamik F-38

Parsons Group

Kamik Fm.	
marine mbr.	3006.6(9864)
transitional mbr.	3102.3(10,178)
non-marine mbr.	3208.6(10,527)
McGuire Fm.	3234.8(10,613)
Martin Creek Fm.	3261.4(10,700)
Husky Fm.	3314.4(10,874)
lower mbr.	3372.0(11,063)

Union Aklavik F-38

Parsons Group

Kamik Fm.	
marine mbr.	1175.6(3857)
transitional mbr.	not present
non-marine mbr.	not present
McGuire Fm.	1222.2(4010)
Martin Creek Fm.	1236.6(4057)
Husky Fm.	1262.8(4143)
lower mbr.	1343.0(4406)

Gulf East Reindeer G-04

Parsons Group

Kamik Fm.	
marine mbr.	2807.2(9210)
transitional mbr.	2973.9(9757)
non-marine mbr.	3131.2(10,273)
McGuire Fm.	3240.9(10,633)
Martin Creek Fm.	3264.1(10,709)
Husky Fm.	3335.4(10,943)
lower mbr.	3458.9(11,348)

Shell Beaverhouse Creek H-13

Parsons Group

Kamik Fm.	
marine mbr.	318.5(1045)?
transitional mbr.	353.6(1160)
non-marine mbr.	387.7(1272)
McGuire Fm.	402.3(1320)
Martin Creek Fm.	417.9(1371)
Husky Fm. (fault contact)	502.9(1650)

Gulf Ikhil I-37

Parsons Group

Kamik Fm.	
marine mbr.	3174.2(10,414)
transitional mbr.	3503.7(11,495)
non-marine mbr.	3773.7(12,381)
McGuire Fm.	4141.3(13,587)
Martin Creek Fm.	4181.9(13,720)
Husky Fm.	4255.0(13,960)?
lower mbr.	4412.9(14,478)?

Gulf Mobil Ogeoqueog J-06

Parsons Group

Kamik Fm.	
marine mbr.	1625.2(5332)
transitional mbr.	1660.6(5448)
non-marine mbr.	not present
McGuire Fm.	1679.8(5511)
Martin Creek Fm.	1690.4(5546)
Husky Fm.	1695.9(5564)
lower mbr.	1734.3(5690)

IOE Eskimo J-07

Parsons Group not present due to non-deposition (and/or erosion)

IOE Mayogiak J-17

Parsons Group not present due to faulting and or erosion

Dome Imnak J-29

~~Parsons Group~~

Kamik Fm.	
 marine mbr.	2846.2(9338)
 transitional mbr.	2917.9(9573)
 non-marine mbr.	2988.6(9805)
McGuire Fm.	3046.2(9994)
Martin Creek Fm.	3070.6(10,074)
Husky Fm.	3130.3(10,270)
lower mbr.	-faulted out-fault contact at 3190(10,466)

IOE BA Tununuk K-10

Parsons Group probably not reached

Shell Tullugak K-31

Parsons Group

Martin Creek Fm.	faulted contact at 1985.5(6514)
Husky Fm.	2054.4(6740)
lower mbr.	2389.6(7840)

Banff Aquitaine-A.R.C.O: Rat Pass K-35

Stratigraphically and sedimentologically unfamiliar but Chamney micropaleontology (in Barnes et al., 1974) indicates Parson Group strata from at least 472.4(1550) to 588.3(1930).

Shell Kugpik L-24

Parsons Group not present probably due to erosion (may be faulted as well).

Gulf Mobil Parsons L-37 (taken from true vertical depth logs

Parsons Group

Kamik Fm.

marine mbr.

2709.7(8890)

transitional mbr.

2844.7(9333)

non-marine mbr.

2999.8(9842)

McGuire Fm.

3047.1(9997)

Martin Creek Fm.

3074.2(10,086)

Husky Fm.

3134.0(10,282)

lower mbr.

3218.7(10,560)

10E Mayogiak L-39

Parsons Group not present due to non-deposition, erosion or faulting.

Gulf Mobil Parsons L-43

Parsons Group

Kamik Fm.

marine mbr.

2697.5(8850)

transitional mbr.

2836.5(9306)

non-marine mbr.

