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DEPARTMENT OF NATURAL RESOURCES
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Tony Knowles, *Governor*

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Milton A. Wiltse, *Director and State Geologist*

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REWORKED PALYNOMORPH TRENDS IN
LATE JURASSIC TO NEOCOMIAN STRATA OF
THE COLVILLE DELTA REGION, ALASKA

by
Hideyo Haga and M.B. Mickey



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REWORKED PALYNOMORPH TRENDS IN LATE JURASSIC TO NEOCOMIAN STRATA OF THE COLVILLE DELTA REGION, ALASKA

by
Hideyo Haga¹ and M.B. Mickey²

ABSTRACT

Palynologists have long recognized the presence of reworked palynomorphs in strata of the North Slope region of Alaska. The reworked forms are a reflection of the formational units from which they were derived, and thus provide indirect evidence for identifying the detrital contributors to a given depositional site. Coarser clastic source units have petrographic and mineralogic characteristics that are utilized in provenance determinations; and data about the reworked palynomorph content can add to the confidence of such interpretations.

A limited study of 25 proprietary wells from the Colville Delta area in northern Alaska was undertaken to identify and quantify the reworked palynomorph fractions in the Oxfordian, Valanginian and Hauterivian stratigraphic intervals. These units were examined in detail, with the specific objective of tabulating the ages, frequencies, and abundance of the various reworked taxa.

The tracking of reworked palynomorphs indicates that Carboniferous units were a major source of detritus during Oxfordian deposition. Devonian and Permian to Triassic age formations were subsidiary contributors. A similar pattern persisted through Valanginian and Hauterivian deposition, with the addition of Jurassic age detritus to the reworked mix. The Valanginian and Hauterivian intervals show a progressive decrease in reworked palynomorphs, culminating in an almost total lack of reworking during post-Hauterivian (Barremian–Aptian) deposition.

INTRODUCTION

Palynologists have noted the presence of reworked palynomorphs in the course of analyzing samples from the North Slope region of Alaska, although little attention has been given to these occurrences in formal publications. Some Canadian palynologists have mentioned the presence of reworked palynomorphs in their published works, but no quantitative information regarding those occurrences were included (Sweet and McIntyre, 1988; Dietrich and others, 1989).

Locally, reworked forms can become so numerous that the indigenous elements can be masked and difficult to find. Often, classic post-depositional alteration such as weathering, degradation, broken and/or poor preservation of recycled specimens is not apparent, and thus, not useful criteria in attempting to determine the indigenous species. It is most helpful to have multidiscipline biostratigraphic analyses and a familiarity with the palynomorph age/formational assemblages of the region.

The reworked taxa are indirect evidence that point to specific stratigraphic units as contributors of detrital material, and can provide additional information for rock unit provenance interpretations.

PURPOSE AND SCOPE

In an effort to identify and quantify the reworked palynomorphs, a limited study of an Alaska North Slope area was undertaken. Twenty-five wells from the Colville Delta

region (fig. 1) were selected. Palynomorph occurrences in the Oxfordian, Valanginian, and Hauterivian stratigraphic intervals were examined in detail, with the specific objective of tabulating the age, frequency, and abundance of reworked taxa.

Of course only positive evidence of reworked taxa can be noted; and there are some formations that contain relatively sparse palynomorph assemblages, or that comprise short sedimentary intervals. These units, in turn, would provide little palynologic evidence of their detrital contributions.

The primary source of Carboniferous spores is the Kekiktuk Formation of Mississippian age, which is rich in durable, thick-walled species. The limestone and dolomitic strata of the Carboniferous age Lisburne Group generally contain few palynomorphs, and therefore, yield few reworked specimens.

The source of Permian or Triassic forms is the Sadlerochit Group; and within this group the Kavik Formation of Triassic age, which contains the richest spore-pollen assemblage, is the largest contributor. The Echooka Formation of Permian age, a relatively thin unit of the Sadlerochit Group, can contain numerous palynomorphs. Most of the Echooka assemblage consists of species ranging in age from the Permian to Triassic with few forms restricted to the Permian. The result is that age-restrictive Permian marker species are rarely observed in the reworked assemblages (Note the absence of Permian reworks in tables 1-6).

