JURASSIC/CRETACEOUS BOUNDARY IN WEST-CENTRAL ALBERTA

J.W.Kramers
and
G. Dolby[1]

ARC Open File Report 1993-26

November, 1993

[1] G. Dolby and Associates, Calgary, Alberta

EXECUTIVE SUMMARY

The Jurassic/Cretaceous boundary in a well is important to both industry and government because it determines the stratigraphic limit of a company's oil and natural gas rights. In west -central Alberta this boundary is elusive because the only definitive way to locate it, is by the use of paleontology. This report, a cooperative effort between industry and government organizations, presents regional cross sections in which the location of the boundary has been defined using palynology, core studies and detailed correlations. The cross sections represent a grid of control wells that can be used to further detailed studies in local areas, such as that presented in the companion volume to this report, ARC Open File Report 1992-23.

The report discusses Jurassic stratigraphy, the nature of the Jurassic/Cretaceous boundary and includes nine regional cross sections, as well as the results of all 268 palynological analyses that were performed for this study. Because paleontological analysis is the only definitive method to locate this important boundary, this study recommends that in future, whenever possible, core is taken and palynological analyses performed to establish the exact location of the boundary. This will help both industry and government in defining the stratigraphic limit of oil and gas leases.

CONTENTS

Page

Introduction 1
Previous Work 1
Regional Stratigraphic Relationships 5
Poker Chip to Rock Creek transition 5
Other Jurassic units 7
Jurassic / Cretaceous Boundary 8
Conclusions 10
Acknowledgements 10
References Cited 11
Appendix 1 - Palynological Analysis 14
Regional Cross Sections ..... in pocket

FIGURES

Figure 1. Location map showing the study area and the location of the nine regional cross sections used in this study 2

Figure 2. Jurassic palynological zonations and stratigraphy (modified from Poulton et al., 1990) 6

Figure 3. Schematic a) early to mid Jurassic paleogeography, and b) early Cretaceous paleogeography (after Marion, 1982 and Jackson, 1984) 9

TABLES

Table 1. Wells logged and sampled for palynological analysis 3

INTRODUCTION

This report on the Jurassic/Cretaceous boundary in west-central Alberta is a follow-up on a request by the Alberta Department of Energy for the Alberta Geological Survey to help solve the definition of this important boundary in several wells in the Niton area, as well as in the Medicine River Field. The boundary between these geological systems is important in defining oil and gas leases. The objective of this study was to establish a bridge between the Niton area and the Gilby/Medicine River/Sylvan Lake fields area by means of regional cross sections and to make the palynological data used in this study available to both industry and government. Studies in the Niton area (Losert, 1986, 1990) have shown that age dating using palynology is the only sure way to differentiate Jurassic and Cretaceous strata.

The study area is shown in Figure 1 and encompasses Townships 33 to 55, west of the fifth meridian between the Jurassic subcrop in the east, and the edge of the disturbed belt in the west. By sampling cores that cross the Jurassic/Cretaceous boundary along a series of NW to SE and NE to SW cross sections, a grid of wells containing the paleontologically defined boundary has been established. These wells (Table 1) can then be used for further detailed correlations or studies in local areas. Cross section B* - B' includes the tie well (7-22-37-4W5) between this regional study and the local study focussed on the Medicine River and Sylvan Lake areas by Strobl et a. (1993b). The present report is made up of three sections. An introductory text section outlines the regional stratigraphic framework and discusses the Jurassic/ Cretaceous boundary; an appendix with the results of all the palynological analyses on a well by well basis; and a folder containing the regional cross sections that show the Jurassic stratigraphy and palynological results. G. Dolby and Associates provided the palynological interpretations. The senior author takes the responsibility for the interpretations expressed in this report and the correlations on the cross sections.

PREVIOUS WORK

The location and nature of the Jurassic/Cretaceous boundary has been the subject of a number of previous stratigraphic studies. In the northern part of the present study area Losert (1986, 1990) and Marion (1982, 1984) have defined the relationships

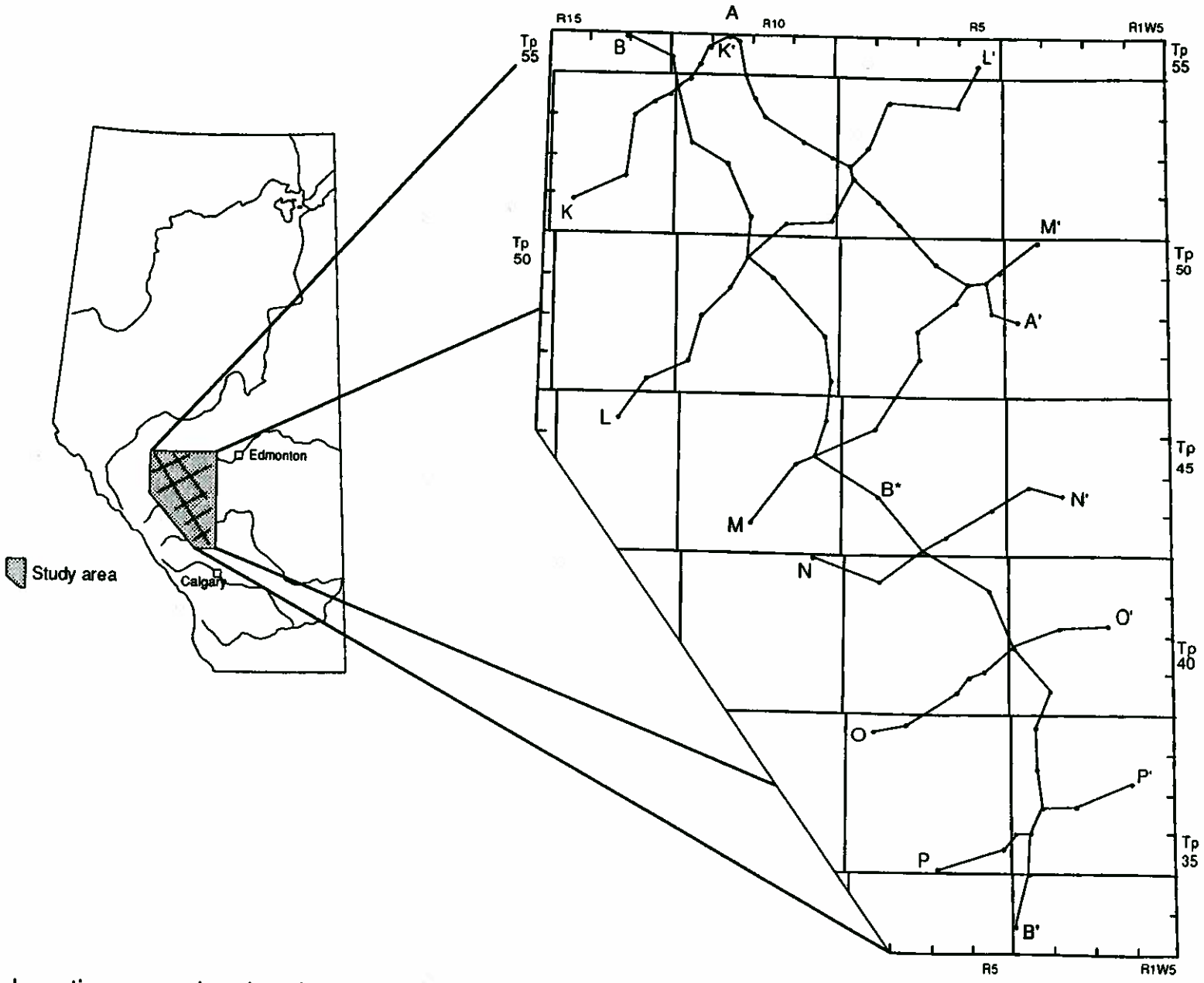


Figure 1. Location map showing the study area and the location of the nine regional cross sections used in this study.

Table 1. Wells logged and sampled for palynological analysis.

Lsd	Sec	Twp	Rge	Mer.	Sample Number	# of samples
10	26	33	3	5		
11	19	33	4	5	92-54	4
11	33	34	4	5	92-51	2
8	24	34	7	5		
10	31	35	4	5	92-49	3
10	33	35	4	5	92-50	3
8	23	35	5	5	92-52	2
4	5	35	6	5	92-53	4
14	22	36	3	5	92-57	3
10	23	36	4	5		
11	23	36	4	5	92-48	3
6	12	37	2	5	92-59	1
10	36	37	2	5	92-58	2
12	21	37	3	5		
7	22	37	4	5	92-47/92-64	4
11	22	38	4	5	92-46	10
14	21	38	7	5	92-30	4
16	15	38	8	5	92-29	3
2	24	39	4	5		
8	24	39	4	5	92-55	4
10	21	39	5	5	92-45	1
14	19	40	4	5	92-31	3
4	4	40	5	5	92-15	1
4	9	41	2	5	92-56	1
12	5	41	3	5	92-32/92-70	6
10	17	41	3	5		
10	24	41	3	5	92-12	2
16	34	41	5	5	92-14	4
8	4	42	5	5	92-26/92-63	6
16	15	42	5	5	92-27	2
8	11	42	8	5	92-44	6
12	32	42	9	5	92-43	1
2	16	43	6	5	92-28	2
6	1	43	7	5	92-13	3
6	26	43	11	5	92-5/92-38	5
10	17	44	3	5	92-33	1
16	21	44	4	5	92-34	2
12	22	44	4	5		
6	3	44	5	5		
6	20	44	5	5		
8	14	44	8	5	92-11	4
7	17	45	9	5	91-19/92-37	8
1	11	45	10	5	92-6/92-39	8
6	2	46	8	5	92-7	4
11	10	46	9	5	91-18/92-35	4
10	19	46	14	5	91-20	7
4	36	47	7	5		

cont'd

Table 1. Wells logged and sampled for palynological analysis (cont'd)

11	11	47	9	5	91-17	7
14	29	48	4	5		
6	15	48	9	5	91-16	5
5	34	48	12	5	91-21	6
2	3	49	5	5		
16	28	49	5	5	92-21	1
12	30	49	5	5	92-8	3
8	32	49	10	5	91-15	2
11	20	49	11	5	91-23/92-41	4
12	35	50	4	5	92-10	1
6	1	50	5	5	92-9	1
6	8	50	6	5		
8	15	50	11	5	91-22/92-40	6
6	9	51	7	5		
14	25	51	8	5	92-20	2
6	33	51	8	5	92-19	2
15	11	51	9	5	91-24	3
8	10	51	10	5	92-25	3
8	14	51	11	5	92-24	6
7	28	51	15	5	92-60	3
15	9	52	8	5	92-18	3
1	17	52	8	5	92-62	5
1	17	52	8	5		
4	29	52	8	5	92-1	3
14	31	52	8	5		
7	35	52	9	5	92-16	3
3	29	52	11	5	C. Singh/Marion (1984)	
3	14	52	14	5	91-14	8
16	3	53	8	5	92-2	3
7	31	53	10	5	92-17	3
8	8	53	12	5		
7	36	53	14	5	92-61	2
6	12	54	6	5	92-4	6
6	18	54	7	5	92-3	4
4	13	54	11	5	92-23	3
10	34	54	11	5	92-22	4
4	30	54	12	5	C. Singh	
6	32	54	12	5	C. Singh	
10	14	54	13	5	C. Singh	
13	21	55	11	5	91-6	6
13	27	55	11	5	91-3	5
10	29	55	11	5	91-5	5
9	32	55	11	5	91-13	4
4	34	55	11	5	91-4	5
6	10	55	12	5	91-12/92-36	4
11	24	55	12	5		
6	13	55	13	5	C. Singh	
7	35	55	14	5	91-11	4

between stratigraphic units (e.g. Fernie, Niton B, Rock Creek, Poker Chip, versus Cretaceous-aged sands and shales) and mapped the boundary between the Jurassic and Cretaceous systems. To the north of the present study area, Poulton et al. (1990) have defined the boundary in a number of wells. In the southeastern corner of the study area (Twp 35 - 40, Rg 1 - 5 W5) a series of authors (Ter Berg; 1966, Watkins, 1966a, 1966b; Deere and Bayliss, 1969; Rall, 1980; Hopkins, 1981, 1982; Collar, 1990; Handcock et al., 1993; and Strobl et al., 1993a, 1993b) have delineated the stratigraphic relationships of a large number of Jurassic and Lower Cretaceous units (Nordegg, Poker Chip Shale, Rock Creek sandstones, Fernie Shale, J1, J2, J3 sandstones, etc.). Young (1992), Kramers et al. (1992), and Putnam and Moore (1993) have looked at the regional nature of the Jurassic units and their relationships with overlying Cretaceous strata. The interested reader is referred to these studies for more details.

REGIONAL STRATIGRAPHIC RELATIONSHIPS

In addition to delineating the Jurassic/Cretaceous boundary, the present study also has sampled the cored Jurassic section to the top of the Nordegg. Figure 2 shows the stratigraphic and age relationships of the regional Jurassic units in the study area, based on palynological zonations. The results of the palynological analyses (268 samples from 95 wells examined) are given in Appendix 1 and shown on the grid of nine regional cross sections (Figure 1 and pocket). These cross sections also show the relationships of the major Jurassic unit from the Nordegg to the sub-Cretaceous unconformity. Because of the extreme complexity of the Lower Cretaceous units, no Cretaceous correlations, other than the Ostracod marker datum are shown. For a detailed description of the Jurassic units, the interested reader is referred to Losert (1986, 1990), Marion (1982, 1984), Collar (1990), Rall (1980), Putnam and Moore (1993) and Strobl et al. (1993b). Springer et al. (1963), Hall (1984), Poulton (1988), Poulton (1989), and Poulton et al. (*in press*), provide a more regional stratigraphic analysis of the Jurassic in the Western Canada Sedimentary Basin.

Poker Chip to Rock Creek transition

Previous to this study the Poker Chip - Rock Creek contact had been assumed to be unconformable. However, in the majority of cores examined, this appears to be a transitional contact, either in age (from palynology) or lithology. The typical Poker

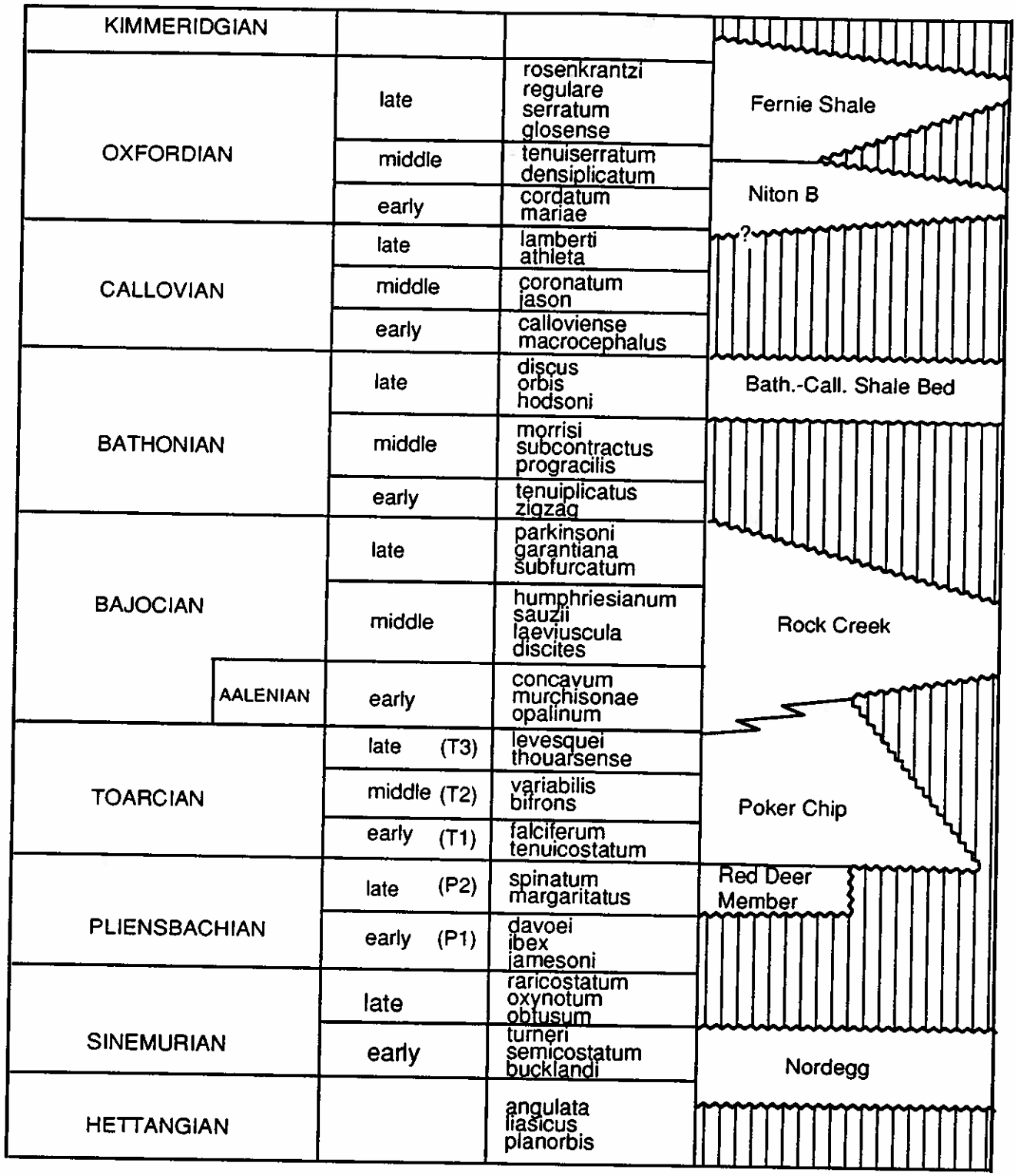


Figure 2. Jurassic palynological zonations and stratigraphy (modified from Poulton et al., 1990).

Chip palynoflora continues on into the shales between the basal Rock Creek sands. Typical Rock Creek sands are also found in stratigraphic positions that are laterally equivalent to Poker Chip shales (wells 6-13-55-13W5 and 4-30-54-12W5, cross section B -B*). Vice versa, Poker Chip shales laterally grade into unquestionable Rock Creek sands (wells 8-11-42-8W5 and 6-1-43-7W5, cross section N - N'). In the extreme southeast of the study area an unconformable relationship can be shown between the Poker Chip shale and the overlying Rock Creek sands (Strobl et al., 1993b). To the north of the study area, Poulton et al. (1990) found several cores where there also appears to be an unconformable relationship. Young (1992) in his sequence stratigraphic analysis of the Jurassic sediments in west-central Alberta has suggested that a major sequence boundary exists between the Poker Chip shales and the Rock Creek sands and that lateral equivalents of Rock Creek and Poker Chip lithologies are the result of Rock Creek channels cutting down into the Poker Chip shales. The palynological evidence from this study shows that sedimentation must have been continuous. Locally the Rock Creek may have cut into underlying shales. Sedimentologically, the transition from the Poker Chip shale to the Rock Creek sands probably is one of energy levels in the depositional environment, probably documenting wave base. Thus the Poker Chip shales are the deeper water lithofacies and the Rock Creek sands the shallower lithofacies, within reach of storm wave base. In the north-west portion of the study area (Niton area), a shale conformably overlies the Rock Creek sands, suggesting a similar transition at the top of the Rock Creek.

Other Jurassic units.

Locally the Rock Creek is overlain by the lower Oxfordian Niton B sands or mid to upper Oxfordian Fernie Shales (Figure 2, cross sections B - B* and K - K'). The Niton B sands are only found in the northwestern portion of the study area, and unconformably overlie the Rock Creek sands or shales. In some wells in this area, a thin capping of the more regionally widespread Fernie shale is found (Losert, 1990). Over the remainder of the study area the Fernie Shale is the youngest Jurassic unit. The Bathonian - Callovian shale shown on figure 2 was not found in this study. However, Strobl et al. (1993b) have found this shale in the Medicine River/Sylvan Lake area.

JURASSIC/CRETACEOUS BOUNDARY

The Jurassic/Cretaceous boundary is an unconformable surface. It records the shifting of sediment sources from a mature, easterly source terrain on the Canadian shield, to the rising Cordillera with a mixture of sediment sources, predominantly immature (Figure 3). Thus one would expect Jurassic sediments to be mature, with sands being quartzose and containing no grains such as feldspars and detrital micas. On the other hand, sediments from the rising Cordillera would have come from a mixed source area containing sedimentary, igneous, metamorphic and volcanic rocks. Therefore, one would expect complex mineralogies in the Lower Cretaceous sands. However, as shown by Hopkins (1982) quartzose sands do occur in the Lower Cretaceous Ellerslie Member, especially in channel sands that rework Jurassic strata. In addition, most researchers agree that the Jurassic sediments were deposited under dominantly nearshore to offshore, marine conditions and the Cretaceous sediments were deposited under a mix of depositional conditions, ranging from nearshore marine to continental. Consequently, the presence of coal, abundant carbonaceous debris, chert, feldspar, and other fragile grains would indicate a Cretaceous age, whereas the presence of marine borrowing traces, calcareous shell debris or coquinas, and an absence of fragile grains would point towards a Jurassic age. If no palynologic data is available, then the above considerations would allow for some distinction between Jurassic and Cretaceous lithologies.