2933.1(9623)

McGuire Fm.

3018.7(9904)

Martin Creek Fm.

3026.1(9928)

Husky Fm.

3086.4(10,126)

lower Fm.

3164.7(10,383)

Gulf Mobil Kamik L-60

Parsons Group

Kamik Fm.

2958.7(9707)

hole apparently TDs in Kamik Fm., but reports of depth are ambiguous

Esso Pex Napartok M-01

Parsons Group

Kamik Fm.	
non-marine mbr.	fault contact at 1320.0(4331)
McGuire Fm.	1448.0(4751)
Martin Creek mbr.	1458.0(4784)
Husky Fm.	1523.0(4997)
lower mbr.	1618.0(5309)

IOE Pikiolik M-26

Parsons Group not present probably due to non-deposition and/or erosion.

Gulf Mobil Ogruknang M-31

Parsons Group

Kamik Fm.	
marine mbr.	3903.3(12,806)?
transitional mbr.	fault contact at 3950.8(12,962). Lower extent defined by fault at 4081.3(13,390).

Gulf Mobil Parsons N-10

Parsons Group

Kamik Fm.	
marine mbr.	2614.6(8578)
transitional mbr.	2682.6(8801)
non-marine mbr.	2746.9(9012)
McGuire Fm.	2827.9(9278)
Martin Creek Fm.	2848.1(9344)
Husky Fm.	2878.6(9444)
lower mbr.	2943.2(9656)

Gulf Mobil Parsons N-17 (taken from true vertical depth logs)

Parsons Group

Kamik Fm.	
marine mbr.	2871.5(9421)
transitional mbr.	2962.7(9720)
non-marine mbr.	3074.8(10,088)
McGuire Fm.	3152.9(10,344)
Martin Creek Fm.	3179.7(10,432)
hole TDs in Martin Creek Fm.	at 3208.3(10,526)

Shell Kugpik 0-13

Parsons Group

Kamik Fm.

marine mbr. eroded out

transitional mbr.

non-marine mbr.

McGuire Fm.

Martin Creek Fm.

Husky Fm.

lower mbr.

2173.2(7130)

2257.0(7405)

2378.4(7803)

2436.3(7993)

2531.1(8304)

2780.7(9123)

IOE Tuktu 0-19

Parsons Group

Kamik Fm.

marine mbr. (erosional contact) 2033.3(6671)

transitional mbr.

non-marine mbr.

McGuire Fm.

Martin Creek Fm.

Husky Fm.

lower mbr.

2050.7(6728)

not present

2082.7(6833)

2084.8(6840)

2100.4(6891)

2140.0(7021)

Shell Kipnik 0-20

Parsons Group

Kamik Fm.

marine mbr.

transitional mbr.

non-marine mbr.

McGuire Fm.

Martin Creek Fm.

Husky Fm.

hole TDs in upper mbr. at 3556.1, 11,667)

2137.9(7014)

2383.3(7821)

2635.6(8647)

3057.1(10,030)

3138.2(10,296)

3299.8(10,826)

Gulf Mobil Parsons 0-27

Parsons Group

Kamik Fm.

marine mbr. (possibly a fault contact) 2926.7(9602)

transitional mbr.

lower extent defined by fault at 3055.0(10,023)

3034.3(9955)

IOE Mayogiak P-17

Parsons Group

Martin Creek Fm. (probably an erosional contact) 2685.3(881)

Husky Fm.

lower mbr.

2696.9(8848)

2713.9(8904)

Gulf Mobil Parsons P-41

Parsons Group

Kamik Fm.	
marine mbr.	2864.5(9398)
transitional mbr.	3013.6(9887)
non-marine mbr.	3116.3(10,224)
McGuire Fm.	3216.3(10,552)
Martin Creek Fm.	3231.5(10,602)
Husky Fm.	3298.8(10,803)
lower mbr.	3400.0(11,155)

Gulf Mobil Parsons P-53

Parsons Group

Kamik Fm.	
marine mbr.	2858.4(9378)
transitional mbr.	2976.1(9764)
fault contact at	3066.9(10,062)
Husky Fm.	
lower mbr.	3135.8(10,288)