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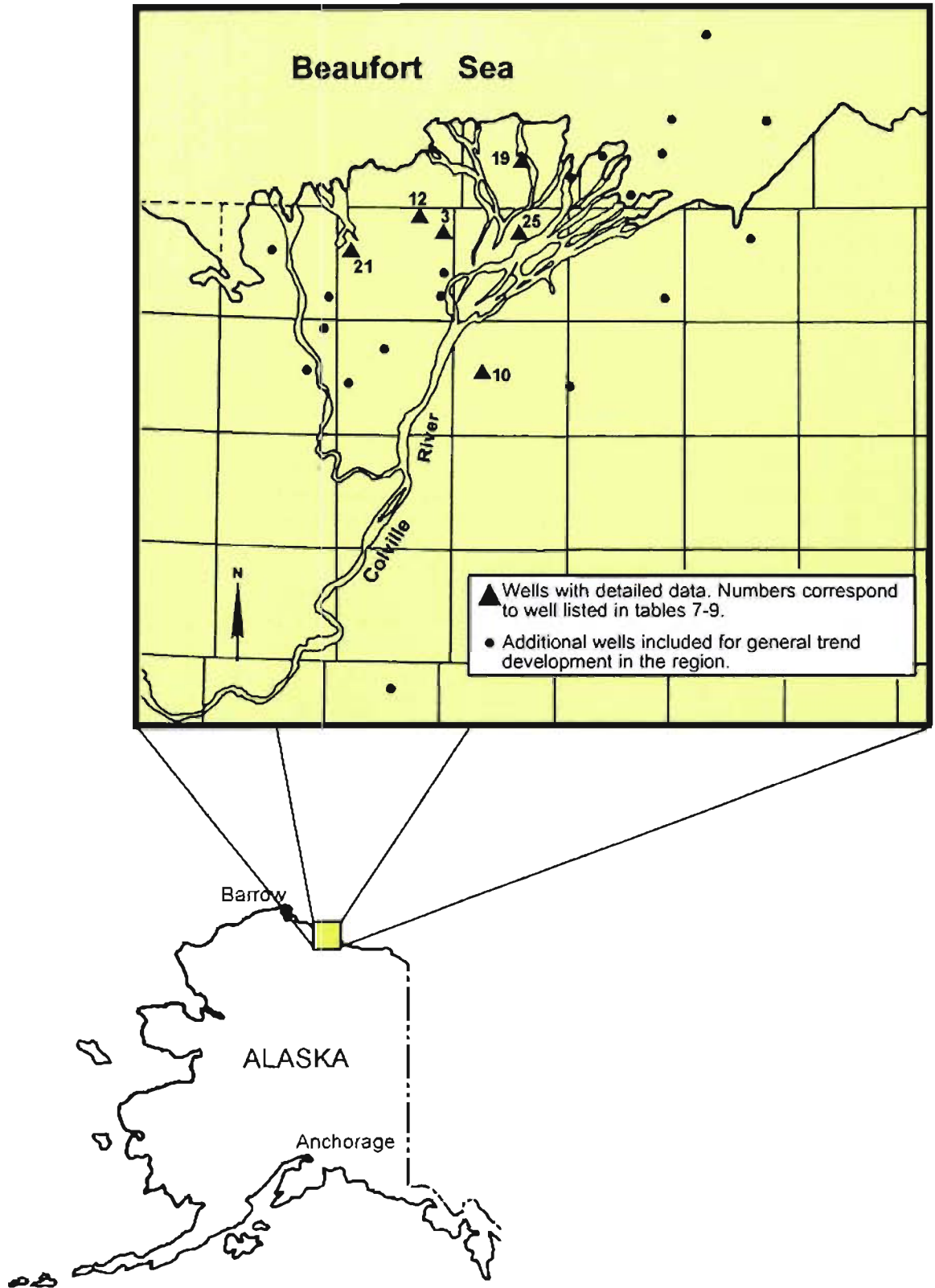


Figure 1. Location map.