The strata on either side of the Jurassic / Cretaceous boundary can be of any lithology. In this study, a variety of combinations and lithologic contacts were found. In some cases an apparently uniform succession of shales consisted of Oxfordian Fernie shales overlain by Lower Cretaceous shales (e.g 16-34-41-5W5), or a thin pebble bed in a shale records the boundary (11-10-46-9W5). Sometimes the unconformity separates two sands, the upper a typical Lower Cretaceous, carbonaceous, salt and pepper sandstone, and the lower a quartzose, argillaceous Rock Creek sandstone (8-14-51-11W5). In a large number of cases, Lower Cretaceous shales directly overlie Jurassic Rock Creek (2-16-43-6W5, 14-25-51-8W5) or Niton B sands (10-14-54-13W5). Another common occurrence is a Lower Cretaceous sandstone lying on top of either Poker Chip shale (7-28-51-15W5) or the late Jurassic Fernie shale (7-17-45-9W5).

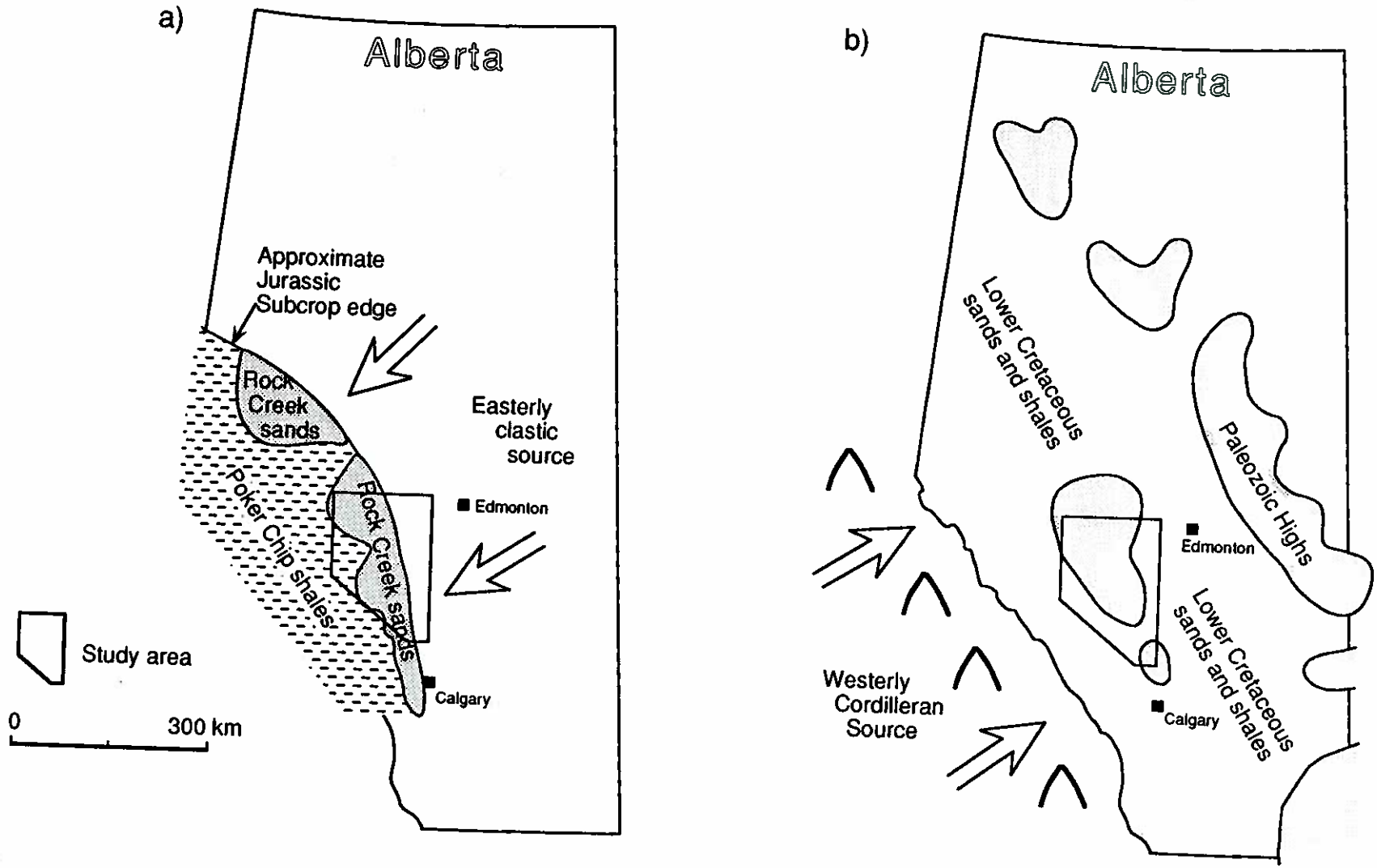


Figure 3. Schematic a) early to mid Jurassic paleogeography and b), early Cretaceous paleogeography. (after Marion, 1982 and Jackson, 1984)

To definitively locate the Jurassic/Cretaceous boundary, a sequence of samples for palynological analysis is needed, because one isolated sample may give the wrong answer. In the 7-35-52-9W5 well, detrital Jurassic shale material overlies Cretaceous age shales. In this case the Jurassic shales came from an eroded valley wall and were deposited into a Cretaceous valley-fill. Lithologically it was not possible to identify the Jurassic-age shale as detrital. Cretaceous-age material can also be found infilling karst caverns or pipes in either Nordegg or Mississippian limestones. When palynological analysis is not conclusive (no recovery) or available, then lithological attributes may allow for a probable determination.

CONCLUSIONS

The Jurassic/Cretaceous boundary can be difficult to delineate because it separates similar lithologies of different ages. However, using core studies, detailed local correlations and paleontological results, the boundary can be defined with certainty. Jurassic sediments were deposited under predominantly marine conditions and were derived from a mature source area. In contrast, Cretaceous strata consist of sediments derived from the rising Cordillera to the west or reworked siliciclastics from underlying strata, and were deposited in a wide variety of depositional environments. Thus the presence of coal, carbonaceous debris, chert, feldspar and other fragile grains indicates a Cretaceous age, whereas the presence of marine borrowing traces, calcareous shell debris or coquinas, and an absence of fragile grains would point towards a Jurassic age. Because paleontological analysis is the only definitive method to locate this important boundary, this study recommends that in future when wells are drilled that are projected to penetrate the Jurassic/Cretaceous contact, core is taken and palynological analyses performed to establish the exact location of the boundary. This will help both industry and government in defining oil and gas leases and will help to solve problems with deeper rights reversion.

ACKNOWLEDGEMENTS

The authors would like to thank the following organizations for their support of this study: Amoco Canada Petroleum Company for financially supporting this study; the Alberta Energy Resources Conservation Board for granting us free use of the ERCB

Core Research Centre facilities; and Chevron Canada Resources for supplying some paleontological data. We would also like to thank the following people that helped with various stages of the study. Ed Niewinski of the Energy Resources Conservation Board helped in reviewing wells, pointing out problem areas and assisted with logging some of the cores. Sheila Stewart and Dennis Nikols of the Alberta Geological Survey helped with establishing and building of the cross sections, which were then transferred to and drafted on a Macintosh workstation by Campbell Kidston. Lastly, we would like to thank Rudy Strobl who gave constructive input on the correlations from his point of view in dealing with the Jurassic/Cretaceous boundary in the Medicine River and Sylvan Lake areas in the southeast corner of the study area. This study has also benefitted from constructive comments by the geological staff of the Alberta Department of Energy and the Alberta Energy Resources Conservation Board.

REFERENCES CITED

Collar, I.S. (1990) Stratigraphy and sedimentology of the Jurassic Fernie Formation in the Sylvan Lake, Medicine River and Gilby Fields, South-Central Alberta: MSc. Thesis, University of Alberta, 232 p.

Deere, R.E. and Bayliss, P. (1969) Mineralogy of the Lower Jurassic in west central Alberta: Bulletin of Canadian Petroleum Geology, vol. 17, no. 2, p. 133-154.

Hall, R.H. (1984) Lithostratigraphy and biostratigraphy of the Fernie Formation (Jurassic) in the southern Canadian Rocky Mountains: *in,* Stott D.F. and Glass, D.J. (*eds.*), The Mesozoic of Middle North America, Canadian Society of Petroleum Geologists Memoir 9, p. 233-248.

Handcock, P.R., Hopkins, J.C., Strobl, R.S. and Dolby, G. (1993) Age of Jurassic valley fill successions, Medicine River and Gilby areas, central Alberta (Abstract): Canadian Society of Petroleum Geologists 1993 Annual Meeting Program and Abstracts, p.129.

Hopkins, J.C. (1981) Sedimentology of quarztose sandstones of Lower Mannville and associated units, Medicine River area, central Alberta: Bulletin of Canadian Petroleum Geology, vol. 29, no. 1, p. 12-41.

Hopkins, J.C. (1982) Reservoir facies patterns in deposits of a shallow inland sea: Ellerslie and Ostracod sandstones of the Medicine River Field in Hopkins, J.C. (*ed.*) Depositional Environments and Reservoir Facies in some Western Canadian Oil and Gas Fields, University of Calgary Core Conference, p. 94-101.

Jackson, P.C. (1984) Paleogeography of the Lower Cretaceous Mannville Group of Western Canada: *in*, J.A.Masters (*ed.*), Elmworth - Case Study of a Deep Basin Gas Field, American Association of Petroleum Geologists Memoir 38, p. 49-77.

Kramers, J.W., Dolby, G., Nikols, D. and Strobl, R.S. (1992) The Jurassic-Cretaceous Boundary in West-Central Alberta (Abstract): 1992 AAPG Annual Meeting Program and Abstracts, p. 69.

Losert, J. (1990) The Jurassic-Cretaceous Boundary Units and Associated Hydrocarbon Pools in the Niton Field, West-Central Alberta: Alberta Research Council Open File Report 1990-1, 41 p.

Losert, J. (1986) Jurassic Rock Creek Member in the subsurface of the Edson area (West-Central Alberta): Alberta Research Council Open File Report 1986-3, 39 p.

Marion, D.J. (1982) Discrimination of Jurassic and Lower Cretaceous lithologies and depositional patterns, West-Central Alberta *in*, Hopkins, J.C. (*ed.*) Depositional Environments and Reservoir Facies in some Western Canadian Oil and Gas Fields, University of Calgary Core Conference, p. 116-125.

Marion, D.J. (1984) The Middle Jurassic Rock Creek member and associated units in the subsurface of West-Central Alberta: *in*, Stott, D.F. and Glass, D.J. (*eds.*) The Mesozoic of North America, Canadian Society of Petroleum Geologists Memoir 9, p. 319-343.

Poulton, T.P. (1989) Upper Absaroka to Lower Zuni: the Transition to the Foreland Basin: *in*, B.D.Ricketts (*ed.*) Western Canada Sedimentary Basin, A Case History, Canadian Society of Petroleum Geologists, Calgary, p. 233-247.

Poulton, T.P., Christopher, J.E., Hayes, B.J.R., Losert, J., Tittemore and Gilchrist, R.D. (*in press*) Jurassic and Lowermost Cretaceous Strata of the Western Canada Sedimentary Basin: *in*, G.D. Mossop and I. Shetsen (*comps.*) Geological Atlas of the Western Canada Sedimentary Basin, Canadian Society of Petroleum Geologists and the Alberta Research Council, Chapter 18.

Poulton, T.P., Tittemore, J. and Dolby, G. (1990) Jurassic strata of northwestern (and west-central) Alberta and northeastern British Columbia: Bulletin of Canadian Petroleum Geology, vol. 38A, p. 159-175.

Putnam, P. and Moore, S. (1993) The Jurassic (Bajocian) Rock Creek Member of West-Central Alberta: Canadian Society of Petroleum Geologists 1993 Annual Meeting Core Workshop, p. 162-181.

Rall, R.D. (1980) Stratigraphy, sedimentology and paleogeography of the lower Jurassic in the Gilby-Medicine River Fields Alberta: MSc. Thesis, University of Calgary, 142 p.

Springer, G.D., MacDonald, W.D. and Crockford, M.B.B. (1963) Jurassic: *in,* McCrossan, R.G. and Glaister, R.P. (*eds.*), Geological History of Western Canada, Alberta Society of Petroleum Geologists, p. 137-155.

Strobl, R.S., Kramers, J.W. and Dolby, G. (1993a) Jurassic Boundary Study, Medicine River/Sylvan Lake (Twp 37 - 40, Rg 3 - 5W5): Alberta Research Council Open File Report 1993-23, 32 p.

Strobl, R.S., Kramers, J.W. and Dolby, G. (1993b) Jurassic-Cretaceous boundary in the Medicine River and Sylvan Lake areas, south central Alberta (Abstract): Canadian Society of Petroleum Geologists 1993 Annual Meeting Program and Abstracts, p.302.

Ter Berg, L.J.A. (1966) Medicine River Field: Jurassic D Pool: *in,* Century, J.R. (*ed.*), Oil Fields of Alberta Supplement, Alberta Society of Petroleum Geologists, Calgary, p. 70-71.

Watkins, P.B. (1966a) Medicine River Field: Jurassic A Pool: *in,* Century, J.R. (*ed.*), Oil Fields of Alberta Supplement, Alberta Society of Petroleum Geologists, Calgary, p. 66-67.

Watkins, P.B. (1966b): Medicine River Field: Jurassic C Pool: *in,* Century, J.R. (*ed.*), Oil Fields of Alberta Supplement, Alberta Society of Petroleum Geologists, Calgary, p. 68-69.

Young, F.G. (1992) Sequence Analysis of the Jurassic Fernie Formation in Alberta - Condensed Deposition on a West-Facing Ramp (Abstract): 1992 AAPG Annual Meeting Program and Abstracts, p. 147.

APPENDIX 1

PALYNOLOGICAL ANALYSES

G. Dolby
G. Dolby and Associates
Calgary, Alberta

PALYNOLOGICAL ANALYSIS OF CRETACEOUS AND JURASSIC CORE SAMPLES FROM CENTRAL ALBERTA

by
G. Dolby

Project 92.01

November 1993

Prepared for:
Alberta Research Council
7th Floor, Terrace Plaza
4445 Calgary Trail South
Edmonton, Alberta T6H 5R7

Prepared by:
G. Dolby, P. Geol.
6719 Leaside Drive S.W.
Calgary, Alberta
T3E 6H6

CONTENTS

SECTION 1 **INTRODUCTION** ..... Page 3

SECTION 2 **SUMMARY OF RESULTS** 4

SECTION 3 **THE PALYNOLOGICAL SUCCESSION** 16

SECTION 4 **RESULTS**

11-19-33-4W5
11-33-34-4W5
10-31-35-4W5
10-33-35-4W5
8-23-35-5W5
4-5-35-6W5
14-22-36-3W5
11-23-36-4W5
6-12-37-2W5
10-36-37-2W5
7-22-37-4W5
11-22-38-4W5
14-21-38-7W5
16-15-42-5W5
8-24-39-4W5
10-21-39-5W5
14-19-40-4W5
4-4-40-5W5
4-9-41-2W5
12-5-41-3W5
10-24-41-3W5
16-34-41-5W5
8-4-42-5W5
16-15-42-5W5
8-11-42-8W5
12-32-42-9W5
2-16-43-6W5
6-1-43-7W5
6-26-43-11W5
10-17-44-3W5
16-21-44-4W5
8-14-44-8W5
7-17-45-9W5
1-11-45-10W5
6-2-46-8W5

92-54 23
92-51 24
92-49 25
92-50 26
92-52 27
92-53 28
92-57 30
92-48 31
92-59 32
92-58 33
92-47, 92-64 34
92-46 35
92-30 37
92-29 39
92-55 40
92-45 41
92-31 42
92-15 43
92-56 44
92-32, 92-70 45
92-12 46
92-14 47
92-26, 92-63 48
92-27 50
92-44 51
92-43 52
92-28 53
92-13 54
92-5, 92-38 55
92-33 56
92-34 57
92-11 58
91-19, 92-37 59
92-6, 92-39 61
92-7 63

SECTION 4 **RESULTS** (continued)

11-10-46-9W5 92-35 65
10-9-46-14W5 91-20 66
11-11-47-9W5 91-17 68
6-15-48-9W5 91-16 70
5-34-48-12W5 91-21 72
16-28-49-5W5 92-21 74
12-30-49-5W5 92-8 75
8-32-49-10W5 91-15 76
11-20-49-11W5 92-41, 91-23 77
12-35-50-4W5 92-10 78
6-1-50-5W5 92-9 79
8-15-50-11W5 92-40, 91-22 80
14-25-51-8W5 92-20 82
6-33-51-8W5 92-19 83
15-11-51-9W5 91-24 84
8-10-51-10W5 92-25 85
8-14-51-11W5 92-24 86
7-28-51-15W5 92-60 87
15-9-52-8W5 92-18 88
1-17-52-8W5 91-62 89
4-29-52-8W5 92-1 91
7-35-52-9W5 92-16 92
3-14-52-14W5 91-14 93
16-3-53-8W5 92-2 94
7-31-53-10W5 92-17 95
7-36-53-14W5 92-61 96
6-12-54-6W5 92-4 97
6-18-54-7W5 92-3 99
4-13-54-11W5 92-23 100
10-34-54-11W5 92-22 101
13-21-55-11W5 91-6 102
13-27-55-11W5 91-3 104
10-29-55-11W5 91-5 106
9-32-55-11W5 91-13 108
4-34-55-11W5 91-4 110
6-10-55-12W5 91-12, 92-36 111
7-35-55-14W5 91-11 113

SECTION 5 REFERENCES 115

SECTION 1

INTRODUCTION

Two hundred and sixty-eight core samples from seventy-two wells were prepared for palynological analysis. The principal aim of the project was to provide palynological data which would help in distinguishing Cretaceous and Jurassic strata in central Alberta. These data might also be expected to provide additional information on the sequence of Jurassic palynological assemblages which would help in the correlation of individual wells and in the definition of the relationships between the various formations.

The Scientific Authority for the project was Dr. J.W. Kramers of the Alberta Geological Survey.

The samples were prepared by Amoco Canada Petroleum Ltd. and by Global Geolab Ltd. The results are summarised in Section 2 and described on a sample by sample basis in Section 4.

JWK #	Depth	Age	Zone
		11-19-33-4W5	
92-54-1	2733.9m	Bajocian	
92-54-2	2734.9m	Bajocian	J13
92-54-3	2736.5m	?Early Bajocian to Aalenian	J13
92-54-4	2738.1m	Aalenian to late Pliensbachian	?J13B-J14A J14
		11-33-34-4W5	
92-51-1	8497.5'	Cretaceous	
92-51-2	8521.8'	Cretaceous	
		10-31-35-4W5	
92-49-1	8584.5'	Late Aptian to Early Albian	
92-49-2	8587.5'	Cretaceous	Ostracod
92-49-3	8609'	Cretaceous	
		10-33-35-4W5	
92-50-1	8035'	Late Aptian to Early Albian	Ostracod
92-50-2	8044'	Late Aptian to Early Albian	Ostracod
92-50-3	8052'	Late Aptian to Early Albian	Ostracod
		8-23-35-5W5	
92-52-1	2708.2m	Cretaceous	
92-52-2	2714.7m	Indeterminable	
		4-5-35-6W5	
92-53-1	3021.5m	Middle to Early Oxfordian	J8-J9B
92-53-2	3022.5m	Bajocian	J13
92-53-3	3034m	Bajocian	J13
92-53-4	3038.2m	?Early Bajocian to Aalenian	?J13B-J14A
		14-22-36-3W5	
92-57-1	2270.2m	Cretaceous	
92-57-2	2280.4m	Cretaceous	
92-57-3	2282.4m	Cretaceous	

JWK #	Depth	Age	Zone
		11-23-36-4W5	
92-48-1	7780.2'	Late Aptian to Early Albian	Ostracod
92-48-2	7795.5'	Late Aptian to Early Albian	Ostracod
92-48-3	7818.5'	Cretaceous	
		6-12-37-2W5	
92-59-1	2212.25m	Indeterminable	
		10-36-37-2W5	
92-58-1	7025.6'	Indeterminable	
92-58-2	7044.9'	Indeterminable	
		7-22-37-4W5	
92-64-1	7618.75'	?Cretaceous	
92-47-1	7621.5'	Probably Oxfordian	
92-47-2	7626.5'	Probably Oxfordian	
92-47-3	7659'	Indeterminable	
		11-22-38-4W5	
92-46-1	7445.5'	Cretaceous	
92-46-2	7451.5'	Cretaceous	
92-46-3	7456.5'	Cretaceous	
92-46-4	7461.5'	Cretaceous	
92-46-5	7466.5'	Cretaceous	
92-46-6	7491'	Cretaceous	
92-46-7	7508'	Indeterminable	
92-46-8	7520'	Indeterminable	
92-46-9	7531'	Probably Toarcian to late Pliensbachian	J14B-D
92-46-10	7536.8'	Probably Toarcian to late Pliensbachian	J14B-D
		14-21-38-7W5	
92-30-1	2748m	Jurassic	
92-30-2	2751.5m	Early Bajocian to ?Aalenian	J13B-?J14A
92-30-3	2760m	Early Bajocian to Toarcian undiff.	
92-30-4	2763.5m	Aalenian - Toarcian undiff.	