Gulf East Reindeer P-60

Parsons Group

Kamik Fm.	
marine mbr.	969.9(3182)
transitional mbr.	not present
non-marine mbr.	not present
McGuire Fm.	1049.7(3444)
Martin Creek Fm.	not present
Husky Fm.	1053.1(3455)
lower mbr.	1104.9(3625)

Appendix 2

Subsurface Biostratigraphy

East Reindeer A-01

Megaspore identification by Sweet (in Brideaux et al., 1976, p.10) suggested an Albian age for the transitional member of the Kamik Formation (7544 - 7579 feet). This age suggested is questionable in light of the correlation of A-01 strata into well-dated Parsons Group rocks. Although caving hampered precise biostratigraphic dating benthonic Foraminifera indicate a possible Neocomian top at 4920 feet, (1900 feet above the Kamik Formation) according to Gulf Canada Resources (unpublished data).

Aklavik A-37

Benthonic foraminiferal work by Gulf Canada Resources (unpublished data) indicates a Barremian to Valanginian age for strata encompassing Parsons Group rocks from 2100 to 3800 feet. An uncertain Berriasian age is assigned to rocks from 3800 feet to the Jurassic top at 3850 feet.

East Reindeer C-38

Based on Foraminifera identification Gulf Canada Resources assigns a Barremian to Valanginian age to strata containing Parsons Group rock from 3350 to 3950 feet and a Berriasian age to strata from 3950 to 4490 feet.

Siku C-55

Benthonic foraminiferal work by Gulf Canada Resources

assigns a Barremian to Valanginian age to strata from 11,430 feet to bottom in the Kamik Formation at 14,785 feet.

Pikiolik E-54

The Parsons Group strata which probably occur in this well are cored from 8,498 to 8,506 feet. Using dominantly foraminiferal assemblages, Chamney, Jeletzky and Pedder (in Brideaux et al., 1975 p.12) assign these rocks to the Cretaceous-Jurassic boundary, while Brideaux (in Brideaux et al., 1976, p.4) using palynomorphs assigns a Hauterivian to Aptian, possibly no younger than Barremian age to the same strata. In this paper, the cored interval is correlated with the upper marine member of the Kamik Formation, of approximately early Hauterivian age.

Parsons F-09

Mainly by palynomorphs Brideaux (in Brideaux et al., 1975, p.4) assigned an Early Cretaceous age, probably Barremian to Hauterivian to strata cored from 9315 to 9375 feet. In this study, the cored interval is correlated with the transitional member of the Kamik Formation, probably of early Hauterivian or late Valanginian age. Elsewhere, Brideaux (in Brideaux et al., 1975, p.4) assigned a similar Barremian to Hauterivian age to strata cored at 9817 to 9847 feet. Gunther (in Myhr and Gunther 1974, p.26) also using palynomorphs dated the same rocks as late Neocomian (Hauterivian or Barremian). These rocks correlate with the McGuire Formation of early to middle Valanginian age elsewhere, suggesting an erroneous biostratigraphic interpretation

by Brideaux and Gunther in the lower core (see Dixon, 1982, p.18).

Benthonic Foraminifera studied by Gulf Canada Resources (unpublished data) indicate Neocomian age for strata from 7,180 feet to the top of the Jurassic at 10,220 feet. Parsons Group rocks are present from 8838 feet to 10,024 feet.

East Reindeer G-04

Palynomorph and mollusc studies by Brideaux and Jeletzky (in Barnes et al., 1974, p.7) and palynomorph studies by Sweet (in Brideaux et al., 1976, p.10) indicate ages of Early Cretaceous for strata cored from 9560 to 9591 feet. Sweet (op. cit.) suggested an Albian age which, in the light of correlations of this cored interval with the marine member of the Kamik Formation, elsewhere known to be Hauterivian in age, may be incorrect.

Benthonic foraminiferal and palynomorph work done by Gulf Canada Resources (unpublished data) assigns a Barremian to Valanginian age to strata from 7567 to 10,240 feet (containing the upper Kamik Formation), and a Berriasian age to strata from 10,240 feet to the top of the Jurassic at 11,110 feet. The base of the Parsons Group strata occurs at 10,943 feet.