Table 1. Reworked palynomorphs in the ARCO Bergschrund #1 well

AGE	Total Palynomorphs			Reworked Palynomorphs										
	Sample	S-P	D-A	Total PALYN	NM (D)	NM (C)	NM (P)	NM (P-Tr)	M (LTr)	M (E J)	M (L J)	M (V-H)	Total Reworked	Percent Reworked
BARREMIAN-EARLY ALBIAN	1	274	29	303	-	-	-	-	-	-	-	1	1	-
	2	275	279	554	-	-	-	-	-	-	-	-	-	-
	3	280	286	566	-	-	-	-	-	-	-	-	-	-
	4	274	340	614	-	-	-	-	-	-	-	1	1	-
	5	34	302	336	-	-	-	-	-	-	-	-	-	-
HAUTERIVIAN	6	274	334	608	-	-	-	-	-	-	-	-	-	-
	7	276	316	592	-	-	-	-	-	-	-	-	-	-
	8	15	855	870	-	2	-	-	-	-	-	-	2	-
	9	27	78	105	-	1	-	-	-	-	-	-	1	1
	10	27	845	872	-	3	-	-	-	-	-	-	3	-
	11	299	102	401	-	3	-	-	-	-	-	-	3	1
PROBABLE VALANGINIAN	12	282	316	598	-	3	-	-	-	-	-	-	3	1
	13	27	575	602	-	-	-	-	-	-	-	-	0	-
	14	29	295	324	-	1	-	-	-	-	-	-	1	-
	15	55	64	119	-	12	-	-	-	-	-	-	12	10
	16	26	48	74	1	10	-	-	-	-	-	-	11	15
OXFORDIAN	17	56	34	90	-	26	-	1	-	-	-	-	27	30
	18	58	17	75	1	24	-	-	-	-	-	-	25	33
	19	27	55	82	1	10	-	-	-	-	-	-	11	13
	20	286	42	328	-	10	-	-	-	-	-	-	10	3
	21	28	44	72	-	12	-	-	-	-	-	-	12	17
	22	15	22	37	-	-	-	1	-	-	-	-	1	3
	23	18	27	45	-	4	-	-	-	-	-	-	4	9
	24	29	34	63	-	3	-	-	-	-	-	-	3	5
	25	25	52	77	-	13	-	-	-	-	-	-	13	17
	26	30	24	54	1	3	-	-	-	-	-	-	4	7
	27	26	49	75	-	10	-	-	-	-	-	-	10	13
	28	296	302	598	-	12	-	-	-	-	-	-	12	2
	29	39	302	341	-	10	-	-	-	-	-	-	10	3
	30	275	31	306	1	22	-	-	-	-	-	-	23	8
	31	26	292	318	1	10	-	1	-	-	-	-	12	4
	32	37	300	337	-	3	-	-	-	-	-	-	3	1
	33	40	295	335	-	14	-	-	-	-	-	-	14	4
	34	27	292	319	-	11	-	-	-	-	-	-	11	3

S-P-Total spore-pollen

D-A-Total dinocysts-acritarchs (microplankton)

PALYN-Palynomorphs

NM-Reworked spore-pollen (nonmarine)

(D)-Devonian (may include some Mississippian)

(C)-Carboniferous (predominantly Mississippian)

(P)-Permian

(P-Tr)-Permian-Triassic

M-Reworked dinocysts-acritarchs (marine)

(L Tr)-Late Triassic

(E J)-Early Jurassic

(L J)-Late Jurassic

(V-H)-Valanginian-Hauterivian

Table 3. Reworked palynomorphs in the ARCO Fiord #1 well—cont.