JWK #	Depth	Age	Zone
		16-15-38-8W5	
92-29-1	2869.8m	Cretaceous	
92-29-2	2871.5m	Cretaceous	
92-29-3	2880.7m	Indeterminable	
		8-24-39-4W5	
92-55-1	2212m	Cretaceous	
92-55-2	2213m	Cretaceous	
92-55-3	2216m	Early Toarcian to late Pleinsbachian	J14C-D
92-55-4	2221.5m	Early Toarcian to late Pleinsbachian	J14C-D
		10-21-39-5W5	
92-45-1	2334.3m	Indeterminable	
		14-19-40-4W5	
92-31-1	2345.1m	Indeterminable	
92-31-2	2345.35m	Probably Jurassic	
92-31-3	2354.7m	Probably Jurassic	
		4-4-40-4W5	
92-15-1	2345.5m	?Cretaceous	
		4-9-41-2W5	
92-56-1	6555.2'	Cretaceous	
		12-5-41-3W5	

JWK #	Depth	Age	Zone
92-32-1	7039.5'	Indeterminable	
92-70-1	7043'	Early Toarcian-Late Pliensbachian	J14C-D
92-70-2	7051.5'	Early Toarcian-Late Pliensbachian	J14C-D
92-70-3	7064.5'	Early Toarcian-Late Pliensbachian	J14C-D
92-32-2	7066.5'	Indeterminable	
92-32-3	7082.4'	Indeterminable	

JWK #	Depth	Age	Zone
		10-24-41-3W5	
92-12-1	6580.5'	Aalenian to late Pliensbachian	J13B-J14
92-12-2	6615'	Aalenian to late Pliensbachian	J13B-J14
		16-34-41-5W5	
92-14-1	2246.8m	Cretaceous	
92-14-2	2250.2m	Cretaceous	
92-14-3	2250.5m	Late to late Middle Oxfordian	J6B-J7
92-14-4	2250.58m	Late to late Middle Oxfordian	J6B-J7
		8-4-42-5W5	
92-63-1	2330.8m	?Jurassic	
92-63-2	2331.2m	?Jurassic	
92-26-1	2331.3m	?Late Jurassic	
92-26-2	2335.3m	Probably Early Bajocian	J13B
92-26-3	2339.3m	Aalenian	J14A
92-26-4	2346.6m	Aalenian to Late Toarcian	J14A-B
		16-15-42-5W5	
92-27-1	2198m	Aalenian	J14A
92-27-2	2200.3m	Aalenian to Late Toarcian	J14A-B
		8-11-42-8W5	
92-44-1	2490.45m	?Cretaceous	
92-44-2	2495.73m	Early Bajocian	J13B
92-44-3	2496.7m	Early Bajocian	J13B
92-44-4	2498m	Early Bajocian	J13B
92-44-5	2504.4m	Early Bajocian	J13B
92-44-6	2507.9m	Aalenian	J14A
		12-32-42-9W5	
92-43-1	2681.4m	Indeterminable	

JWK #	Depth	Age	Zone
		2-16-43-6W5	
92-28-1	2280.7m	Probably Cretaceous	
92-28-2	2287.5m	Early Bajocian to latest Aalenian	J13B-J14A
		6-1-43-7W5	
92-13-1	2396.5m	Cretaceous	
92-13-2	2410m	Cretaceous	
92-13-3	2413.15m	Possibly Early Cretaceous	
		6-26-43-11W5	
92-5-1	9478.8'	Indeterminable	
92-5-2	9485.5'	Indeterminable	
92-38-1	9486.3'	Probably Jurassic	
92-38-2	9492'	Probably Jurassic	
92-5-3	9508'	Early Bajocian to Toarcian (undiff.)	
		10-17-44-3W5	
92-33-1	6472'	Cretaceous	
		16-21-44-4W5	
92-34-1	2071.4m	Cretaceous	
92-34-2	2073.1m	Cretaceous	
		8-14-44-8W5	
92-11-1	2405.75m	Indeterminable	
92-11-2	2406.2m	Probably Cretaceous	
92-11-3	2406.7m	Jurassic	
92-11-4	2407.2m	Jurassic	
		7-17-45-9W5	
91-19-1	2416.75m	Cretaceous	
91-19-2	2417.4m	Earliest Kimmeridgian to late Middle Oxfordian	J6-J7
91-19-3	2418.1m	Earliest Kimmeridgian to late Middle Oxfordian	J6-J7
92-37-1	2418.4m	Bajocian	J13
91-19-4	2418.4m	Bajocian	J13
92-37-2	2426.3m	?Early Bajocian to Aalenian	?J13B-J14A
91-19-5	2426.3m	?Early Bajocian to Aalenian	?J13B-J14A
91-19-6	2434.3m	Indeterminable	

JWK #	Depth	Age	Zone
		1-11-45-10W5	
92-6-1	2481.1m	Indeterminable	
92-39-1	2481.5m	Indeterminable	
92-39-2	2482.2m	Early Middle Oxfordian	J8
92-39-3	2482.9m	Early Middle Oxfordian	J8
92-6-2	2484.3m	Possibly Middle Jurassic	
92-6-3	2485.2m	Early Bajocian	J13B
92-6-4	2501.5m	Early Bajocian - Aalenian	J13B-J14A
92-6-5	2507.7m	Aalenian - Toarcian (undiff.)	
		6-2-46-8W5	
92-7-1	2189.2m	Cretaceous	
92-7-2	2193.1m	Bajocian	J13
92-7-3	2194.5m	Early Bajocian to Aalenian	J13B-J14A
92-7-4	2201.6m	Early Bajocian to Aalenian	J13B-J14A
		11-10-46-9W5	
92-35-1	2075.66m	Probably Cretaceous	
92-35-2	2075.91m	Early Middle Oxfordian	J8
91-18-1	2077.6m	Early Middle Oxfordian	J8
91-18-2	2077.98m	Early Middle Oxfordian	J8
		10-9-46-14W5	
91-20-1	10271.5'	Cretaceous	
91-20-2	10285.4'	Indeterminable	
91-20-3	10287.4'	Jurassic	
91-20-4	10287.8'	Jurassic	
91-20-5	10290.8'	Jurassic	
91-20-6	10291.3'	?Oxfordian	
91-20-7	10293.4'	Jurassic	
		11-11-47-9W5	
91-17-1	2086m	Cretaceous	
91-17-2	2087.95m	Late Aptian - early Albian	Ostracod
91-17-3	2091.6m	Early Cretaceous	
91-17-4	2094.5m	Early Cretaceous	
91-17-5	2099.5m	Early Cretaceous	
91-17-6	2102.6m	Early Cretaceous	
91-17-7	2103.9m	Early Cretaceous	

JWK #	Depth	Age	Zone
		6-15-48-9W5	
91-16-1	2119m	Late Aptian - Early Albian	
91-16-2	2119.6m	Possibly Cretaceous	Ostracod
91-16-3	2120.8m	Oxfordian	
91-16-4	2121.8m	Bajocian	?J6B-J7
91-16-5	2140.6m	Probably Aalenian - Late Toarcian	J13 J14A-B
		5-34-48-12W5	
91-21-1	2497.1m	Cretaceous	
91-21-2	2498.4m	Jurassic	
91-21-3	2499.4m	Jurassic	
91-21-4	2502.3m	Jurassic	
91-21-5	2517.8m	Early Bajocian - Aalenian	
91-21-6	2522.5m	Aalenian - Late Toarcian	J13B-J14A J14A-B
		16-28-49-5W5	
92-21-1	1726.8m	Cretaceous	
		12-30-49-5W5	
92-8-1	1757.3m	Cretaceous	
92-8-2	1763m	Early Toarcian - late Pliensbachian	
92-8-3	1764m	Indeterminable	J14C-D
		8-32-49-10W5	
91-15-1	2175.15m	Early Cretaceous	
91-15-2	2177.84m	Early Cretaceous	
		11-20-49-11W5	
92-41-1	2315.79m	Probably Middle to Early Oxfordian	J8-J9B
91-23-1	2316.3m	Early Oxfordian	J9B
91-23-2	2316.5m	Early Oxfordian	J9B
91-23-3	2317.1m	?Early Oxfordian	?J9B
		12-35-50-4W5	
92-10-1	1533.5m	Cretaceous	

JWK #	Depth	Age	Zone
		6-1-50-5W5	
92-9-1	1701.45m	Cretaceous	
		8-15-50-11W5	
92-40-1	2210.65m	Early Oxfordian	J9A-B
92-40-2	2211.7m	Early Oxfordian	J9A-B
92-40-3	2211.95m	Early Oxfordian	J9A-B
91-22-1	2212.5m	Early Oxfordian	J9B
91-22-2	2212.98m	Early Oxfordian	J9B
91-22-3	2218m	Probably Bajocian	J13
		14-25-51-8W5	
92-20-1	1770.5m	Probably Middle Albian	
92-20-2	1778.75m	Possibly Aalenian to Late Toarcian	?J14A-B
		6-33-51-8W5	
92-19-1	6022.5'	?Cretaceous - Late Jurassic	
92-19-2	6039'	Aalenian	J14A
		15-11-51-9W5	
91-24-1	1948.1m	Cretaceous	
91-24-2	1956.05m	Cretaceous	
91-24-3	1960.75m	Aalenian to Late Toarcian	J14A-B
		8-10-51-10W5	
92-25-1	2050.2m	Late Aptian to Early Albian	Ostracod
92-25-2	2051.8m	Indeterminable	
92-25-3	2055.1m	Aalenian	J14A
		8-14-51-11W5	
92-24-1	2158.7m	Cretaceous	
92-24-2	2162.05m	Cretaceous	
92-24-3	2168.5m	Cretaceous	
92-24-4	2171.05m	Aalenian	J14A
92-24-5	2172.9m	Aalenian	J14A
92-24-6	2179.8m	Aalenian	J14A

JWK #	Depth	Age	Zone
		7-28-51-15W5	
92-60-1	2600.5m	Aalenian-Late Toarcian	J14A-B
92-60-2	2601.5m	Aalenian-Late Toarcian	J14A-B
92-60-3	2607.4m	Aalenian-late Toarcian	J14A-B
		15-9-52-8W5	
92-18-1	1818.5m	Early Bajocian to ?Aalenian	J13B-?J14A
92-18-2	1821.6m	Early Bajocian to ?Aalenian	J13B-?J14A
92-18-3	1822.75m	Early Bajocian to ?Aalenian	J13B-?J14A
		1-17-52-8W5	
92-62-1	1822.35m	Probably Cretaceous	
92-62-2	1824.2m	Early Bajocian	J13B
92-62-3	1824.7m	Early Bajocian	J13B
92-62-4	1829.9m	Early Bajocian-Late Aalenian	J13B-14A
92-62-5	1833m	Early Aalenian	J14A
		4-29-52-8W5	
92-1-1	1815.5m	Cretaceous	
92-1-2	1820.1m	Cretaceous	
92-1-3	1821.8m	Indeterminable	
		7-35-52-9W5	
92-16-1	6273.5'	Toarcian debris	
92-16-2	6320'	?Cretaceous	
92-16-3	6363'	?Cretaceous	
		3-14-52-14W5	
91-14-1	2334.3m	Possibly Early Cretaceous	
91-14-2	2335.9m	Possibly Early Cretaceous	
91-14-3	2336.4m	Middle to ?Early Oxfordian	J8-?J9A-B
91-14-4	2339.9m	Middle to ?Early Oxfordian	J8-?J9A-B
91-14-5	2345.2m	Middle to ?Early Oxfordian	J8-?J9A-B
91-14-6	2348.5m	Middle to ?Early Oxfordian	J8-?J9A-B
91-14-7	2359.9m	Middle to ?Early Oxfordian	J8-?J9A-B
91-14-8	2362.6m	Middle to ?Early Oxfordian	J8-?J9A-B

JWK #	Depth	Age	Zone
		16-3-53-8W5	
92-2-1	1768m	Early Bajocian to Aalenian	J13B-J14A
92-2-2	1768.1m	Early Bajocian to Aalenian	J13B-J14A
92-2-3	1768.3m	Aalenian - Late Toarcian	J14A-B
		7-31-53-10W5	
92-17-1	6002'	late Early Bajocian	J13B
92-17-2	6008'	late Early Bajocian	J13B
92-17-3	6023.5'	late Early Bajocian	J13B
		7-36-53-14W5	
92-61-1	2175.85m	Early Bajocian	J13B
92-61-2	2178m	Early Bajocian	J13B
		6-12-54-6W5	
92-4-1	4954.5'	Late Aptian to Early Albian	Ostracod
92-4-2	4959.5'	Cretaceous	
92-4-3	4963'	Cretaceous	
92-4-4	4967'	Indeterminable	
92-4-5	4974.7'	Aalenian - Late Toarcian	J14A-B
92-4-6	4976.5'	Aalenian - Late Toarcian	J14A-B
		6-18-54-7W5	
92-3-1	1625m	Cretaceous	
92-3-2	1634.2m	Aalenian - Late Toarcian	J14A-B
92-3-3	1637m	Aalenian - Late Toarcian	J14A-B
92-3-4	1646.3m	?Aalenian - ?Toarcian	
		4-13-54-11W5	
92-23-1	1840.78m	Late Early Bajocian	J13B
92-23-2	1845.1m	Late Early Bajocian	J13B
92-23-3	1851.7m	Probably Aalenian	J14A
		10-34-54-11W5	
92-22-1	1815.35m	Indeterminable	
92-22-2	1815.9m	Indeterminable	
92-22-3	1819.5m	Earliest Aalenian to Late Toarcian	J14A-B
92-22-4	1820.5m	Earliest Aalenian to Late Toarcian	J14A-B

JWK #	Depth	Age	Zone
		13-21-55-11W5	
91-6-1	1858m	Probably Cretaceous	
91-6-2	1861.5m	Probably Cretaceous	
91-6-3	1864.3m	Probably Cretaceous	
91-6-4	1864.55m	Indeterminable	
91-6-5	1865.6m	Indeterminable	
91-6-6	1868.5m	Aalenian-late Toarcian	J14A-B
		13-27-55-11W5	
91-3-1	1871.9m	Indeterminable	
91-3-2	1873.4m	late Middle Bajocian	J13
91-3-3	1874.2m	Indeterminable	
91-3-4	1878.15m	Aalenian-late Toarcian	J14 A-B
91-3-5	1884.2m	Aalenian-late Toarcian	J14 A-B
		10-29-55-11W5	
91-5-1	1864.5m	Probably Cretaceous	
91-5-2	1869.3m	Indeterminable	
91-5-3	1873.3m	Aalenian-late Toarcian	J14A-B
91-5-4	1873.9m	Aalenian-late Toarcian	J14A-B
91-5-5	1874.3m	Aalenian-late Toarcian	J14A-B
		9-32-55-11W5	
91-13-1	1962m	Possibly Early Cretaceous	
91-13-2	1962.4m	Early Middle Jurassic	
91-13-3	1966m	Aalenian	J14A
91-13-4	1967.8m	Aalenian	J14A
		4-34-55-11W5	
91-4-1	1872.m	Indeterminable	
91-4-2	1875.7m	Aalenian-late Toarcian	J14 A-B
91-4-3	1876.3m	Aalenian-late Toarcian	J14 A-B
91-4-4	1879.1m	Aalenian-late Toarcian	J14 A-B
91-4-5	1880.1m	Aalenian-late Toarcian	J14 A-B

JWK #	Depth	Age	Zone
		6-10-55-12W5	
91-12-1	6228'	Cretaceous	
92-36-1	6229'	Cretaceous	
91-12-2	6229.7'	?Jurassic	
91-12-3	6241.5'	Early Middle Oxfordian	J8
		7-35-55-14W5	
91-11-1	2029.7m	Early Cretaceous	
91-11-2	2030.1m	Early Oxfordian	J9A-B
91-11-3	2035.7m	Aalenian	J14A
91-11-4	2043.45m	Aalenian	J14A

The principal aim of this study was to use palynological data to aid in identifying and correlating the relatively thin Jurassic sequence of central Alberta and also to confirm the age of the overlying Cretaceous strata. In the study area, cores rarely penetrate more than part of the Jurassic section. The program could be considered to have been based on spot-samples and establishing the sequence of palynological events is therefore difficult. The assemblages consist of a mixture of species the stratigraphic ranges of which are well known from the European standards. However, a number of species found in the Jurassic of the Western Canada Basin have not been described in the literature and their ranges are, as yet, imperfectly known.

The sequence of palynological assemblages described below is based partly on the occasional occurrences of known species with the unpublished forms and partly on the affinity of the assemblage when these markers are absent. It is obviously tentative and will be refined as more data become available. Where possible the zonal scheme outlined in the text-figure on page 22 has been used for the Jurassic. This is based on the European stratotypes. It is clear from this work, and from previous studies (Dolby, 1990, 1991) that some of the sub-zones may be divided further.

Late Pliensbachian - Middle Toarcian Assemblages

These are characterised by an abundance of sapropelic kerogen and large clumps of small sphaeromorphs. In north-west Europe they are abundant to the top of the *bifrons* Ammonite Zone (J14C) but may still be significant to the top of the Middle Toarcian, *variabilis* Ammonite Zone (lower J14B). This feature was almost certainly a response to specific environmental conditions but is widespread in north-west Europe and the Arctic, including the Sverdrup Basin. The kerogen often obscures or dilutes the palynomorph assemblages.

Typical dinocyst species from this zone include:

Nannoceratopsis gracilis
Mancodinium semitabulatum
Scriniocassis weberii
Dinocyst PC-1
N. senex
Maturodinium inornatum
S. priscus
Lithodinia serrulata

N. senex tends to be more numerous than *N. gracilis* and the converse applies to overlying zones although both may be abundant. Acritarchs are occasionally numerous and rare specimens of prasinophytes may occur.

Apart from the sphaeromorphs, which are often termed *Spheripollenites* in the literature, the pollen and spore flora is poorly developed. Small numbers of the following species may be present:

Distalannulisporites incertus
Corrugatisporites anagrammensis
Classopollis spp.
Mathesporites tumulosus
C. amplectaeformis

Late Toarcian Assemblages

These are not always well defined and it is generally difficult to distinguish them from early Aalenian assemblages if certain markers are absent. The distinctive gymnosperm pollen *Callialasporites dampierii* appears at the base of the Late Toarcian and its presence therefore provides a lower age-limit to these associations.

The dinocyst species listed for the underlying zone persist here and *Lithodinia serrulata* and Dinocyst PC-1 may be abundant. Species such as *Evansia evittii* and *Phallocysta* spp. may also occur sporadically and the first *Fromea* spp. may also occur toward the top of the zone.

Spheripollenites spp. are rare but the remainder of the spore-pollen association from the underlying zone is often abundant.

Aalenian Assemblages

The species encountered in the Late Toarcian continue into the early Aalenian in similar numbers. The base of the Aalenian is defined by the appearance of *Jansonia jurassica* and *Fromea senilis*. The first appearance of *Nannoceratopsis dictyambonis* also occurs, for all practical purposes, at this level.

The *Lithodinia serrulata* - Dinocyst PC-1 association dies out in the early Aalenian, probably close to the *opalinum - murchisonae* Ammonite Zone boundary. Most of the *Parvocysta* group such as *?P. cracens* also die out at this point.

Although Dinocyst PC-1 dies out in the early Aalenian, a variety (Dinocyst cf. PC-1) persists into later strata. Few of these have been found as yet and so the complete range has not been determined. It may go as high as the top of the *murchisonae* Zone but similar forms reach the top of the Aalenian in north-west Europe.

The most distinctive feature of the Aalenian samples in this study is the presence of *Fromea* 83/1 and *F. senilis* which can form as much as 15% of the total assemblage. *Nannoceratopsis senex* and *N. gracilis* are numerous to abundant elsewhere but in this study they are rare. The *Escharisphaeridia - Batiacasphaera* complex becomes significant, but not abundant, towards the top of the Aalenian. *Valensiella ovula* appears in the late Aalenian *concavum* Ammonite Zone and can be significant in the overlying Bajocian. *Evansia granulata* also appears in the Aalenian - Bajocian transition.

In the terrestrial fraction, the association of *D. incertus*, *M. tumulosus*, *C. anagrammensis* and *C. amplectaeformis* is abundant in the early Aalenian but diminishes in importance thereafter. It is typical of many Poker Chip samples and the reduction in numbers may be in response to the changing conditions which gave rise to the deposition of the Rock Creek Formation.

Bajocian Assemblages

The Aalenian - Bajocian boundary is marked, under ideal circumstances, by the abrupt decline in *N. gracilis* and *N. senex* as well as the disappearance of *Scriniocassis weberii*. In this study, these three species are usually rare and different criteria have been used.

The transition into the Bajocian is marked by a significant reduction in the numbers of *Fromea* spp. Whether these are confined to the Aalenian is difficult to determine given the fact that these came from spot samples. The base of the Bajocian appears to be marked by the abundance of *Escharisphaeridia* - *Batiacasphaera* spp. (especially large forms of the former) *Dissiliodinium* spp. and by the appearance of *Evansia tripartita* and *Meiourogonyaulax decapitata*. *Nannoceratopsis dictyambonis* probably dies out in the Early Bajocian (*discites* Ammonite Zone) and *Phallocysta minuta* probably dies out slightly later. The mid- to late Early Bajocian is distinguished by the disappearance of *Scriniocassis priscus* more or less concomitant with the appearance of *Acanthaulax crispa* and *Escharisphaeridia asymmetra*. *N. senex* dies out at the top of the Early Bajocian as does *N. gracilis* for all practical purposes.