Beaver House Creek H-13

Benthonic Foraminifera studied by Gulf Canada Resources

suggest a Neocomian age for strata from surface to the Jurassic top at 1850 feet. Parsons Group strata are present in the hole from approximately 1045 feet to 1650 feet.

Ikhil I-37

Benthonic foraminiferal and other microfossil work by Gulf Canada Resources indicates strata from 9140 to 14,550 feet are of Barremian to Berraisian age. Parsons Group rocks are present in the hole from 10,414 feet to 14,478 feet.

Mayogiak J-17

Using palynomorphs, Foraminifera and related microfauna, Brideaux, Chamney and Pedder (in Barnes et al., 1974 pp. 14-16) and Jeletzky (in Brideaux et al., 1975, p.7) , using pelecypods , assigned a (Late Jurassic?) Early Berriasian age to strata cored at 8850 feet. Rocks directly overlying this cored zone are lithostratigraphically similar to post-Parsons strata. Brideaux, Chamney and Pedder tentatively assign a Late Cretaceous age to rocks at 7,146 to 7,163 feet. Consequently, Parsons Group strata are thought to be absent by either faulting or erosion/non-deposition.

Rat Pass K-35

With palynomorphs, Brideaux (in Barnes et al., 1974, pp. 7-11) assigned strata from at least 1,550 to 1,930 feet a pre-Hauterivian-Neocomian age. These beds are stratigraphically and lithologically not comparable to typical Parsons Group rocks nearby and thus make the ages proposed suspect.

Pikiolik M-26

Strata directly overlying Paleozoic carbonates here are assigned an Aptian to Barremian age from 5,546 to 5,572 feet and an Aptian age from 5,572 to 5,576 feet by Chamney (in Brideaux et al., 1975, p.6). Consequently, no Parsons Group strata are believed present in the wellhole.

Parsons N-10

Dinoflagellate cysts identified by Brideaux and Mynr 1976 indicate a Valanginian to Hauterivian age for rocks from 7,900 to 9,325 feet (mainly Kamik Formation) and a Berriasian age to lowermost McGuire Formation, Martin Creek Formation and upper Husky Formation from 9,325 to 9,550 feet.

Benthonic Foraminifera and palynomorphs studied by Gulf Canada Resources (unpublished data) date strata from approximately 7,230 feet to the top of the Jurassic at 9,610 feet as of Neocomian age.

Kugpik 0-13

Palynomorph and pelecypod identifications by Brideaux and Jeletzky (in Brideaux et al., 1976, pp. 4-6) place strata from 7,137 feet to 7,610 feet as Early Cretaceous in age, and strata from 7,876 to 8,025 feet most likely as Valanginian in age. Less well defined strata from 8,160 to 8,320 feet are assigned a Late Jurassic to Early Cretaceous age by Brideaux and Jeletzky

(op. cit.). Parsons Group rocks extend from 7130 feet to 8304 feet.

Tuktu 0-19

Brideaux, Chamney and Pedder (in Barnes et al., 1974, p. 16) used palynomorphs, foraminifers and associated microfaunas to date the complex strata in this hole. They assigned a Jurassic-Cretaceous boundary age to strata which in this report, is believed to be post- Parsons rock, elsewhere of Barremian and younger age. They, as well, assigned a Late Jurassic age to cored strata from 6,883 to 6,913 feet. In contrast, palynomorph work by Brideaux (in Brideaux et al. 1976, p.4) assigns the same strata (6,810 to 7,050 feet) an Early Cretaceous (Hauterivian to Albian) age. Brideaux (op.cit.) assigned a Late Jurassic, Early Tithonian age to strata immediately below the above mentioned interval.

The ambiguous nature of the biostratigraphic work attempted in this well makes age assignments difficult. In this study, the stratigraphy of this locality is based upon the lithology, log responses and the correlation of typical stratigraphic characteristics to neighbouring wells.

Kipnik 0-20

Palynological and foraminiferal work by Gulf Canada Resources (unpublished data) assigns strata from 5,190 to 10,700 feet as Early Cretaceous, no younger than Barremian in age. Parsons Group rocks extend from 7014 feet to 10,826 feet in this

well.