AGE	Total Palynomorphs			Reworked Palynomorphs									Total Reworked	Percent Reworked
	Sample	S-P	D-A	Total PALYN	NM (D)	NM (C)	NM (P)	NM (P-Tr)	M (LTr)	M (E J)	M (L J)	M (V-H)		
HAUTERIVIAN	6	22	590	612	-	-	-	-	-	-	-	-	-	-
	7	273	846	1,119	-	-	-	-	-	-	-	-	-	-
	8	274	588	862	-	-	-	-	-	-	-	-	-	-
	9	272	604	876	-	-	-	-	-	-	-	-	-	-
	10	276	623	899	-	-	-	-	-	-	-	-	-	-
	11	270	602	872	-	-	-	-	-	-	-	-	-	-
PROBABLE VALANGINIAN	12	2	5	7	-	-	-	-	-	-	-	-	-	-
	13	273	316	589	-	-	-	-	-	-	-	-	-	-
	14	286	48	334	-	1	-	-	-	-	-	-	1	-
	15	293	311	604	1	2	-	-	-	-	-	-	3	-
	16	292	36	328	2	2	-	-	-	-	-	-	4	1
	17	286	56	342	-	2	-	-	-	-	-	-	2	1
	18	278	40	318	-	2	-	-	-	-	-	-	2	1
	19	289	309	598	1	2	-	-	-	-	-	-	3	1
	20	280	352	632	2	3	-	1	-	-	-	-	6	1
	21	276	328	604	2	4	-	-	-	-	-	-	6	1
OXFORDIAN	22	314	36	350	1	38	-	1	-	-	-	-	40	11
	23	561	308	869	1	286	-	-	-	-	-	-	287	33
	24	292	337	629	2	3	-	1	-	-	-	-	6	1
	25	302	304	606	-	20	-	2	-	-	-	-	22	4
	26	284	320	604	1	-	-	1	-	-	-	-	2	-
	27	303	281	584	1	20	-	2	-	-	-	-	23	4
	28	298	293	591	1	24	-	3	-	-	-	-	28	5
	29	38	296	334	-	14	-	2	-	-	-	-	16	5
	30	61	337	398	2	11	-	1	-	-	-	-	14	4
	31	288	607	895	-	11	-	1	-	-	-	-	12	1
	32	284	596	880	2	2	-	2	-	-	-	-	6	1
	33	287	334	621	2	1	-	-	-	-	-	-	3	-
	34	322	336	658	2	12	-	2	-	-	-	-	16	2
	35	296	306	602	2	2	-	-	-	-	-	-	4	1
	36	303	298	601	-	15	-	2	-	-	-	-	17	3
	37	307	4	311	1	10	-	2	-	-	-	-	13	4
	38	278	34	312	-	2	-	2	-	-	-	-	4	1
	39	274	42	316	-	2	-	-	-	-	-	-	2	1
40	286	27	313	-	2	-	-	-	-	-	-	2	1	
41	282	32	314	-	-	-	-	-	-	-	-	-	-	
42	32	22	54	1	1	-	-	-	-	-	-	2	4	
43	278	22	300	-	3	-	-	-	-	-	-	3	1	
44	564	35	599	1	2	-	-	-	-	-	-	3	1	
45	45	16	61	-	1	-	-	-	-	-	-	1	2	
46	44	14	58	-	-	-	-	-	-	-	-	-	-	
47	295	5	300	-	2	-	-	-	-	-	-	2	1	
48	306	10	316	-	-	-	-	-	-	-	-	-	-	
49	284	5	289	-	-	-	-	-	-	-	-	-	-	
50	288	12	300	-	1	-	1	-	-	-	-	2	1	
51	38	12	50	-	-	-	-	-	-	-	-	-	-	
52	284	2	286	-	2	-	-	-	-	-	-	2	1	
53	2	-	2	-	-	-	-	-	-	-	-	-	-	
54	2	-	2	-	-	-	-	-	-	-	-	-	-	
55	295	270	565	-	-	-	-	-	-	-	-	-	-	
56	285	12	297	1	-	-	-	-	-	-	-	1	-	
57	295	10	305	-	1	-	-	-	-	-	-	1	-	
58	295	270	565	-	-	-	-	-	-	-	-	-	-	