There is a marked change in the terrestrial microfloras which begins in the Aalenian but develops in the Early Bajocian. The small spore flora of the Poker Chip is replaced by assemblages rich in the following species.

Callialasporites dampierii
Araucariacites australis
Classopollis spp.
C. turbatus
Lycopodiumsporites
Corollina spp.

The latter two are often abundant in the underlying strata but larger, "heavier" forms predominate here.

During the Late Bajocian, dinocyst species appear which go on to characterise the remainder of the Middle Jurassic and, in some cases, the Late Jurassic. They were not recorded in this study and the youngest early Middle Jurassic floras recovered may have come from the early Late Bajocian.

Oxfordian - Kimmeridgian Assemblages

No evidence for Bathonian or Callovian strata was seen in this study. The earliest Oxfordian palynofloras can be found in the latest Callovian but no Callovian index species were recovered.

Early Oxfordian assemblages in this study are characterised by *Sentusidinium* spp., especially *S. rioultii* and *S. villersense*, *Escharisphaeridia rudis* and *Ellipsoidictyum gochtii*. *Acanthaulax* spp. and *Gonyaulacysta jurassica* are usually present and can be abundant. Other species present include *Valensiella ovula*, *E. cinctum*, *Aldorfia dictyota*, *Scriniodinium crystallinum* and *Leptodinium eumorphum*.

The early Middle Oxfordian is often characterised by *Acanthaulax* spp. in great abundance. Also appearing at this point are such species as *Scriniodinium luridum* and *Leptodinium mirabile*.

The late Middle Oxfordian to earliest Kimmeridgian contains abundant specimens of *Gonyaulacysta* spp., *Leptodinium* spp. and *Scriniodinium* spp. The presence of *S. crystallinum* in this assemblage indicates an age no younger than earliest Kimmeridgian, *baylei* Ammonite Zone.

The terrestrial assemblages consist generally of long-ranging species. In contrast to the Middle and Early Jurassic, bisaccate pollen can be abundant.

Cretaceous Assemblages

There was no unequivocal evidence for younger Jurassic strata in this study although it is present elsewhere (Dolby, 1990). Some of the samples which were tentatively assigned a Cretaceous age did not contain species restricted to the Cretaceous. They were assigned partly on sedimentological grounds. These assemblages are often characterised by spore species such as *Convacissimisporites exquisitus* and *C. apiverrucatus* which are known to range down to the latest Kimmeridgian (*rotunda* Ammonite Zone, J2).

Most of the Cretaceous assemblages are dominated by bisaccate pollen which usually comprise a greater proportion of the assemblages than in the Late Jurassic. The spore flora is dominated by the following:

Cicatricosisporites spp.
Concavissimisporites spp.
C. trioreticulosus
Couperisporites tabulatus
Taxodiaceaepollenites hiatus
Appendicisporites spp.
C. tribotrys
Foraminisporis wonthaggiensis
Aequitriradites spinulosus
Januasporites spiniferus

Most of the samples yielded terrestrial assemblages but a small number are rich in dinocysts. The most distinctive of these are usually dominated by *Balmula tripenta*, *Vesperopsis* spp. and *Atopodinium* sp. It is a strongly environmentally controlled assemblage, probably of brackish-water origin which Singh (pers.comm.) has found in the Ostracod Zone (late Aptian - early Albian). The only published record of this group is from the Late Albian of the U.S.

The only other marine assemblage found is of Middle Albian age and contains the following:

Psuedoceratium pelliferum
Palaeoperidinium cretaceum
Aptea polymorpha
Circulodinium brevispinosum
P. gochtii
Odontochitina operculata
Apteodinium indicosum
Batioladinium jaegerii

TEXT FIGURE: JURASSIC PALYNOLOGICAL ZONATION

PORTLANDIAN	late	lamplughi prepliconphalus primitivus oppressus	J1	
	early	anguiformis kerberus okusensis glaucolithus albani	J2	A
				B
			J3	
KIMMERIDGIAN	late	fittoni rotunda pallasioides pectinatus		
	middle	hudlestoni wheatleyensis scitulus elegans	J4	A
				B
	early	autissiodorensis eudoxus mutabilis cymodoce	J5	
		baylei	J6	A
				B
OXFORDIAN	late	rosenkrantzi regulare serratum glosense	J7	A
	middle	tenuiserratum densiplicatum		B
	early	cordatum mariae	J8	
			J9	A
CALLOVIAN	late	lamberti athleta		B
				C
	middle	coronatum jason	J10	D
	early	calloviense macrocephalus	J11	A
BATHONIAN	late	discus orbis hodsoni		B
	middle	morrisi subcontractus progracilis		
	early	tenuiplicatus zigzag	J12	A
BAJOCIAN	late	parkinsoni garantiana subfurcatum		B
	middle	humphriesianum sauzii laeviuscula discites	J13	A
				B
AALENIAN	early	concavum murchisonae opalinum	J14	A
TOARCIAN	late	levesquei thouarsense		B
	middle	variabilis bifrons		
	early	falciferum tenuicostatum		C
PLIENSBACHIAN	late	spinatum margaritatus		D

WELL: **11-19-33-4W5**

Samples: **JWK92-54-1, 54-2**
Depth: 2733.9m, 2734.9m
Age: Bajocian, J13

Remarks

These samples strongly resemble 92-53-2 but are of much poorer quality. Palynomorphs are rare.

Significant species

Escharisphaeridia spp. *Evansia evittii*

Sample: **JWK92-54-3**
Depth: 2736.5m
Age: ?Early Bajocian - Aalenian, ?J13B-J14A

Remarks

This extremely poor sample contains *Dictyotidium eastendensis* and abundant *Cymatiosphaera* spp. similar to 92-53-4. A transitional Rock Creek - Poker Chip age is suggested.

Sample: **JWK92-54-4**
Depth: 2738.1m
Age: Aalenian - late Pliensbachian, J14

Remarks

Palynomorphs are rare and thermally altered. The few species present are typical of the Poker Chip.

Significant species

Mathesporites tumulosus *Distalannulisporites incertus*
Nannoceratopsis senex

WELL: **11-33-34-4W5**

Samples: **JWK92-51-1, 51-2**
Depths: 8497.5', 8521.8'
Age: Cretaceous

Remarks

These are poorly-preserved, thermally altered samples in which many of the palynomorphs are unidentifiable. However, *Cicatricosisporites* spp. are present in both indicating a Cretaceous age.

WELL: **10-31-35-4W5**

Sample: **JWK92-49-1**
Depth: 8584.5'
Age: Late Aptian - Early Albian

Remarks

This rich Cretaceous sample contains specimens of *Balmula tripenta* indicating a probable Ostracod Zone age.

Significant species

Balmula tripenta
Appendicisporites spp.
Cicatricosisporites spp.
Januasporites sp.

Sample: **JWK92-49-2**
Depth: 8587.5'
Age: Cretaceous

Remarks

The yield from this sample was extremely low but the *Cicatricosisporites* group is prominent suggesting a possible riverbank environment.

Significant species

Cicatricosisporites spp.
Appendicisporites spp.

Sample: **JWK92-49-3**
Depth: 8609'
Age: Cretaceous

Remarks

A low yielding sample from a high energy environment. The presence of several *Cicatricosisporites* specimens indicates a Cretaceous age.

WELL: **10-33-35-4W5**

Samples: **JWK92-50-1, 50-2, 50-3**
Depths: 8035', 8044', 8052'
Age: Late Aptian - Early Albian

Remarks

These samples contain rich Cretaceous assemblages. The composition of 50-1 resembles those from lowland floodplain swamp environments. Samples 50-2 and 50-3 also contain rare dinocysts indicating possible lagoonal environments. Jurassic reworking is prominent in 50-2. The presence of *Balmula tripata* indicates a possible correlation with the Ostracod Zone.

Significant species

Cicatricosisporites spp.
Appendicisporites spp.
Balmula tripenta
Taxodiaceaepollenites hiatus
Januasporites sp.
Pseudoceratium sp.

WELL: **8-23-35-5W5**

Sample: **JWK92-52-1**
Depth: 2708.2m
Age: Cretaceous

Remarks

Cicatricosisporites spp. predominate in this low-yielding sample suggesting a possible riverbank environment.

Significant species

Cicatricosisporites spp.
Microreticulatisporites uniformis
Appendicisporites spp.
Januasporites spiniferus

Sample: **JWK92-52-2**
Depth: 2714.7m
Age: Indeterminable

Remarks

A barren sample.

WELL: **4-5-35-6W5**

Sample: **JWK92-53-1**
Depth: 3021.5m
Age: Middle to Early Oxfordian, J8-J9B

Remarks

Pollen and spores are abundant but the dinocyst assemblage is somewhat limited. Specimens of *Gonyaulacysta jurassica*, *G. cladophora* and *Ellipsoidictyum gochtii* suggest a Middle to Early Oxfordian age.

Significant species

Gonyaulacysta jurassica — *G. cladophora*
Ellipsoidictyum gochtii

Samples: **JWK92-53-2, 53-3**
Depths: 3022.5m, 3034m
Age: Bajocian, J13

Remarks

Specimens of *Escharisphaeridia* - *Batiacasphaera* spp. are abundant in 53-2 with smaller numbers of *Evansia evittii*. The situation is reversed in 53-3. No Aalenian influence is present and an undifferentiated Bajocian age is assigned.

Significant species

Escharisphaeridia spp. — *C.* aff. *asymmetra*
Evansia evittii — *Batiacasphaera* spp.

Sample: **JWK92-53-4**
Depth: 3038.2m
Age: ?Early Bajocian - Aalenian, ?J13B-J14A

Remarks

Acritarchs are abundant in this sample, especially *Cymatiosphaera* spp. and *Dictyotidium* spp. suggesting a highly restricted environment. Small numbers of

spores typical of the Poker Chip are also present. The sample may come from the Poker Chip - Rock Creek transition. See 92-54-3.

Significant species

Cymatiosphaera (A)
Mathesporites tumulosus
Distalannulisporites incertus
Dictyotidium eastendensis
Corrugatisporites anagrammensis
C. amplectaeformis

WELL: **14-22-36-3W5**

Samples: **JWK92-57-1, 57-2, 57-3**
Depths: 2270.2m, 2280.4m, 2282.4m
Age: Cretaceous

Remarks

All three samples contain very abundant bisaccate pollen as well as typically Cretaceous spores. Many of the spores and pollen in 57-3 are fragmented similar to 55-2 and 56-1.

Significant species

Cicatricosisporites spp.
Concavissimisporites trioreticulosus
Appendicisporites erdtmannii
Januasporites spiniferus
C. tribotrys
Microreticulatisporites uniformis

WELL: **11-23-36-4W5**

Samples: **JWK92-48-1, 48-2**
Depths: 7780.2', 7795.5'
Age: Late Aptian - Early Albian

Remarks

In addition to rich and varied Cretaceous spore-pollen assemblages, numerous specimens of *Balmula tripenta* indicate a Late Aptian - Early Albian age equivalent to the Ostracod Zone.

Significant species

Balmula tripenta
Appendicisporites spp.
Januasporites sp.
Cicatricosisporites spp.
Concavissimisporites trioreticulosus
C. tribotrys

Sample: **JWK92-48-3**
Depth: 7818.5'
Age: Cretaceous

Remarks

No dinocysts were recovered in this Cretaceous sample.

Significant species

Cicatricosisporites spp.
Foraminisporis wonthaggiensis
Appendicisporites spp.
Microreticulatisporites uniformis

WELL: **6-12-37-2W5**

Sample: **JWK92-59-1**
Depth: 2212.25m
Age: Indeterminable

Remarks

A barren sample.

WELL:	**10-36-37-2W5**
Samples:	**JWK92-58-1, 58-2**
Depths:	7025.6', 7044.9'
Age:	Indeterminable

Remarks

Barren samples.

WELL: **7-22-37-4W5**

Sample: **JWK92-64-1**
Depth: 7618.75'
Age: ?Cretaceous

Remarks

This poor sample contains a specimen of *Foraminisporis* cf. *wonthaggiensis* and a highly questionable specimen of *Lecaniella foveata* which suggest a Cretaceous age. There are no really convincing Cretaceous markers present however and no Jurassic species were recorded.

The age assigned must remain very tentative.

Significant species

Bissacate pollen
Foraminisporis cf. *wonthaggiensis*
Neoraistrickia truncata
?*Lecaniella foveata*

Samples: **JWK92-47-1, 47-2**
Depths: 7621.5', 7626.5'
Age: Probably Oxfordian

Remarks

These poor samples contain rare Jurassic dinocysts such as *Gonyaulacysta jurassica*, *Sentusidinium* spp. and *Ellipsoidictyum* sp. They range from Bathonian to Oxfordian strata, but, given the age of similar samples in this study, an Oxfordian age is more likely.

Sample: **JWK92-47-3**
Depth: 7659'
Age: Indeterminable

Remarks

The kerogen consists of highly altered, inertinitic debris. No age can be assigned.

WELL: **11-22-38-4W5**

Samples: **JWK92-46-1, 46-2, 46-3, 46-4, 46-5, 46-6**
Depths: 7445.5', 7451.5', 7456.5', 7461.5', 7466.5', 7491'
Age: Cretaceous

Remarks

Samples 46-1 to 46-5 yielded good Cretaceous (probably Albian) assemblages. Sample 46-6 is poor but contains a number of Cretaceous species.

Significant species

Cicatricosisporites australiensis
C. imbricatus
Microreticulatisporites uniformis
Concavissimisporites trioreticulosus
Appendicisporites cf. *bilateralis*
Tigrisporites reticulatus
Couperisporites tabulatus
C. hallei
C. augustus
Pilosisporites trichopapillosus
C. tribotrys
A. problematicus
T. scurrandus
Aequitriradites spinulosus

Samples: **JWK92-46-7, 46-8**
Depths: 7508', 7520'
Age: Indeterminable

Remarks

Kerogen is abundant but all the palynomorphs appear to have been winnowed out and an age cannot be assigned.

Samples: **JWK92-46-9, 46-10**
Depths: 7531', 7536.8'
Age: Probably Toarcian - late Pliensbachian, J14B-D

Remarks

The spore assemblages are typical of the Poker Chip but the most obvious feature here are the great abundances of *Nannoceratopsis senex* in both samples. *N. gracilis* is present in 46-9 (one specimen) and there are no other dinocysts. The dominance of *N. senex* is more typical of the Toarcian - late Pliensbachian and there are no signs of an Aalenian influence. See 55-3 and 55-4.

Significant species

Nannoceratopsis senex (A)
Distalannulisporites incertus
Mathesproites tummulosus

N. gracilis
Corrugatisporites anagrammensis
C. amplectaeformis

WELL: **14-21-38-7W5**

Sample: **JWK92-30-1**
Depth: 2748m
Age: Jurassic

Remarks

There are no marker species with limited ranges in this sample but the abundance of *Classopollis* spp. indicates a Jurassic age.

Sample: **JWK92-30-2**
Depth: 2751.5m
Age: Early Bajocian to ?Aalenian, J13B-?J14A

Remarks

There is a strong resemblance between this sample and 92-18-2 in that the terrestrial component has a similarly distinctive composition. Dinocysts are relatively rare but include large species of *Escharisphaeridia* spp. *Scriniocassis* cf. *priscus*, *Caddasphaera halosa* and *Jansonia* sp. As in 18-2, the Bajocian influence is stronger.

Significant species

Araucariacites australis (A)
Jansonia sp.
Escharisphaeridia spp.
Lycopodiumsporites spp. (A)
Scriniocassis cf. *priscus*

Sample: **JWK92-30-3**
Depth: 2760m
Age: Early Bajocian to Toarcian (undifferentiated)

Remarks

The yield from this sample was too low to provide a precise age.

Sample: JWK92-30-4
Depth: 2763.5m
Age: Aalenian - Toarcian (undifferentiated)

Remarks

The yield was low but a significant number of small spores and pollen typical of the Poker Chip are present. No dinocysts were recorded.

Significant species

Mathesporites tumulosus
Distalannulisporites incertus
Corrugatisporites anagrammensis
C. amplectaeformis

WELL: **16-15-38-8W5**

Samples: **JWK92-29-1, 29-2**
Depths: 2869.8m, 2871.5m
Age: Cretaceous

Remarks

Although the kerogen yield was high for both samples, spores and pollen are rare. Judging by the sorting, the energy level was relatively high. A fragment of *Cicatricosisporites* sp., which appears to be *in situ* in 29-2, indicates a Cretaceous age.

Sample: **JWK92-29-3**
Depth: 2880.7m
Age: Indeterminable

Remarks

The residue is similar to 29-1 and 29-2 with very few palynomorphs. The overall composition tends to favor a Jurassic age over a Cretaceous age but this is pushing the data beyond acceptable limits.

WELL: **8-24-39-4W5**

Samples: **JWK92-55-1, 55-2**
Depths: 2212m, 2213m
Age: Cretaceous

Remarks

These rich assemblages contain abundant Cretaceous markers. The palynomorphs in the lower one are mostly broken, a feature also seen in 56-1 and 57-3.

Significant species

Cicatricosisporites spp.
Concavissimisporites trioreticulosus
Foraminisporis wonthaggiensis
Appendicisporites erdtmannii
C. tribotrys
Tigrisporites reticulatus

Samples: **JWK92-55-3, 55-4**
Depths: 2216m, 2221.5m
Age: Early Toarcian - late Pliensbachian, J14C-D

Remarks

Both samples are rich in *Nannoceratopsis senex* and *Spheripollenites* spp. Assemblages such as this are typical of mid-Toarcian to late Pliensbachian in the Sverdrup Basin and north-west Europe. Samples 46-9 and 46-10 are similar except that the *Spheripollenites* spp. are not so prominent.

Significant species

Nannoceratopsis senex (A)
Distalannulisporites incertus
Corrugatisporites anagrammensis
Spheripollenites spp. (A)
Mathesporites tumulosus
C. amplectaeformis

WELL: **10-21-39-5W5**

Sample: **JWK92-45-1**
Depth: 2334.3m
Age: Indeterminable

Remarks

Despite a fair kerogen yield, palynomorphs are extremely rare and an age cannot be assigned.

WELL: **14-19-40-4W5**

Sample: **JWK92-31-1**
Depth: 2345.1m
Age: Indeterminable

Remarks

A virtually barren sample.

Samples: **JWK92-31-2, 31-3**
Depths: 2345.35m, 2354.7m
Age: Probably Jurassic

Remarks

Both samples yielded small numbers of identifiable palynomorphs. The higher one contains *Distalannulisporites incertus* and *Mathesporites tumulosus* suggesting equivalence with the Poker Chip or Poker Chip - Rock Creek transition.

WELL: **4-4-40-5W5**

Sample: **JWK92-15-1**
Depth: 2345.5m
Age: ?Cretaceous

Remarks

Spores and pollen are generally fragmented. Bisaccate pollen are abundant, however, and a Cretaceous age is very tentatively assigned. No marker species are present.

WELL: **4-9-41-2W5**

Sample: **JWK92-56-1**
Depth: 6555.2'
Age: Cretaceous

Remarks

Many of the palynomorphs are broken as in 55-2 and 57-3. Cretaceous spores are numerous.

Significant species

Cicatricosisporites spp.
Januasporites spiniferus
Appendicisporites erdtmannii
Foraminisporis wonthaggiensis

WELL: **12-5-41-3W5**

Samples: **JWK92-32-1, 32-2, 32-3**
Depths: 7039.5', 7066.5', 7082.4'
Age: Indeterminable

Remarks

Apart from rare small, unidentifiable spores and pollen in 32-1 and 32-2, these samples are essentially barren.

Samples: **JWK92-70-1, 70-2, 70-3**
Depths: 7043', 7051.5', 7064.5'
Age: Early Toarcian-Late Pliensbachian, J14C-D

Remarks

These three samples yielded organic residues typical of the lower part of the Poker Chip shale. Sapropelic debris is abundant and often obscures the palynomorphs. The abundance of small *Spheripollenites* spp., often in clumps or tetrads along with numerous to abundant *Nannoceratopsis senex* is typical of the Early Toarcian-Late Pliensbachian.

Significant species

Spheripollenites spp. (A)
Distalannulisporites incertus
Corrugatisporites amplectaeformis
Lycopodiacidites spinatus/baculatus

Nannoceratopsis senex (A)

Classopollis spp.
Mathesporites tumulosus
C. anagramensis
Ischyosporites crateris

Micrhystridium spp.

WELL: **10-24-41-3W5**

Samples: **JWK92-12-1, 12-2**
Depths: 6580.5', 6615'
Age: Aalenian to late Pliensbachian, J13B-J14

Remarks

Amorphous kerogen dominates both samples and palynomorphs are relatively rare. The spore-pollen association is typical of the Poker Chip and rare specimens of *Nannoceratopsis senex* are present. The marine fraction is insufficiently rich and diverse to assign a more precise age.

Significant species

Distalannulisporites incertus
Corrugatisporites anagrammensis
Mathesporites tumulosus
Nannoceratopsis senex

WELL: **16-34-41-5W5**

Samples: **JWK92-14-1, 14-2**
Depths: 2246.8m, 2250.2m
Age: Cretaceous

Remarks

Bisaccate pollen are abundant in both samples (81% and 63%). A Cretaceous age is indicated by the presence of *Cicatricosisporites* spp. and *Concavissimisporites tribotrys* in 14-1 and by *Tigrisporites scurrandus* and *Taxodiaceaepollenites hiatus* in 14-2.