East Reindeer P-60

Gulf Canada Resources (unpublished data) assigns an Aptian to Valanginian age to strata from 2,550 to 3,500 feet and a Berriasian age to strata from 3,500 to 4,560 feet. Parsons Group rocks are present from 7014 to 10,826 feet in this well.

Appendix 3

X-ray Analyses

Sample Depth (m)	Montmorillonite	Illite	Kaolinite	Chlorite
N-10				
2752.0	-	50	50	-
2760.6	54	39	7	-
2765.2	38	49	13	-
2798.1	8	38	54	-
2803.9	-	66	34	-
2845.0	-	92	8	-
2850.2	3	62	35	-
2855.1	6	58	36	-
2858.7	-	85	15	-
2863.9	-	76	24	-
A-01				
2305.2	-	66	32	2
2308.9	-	58	41	1
G-04				
2921.5	-	75	25	-
2937.1	-	77	23	-

Samples N-10 2752.0m and 2803.9m as well as samples from A-01 and G-04 show indication of mixed-clay layers being present. Semi-quantitative X-ray diffraction analysis of clay content in 5um fraction-in percent. Analyses done by Gulf Canada Resources, Calgary, August, 1983.

10E TUKTU O-19

PARSONS N-10

Figure 41. Detailed graphic display of core 10E TUKTU O-19 & PARSONS N-10

11

Figure 43. Detailed graphic display of core-Tullugak K-31

Figure 43. Detailed graphic display of core-Parsons N-10

PARSONS F-09

Figure 45. Detailed graphic display of core-Parsons F-09

PARSONS N-10

Figure 46. Detailed graphic display of core-Parsons N-10

PARSONS L-43

Figure 47. Detailed graphic display of core-Parsons L-43

WAGNARK C-23

IKHIL I-37

Figure 48. Detailed graphic display of core-Wagnark C-23&Ikhil I-37

SIKU E-21

Figure 49. Detailed graphic display of core-Siku E-21

PARSONS L-43

SIKU E-21

Figure 50. Detailed graphic display of core-Parsons L-43&Siku E-21

PARSONS F-09

Figure 51. Detailed graphic display of core-Parsons F-09

SIKU A-12

Figure 52. Detailed graphic display of core-Siku A-12

OGRUKNANG M-31

WAGNARK C-23

Figure 53. Detailed graphic display of core-Ogruknang M-31&Wagnark C-23

3 3

OF / DE

EAST REINDEER A-01

Figure 54. Detailed graphic display of core-Reindeer A-01
& IOE Tuk F-18

The figure is a stratigraphic column diagram. On the left, two vertical scales show depth in FEET (9560 to 9590) and METRES (2914 to 2922). The central part of the diagram shows a series of horizontal bars representing different geological layers or fossils, some labeled with letters like 'A' and 'B'. To the right of the column, there are three columns of information: FAUNAL REMNANTS and ENVIRONMENT. The FAUNAL REMNANTS column contains symbols like 'U' and 'V' followed by text such as 'TEREBELLINA SP. BURROW' and 'CHONDRITES SP. BURROW'. The ENVIRONMENT column contains text like 'UPPER OFFSHORE TO LOWER SHOREFACE'. At the bottom of the diagram, there is a row of boxes labeled CLAY, SLT, VF, F, M, C, VC.

FEET	METRES	LITHOLOGY / FEATURES	FAUNAL REMNANTS	ENVIRONMENT
9560	2914		V	
			∞	
			V	
			∞	
			V	
9570	2917		? V	<u>TEREBELLINA</u> SP. BURROW
			∞ V	
			∞ V	
			? ∞ V	CHONDRITES SP. BURROW UPPER OFFSHORE TO LOWER SHOREFACE
			∞	(LOCATION UNCERTAIN)
			∞	
9580	2920		V V	
			? ∞ V	<u>TEREBELLINA</u> SP. BURROW
			∞	
			∞ V	
			∞ V	
	2922			
9590			? ∞ V	<u>TEREBELLINA</u> SP. BURROW
9591				

CLAY	SLT	VF	F	M	C	VC
------	-----	----	---	---	---	----

PARSONS P-41

Figure 56. Detailed graphic display of core-Parsons P-41

SIKU A-12

Figure 57. Detailed graphic display of core-Siku A-12

PARSONS L-43

Figure 58. Detailed graphic display of core-Parsons L-43

IOE TUK P

FEET METRES

IOE PIKIOLIK

FEET METRES

SIKU E-2

FEET METRES

Figure 59. Detailed graphic display of IOE Pikiolik E-54&Siku E-2

10E TUK F-18

10E PIKILIK E-54

SIKU E-21

Figure 59. Detailed graphic display of core- 10E Tuk F-18, 10E Pikilik E-54, SIKU E-21

14

642

24

* Kugpiq O-13

Kipnik O-20

* Ikhlil I-37

* Reindeer A-01

20km.