S-P—Total spore-pollen

D-A—Total dinocysts-acentarchs (microplankton)

PALYN—Palynomorphs

NM—Reworked spore-pollen (nonmarine)

(D)—Devonian (may include some Mississippian)

(C)—Carboniferous (predominantly Mississippian)

(P)—Permian

(P-Tr)—Permian-Triassic

M—Reworked dinocysts-acentarchs (marine)

(L Tr)—Late Triassic

(E J)—Early Jurassic

(L J)—Late Jurassic

(V-H)—Valanginian-Hauterivian

Table 4. Reworked palynomorphs in the ARCO Kuukpik #3 well

AGE	Total Palynomorphs			Reworked Palynomorphs									Percent Reworked	
	Sample	S-P	D-A	Total PALYN	NM (D)	NM (C)	NM (P)	NM (P-Tr)	M (LTr)	M (E J)	M (L J)	M (V-H)		Total Reworked
BARREMIAN-EARLY ALBIAN	1	40	24	64	-	-	-	-	-	-	-	-	-	-
	2	20	277	297	-	-	-	-	-	-	-	-	-	-
	3	22	300	322	-	-	-	-	1	-	1	-	2	1
	4	22	585	607	-	-	-	-	-	-	-	-	-	-
	5	22	41	63	-	-	-	-	-	-	-	-	-	-
HAUTERIVIAN	6	40	309	349	-	-	-	-	-	-	-	-	-	-
	7	282	91	373	-	-	-	-	-	-	1	-	1	-
	8	282	98	380	-	-	-	-	-	-	-	-	-	-
	9	272	64	336	-	-	-	-	-	-	-	-	-	-
	10	53	547	600	-	23	-	-	-	-	2	-	25	4
	11	24	564	588	-	8	-	-	-	-	-	-	8	1
PROBABLE VALANGINIAN	12	41	544	585	-	27	-	-	-	-	1	-	28	5
	13	24	26	50	-	-	-	-	-	-	-	-	-	-
	14	42	2	44	-	3	-	1	-	-	-	-	4	9
	15	282	32	314	-	-	-	-	-	-	-	-	-	-
	16	34	13	47	-	2	-	-	-	1	-	-	3	6
OXFORDIAN	17	10	42	52	-	3	-	1	-	-	-	-	4	8
	18	13	32	45	-	5	-	1	-	-	-	-	6	13
	19	11	42	53	-	6	-	1	-	-	-	-	7	13
	20	46	2	48	-	2	-	-	-	-	-	-	2	4
	21	23	42	65	-	16	-	2	-	-	-	-	18	28
	22	23	321	344	1	14	-	2	-	-	-	-	17	5
	23	29	300	329	1	15	-	2	-	-	-	-	18	5
	24	298	3	301	-	0	-	-	-	-	-	-	0	-
	25	550	13	563	-	2	-	-	-	-	-	-	2	-
	26	548	14	562	-	3	-	-	-	-	-	-	3	1
	27	563	15	578	-	288	-	1	-	-	-	-	289	50
	28	308	304	612	-	12	-	-	-	-	-	-	12	2
	29	556	304	860	-	2	-	-	-	-	-	-	2	-
	30	553	306	859	1	3	-	1	-	-	-	-	5	1
31	43	305	348	-	5	-	2	-	-	-	-	7	2	
32	297	304	601	-	1	-	2	-	-	-	-	3	-	
33	47	306	353	-	2	-	1	-	-	-	-	3	1	
34	334	302	636	-	14	-	10	-	-	-	-	24	4	
35	570	303	873	-	4	-	10	-	-	-	-	14	2	
36	574	320	894	-	2	-	2	-	-	-	-	4	-	
37	555	302	857	-	3	-	-	-	-	-	-	5	1	
38	565	47	612	-	14	-	-	-	-	-	-	14	2	
39	294	32	326	-	2	-	-	-	-	-	-	2	1	
40	294	272	566	-	-	-	-	-	-	-	-	-	-	