Significant species

Cicatricosisporites hughesii
Concavissimisporites tribotrys
Taxodiaceaepollenites hiatus
C. australiensis
Tigrisporites scurrandus

Samples: **JWK92-14-3, 14-4**
Depths: 2250.5m, 2250.58m
Age: Late to late Middle Oxfordian, J6B-J7

Remarks

Sample 14-3 contains abundant *Gonyaulacysta jurassica* and *Aldorfia dictyota* with significant numbers of *Valensiella ovula* and specimens of *Scriniodinium luridum* and *S. crystallinum*. The lower sample has abundant *G. jurassica* and *V. ovula* but few other dinocysts. Assemblages such as this are typical of the Late to late Middle Oxfordian.

Significant species

Gonyaulacysta jurassica (A)
Valensiella ovula
S. luridum
Aldorfia dictyota
Scriniodinium crystallinum

WELL: **8-4-42-5W5**

Samples: **JWK92-63-1, 63-2**
Depth: 2330.8m, 2331.2m
Age: ?Jurassic

Remarks

These samples have been thermally altered and indeterminate spores and pollen are abundant. Bisaccate pollen comprise approximately 23% of the assemblages, which is somewhat higher than is usually found in Oxfordian and older samples. No Cretaceous markers are present.

A specimen of *Escharisphaeridia* cf. *rudis* in 63-1 and *Gonyaulacysta jurassica* in 63-2 suggest a Jurassic possibly Oxfordian age but there is evidence of reworking of Jurassic forms such as *Scriniocassis priscus*.

A Jurassic age is assigned but this must remain very tentative since the data are inconclusive.

Significant species

Bissacate pollen (A)
Ischyosporites crateris
Callialasporites dampierii

Gonyaulacysta jurassica
Escharisphaeridia cf *rudis*

Neoraistrickia truncata
Cerebropollenites mesozoicus
C. turbatus

Scriniocassis priscus (RW)

Sample: **JWK92-26-1**
Depth: 2331.3m
Age: ?Late Jurassic

Remarks

Bisaccate pollen are extremely abundant in this sample forming a higher proportion of the assemblage than is usual in Late Jurassic samples in this study. However, the presence of *Gonyaulacysta jurassica* and *Lycopodiacidites spinulosus* suggest a Jurassic age and there are no obvious Cretaceous markers present to contradict this.

Significant species

Gonyaulacysta jurassica

Lycopodiacidites spinulosus

Sample: JWK92-26-2
Depth: 2335.3m
Age: Probably Early Bajocian, J13B

Remarks

This sample is similar in composition to 92-25-3 except that the *Fromea* spp. are absent. *Escharisphaeridia* spp. are also more prominent. An Early Bajocian age is tentatively assigned. The total kerogen resembles that from delta-front or basal distributory mouth bars.

Significant species

Evansia granulata
Escharisphaeridia spp.
Batiacasphaeridia sp.

Sample: JWK92-26-3
Depth: 2339.3m
Age: Aalenian, J14A

Remarks

This sample contains *Fromea* spp. and resembles 92-25-3.

Significant species

Fromea 83/1
Scriniocassis cf. *priscus*
Fromea senilis
Evansia granulata

Sample: JWK92-26-4
Depth: 2346.6m
Age: Aalenian - Late Toarcian, J14A-B

Remarks

The yield from this sample was extremely low. The small number of spores and pollen are typical of the Poker Chip but the higher energy conditions which resulted in a poor yield may place the sample in the Poker Chip - Rock Creek transition.

Significant species

Callialasporites dampierii
Distalannulisporites incertus
Corrugatisporites anagrammensis
Leptolepidites/Mathesporites sp.

WELL: **16-15-42-5W5**

Sample: **JWK92-27-1**
Depth: 2198m
Age: Aalenian, J14A

Remarks

This sample is similar to 92-26-3 and 92-25-3. In addition, a specimen of *Scriniocassis weberi* indicates an age no younger than earliest Bajocian, *discites* Ammonite Zone.

Significant species

Fromea 83/1
Evansia granulata
S. weberi
F. senilis (A)
Scriniocassis priscus

Sample: **JWK92-27-2**
Depth: 2200.3m
Age: Aalenian to Late Toarcian, J14A-B

Remarks

The kerogen indicates a relatively high energy environment of deposition where most of the palynomorphs have been winnowed out. A precise age determination is impossible but a specimen of *Callialasporites dampierii* places a lower age limit of Late Toarcian.

WELL: **8-11-42-8W5**

Sample: **JWK92-44-1**
Depth: 2490.45m
Age: ?Cretaceous

Remarks

This sample is dominated by inertinitic debris. The assemblage is extremely limited in composition being dominated by bisaccate pollen (70%). There are no marker species present and a Cretaceous age is tentatively assigned.

Samples: **JWK92-44-2, 44-3, 44-4, 44-5**
Depths: 2495.73m, 2496.7m, 2498m, 2504.4m
Age: Early Bajocian, J13B

Remarks

Dinocysts are present in all these samples and include specimens of *Escharisphaeridia* spp. and *Scriniocassis priscus* which means that they are no younger than Early Bajocian. There are no obvious Aalenian influences such as specimens of *Fromea* spp. and an Early Bajocian age is assigned.

Significant species

Scriniocassis priscus
Escharisphaeridia spp.

Sample: **JWK92-44-6**
Depth: 2507.9m
Age: Aalenian, J14A

Remarks

The spore assemblage is typical of Poker Chip samples and specimens of Dinocyst cf. PC-1 resemble those found in 92-19-2 which is also Aalenian.

Significant species

Dinocyst cf. PC-1
Mathesporites tumulosus
Corrugatisporites anagrammensis
Fromea 83/1
Distalannulisporites incertus
C. amplectaeformis

WELL: 12-32-42-9W5

Sample: JWK92-43-1
Depth: 2315.79m
Age: Indeterminable

Remarks

An essentially barren sample.

WELL: **2-16-43-6W5**

Sample: **JWK92-28-1**
Depth: 2280.7m
Age: Probably Cretaceous

Remarks

Bisaccate pollen comprise 68% of the assemblage. This factor, with a specimen of *Klukisporites* cf. *areolatus* favors a Cretaceous rather than a Jurassic age.

Sample: **JWK92-28-2**
Depth: 2287.5m
Age: Early Bajocian to latest Aalenian, J13B-J14A

Remarks

Specimens of *Scriniocassis priscus* indicate an age no younger than late Early Bajocian whereas *Valensiella ovula* places a lower age limit of latest Aalenian, *concavum* Ammonite Zone on the sample. *Fromea* spp. are present but rare.

Significant species

Scriniocassis priscus
Valensiella ovula
Fromea senilis

WELL: **6-1-43-7W5**

Sample: **JWK92-13-1**
Depth: 2396.5m
Age: Cretaceous

Remarks

Bisaccate pollen are abundant in this poorly preserved sample. Specimens of *Cicatricosisporites* spp. and a dinocyst resembling *Muderongia* sp. indicate a Cretaceous age.

Significant species

Cicatricosisporites sp. *C. hughesii*
cf. *Muderongia* sp.

Sample: **JWK92-13-2**
Depth: 2410m
Age: Cretaceous

Remarks

Bisaccate pollen comprise 80% of the assemblage which is typical for Cretaceous samples in this study. However, apart from rare *Taxodiaceaepollenites hiatus*, there are no Cretaceous markers present.

Sample: **JWK92-13-3**
Depth: 2413.5m
Age: Possibly Early Cretaceous

Remarks

Long-ranging pollen dominate the sample (83%) which is typical of the Early Cretaceous but there are no marker species present. There are specimens of *Concavissimisporites* cf. *exquisitus* which ranges down to the latest Kimmeridgian. JWK91-13-1 is grossly similar.

An early Cretaceous age is tentatively assigned but a latest Jurassic age cannot be ruled out.

WELL: **6-26-43-11W5**

Samples: **JWK92-5-1, 5-2**
Depths: 9478.8', 9485.5'
Age: Indeterminable

Remarks

Virtually barren samples.

Samples: **JWK92-38-1, 38-2**
Depths: 9486.3', 9492'
Age: Probably Jurassic

Remarks

The recoveries were low from these coarse lithologies and the preservance is poor due to carbonisation. The small number of spores and pollen recovered tend to favor a Jurassic rather than Cretaceous age.

Sample: **JWK92-5-3**
Depth: 9508'
Age: Early Bajocian to Toarcian (undiff.)

Remarks

The organic material has been severely thermally altered and only the more distinctive species are identifiable. *Classopollis* spp. are abundant and a specimen of *Corrugatisporites anagrammensis* favors a Poker Chip or lower Rock Creek age. The total residue appears to be well-sorted, indicated a high energy environment typical of the Rock Creek, but this could have been exaggerated by the maturation process.

WELL: 10-17-44-3W5

Sample: JWK92-33-1
Depth: 6472'
Age: Cretaceous

Remarks

Bisaccate pollen comprise 81% of the assemblage and the *Cicatricosisporites* group is abundant in this Cretaceous sample.

Significant species

Cicatricosisporites exilioides
Appendicisporites spp.
Concavissimisporites tribotrys
C. hallei
A. erdtmanii
C. trioreticulosus

WELL: **16-21-44-4W5**

Samples: **JWK92-34-1, 34-2**
Depths: 2071.4m, 2073.1m
Age: Cretaceous

Remarks

Bisaccate pollen are abundant and numerous Cretaceous markers are present in both samples.

Significant species

Cicatricosisporites australis
Concavissimisporites tribotrys
Foraminisporis wonthaggiensis
C. exilioides
C. trioreticulosus
Januasporites spinulosus

WELL: **8-14-44-8W5**

Sample: **JWK92-11-1**
Depth: 2405.75m
Age: Indeterminable

Remarks

The organic residue consists almost entirely of inertinitic debris. No useful, indubitably *in situ* palynomorphs were recorded.

Sample: **JWK92-11-2**
Depth: 2406.2m
Age: Probably Cretaceous

Remarks

Most of the palynomorphs are poorly preserved and fragmented. A specimen of *Cicatricosisporites* sp. suggests that a Cretaceous age is most likely.

Samples: **JWK92-11-3, 11-4**
Depths: 2406.7m, 2407.2m
Age: Jurassic

Remarks

Palynomorphs are rare and poorly preserved due to the high level of thermal maturity. Specimens of *Escharisphaeridia* spp., *Sentusidinium* spp. and *?Ellipsoidictyum* sp. indicate a Jurassic age. There are insufficient data to be more precise.

WELL: **7-17-45-9W5**

Sample: **JWK91-19-1**
Depth: 2416.75m
Age: Cretaceous

Remarks

The palynomorphs in this sample are highly degraded and pyritized such that few are identifiable. A small number of *Cicatricosisporites* spp. indicates a Cretaceous age.

Samples: **JWK91-19-2, 19-3**
Depths: 2417.4m, 2418.1m
Age: Late Jurassic, earliest Kimmeridgian to late Middle Oxfordian, J6-J7

Remarks

The upper sample yielded specimens of *Leptodinium* aff. *mirabile* and other indeterminate cysts of Jurassic aspect. Sample 19-3 yielded abundant dinocysts, many of them unidentifiable due to the high level of thermal maturation. *Leptodinium mirabile* is abundant with specimens of *L. subtile*, *Scriniodinium luridum*, *S. crystallinum*, *Valensiella ovula*, *Ellipsoidictyum* cf. *cinctum* and *Gonyaulacysta jurassica*.

S. crystallinum indicates a J6 or older age whereas the Leptodinium spp. do not range below J8. The lack of J8 markers, which are abundant in some samples in this study, suggest that a J6-J7 age is more likely.

Significant species

Leptodinium subtile *L. mirabile*
Scriniodinium crystallinum *S. luridum*

Samples JWK92-37-1, 91-19-4
Depth: 2418.4m
Age: Bajocian, J13

Remarks

Acritarchs are abundant in this sample as are specimens of *Classopollis* spp. A small number of simple dinocysts belonging to the genera *Escharisphaeridia* *Dissiliodinium* and *Batiacasphaera* is typical of the Bajocian, Rock Creek Formation.

Samples: JWK92-37-2, 91-19-5
Depth: 2426.3m
Age: ?Early Bajocian to Aalenian, ?J13B-J14A

Remarks

This sample resembles others from the Early Bajocian - Aalenian transition in this study such as 92-25-3, 92-26-3 and 92-27-1. Dinocysts are rare but include *Scriniocassis priscus*, *Nannoceratopsis senex*, *Fromea* cf. *senilis* and *Escharisphaeridia* spp.

Significant species

Scriniocassis priscus
Nannoceratopsis senex
Fromea cf. *senilis*
Escharisphaeridia spp.

Sample: JWK91-19-6
Depth: 2434.3m
Age: Indeterminable

Remarks

An essentially barren sample.

WELL: **1-11-45-10W5**

Samples: **JWK92-6-1, 92-39-1**
Depths: 2481.1m, 2481.5m
Age: Indeterminable

Remarks

Palynomorphs are extremely rare in these kerogen rich samples. Ages cannot be assigned.

Samples: **JWK92-39-2, 39-3**
Depths: 2482.2m, 2482.9m
Age: Most probably early Middle Oxfordian, J8

Remarks

These samples are rich in organic debris but palynomorphs are rare, especially in 39-3. Sample 39-2 contains a significant number of *Acanthaulax* spp. which is typical of other J8 samples in this study. A specimen of *Escharisphaeridia* cf. *rudis* in 39-3 indicates that this sample is not significantly older than 39-2.

Significant species

Acanthaulax spp. *Escharisphaeridia* cf. *rudis*

Sample: **JWK92-6-2**
Depth: 2484.3
Age: Possibly Middle Jurassic

Remarks

The yield from this sample was low but the preponderance of small spores and pollen suggest a Middle rather than Late Jurassic age.

Sample: JWK92-6-3
Depth: 2485.2m
Age: Bajocian, probably early, J13B

Remarks

The palynomorphs have been severly affected by thermal maturation processes.

Specimens of *Evansia evittii*, *Escharisphaeridia* spp. together with a lack of "Poker Chip" spore types, indicate a probable Bajocian age. A questionable specimen of *Scriniocassis priscus* suggests that an Early Bajocian age is more likely.

Sample: JWK92-6-4
Depth: 2501.5m
Age: Early Bajocian - Aalenian, J13B-J14A

Remarks

Few palynomorphs are present. The total kerogen is well-sorted indicating high energies more typical of the Rock Creek than the Poker Chip.

Sample: JWK92-6-5
Depth: 2507.7m
Age: Aalenian - Toarcian undifferentiated

Remarks

The yield from this sample was small but the total kerogen is rich in small pollen. Numerous specimens of spores typical of the Poker Chip indicate an Aalenian - Toarcian age but there are no dinocysts to provide a more precise age.

Significant species

Distalannulisporites incertus
C. amplectaeformis
Corrugatisporites anagrammensis

WELL: **6-2-46-8W5**

Sample: **JWK92-7-1**
Depth: 2189.2m
Age: Cretaceous

Remarks

This poorly preserved assemblage contains several specimens of *Cicatricosisporites* spp. indicating a Cretaceous age.

Sample: **JWK92-7-2**
Depth: 2193.1m
Age: Bajocian, J13

Remarks

Terrestrial taxa such as *Classopollis* spp. and *Corollina* spp. are abundant in this sample whereas dinocysts are rare. The presence of specimens of *Sestrosporites pseudoalveolatus*, *Dissiliodinium* spp. and *Escharisphaeridia* spp. is typical of the essentially Bajocian Rock Creek.

Significant species

Dissiliodinium spp.
Sestrosporites pseudoalveolatus
Escharisphaeridia spp.
Classopollis spp. (A)

Samples: **JWK92-7-3, 7-4**
Depths: 2194.5m, 2201.6m
Age: Early Bajocian to Aalenian, J13B-J14A

Remarks

Identifiable dinocysts are present in small numbers in these samples and include *Scriniocassis priscus* which indicates an age no younger than Early Bajocian (*sauzei* Ammonite Zone). Also present are *Nannoceratopsis gracilis*, *N. senex*, *Phallocysta minuta*, *P.* cf. *eumekes* and, in the higher sample, *Fromea* aff. *senilis*. The overall composition and appearance of the assemblages do not resemble

those from typical Poker Chip samples. It is possible that these are slightly younger although the age-range is similar.

Significant species

Scriniocassis priscus
Nannoceratopsis gracilis
Phallocysta cf. *eumekes*
Fromea aff. *senilis*
N. senex
P. minuta

WELL: **11-10-46-9W5**

Sample: **JWK92-35-1**
Depth: 2075.66m
Age: probably Cretaceous

Remarks

Bisaccate pollen comprise 82% of this assemblage and although they can be abundant in the Late Jurassic of this area, abundances such as this are more typical of the Cretaceous. However, the lack of Cretaceous markers means that a Jurassic age cannot be ruled out.

Samples: **JWK92-35-2, 91-18-1, 91-18-2**
Depths: 2075.91m, 2077.6m, 2077.98m
Age: Early Middle Oxfordian, J8

Remarks

All three samples contain abundant dinocysts but the composition of the assemblage is varied. Sample 92-35-2 contains abundant *Acanthaulax* spp. which is typical of the J8 Zone. The presence of *Leptodinium subtile* in 91-18-1 and of *L.* cf. *mirabile* in 91-18-2 indicate that the samples are no older than J8. The lowermost sample also contains abundant *Ellipsoidictyum gochtii* which is also typical of Middle Oxfordian and older sediments elsewhere.

Significant species

Acanthaulax spp.
Leptodinium cf. *mirabile*
L. eumorphum
Ellipsoidictyum gochtii
L. subtile
Scriniodinium luridum

WELL: **10-9-46-14W5**

Sample: **JWK91-20-1**
Depth: 10271.5'
Age: Cretaceous

Remarks

Although this sample is rich in kerogen, palynomorphs are relatively rare, possibly due to a high energy level in the environment. *Cicatricosisporites* spp. are numerous, more so than pollen, and with specimens of *Foraminisporis wonthaggiensis* and *Klukisporites areolatus* present, a Cretaceous age is indicated.

Significant species

Cicatricosisporites spp.
Klukisporites cf. *areolatus*
Foraminisporis wonthaggiensis

Sample: **JWK91-20-2**
Depth: 10285.4'
Age: Indeterminable

Remarks

The yield from this sample was extremely small and limited to a few long-ranging bisaccate pollen and indeterminable spores. An age cannot be assigned.

Samples: **JWK91-20-3, 20-4, 20-5**
Depths: 10287.4', 10287.8', 10290.8'
Age: Jurassic

Remarks

Palynomorphs are rare in 20-3, possibly due to high energy levels in the environment of deposition. A dinocyst of Jurassic aspect along with rare specimens of *Escharisphaeridia* sp. favor a Jurassic age. This must remain tentative given the poor quality of the assemblages.

Samples 20-4 and 20-5 are richer but are of essentially similar composition.

Sample: JWK91-20-6
Depth: 10291.3'
Age: ?Oxfordian

Remarks

This sample is obviously Jurassic and resembles many of the Rock Creek Bajocian samples in this study. The age is based on the presence of numerous specimens of *Escharisphaeridia* sp., some of which resemble *E. rudis*, a form which characterises the Oxfordian in this study, along with a Jurassic spore-pollen assemblage. The sample is too poor to assign a precise age.

Significant species

Escharisphaeridia cf. *rudis*
Matonisporites crassiangulatus
Couperisporites jurassicus
Converrucosisporites congregatus

Sample: JWK91-20-7
Depth: 10293.4'
Age: Jurassic

Remarks

This sample yielded a very small assemblage of long-ranging palynomorphs, none of which can be used to date the sample with any degree of precision.

WELL: **11-11-47-9W5**

Sample: **JWK91-17-1**
Depth: 2086m
Age: Cretaceous

Remarks

As in some other Cretaceous samples in this study, bisaccate pollen are overwhelmingly abundant comprising 88% of the assemblage. Specimens of *Cicatricosisporites* sp. and *Foraminisporis wonthaggiensis* confirm the Cretaceous age.

Significant species

Cicatricosisporites sp. *Foraminisporis wonthaggiensis*

Sample: **JWK91-17-2**
Depth: 2087.95m
Age: Late Aptian - Early Albian

Remarks

This sample is similar in composition to 91-16-1. The association of abundant *Balmula tripenta* and *Pseudoceratium* spp. with rare *Vesperopsis mayi* is typical of the Ostracod Zone at some localities. Bisaccate pollen comprise 75% of the assemblage with dinocysts comprising 6%.

Significant species

Balmula tripenta (A) *Vesperopsis mayi*
Pseudoceratium spp. (A) *P.* cf. *pelliferum*

Samples: **JWK91-17-3, 17-4, 17-5, 17-6, 17-7**
Depths: 2091.6m, 2094.5m, 2099.5m, 2102.6m, 2103.9m
Age: Early Cretaceous

Remarks

The preservation of the palynomorphs in these samples varies but is generally poor, probably due to diagenetic rather than thermal degradation. Bisaccate pollen are abundant forming at least 75% of each assemblage. *Cicatricosisporites* species and the related *Appendicisporites* are numerous to abundant indicating a Cretaceous age. Dinocysts are rare, present only in 17-3

and 17-4, and are of Early Cretaceous age. Other Cretaceous markers are listed below.