29km.

12km.

NW

SE

DATUM

Base of Mount
Goodenough
Formation

6500 Siku

Formation

10000

7000

10500

7500

Upper
Cretaceous
rocks

marine

member

7500

intertidal
mixed flat

C Early Cretaceous

11000

8000

non-marine member

transitional

Kan

30

10500
Gulf Form
For

40f

54

Formation boundary.....
Intraformational boundary..
Unconformity.....

*Parsons Group strata
assigned a general
Neocomian age

Vertical Scale
Metres

Tununuk High

Lithologies given for Reindeer A-01
and Kugpik 0-13 from Dixon, 1982

* Biostratigraphic determinations on file
at Gulf Canada Resources, Calgary.

* C Brédeaux, et al., 1976

Husky Formation

BOTTOM

Kugmallit

54

Tununuk High

Lithologies given for Reindeer A-01
and Kugvik 0-13 from Dixon, 1982

* Biostratigraphic determinations on file
at Gulf Canada Resources, Calgary.

C Bideaux, et al., 1976

100
150
200

All vertical sections have depths disp

er A-01
1982

ns on file
Calgary.

Kugmallit Trough

Figure 8. Detailed SE-NW stratigraphic cross-section across the Kugmallit Trough. For location

Tununuk High

er A-01
1982

ns on file
algary.

HUSKY FORMATION

member

McGuire
Formation

Martin Creek

Formation

upper member

* Parsons Group strata assigned
a general Barremian to Berriasian
age. Top of Jurassic at 14,550

BOTTOM OF HOLE

Kugmallit Trough

All vertical sections have depths displayed in feet

These
M.S.C.
1984
S.G.

Aklavik A-37 *

Napartuk M-01

Reindeer P-60 *

Reindeer A-01 *

Ikhil-37 *

Reindeer C *

24

304

Reindeer G-04 * Parsons F-09 * Imnak J-29 Tuktu O-19 Pikiolik E-54 Pikiolik M-28

30

40f

Kam
Forma

Vertical Scale
Metres

All vertical scale
depths are in metres

Formation boundary.....

Intraformational correlation.....

Unconformity (may occur at
formation boundary).....

Secondary correlation.....

5 of 1

Lithologies given for Pikiolik E-54,
Tuktu O-19, Parsons F-09, Reindeer
A-01 and Aklavik A-37 from Dixon, 1982

A Barnes et al., 1974
B Brideaux et al., 1975
C Brideaux et al., 1976

* Biostratigraphic determinations on file at Gulf Ca

Figure 5. Detail

Tunuvuk High

100

Coal lense or bed
Mudstone interbeds

5 of

Lithologies given for Pikiolluk E-54,
Tukty O-19, Parsons F-09, Reindeer
A-01 and Aklavik A-37 from Dixon, 1982

A Barnes *et al.*, 1974

B Brideaux *et al.*, 1976

C Brideaux *et al.*, 1976

* Biostratigraphic determinations on file at Gulf Canada Resources, Calgary.

* Parsons Group strata
assigned a general
Barremian to Burrianian
age. Top of Jurassic
at 14,550 feet.

Kugmallit Trough

Figure 5. Detailed NE-SW stratigraphic cross-section along the

d fla

Figure 2. Detailed NW-SE stratigraphic cross-section across the Kugmunt Trough. For location see figure 1.

150

200

- Sandstone
- Mudstone
- Limestone
- Coal lense or bed
- Mudstone interbeds
- Silty
- Sandy
- Pebbly

d flank of the Eskimo Lakes Arch. For location see figure 2.

END

11-06-86

FIN