S-P—Total spore-pollen
D-A—Total dinocysts-acritarchs (microplankton)
PALYN—Palynomorphs
NM—Reworked spore-pollen (nonmarine)
(D)—Devonian (may include some Mississippian)

(C)—Carboniferous (predominantly Mississippian)
(P)—Permian
(P-Tr)—Permian-Triassic
M—Reworked dinocysts-acritarchs (marine)

(L Tr)—Late Triassic
(E J)—Early Jurassic
(L J)—Late Jurassic
(V-H)—Valanginian-Hauterivian

Table 5. Reworked palynomorphs in the SOHIO Nechelik #1 well

AGE	Total Palynomorphs			Reworked Palynomorphs									Total Reworked	Percent Reworked
	Sample	S-P	D-A	Total PALYN	NM (D)	NM (C)	NM (P)	NM (P-Tr)	M (LTr)	M (E J)	M (L J)	M (V-H)		
BARREMIAN-EARLY ALBIAN	1	4	15	19	-	-	-	-	-	-	-	-	-	-
	2	10	13	23	-	-	-	-	-	-	-	-	-	-
	3	2	25	27	-	-	-	-	-	-	-	-	-	-
	4	14	36	50	-	-	-	-	-	-	-	-	-	-
	5	10	306	316	-	-	-	-	-	-	1	-	1	-
HAUTERIVIAN	6	2	325	327	-	-	-	-	-	-	-	-	-	-
	7	2	59	61	-	-	-	-	-	-	-	-	-	-
	8	4	24	28	-	2	-	-	-	-	-	-	2	7
	9	6	42	48	-	4	-	-	-	-	-	-	4	8
	10	5	34	39	-	2	-	-	-	-	-	-	2	5
	11	5	47	52	-	3	-	-	-	-	-	-	3	6
PROBABLE VALANGINIAN	12	35	41	76	1	14	-	-	-	-	-	-	15	20
	13	14	37	51	-	4	-	-	-	-	-	-	4	8
	14	270	44	314	-	-	-	-	-	-	-	-	-	-
	15	273	43	316	-	3	-	-	-	-	-	-	3	1
	16	25	34	59	1	4	-	-	-	-	-	-	5	8
	17	24	42	66	-	4	-	-	-	-	-	-	4	6
OXFORDIAN	18	282	44	326	-	10	-	-	-	-	-	-	10	3
	19	274	32	306	-	1	-	-	-	-	-	-	1	-
	20	273	34	307	-	1	-	1	-	-	-	-	2	1
	21	285	12	297	-	-	-	2	-	-	-	-	2	1
	22	286	18	304	-	1	-	1	-	-	-	-	2	1
	23	282	16	298	-	-	-	2	-	-	-	-	2	1
	24	296	16	312	-	-	-	1	-	-	-	-	1	-
	25	40	19	59	-	-	-	-	-	-	-	-	-	-
	26	30	23	53	-	-	-	-	-	-	-	-	-	-
	27	35	8	43	-	2	-	1	-	-	-	-	3	7
	28	28	5	33	-	3	-	-	-	-	-	-	3	9
	29	25	8	33	-	2	-	-	-	-	-	-	2	6
	30	25	12	37	-	-	-	-	-	-	-	-	-	-
	31	23	6	29	-	-	-	-	-	-	-	-	-	-
32	30	4	34	-	-	-	-	-	-	-	-	-	-	
33	32	6	38	-	-	-	-	-	-	-	-	-	-	
34	25	10	35	-	2	-	-	-	-	-	-	2	6	
35	31	8	39	-	-	-	-	-	-	-	-	-	-	
36	10	8	18	-	-	-	-	-	-	-	-	-	-	
37	1	1	2	-	-	-	-	-	-	-	-	-	-	
38	2	-	2	-	-	-	-	-	-	-	-	-	-	
39	2	-	2	-	-	-	-	-	-	-	-	-	-	
40	13	-	13	-	-	-	-	-	-	-	-	-	-	