Significant species

Cicatricosisporites spp.
Concavissimisporites tribotrys
Couperisporites tabulatus
Tigrisporites scurrandus

Appendicisporites spp.
Aequitriradites spinulosus
Foraminisporites wonthaggiensis

Pseudoceratium sp.

Atopodinium sp.

WELL: **6-15-48-9W5**

Sample: **JWK91-16-1**
Depth: 2119m
Age: Late Aptian - Early Albian

Remarks

This sample contains a high proportion of bisaccate pollen (73%) but dinocysts are abundant and *Cicatricosisporites* spp. are quite numerous. The dinocyst association is dominated by *Balmula tripenta* with small numbers of *Vesperopsis* sp. and *Atopodinium* sp. This unusual assemblage is probably of brackish water origin and may be found in the Ostracod Zone of the Late Aptian - Early Albian.

Significant species

Balmula tripenta (A)
Atopodinium sp.
Vesperopsis sp.
Cicatricosisporites spp.

Sample: **JWK91-16-2**
Depth: 2119.6m
Age: Possibly Cretaceous

Remarks

This sample yielded an assemblage similar to 91-14-1, 14-2 and 91-13-1 and is dominated by bisaccate pollen (76%) with specimens of *Ischyosporites pseudoreticulatus* and *Concavissimisporites* cf. *equisetus* which indicate an age no older than latest Kimmeridgian J2. Rare, recycled Jurassic dinocysts are also present.

Sample: **JWK91-16-3**
Depth: 2120.8m
Age: Oxfordian, ?J6B-J7

Remarks

Although there are distinct similarities in the terrestrial fraction with the overlying sample, bisaccates comprise 85% for example, a number of well-preserved dinocysts indicate a Jurassic age. The presence of *Gonyaulacysta jurassica*,

Adnatosphaeridium filamentosum, *Valensiella ovula* and *Scriniodinium luridum* without older markers suggest an Oxfordian, possibly late Oxfordian age.

Significant species

Gonyaulacysta jurassica
Valensiella ovula
Adnatosphaeridium filamentosum
Scriniodinium luridum

Sample: **JWK91-16-4**
Depth: 2121.8m
Age: Bajocian, J13

Remarks

Although this sample yielded a small amount of organic material, dinocysts are numerous. The age is based on the presence of *Evansia tripartita* (Bajocian - Middle Callovian) with a specimen of *Meiourogonyaulax decapitata* (Bajocian - Bathonian). The prevalence of simple forms belonging to *Escharisphaeridia* and *Dissiliodinium* is also typical of the Bajocian.

Significant species

Meiourogonyaulax decapitata
Escharisphaeridia spp.
Evansia tripartita
Dissiliodinium spp.

Sample: **JWK91-16-5**
Depth: 2140.6m
Age: Probably Aalenian - Late Toarcian, J14A-B

Remarks

The yield from this sample was extremely low. Specimens of *Callialasporites dampierii*, *Corrugatisporites amplectaeformis*, *Distalannulisporites incertus* and *Mathesporites tumulosus* suggest an Aalenian - Late Toarcian age. The low yield may reflect Rock Creek - Poker Chip transition facies.

WELL: **5-34-48-12W5**

Sample: **JWK91-21-1**
Depth: 2497.1m
Age: Cretaceous

Remarks

This sample yielded an assemblage of poorly preserved palynomorphs. A questionable specimen of *Cicatricosisporites* sp. and several specimens of *Taxodiaceaepollenites* sp. indicate a Cretaceous age. Recycled Jurasic dinocysts are quite numerous.

Samples: **JWK91-21-2, 21-3, 21-4**
Depths: 2498.4m, 2499.4m, 2502.3m
Age: Jurassic

Remarks

These three samples contained very poor assemblages of palynomorphs and little organic debris. Small numbers of *Escharisphaeridia* spp. in each sample favor a Jurassic age.

Sample: **JWK91-21-5**
Depth: 2517.8m
Age: Jurassic, Early Bajocian - Aalenian, J13B-J14A

Remarks

The effects of high thermal maturation are obvious here and very few palynomorphs can be identified to species-level. The *Classopollis* group is abundant and rare specimens of *Escharisphaeridia* sp. and *Mathesporites* cf. *tumulosus* point to an Early Bajocian or older age. A precise age determination is not possible.

Sample: JWK91-21-6
Depth: 2522.5m
Age: Aalenian - Late Toarcian, J14A-B

Remarks

This sample is richer than any of the overlying samples. The presence of *Nannoceratopsis gracilis*, *Fromea* spp., *Mathesporites tumulosus* and a complex of *Leptolepidites - Uvaesporites* spp. is typical of the Poker Chip.

Significant species

Nannoceratopsis gracilis
Mathesporites tumulosus
Fromea spp.
Leptolepidites - Uvaesporites spp.

WELL: **16-28-49-5W5**

Sample: **JWK92-21-1**
Depth: 1726.8m
Age: Cretaceous

Remarks

Bisaccate pollen comprise 96% of the assemblage. The remainder contains a diverse assemblage of typically Cretaceous spores.

Significant species

Cicatricosisporites hallei
Concavissimisporites tribotrys
Januasporites cf. *spiniferus*
C. exilioides
Appendicisporites sp.
Pilosisporites trichopapillosus

WELL: **12-30-49-5W5**

Sample: **JWK92-8-1**
Depth: 1757.3m
Age: Cretaceous

Remarks

The organic matter in this sample is dark-colored, presumably due to primary oxidation. Numerous specimens of the *Cicatricosisporites* group along with specimens of *Concavissimisporites tribotrys*, *Aequitriradites spinulosus* and *Foraminisporis wonthaggiensis* indicate a Cretaceous age.

Significant species

Cicatricosisporites spp.
C. australiensis
Concavissimisporites tribotrys
C. exilioides
Appendicisporites bilateralis
Foraminisporis wonthaggiensis

Sample: **JWK92-8-2**
Depth: 1763m
Age: Early Toarcian to Late Pliensbachian, J14C-D

Remarks

Amorphous debris predominates in this sample although palynomorphs are abundant. Indeterminate dinocysts are extremely rare but the spore-pollen association typical of the Poker Chip is present in reasonable numbers. The presence of clumps of *Spheripollenites* sp. in abundance could be due to local environmental conditions, however, this feature characterises the mid-Toarcian to Late Pliensbachian in the Arctic and in north-west Europe.

Significant species

Spheripollenites spp. (A)
Distalannulisporites incertus
Mathesporites tumulosus
Corrugatisporites anagrammensis

Sample: **JWK92-8-3**
Depth: 1764m
Age: Indeterminable

Remarks

A virtually barren sample.

WELL: **8-32-49-10W5**

Samples: **JWK91-15-1, 15-2**
Depths: 2175.15m, 2177.84m
Age: Early Cretaceous

Remarks

Bisaccate pollen dominate both samples, 78% and 75% respectively. Both samples contain spores which range down to the latest Kimmeridgian (J2) but the presence of *Klukisporites areolatus* in the lower sample indicates a Cretaceous age.

Recycled Jurassic dinocysts are present in both samples but are especially numerous in the higher one.

Significant species

Klukisporites areolatus

WELL: **11-20-49-11W5**

Sample: **JWK92-41-1**
Depth: 2315.79m
Age: Probably Middle to Early Oxfordian, J8-J9B

Remarks

Dinocysts are rare which is dominated by spores and pollen. Specimens of *Escharisphaeridia rudis*, *Sentusidinium* spp. and *Gonyaulacysta* cf. *cladophora* suggest a Middle to Early Oxfordian age. The lack of diversity prevents a more precise assignment.

Significant species

Escharisphaeridia rudis — *Sentusidinium* spp.

Samples: **JWK91-23-1, 23-2**
Depths: 2316.3m, 2316.5m
Age: Early Oxfordian, J9B

Remarks

These samples are very similar in composition to 91-22-1 and 91-22-2. *Escharisphaeridia rudis* is abundant in 23-1 and there are a few specimens of *Sentusidinium villersense* and *S. rioultii* present in both samples.

Significant species

Escharisphaeridia rudis (A) — *Sentusidinium villersense*
S. rioultii — Bisaccate pollen (A)

Sample: **JWK91-23-3**
Depth: 2317.1m
Age: ?Early Oxfordian, J9B

Remarks

Dinocysts are fairly numerous but are difficult to identify. Some specimens resemble *Acanthaulax* sp., similar to Oxfordian - latest Callovian forms present in other Oxfordian samples in this study. Bisaccate pollen are also abundant. A clear age determination cannot be made but the overall composition suggests a Late Jurassic age.

WELL: **12-35-50-4W5**

Sample: **JWK92-10-1**
Depth: 1533.5m
Age: Cretaceous

Remarks

This is a rich and diverse Cretaceous assemblage in which the *Cicatricosisporites* group is prominent.

Significant species

Cicatricosisporites spp. (A)
C. exilioides
Appendicisporites bilateralis
Aequitriradites spinulosus
C. hallei
C. imbricatus
Tigrisporites reticulatus

WELL: **6-1-50-5W5**

Sample: **JWK92-9-1**
Depth: 1701.45m
Age: Cretaceous

Remarks

A typical Cretaceous sample dominated by bisaccate pollen (90%) with *Cicatricosisporites* spp., *Taxodiaceaepollenites hiatus*, *Aequitriradites spinulosus* and *Couperisporites tabulatus*.

Significant species

Cicatricosisporites spp.
Aequitriradites spinulosus
Taxodiaceaepollenites hiatus
Couperisporites tabulatus

WELL: **8-15-50-11W5**

Samples: **JWK92-40-1, 40-2, 40-3**
Depths: 2210.65m, 2211.7m, 2211.95m
Age: Early Oxfordian, J9A-B

Remarks

Dinocysts are rare in these spore/pollen rich samples but the assemblages are consistent with an Early Oxfordian age.

Significant species

Escharisphaeridia rudis
Valensiella ovula
Sentusidinium villersense
Acanthaulax spp.
Ellipsoidictyum gochtii
Gonyaulacysta jurassica
S. cf. rioultii

Samples: **JWK91-22-1, 22-2**
Depths: 2212.5m, 2212.98m
Age: Early Oxfordian, J9B

Remarks

These samples contain abundant *Escharisphaeridia rudis* which is also present in 81-11-2. In addition, significant number of *Sentusidinium rioultii* and *S. villersense* indicate an age no younger than Early Oxfordian, J9B. the lack of any Callovian markers is used to confine the age to the Oxfordian.

Significant species

Sentusidinium rioultii
Aldorfia dictyota
Acanthaulax sp.
Bisaccate pollen (A)
S. villersense
Scriniodinium luridum
Escharisphaeridia rudis (A)

Sample: **JWK91-22-3**
Depth: 2218m
Age: Middle Jurassic, probably Bajocian, J13

Remarks

Classopollis spp. are extremely abundant (56%) in this sample and there is very little marine influence. Spores such as *Concavissimisporites* cf. *southeyensis* and *Mathesporites tumulosus* suggest a Bajocian age but a precise age is not possible due to the lack of marine markers.

WELL: **14-25-51-8W5**

Sample: **JWK92-20-1**
Depth: 1770.5m
Age: Cretaceous, probably Middle Albian

Remarks

This sample yielded a rich assemblage of Cretaceous dinocysts, probably of Middle Albian age. Spores and pollen are relatively rare.

Significant species

Pseudoceratium pelliferum
P. gochtii
Palaeoperidinium cretaceum
Apteodinium indicosum
Circulodinium brevispinosum
P. cf. retusum
Odontochitina operculata
Batioladinium jaegerii
Aptea polymorpha

Sample **JWK92-20-2**
Depth: 1778.75m
Age: Possibly Aalenian - Late Toarcian, ?J14A-B

Remarks

The organic yield from this sample was extremely low. Rare specimens of *Distulannulisporites incertus*, *Uvaesporites* sp., *Exesipollenites* spp. and *Callialasporites dampierii* suggest a possible Poker Chip origin. The yield is unusually low however, and this correlation must remain tentative.

WELL: **6-33-51-8W5**

Sample: **JWK92-19-1**
Depth: 6022.5'
Age: ?Cretaceous - Late Jurassic

Remarks

This assemblage contains abundant bisaccate pollen which is more typical of the Late Jurassic and Cretaceous. However, the only species present with limited ranges appear to have a Poker Chip origin. The latter were probably recycled.

Significant species

Scriniocassis priscus
Mathesporites tumulosus
Leptolepidites sp.
Bisaccate pollen (A)

Sample **JWK92-19-2**
Depth: 6039'
Age: Aalenian, J14A

Remarks

This is a rich assemblage typical of the Poker Chip. The presence of *Jansonia* cf. *jurassica* indicates an age no older than Aalenian.

Significant species

Fromea 83/1
Dinocyst cf. PC-1
Scriniocassis priscus
Nannoceratopsis gracilis
Fromea senilis
Jansonia cf. *jurassica*
Phallocysta minuta

WELL: **15-11-51-9W5**

Samples: **JWK91-24-1, 24-2**
Depths: 1948.1m, 1956.05m
Age: Cretaceous

Remarks

Both samples yielded large numbers of bisaccate pollen with a few specimens of *Cicatricosisporites* spp. This composition is typical of Cretaceous samples in this study.

Sample: **JWK91-24-3**
Depth: 1960.75m
Age: Aalenian to Late Toarcian, J14A-B

Remarks

Sapropelic debris obscures many of the palynomorphs. The association of numerous *Fromea* 83/1 and Dinocyst PC-1 is often found in the Poker Chip.

Significant species

Dinocyst PC-1
Classopollis spp. (A)
Fromea 83/1
Uvaesporites sp.

WELL: **8-10-51-10W5**

Sample: **JWK92-25-1**
Depth: 2050.2m
Age: Late Aptian - Early Albian

Remarks

Bisaccate pollen comprise 97% of the assemblage. The presence of a small number of *Balmula tripenta* is indicative of a possible Ostracod Zone origin, i.e., of late Aptian - Early Albian age.

Significant species

Balmula tripenta *Cicatricosisporites hallei*

Sample: **JWK92-25-2**
Depth: 2051.8m
Age: Indeterminable

Remarks

This sample contained highly oxidized, inertinitic debris only.

Sample: **JWK92-25-3**
Depth: 2055.1m
Age: Aalenian, J14A

Remarks

This is a rich assemblage in which *Fromea* 83/1 is abundant. There are also several specimens of *Evansia granulata* which suggest a Bajocian influence. The kerogen is more typical of the Poker Chip but the small spores and dinocysts, which are often characteristic, are absent. An Aalenian age is assigned but a Bajocian (?earliest) cannot be ruled out.

Significant species

Fromea 83/1 (A) *Evansia granulata*
Nannoceratopsis gracilis

WELL: **8-14-51-11W5**

Samples: **JWK92-24-1, 24-2**
Depths: 2158.7m, 2162.05
Age: Cretaceous

Remarks

Both samples appear to have been deposited in an oxidizing environment and the assemblages are of limited composition. *Cicatricosisporites* spp. are present in both samples indicating a Cretaceous age.

Significant species

Cicatricosisporites hughesii *C. imbricatus*

Sample: **JWK92-24-3**
Depth: 2168.5m
Age: Cretaceous

Remarks

This is a richer and more varied assemblage of Cretaceous age.

Significant species

Cicatricosisporites exilioides *C. hallei*
Concavissimisporites tribotrys

Samples: **JWK92-24-4, 24-5, 24-6**
Depths: 2171.05m, 2172.9m, 2179.8m
Age: Aalenian, J14A

Remarks

The composition of these assemblages resembles some from the Poker Chip but the small dinocysts and spores which characterise this formation are absent or rare. The yields are also low. It is possible that they come from the Poker Chip - Rock Creek transition. The presence of *Scriniocassis priscus* indicates an age no younger than late Early Bajocian but numerous *Fromea* spp. are more typical of the Aalenian samples in this study.

Significant species

Fromea 83/1 *F. senilis*

WELL: **7-28-51-15W5**

Samples: **JWK92-60-1, 60-2, 60-3**
Depths: 2600.5m, 2601.5m, 2607.4m
Age: Aalenian-Late Toarcian, J14A-B

Remarks

The assemblages from these samples have been subjected to significant thermal alteration. There is little sign of marine influence apart from rare acritarchs and many of the specimens are unidentifiable. The spore-pollen association is typical of the Poker Chip and Poker Chip-Rock Creek transition and the presence of *Callialasporites dampierii* indicates an age no older than Late Toarcian.

Significant species

Classopollis spp. (A)
Uvaesporites sp.
Callialasporites dampierii

Micrhystridium spp.

Mathesporites tumulosus
Distalannulisporites incertus
C. turbatus

WELL: **15-9-52-8W5**

Samples: **JWK92-18-1, 18-2, 18-3**
Depths: 1818.5m, 1821.6m, 1822.75m
Age: Early Bajocian to ?Aalenian, J13B-?J14A

Remarks

Yields were low from these samples, particularly 18-3. Dinocysts are rare but include *Scriniocassis priscus* and *Evansia* spp. The terrestrial fraction is quite varied but *Classopollis* spp. predominate. Other prominent species include *Lycopodiumsporites* spp. and *Converrucosisporites congregatus*. An Early Bajocian to Aalenian age is indicated but judging by the composition of the terrestrial fraction, it is doubtful whether the section extends significantly into the Aalenian.

Significant species

Scriniocassis priscus
Lycopodiumsporites spp.
Evansia spp.
Converrucosisporites congregatus

WELL: **1-17-52-8W5**

Sample: **JWK91-62-1**
Depth: 1822.35m
Age: Probably Cretaceous

Remarks

This sample yielded a rich assemblage of long-ranging spores and pollen. Specimens of *Concavissimisporites montuosus*, *Contignisporites glebulentus* and *Concavissimisporites* spp. are more typical of the Cretaceous but the first two species have been recorded in the Kimmeridgian.

Significant species

Bisaccate pollen (A)
Concavissimisporites spp.
Cerebropollenites mesozoicus
Contignisporites glebulentus
C. montuosus
Callialasporites trilobatus

Samples: **JWK92-62-2, 62-3**
Depths: 1824.2m, 1824.7m
Age: Early Bajocian, J13B

Remarks

Both assemblages represent a highly restricted marine environment where specimens of *Caddasphaera halosa* and *Evansia tripartita* are abundant. The latter appears in the Bajocian and there are no specifically Late Bajocian elements present. The spore-pollen association is similar to other Bajocian samples in this study.

Significant species

Classopollis spp. (A)
Callialasporites turbatus
Cerebropollenites mesozoicus
Corollina spp. (A)
C. dampierii
Ischyosporites crateris

Escharisphaeridia spp.
Caddasphaera halosa (A)
Evansia tripartita (A)
Micrhystridium spp.

Sample: JWK92-62-4
Depth: 1829.9m
Age: Early Bajocian-Late Aalenian, J13B-A

Remarks

Spores and pollen are less numerous in this sample and dinocysts are rare. A specimen of *Nannoceratopsis senex* suggests an Aalenian influence although it does range into the early Bajocian. Rare specimens of *Corrugatisporites* spp. and *Uvaesporites* sp. are infrequent above the Aalenian samples in this study.

Signficant species

Classopollis spp. (A)
Callialasporites turbatus
Corrugatisporites anagramensis

Batiacasphaera sp.

Corollina spp. (A)
C. dampierii
Uvaesporites sp.

Nannoceratopsis senex

Sample: JWK92-62-5
Depth: 1833m
Age: Early Aalenian, J14A

Remarks

Small indeterminate dinocysts are abundant in this sample. The presence of Dinocyst PC-1 with *Jansonia jurassica* indicates an early Aalenian age.

Significant species

Classopollis spp. (A)
Callialasporites dampierii
C. trilobatus

Scriniocassis priscus
Jansonia jurassica
Fromea cf *senilis*
Nannoceratopsis senex

Ischyosporites crateris
C. turbatus
Distalannulisporites incertus

S. weberii
Dinocyst PC-1
Phallocysta minuta

WELL: **4-29-52-8W5**

Samples: **JWK92-1-1, 1-2**
Depths: 1815.5m, 1820.1m
Age: Cretaceous

Remarks

Both samples yielded small residues although the lower one is somewhat richer. The Cretaceous age is based on the presence of *Cicatricosisporites* spp., *Taxodiaciaepollenites hiatus* and *Tigrisporites scurrandus*.

Significant species

Cicatricosisporites cf. *minor*
Taxodiaceaepollenites hiatus
C. hallei
Tigrisporites scurrandus

Sample: **JWK92-1-3**
Depth: 1821.8m
Age: Indeterminable

Remarks

The extremely small residue contains rare, long-ranging spores and pollen and one questionable dinocyst.

WELL: **7-35-52-9W5**

Sample: **JWK92-16-1**
Depth: 6273.5'
Age: Probably Toarcian debris

Remarks

The sparse kerogen is dominated by sapropelic debris. Rare *Sphaeripollenites* sp., *Distalannulisporites incertus*, *Corrugatisporites anagrammensis* and *Callialasporites turbatus* suggest a Toarcian age. However, given the nature of the underlying samples, this is probably a reworked assemblage.

Samples **JWK92-16-2, 16-3**
Depths: 6320', 6363'
Age: ?Cretaceous

Remarks

Both samples are highly oxidized and dominated by inertinitic debris which contrasts with 16-1. Spores and pollen are relatively rare, especially in 16-2, but bisaccate pollen are abundant in 16-3, a feature more typical of Cretaceous samples in this study. A precise age cannot be assigned to these two samples.

WELL: **3-14-52-14W5**

Samples: **JWK91-14-1, 14-2**
Depths: 2334.3m, 2335.9m
Age: Possibly Early Cretaceous

Remarks

These samples are similar to 91-13-1 in that they are typical of the Early Cretaceous but do not contain any marker species to confirm the age-range. The lower sample contains specimens of *Ischyosporites pseudoreticulatus* and *Concavissimisporites apiverrucatus* which indicates that the sample is no older than latest Kimmeridgian, J2. The preservation is poor due to thermal maturation.

Samples: **JWK91-14-3, 14-4, 14-5, 14-6, 14-7, 14-8**
Depths: 2336.4m, 2339.9m, 2345.2m, 2348.5m, 2359.9m, 2362.6m
Age: Middle to ?Early Oxfordian, J8-?J9A-B

Remarks

The yields and overall compositions of these samples vary considerably. Sample 14-3 is rich in spores and pollen with few dinocysts; 14-4 is rich in dinocysts (85%); samples 14-5, 14-6 and 14-7 are poor and dominated by terrestrial microfloras; sample 14-8 is slightly richer with numerous dinocysts.

Acanthaulax spp. are present in most samples and are especially abundant in 14-4 and 14-8. This is typical of early Middle Oxfordian (J8) to latest Callovian strata (J9C). The presence of *Leptodinium* cf. *subtile* in 14-4 indicates that this sample is no older than Middle Oxfordian (J8). Although some species typical of the Early Oxfordian in this study are present (e.g., *Escharisphaeridia rudis*, *Sentusidinium* cf. *rioultii*), the overall character of the asemblages appears to be younger than 91-11-2, 22-1, 22-2, 23-1 and 23-2.

Significant species

Acanthaulax spp. *Leptodinium* cf. *subtile*

WELL: **16-3-53-8W5**

Samples: **JWK92-2-1, 2-2**
Depths: 1768m, 1768.1m
Age: Early Bajocian to Aalenian, J13B-J14A

Remarks

These extremely rich samples are typical of the Poker Chip. The presence of *Phallocysta minuta*, *Nannoceratopsis dictyambonis* and *Jansonia* aff. *jurassica* indicate a basal Early Bajocian (*discites* Ammonite Zone) to Aalenian age. No representatives of the *Lithodinia serrulata* - Dinocyst PC-1 complex are present.

Significant species

Phallocysta minuta
Jansonia cf. *jurassica*
Nannoceratopsis dictyambonis
Fromea spp.

Sample: **JWK92-2-3**
Depth: 1768.3m
Age: Aalenian - Late Toarcian, J14A-J14B

Remarks

The terrestrial fraction is more noticeable in this sample. *Distalannulisporites incertus* is abundant and there are numerous specimens of *Mathesporites tumulosus* and *Corrugatisporites anagrammensis*. *Phallocysta minuta* is as numerous as in the overlying samples but the other marker species are absent. *Lithodinia* aff. *serrulata* is present here. Obviously, this sample is not significantly older than 2-1 and 2-2 but a slightly broader age range is assigned due to the lack of Aalenian and younger marker species.

Significant species

Phallocysta minuta
Lithodinia aff. *serrulata*

WELL: **7-31-53-10W5**

Samples: **JWK92-17-1, 17-2, 17-3**
Depths: 6002', 6008', 6023.5'
Age: late Early Bajocian, J13B

Remarks

Scriniocassis priscus is present in all three samples indicating an age no younger than Early Bajocian, *sauzei* Ammonite Zone. Samples 17-1 and 17-2 also contain specimens of *Acanthaulax* cf. *crispa*, *sensu stricto* specimens of which do not range below the late Early Bajocian. These two samples also contain several specimens of *Jansonia jurassica* which does not range below the Aalenian. *Pareodinia* spp. predominate in 17-3. The samples in some ways resemble 92-7-3 and 7-4 but are closer in composition to 92-23-1 and 23-2 which are of late Early Bajocian age.

Significant species

Scriniocassis priscus
Fromea senilis
Evansia evittii
Acanthaulax cf. *crispa*
Phallocysta minuta
Jansonia jurassica

WELL: **7-36-53-14W5**

Samples: **JWK92-61-1, 61-2**
Depths: 2175.85m, 2178m
Age: Early Bajocian, J13B

Remarks

Both samples yielded spore-pollen assemblages typical of the Bajocian with numerous specimens of very robust forms of *Corollina* sp. Dinocysts are abundant in 61-1, mainly specimens of *Escharisphaeridia* spp., but the presence of *Scriniocassis priscus* in both samples indicates an age no younger than Early Bajocian.

Significant species

Classopollis spp. (A)
Ischyosporites crateris
Callialasporites dampierii
Ovalipollis enigmatica

Escharisphaeridia spp. (A)
Scriniocassis priscus
Micrhystridium spp.

Corollina spp. (A)
Mathesporites tumulosus (R)
C. turbatus
Cerebropollenites mesozoicus

Batiacasphaera sp.
Jansonia jurassica
Cymatiosphaera sp.

WELL: **6-12-54-6W5**

Sample: **JWK92-4-1**
Depth: 4954.5'
Age: Late Aptian - Early Albian

Remarks

This Cretaceous assemblage contains abundant *Balmula tripenta* with specimens of *Atopodinium* sp. and *Vesperopsis* sp. Similar assemblages are present in 91-16-1 and 91-17-2. They probably indicate a brackish environment within the Ostracod Zone

Significant species

Balmula tripenta
Vesperopsis sp.
Atopodinium sp.
Cicatricosisporites spp.

Samples: **JWK92-4-2, 4-3**
Depths: 4959.5', 4963'
Age: Cretaceous

Remarks

In addition to abundant bisaccate pollen, both samples contain numerous specimens of *Cicatricosisporites* spp. typical of the Cretaceous.

Significant species

Cicatricosisporites spp.
Appendicisporites jansonii

Sample: **JWK92-4-4**
Depth: 4967'
Age: Indeterminable

Remarks

A virtually barren sample.

Samples: **JWK92-4-5, 4-6**
Depths: 4974.7', 4976.5'
Age: Aalenian - Late Toarcian, J14A-B

Remarks

These samples are rich in spores and pollen typical of the Poker Chip and closely resemble samples 92-3-2 and 3-3. Dinocysts are extremely rare and include *Nannoceratopsis senex*. A restricted, possibly lagoonal environment is indicated.

Significant species

Mathesporites tumulosus
Corrugatisporites anagrammensis
Distalannulisporites incertus (A)
Nannoceratopsis senex

WELL: **6-18-54-7W5**

Sample: **JWK92-3-1**
Depth: 1625m
Age: Cretaceous

Remarks

Although spores and pollen are abundant, most are broken. Numerous representatives of the *Cicatricosisporites* group indicate a Cretaceous age.

Significant species

Cicatricosisporites spp.
C. exilioides
Tigrisporites scurrandus
C. hallei
Appendicisporites erdtmanii
Taxodiaceaepollenites hiatus

Samples: **JWK92-3-2, 3-3**
Depths: 1634.2m, 1637m
Age: Aalenian - Late Toarcian, J14A-B

Remarks

The spore-pollen association often found in Poker Chip samples is present in abundance here but dinocysts are extremely rare and include *Nannoceratopsis senex*, *Wallodinium* sp. and *Caddasphaera halosa*. A highly restricted, possibly lagoonal environment is envisaged.

Significant species

Mathesporites tumulosus (A)
Corrugatisporites anagrammensis (A)
Distalannulisporites incertus (A)
Nannoceratopsis senex

Sample: **JWK92-3-4**
Depth: 1646.3m
Age: ?Aalenian - ?Toarcian

Remarks

Only five palynomorphs were recorded from this low-yielding sample. They include *Mathesporites tumulosus* and *Distalannulisporites incertus* which are typical of the Poker Chip. A precise age cannot be assigned.

WELL: **4-13-54-11W5**

Samples: **JWK92-23-1, 23-2**
Depths: 1840.78m, 1845.1m
Age: Late Early Bajocian, J13B

Remarks

These samples are rich in dinocysts and the presence of *Sentusidinium asymmetrum* with *Scriniocassis priscus* indicates a late Early Bajocian age for the samples. *Pareodinia* spp. predominate in 23-1 and *Caddasphaera halosa* is abundant in 23-2. The samples bare a striking resemblance to 92-17-3.

Significant species

Scriniocassis priscus
Evansia evittii
Caddasphaera halosa (A)
Sentusidinium asymmetrum
Pareodinia spp. (A)

Sample: **JWK92-23-3**
Depth: 1851.7m
Age: probably Aalenian, J14A

Remarks

This rich sample has a rather limited composition which in some ways resembles a Poker Chip assemblage. For example, *Mathesporites tumulus* is numerous and there are a few specimens of *Leptolepidites/Uvaesporites* spp. *Araucariacites australis* is unusually abundant however which, in this area, is more typical of post-Poker chip samples. Small dinocysts are absent but *Fromea* 83/1 is abundant. An Aalenian age is tentatively proposed.

Significant species

Fromea 83/1 (A)
Leptolepidites/Uvaesporites spp.
Mathesporites tumulosus
Araucariacites australis (A)

WELL: **10-34-54-11W5**

Samples: **JWK92-22-1, 22-2**
Depths: 1815.35m, 1815.9m
Age: Indeterminable

Remarks

These samples are rich in highly oxidized, inertinitic debris. No identifiable palynomorphs are present.

Samples: **JWK92-22-3, 22-4**
Depths: 1819.5m, 1820.5m
Age: Earliest Aalenian to Late Toarcian, J14A-B

Remarks

These are typical Poker Chip assemblages. The presence of ?*Parvocysta cracens* in 22-3 means that the sample is no younger than the earliest Aalenian, *opalinum* Ammonite Zone. There are also several specimens of *Fromea* 83/1 in both samples and *Callialasporites dampierii* is numerous in 22-3. *Nannoceratopsis senex* is abundant in 22-4.

Significant species

?Parvocysta cracens
Lithodinia serrulata
Nannoceratopsis gracilis
Callialasporites dampierii
Fromea 81/1
Phallocysta minuta
N. senex (A)

WELL: **13-21-55-11W5**

Samples: **JWK91-6-1, 6-2, 6-3**
Depths: 1858m, 1861.5m, 1864.3m
Age: Probably Cretaceous

Remarks

The preservation of the spores and pollen in these three samples is extremely poor and most specimens are unidentifiable. The overall appearance is similar to sample 5-1 and the presence of cf. *Taxodiaceaapollenites hiatus* suggest a Cretaceous age. A specimen of *Cicatricosisporites* sp. also tends to favor a Cretaceous age, although this taxon is found, albeit relatively rarely, in rocks as old as Late Kimmeridgian. A spore resembling *Ischyosporites disjunctus* is present in 6-3. Undoubted specimens would indicate a Cretaceous age.

Significant species

cf. *Taxodiaceaepollenites hiatus*
Classopollis spp.
Cicatricosisporites sp.
Callialasporites turbatus
C. trilobatus
Lycopodiumsporites reticulumsporites
Bisaccate pollen (A)
Cerebropollenites mesozoicus
Baculatisporites cf. *comaumensis*
C. dampierii
Ischyosporites cf. *disjunctus*
L. spp.

Samples: **JWK91-6-4, 6-5**
Depths: 1864.55m, 1865.6m
Age: Indeterminable

Remarks

Sample 6-4 yielded a small residue containing a few indeterminable spores. Sample 6-5 yielded abundant amorphous inertinitic kerogen similar to many of the samples in 4-30-37-3W5.

Sample: **JWK91-6-6**
Depth: 1868.5m
Age: Aalenian - late Toarcian, J14A-B

Remarks

This assemblage is grossly similar to samples 5-3 to 5-5 and is typical of the Poker Chip and contiguous strata.

Significant species

Lithodinia cf. *serrulata*
Fromea sp.

Classopollis spp. (A)
Exesipollenites spp. (A)
Leptolepidites spp.
Callialasporites turbatus
C. trilobatus
Araucariacites sp.

Dinocyst PC-1
Scriniocassis cf. *weberii*

Corollina spp. (A)
Mathesporites tumulosus (A)
Uvaesporites spp.
C. dampierii
Corrugatisporites amplectaeformis
Perinopollenites elatioides

WELL: **13-27-55-11W5**

Sample: **JWK91-3-1**
Depth: 1871.9m
Age: Indeterminable

Remarks

This sample consists of amorphous kerogen similar to samples 2-3 to 2-9. An age cannot be assigned.

Sample: **JWK91-3-2**
Depth: 1873.4m
Age: late Middle Bajocian, J13

Remarks

This sample is rich in well-preserved palynomorphs. Abundant *Sentusidinium asymmetrum* with a specimen of *Phallocysta eumekes* indicates a late Middle Bajocian age, J13B, *humphriesianum* Ammonite Zone.

Significant species

Sentusidinium asymmetrum (A)
Phallocysta eumekes
Caddasphaera halosa (A)

Classopollis spp. (A)
Callialasporites turbatus
Perinopollenites cf. *elatoides*
Exesipollenites sp. (A)
Cerebropollenites mesozoicus
Bisaccate pollen (A)
C. dampierii
Uvaesporites sp.
Leptolepidites sp.
Sestrosporites pseudalveolatus

Sample: **JWK91-3-3**
Depth: 1874.2m
Age: Indeterminable

Remarks

This sample yielded a small residue of inertinitic grains only.

Samples: **JWK91-3-4, 3-5**
Depths: 1878.15m, 1884.2m
Age: Aalenian-late Toarcian, J14 A-B

Remarks

These samples yielded rich assemblages dominated by spores and pollen. They closely resemble samples 4-2 to 4-5 in the 4-34 well.

The age is based on a distinctive dinocyst association which is often found in the shales assigned to the Poker Chip Formation. The marker species include *Evansia evittii, Lithodinia* cf. *serrulata*, Dinocyst PC-1, *Fromea* sp. and *Caddasphaera halosa*.

The abundance of spores resembling *Mathesporites tumulosus* suggests a position relatively close to a shoreline.

Significant species

Evansia evittii
Dinocyst PC-1
Caddasphaera halosa
Leptodinia cf. *serrulata*
Fromea sp.

Mathesporites tumulosus (A)
Classopollis spp. (A)
Exesipollenites spp. (A)
Perinopollenites cf. *elatioides*
Cerebropollenites mesozoicus
Ischyosporites crateris
Lycopodiumsporites austroclavatidites
Leptolepidites sp.
Corollina spp. (A)
Callialasporites turbatus
C. dampierii
Corrugatisporites amplectaeformis
I. cf. *punctatus*
Uvaesporites spp.

WELL: **10-29-55-11W5**

Samples: **JWK91-5-1**
Depths: 1864.5m
Age: Probably Cretaceous

Remarks

This sample is rich in largely unidentifiable small spores and pollen. Bisaccate pollen is also abundant and a single long-ranging dinocyst is present.

Most of the recognisable spores and pollen have long stratigraphic ranges through much of the Jurassic and Cretaceous. However, the presence of some grains which resemble *Taxodiaceaepollenites hiatus* indicates a Cretaceous age for the sample. The overall character of the spores and pollen is also more typical of the Cretaceous than the Jurassic when compared with other samples in this and previous studies.

Significant species

cf. *Taxodiaceaepollenites hiatus*
Cerebropollenites mesozoicus
Callialasporites turbatus
Bisaccate pollen (A)

Lycopodiumsporites spp.
Concavissimisporites spp.
Neoraistrickia truncata

Pareodinia ceratophora

Sample: **JWK91-5-2**
Depth: 1869.3m
Age: Indeterminable

Remarks

The kerogen consists of inertinite and semi-fusinite grains with extremely rare palynomorphs. If the species listed below were present in large numbers the sample would probably be assigned a Jurassic age, however, because of the poor recovery, an age cannot be assigned with any confidence. A similar situation occurred in JWK91-2-2 (4-30-37-3W5) where it was interpreted as being due to reworking.

Significant species

Corollina sp.
Exesispollenites sp.

Classopollis sp.
Leptolepidites sp.

Dinocyst indet.

Samples: **JWK91-5-3, 5-4, 5-5**
Depths: 1873.3m, 1873.9m, 1874.3m
Age: Aalenian - late Toarcian, J14 A-B

Remarks

These three samples yielded rich assemblages which closely resemble those in samples 3-4, 3-5 and 4-2 to 4-5. Marker species include *Lithodinia* cf. *serrulata*, Dinocyst PC-1, *Caddasphaera halosa, Nannoceratopsis gracilis*, *Fromea* sp. and an array of spore species assignable to *Mathesporites tumulosus*, *Leptolepidites* spp. and *Uvaesporites* spp.

The presence in 5-4 and 5-5 of dinocyst fragments which closely resemble *Parvocysta cracens* suggest that these samples are no younger than earliest Aalian in age (*opalinum* Ammonite Zone).

Significant species

Lithodinia cf. *serrulata*
Caddasphaera halosa
Fromea sp.

Dinocyst PC-1
Nannoceratopsis gracilis
Parvocysta cf. *cracens*

Classopollis spp. (A)
Exesipollenites spp. (A)
Leptolepidites spp.
Callialasporites turbatus
Perinopollenites elatoides
Corrugatisporites amplectaeformis

Corollina spp. (A)
Mathesporites tumulosus (A)
Uvaesporites spp.
C. dampierii
Ischyosporites spp.
Araucariacites sp.

WELL: **9-32-55-11W5**

Sample: **JWK91-13-1**
Depth: 1962m
Age: Possibly Early Cretaceous

Remarks

This sample is dominated by long-ranging bissaccate pollen which comprise 88% of the assemblage. This feature is typical of other Early Cretaceous samples in this study although there are no Cretaceous markers present. There are species present which range down into the Kimmeridgian such as *Concavissimisporites exquisitus*, *C. montuosus* and *Ischyosporites pseudoreticulatus*. The latter does not range below the latest Kimmeridgian, J2, in western Canada.

An Early Cretaceous age is tentatively assigned but a latest Jurassic age cannot be ruled out.

Sample: **JWK91-13-2**
Depth: 1962.4m
Age: Early Middle Jurassic

Remarks

Small, mostly indeterminale spores and pollen (41%) and *Classopollis* spp. (28%) species dominate this assemblage. Bisaccate pollen are relatively rare at 4%. Identifiable dinocysts are extremely rare and limited to small specimens of *Escharisphaeridia* sp. Small, simple Leiospheres are abundant suggesting a highly restricted environment such as a lagoon.

The overall character of the assemblage is typical of the early Middle and Early Jurassic of western Canada but the lack of any marker species prevents a more accurate age assignment.

Samples: JWK91-13-3, 13-4
Depths: 1966m, 1967.8m
Age: Aalenian, J14A

Remarks

Dinocysts, especially very small species, typical of the Poker Chip Shale are abundant in both samples. The presence of *Fromea* 83/1 and *F. senilis* at 1967.8m suggests that these samples are more likely Aalenian than Toarcian in age.

Significant species

Fromea 83/1 (A)
Nannoceratopsis gracilis
Lithodinia serrulata (A)
F. senilis
Evansia evittii
Dinocyst PC-1 (A)

WELL: **4-34-55-11W5**

Sample: **JWK91-4-1**
Depth: 1872m
Age: Indeterminable

Remarks

This sample contains amorphous kerogen similar to sample 3-1. An age cannot be assigned.

Samples: **JWK91-4-2 to 4-5**
Depths: 1875.7m, 1876.3m, 1879.1m, 1880.1m
Age: Aalenian-late Toarcian, J14 A-B

Remarks

The rich, well-preserved assemblages from these samples are virtually indistinguishable from samples 3-4 and 3-5. They are typical of the Poker Chip and an undifferentiated Aalenian-late Toarcian age is assigned.

Significant species

Evansia evittii
Dinocyst PC-1
Caddasphaera halosa
Phallocysta eumekes

Mathesporites tumulosus (A)
Classopollis spp. (A)
Exesipollenites spp. (A)
Perinopollenites cf. *elatioides*
Cerebropollenites mesozoicus
Corrugatisporites amplectaeformis
Lycopodiumsporites reticulumsporites
Uvaesporites spp.

Lithodinia cf. *serrulata*
Fromea sp.
Nannoceratopsis gracilis
Scriniocassis cf. *weberi*

Leptolepidites sp.
Corollina spp. (A)
Callialasporites turbatus
C. dampierii
Araucariacites cf. *australis*
Ischyosporites crateris
L. austroclavatidites
cf. *Couperisporites* sp.

WELL: **6-10-55-12W5**

Samples: **JWK91-12-1, 92-36-1**
Depths: 6228', 6229'
Age: Cretaceous

Remarks

Bissaccate pollen are abundant in both samples but undoubted Cretaceous markers are rare. Specimens of *Appendicisporites bilateralis*, *Aequitriradites spinulosus* and *Foraminisporis* cf. *wonthaggiensis* in 92-36-1 indicate a Cretaceous age. Recycled Jurassic palynomorphs are present, especially in 91-12-1 where it is difficult to assign a Cretaceous age based on that assemblage alone.

Significant species

Appendicisporites bilateralis
Aequitriradites spinulosus
Foraminisporis cf. *wonthaggiensis*

Sample: **JWK91-12-2**
Depth: 6229.7'
Age: ?Jurassic

Remarks

This sample is not dissimilar to 91-12-1 in that bisaccate pollen are abundant (75%) but there are no Cretaceous markers. Specimens of *Escharisphaeridia rudis*, *Acanthaulax* sp. and *Gonyaulacysta* cf. *jurassica* suggest a Middle Oxfordian age but, given the high level of reworking in the higher samples, a Cretaceous age cannot be ruled out.