S-P—Total spore-pollen
 D-A—Total dinocysts-acritarchs (microplankton)
 PALYN—Palynomorphs
 NM—Reworked spore-pollen (nonmarine)
 (D)—Devonian (may include some Mississippian)
 (C)—Carboniferous (predominantly Mississippian)
 (P)—Permian

(P-Tr)—Permian-Triassic
 M—Reworked dinocysts-acritarchs (marine)
 (L Tr)—Late Triassic
 (E J)—Early Jurassic
 (L J)—Late Jurassic
 (V-H)—Valanginian-Hauterivian

The Jurassic Kingak Formation is usually a minor reworked constituent of the early Cretaceous units, but locally, an abundance of reworked Jurassic palynomorphs can make the recognition of the Jurassic/Cretaceous boundary tentative.

The Miluveach Formation and lower part of the Kuparuk Formation, both of Valanginian age, supply insignificant reworked elements in the wells of this study.

The detrital source units have petrographic and mineralogic properties that can be utilized in provenance interpretations of clastic deposits (Reifenstuhl and others, 1997), and data about the reworked palynomorph content

can provide an additional parameter upon which such interpretations may be based.

METHODS

Palynomorph distribution charts for the stratigraphic intervals of interest in Mickey and Haga (1998) were reviewed as a basis for this study. Due to the proprietary nature of that report, the distribution chart data presented here do not include sample depths or identification of specific palynomorph taxa. However, detailed occurrence estimates of all indigenous and reworked taxa were tabulated for 25 wells. Charts

Table 6. Reworked palynomorphs in the ARCO Till #1 well

AGE	Total Palynomorphs				Reworked Palynomorphs									Percent Reworked
	Sample	S-P	D-A	Total PALYN	NM (D)	NM (C)	NM (P)	NM (P-Tr)	M (LTr)	M (E J)	M (L J)	M (V-H)	Total Reworked	
BARREMIAN-EARLY ALBIAN	1	42	278	320	-	-	-	-	-	-	-	-	-	-
	2	22	61	83	-	-	-	-	-	-	2	-	2	2
	3	34	282	316	-	-	-	-	-	-	-	-	-	-
	4	20	306	326	-	-	-	-	-	-	-	-	-	-
	5	22	576	598	1	5	-	2	-	-	-	-	8	1
HAUTERIVIAN	6	10	626	636	-	-	-	-	-	-	-	-	-	-
	7	24	332	356	-	-	-	-	-	-	2	-	2	1
	8	23	79	102	-	-	-	-	-	-	-	-	-	-
	9	558	296	854	-	-	-	-	-	-	-	-	-	-
	10	625	22	647	1	5	-	2	-	-	-	-	8	1
	11	643	1	644	-	5	-	1	-	-	1	-	7	1
PROBABLE VALANGINIAN	12	602	-	602	-	11	-	2	-	-	-	-	13	2
	13	620	12	632	2	13	-	-	-	-	-	-	15	2
	14	594	4	598	2	4	-	-	-	-	-	-	6	1
	15	591	7	598	1	2	-	-	-	-	-	-	3	1
	16	310	29	339	2	12	-	1	-	-	-	-	15	4
OXFORDIAN	17	316	321	637	1	24	-	-	-	-	-	-	25	4
	18	296	563	859	2	10	-	2	-	-	-	-	14	2
	19	38	304	342	-	11	-	-	-	-	-	-	11	3
	20	296	38	334	1	0	-	-	-	-	-	-	1	-
	21	30	32	62	-	3	-	1	-	-	-	-	4	6
	22	41	568	609	-	5	-	-	-	-	-	-	5	1
	23	29	314	343	1	14	-	-	-	-	-	-	15	4
	24	35	312	347	1	12	-	2	-	-	-	-	15	4
	25	310	556	866	-	32	-	-	-	-	-	-	32	4
	26	40	564	604	1	32	-	1	-	-	-	-	34	6
	27	304	317	621	-	20	-	-	-	-	-	-	20	3
	28	312	580	892	2	21	-	2	-	-	-	-	25	3
	29	50	330	380	2	22	-	2	-	-	-	-	26	7
	30	44	304	348	-	14	-	2	-	-	-	-	16	5
	31	34	304	338	-	10	-	2	-	-	-	-	12	4