Significant species

Bisaccate pollen (A)
Escharisphaeridia rudis
Gonyaulacysta cf. *jurassica*
Acanthaulax sp.

Sample: JWK91-12-3
Depth: 6241.5'
Age: Early Middle Oxfordian, J8

Remarks

Dinocysts are abundant in this sample especially *Gonyaulacysta jurassica* and *Liesbergia* cf. *scarburghensis*. The abundance of the latter species and the lack of older markers is typical of the early Middle Oxfordian, zone J8. Also present are specimens of *Ellipsoidictyum* cf. *cinctum* and *Valensiella ovula*.

Many of the dinocyst specimens are poorly preserved due to bacterial attack and are difficult to identify to species level.

Significant species

Liesbergia cf. *scarburghensis* (A)
Gonyaulacysta jurassica (A)
Acanthaulax spp. (A)
Escharisphaeridia rudis

WELL: **7-35-55-14W5**

Sample: **JWK91-11-1**
Depth: 2029.7m
Age: Early Cretaceous

Remarks

This rich sample is dominated by non-age diagnostic bisaccate pollen which comprise 75% of the assemblage. Most of the spore and pollen species have long stratigraphic ranges but species such as *Foraminisporis dailyi* and *Taxodiaceaepollenites* sp. indicate an Early Cretaceous age.

A small number of dinocysts is present but appear to be largely reworked. A specimen of cf. *Atopodinium* sp. which resembles forms found with *Balmula tripenta* in 91-16-1 and 91-17-2 also confirms the age.

Significant species

Foraminisporis dailyi *Taxodiaceaepollenites* sp.

cf. *Atopodinium* sp.

Sample: **JWK91-11-2**
Depth: 2030.1m
Age: Early Oxfordian J9A-B

Remarks

This relatively rich sample contains abundant dinocysts of Jurassic aspect, especially *Escharisphaeridia rudis* which is abundant in 91-22-1, 22-2, 23-1 and 23-2. Other significant species include *Sentusidinium villersense*, *Ellipsoidictyum gochtii* and *Gonyaulacysta jurassica*. Bisaccate pollen are also abundant as they are in the other two wells. Specimens of *Lithodinia* sp. and *Meiourogonyaulax* cf. *callomonii* may indicate a Callovian influence but there is a stronger resemblance with the Oxfordian samples in wells 91-22, 91-23 and 92-40.

Significant species

Escharisphaeridia rudis (A) *Sentusidinium villersense*

Samples: **JWK91-11-3, 11-4**
Depths: 2035.7m, 2043.45m
Age: Aalenian, J14A

Remarks

These two rich samples yielded similar assemblages in which dinocysts are quite numerous. The presence of *Scriniocassis priscus* indicates that the sample is no younger than Early Bajocian (*sauzei* Zone). However, numerous specimens of *Fromea senilis* suggest an Aalenian age.

Significant species

Scriniocassis priscus *Fromea senilis*
Nannoceratopsis gracilis

Davies, E.H., 1983. The dinoflagellate Oppel-zonation of the Jurassic-Lower Cretaceous sequence in the Sverdrup Basin, Arctic Canada. G.S.C. Bull. 359.

Dolby, G., 1990. Palynological analysis of Jurassic samples from west-central and northern Alberta. Project 89/13, DSS contract 23294-9-0646/01-XSG prepared for the Geol. Surv. Canada.

Dolby, G., 1991. Palynological analysis of samples from the 8-30-37-3W5, 4-30-37-3W5, 13-27-55-11W5 and 4-34-55-11W5 wells. Report 91.12 prepared for the Alberta Research Council.

Jansonius, J., 1986. Reexamination of Mesozoic Canadian dinoflagellate cysts published by S.A.J. Pocock (1962, 1972). Palynology 10.

Johnson, C.D. and Hills, L.V., 1973. Microplankton zones of the Savik Formation (Jurassic) Axel Heiberg and Ellesmere Islands, District of Franklin. Bull. CSPG 21.

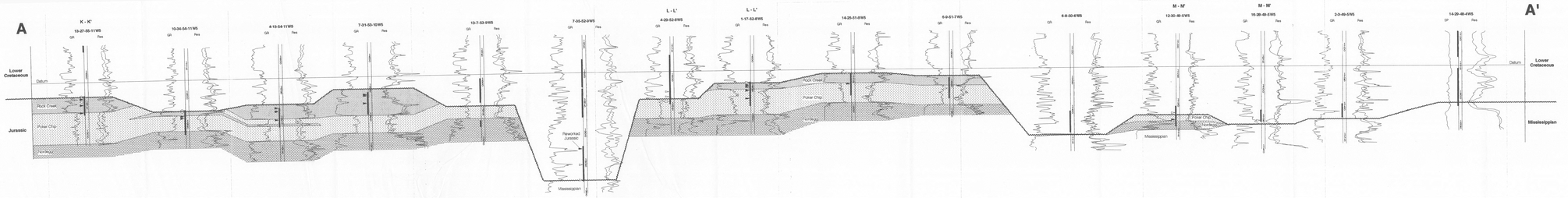
Pocock, S.A.J., 1970. Palynology of the Jurassic sediments of western Canada. Part 1, Terrestrial species. Palaeontographica B130.

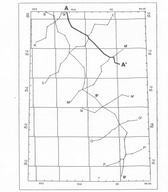
Pocock, S.A.J., 1972. Part 2, Marine species. *Ibid* B137.

Riding, J.B., 1984. A palynological investigation of Toarcian to early Aalenian strata from the Blea Wyke area, Ravenscar, North Yorkshire. Proc. Yorkshire G.S. 45.

Riding, J.B., Walton, W., and Shaw, D., 1991. Toarcian to Bathonian (Jurassic) palynology of the Inner Hebrides, north-west Scotland. Palynology 15.

Singh, C., 1971. Lower Cretaceous microfloras of the Peace River area, northwestern Alberta. Research Council of Alberta. Bull. 28.

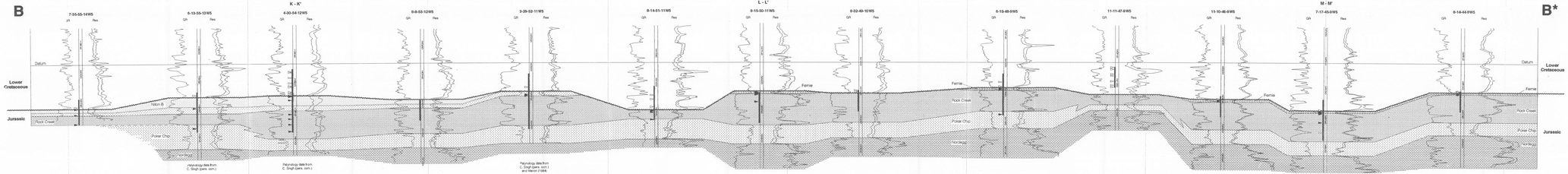




Cross Section A - A'

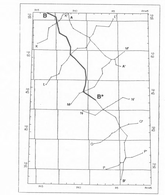
ARC Open File Report 1993-26

ALBERTA RESEARCH COUNCIL | Alberta Geological Survey



Legend

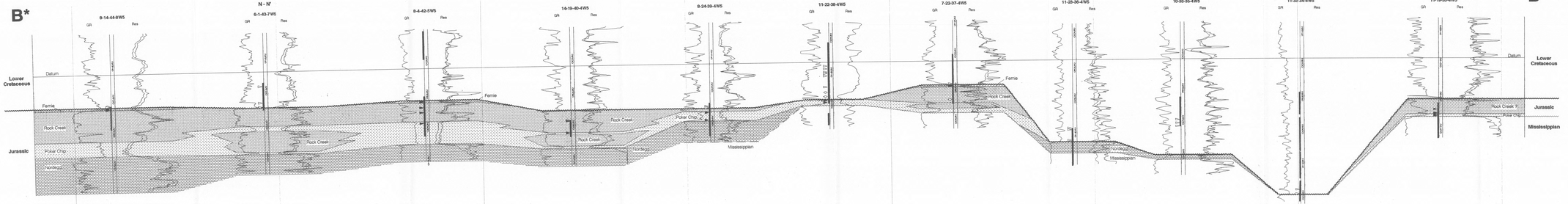
- Fernie shale
- Nton B sandstone
- Upper Rock Creek shale
- Rock Creek sandstone
- Poker Chip shale
- Nordegg
- Jurassic/Cretaceous boundary
- Unconformity
- Cretaceous sample
- Jurassic sample
- Bannin sample

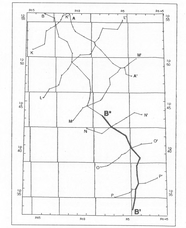


Cross Section B - B*

AER Open File Report 1993-26

ALBERTA RESEARCH Alberta

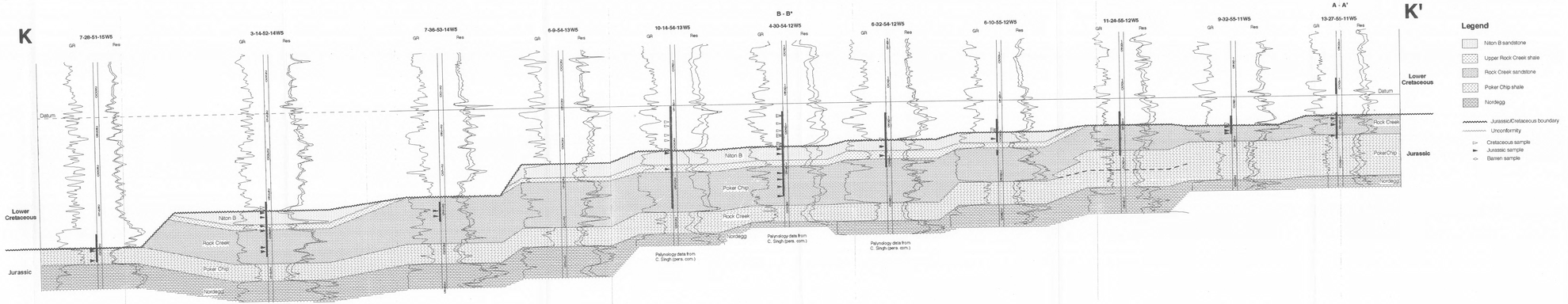


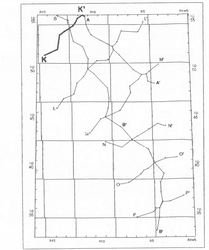


Cross Section B* - B'

ARC Open File Report 1993-26

ALBERTA RESEARCH COUNCIL
Alberta Geological Survey

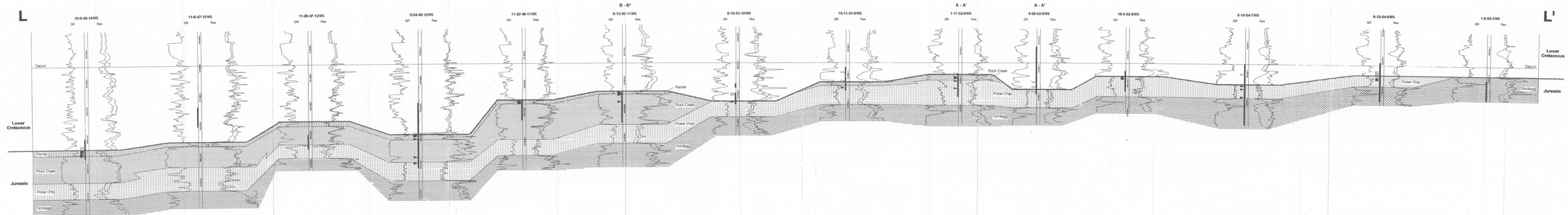


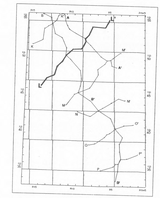


Cross Section K - K'

ARC Open File Report 1993-26

ALBERTA RESEARCH COUNCIL | Alberta Geological Survey

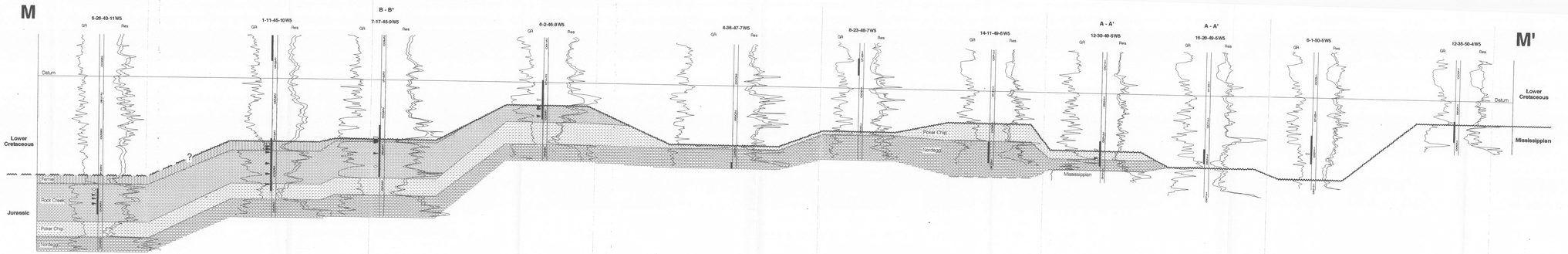




Cross Section L - L'

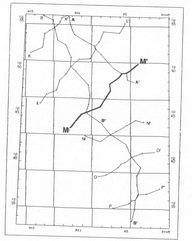
ARC Open File Report 1993-26

ALBERTA RESEARCH Alberta



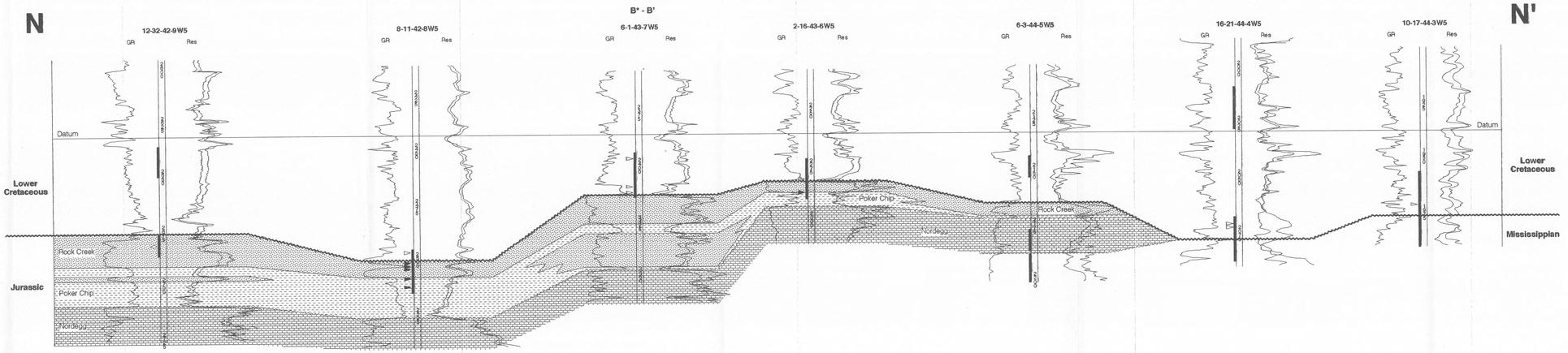
Legend

- Fernie shale
- Rock Creek sandstone
- Poker Chip shale
- Nordegg
- Jurassic/Cretaceous boundary
- Unconformity
- Cretaceous sample
- Jurassic sample
- Bamen sample



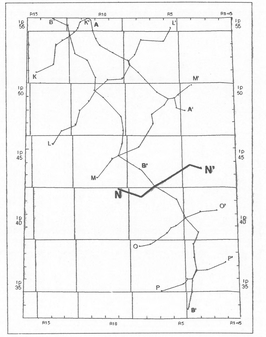
Cross Section M - M'

ARC Open File Report 1993-26



Legend

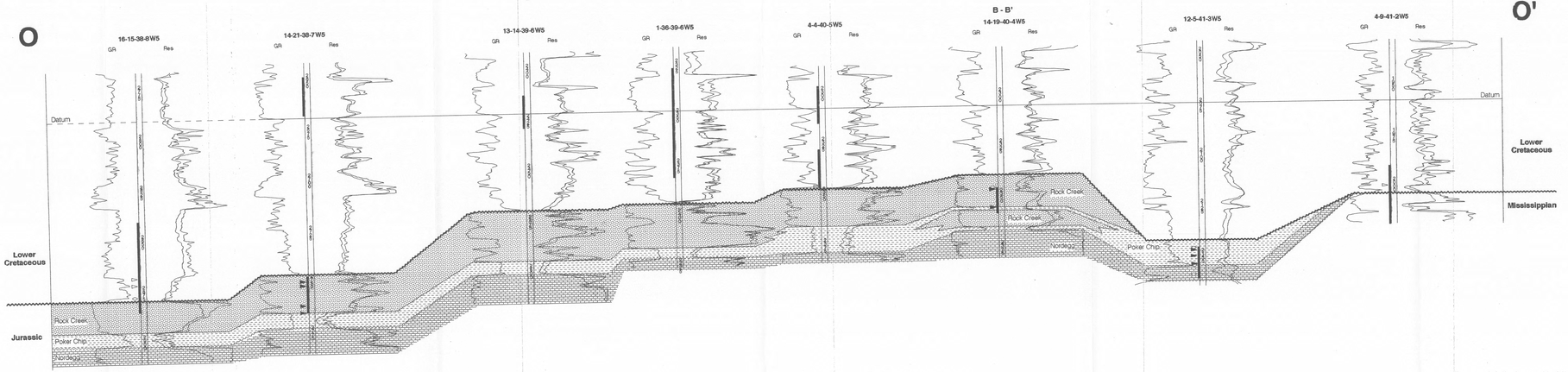
- Rock Creek sandstone
- Poker Chip shale
- Nordegg
- Jurassic/Cretaceous boundary
- Unconformity
- Cretaceous sample
- Jurassic sample
- Barren sample

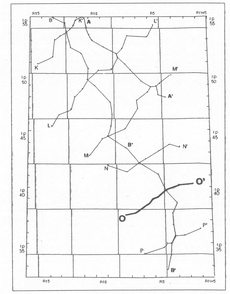


Cross Section N - N'

ARC Open File Report 1993-26

ALBERTA RESEARCH COUNCIL Alberta Geological Survey

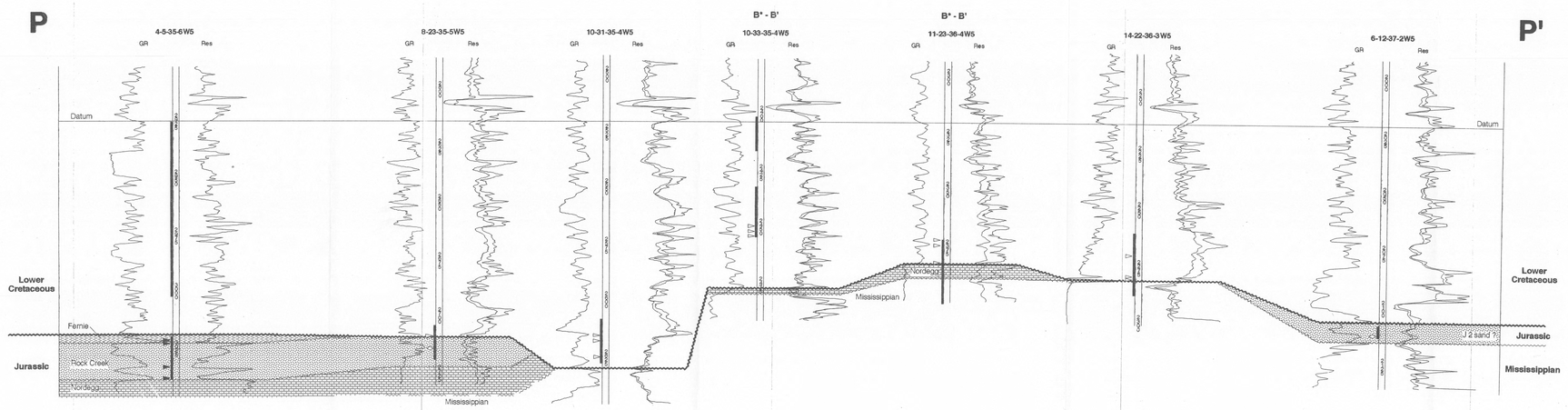




Cross Section O - O'

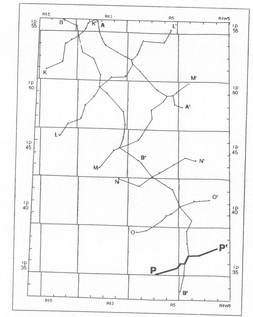
ARC Open File Report 1993-26

ALBERTA RESEARCH COUNCIL Alberta Geological Survey



Legend

- Fernie shale
- J 2 Sandstone
- Rock Creek sandstone
- Nordegg
- Jurassic/Cretaceous boundary
- Unconformity
- Cretaceous sample
- Jurassic sample
- Barren sample



Cross Section P - P'

ARC Open File Report 1993-26

ALBERTA