S-P-Total spore-pollen

D-A-Total dinocysts-acritarchs (microplankton)

PALYN-Palynomorphs

NM-Reworked spore-pollen (nonmarine)

(D)-Devonian (may include some Mississippian)

(C)-Carboniferous (predominantly Mississippian)

(P)-Permian

(P-Tr)-Permian-Triassic

M-Reworked dinocysts-acritarchs (marine)

(L Tr)-Late Triassic

(E J)-Early Jurassic

(L J)-Late Jurassic

(V-H)-Valanginian-Hauterivian

for six of the wells showing this detailed information are included (tables 1-6). Some editing of the recorded data was required in order to minimize the effect of sloughing or downhole transport of drilling chips that is normal in most ditch sample recoveries.

The subsurface formational terminology ascribed to the Oxfordian, Valanginian, and Hauterivian stratal units is from Carmen and Hardwick (1983). The age units have their respective formational names noted in the titles of tables 7-9 and figures 2-4.

DATA COMPILATION

Well Samples (tables 1-6)

Spreadsheets from six of the 25 wells display the basic data compiled for each well in the study. For each sample there is a listing of:

- Estimated counts for spore-pollen and microplankton cysts, as well as their combined totals.
- Numbers of reworked specimens categorized by age as either nonmarine or marine palynomorphs.
- A calculated total of reworked specimens and their percentage.

Table 7. Presence of reworked palynomorphs in Oxfordian (Kingak Formation) strata

Well name	Samples containing reworked palynomorphs								
	Samples	D	(*)	C	(*)	P-Tr	(*)	E J	(*)
1 Alpine No. 1	27	10	(18)	25	(790)	7	(9)	-	-
2 Alpine No. 3	44	21	(32)	44	(469)	19	(38)	-	-
3 Bergschrund No. 1	19	6	(6)	19	(207)	3	(3)	-	-
4 Bergschrund No. 2	12	9	(21)	11	(76)	1	(1)	-	-
5 Colville No. 1 (Sinclair)	11	1	(1)	11	(101)	1	(1)	1	(20)
6 Colville Delta No. 1 (Am Hess)	18	8	(10)	15	(688)	5	(9)	3	(3)
7 Colville Delta No. 1/1a	7	2	(3)	5	(20)	1	(1)	-	-
8 Colville Delta No. 2	19	5	(10)	19	(707)	8	(12)	5	(20)
9 Colville Delta No. 3	15	6	(16)	14	(441)	3	(5)	-	-
10 Colville River No. 1 (Arco)	18	8	(23)	16	(167)	13	(28)	-	-
11 East Harrison Bay No. 1	16	7	(20)	13	(93)	2	(3)	-	-
12 Fiord No. 1	21	15	(24)	20	(474)	13	(21)	-	-
13 Fiord No. 2	15	3	(3)	14	(67)	2	(2)	-	-
14 Fiord No. 3	14	12	(29)	13	(130)	7	(9)	-	-
15 Itkillik River No. 1 (Arco)	12	-	-	4	(14)	-	-	1	(2)
16 Kalubik No. 1	21	6	(10)	6	(40)	5	(6)	-	-
17 Kalubik Creek No. 1	9	-	-	2	(3)	4	(4)	-	-
18 Kookpuk No. 1	9	-	-	-	-	3	(6)	-	-
19 Kuukpik No. 3	23	3	(3)	22	(418)	15	(40)	-	-
20 Nanuk No. 1	15	12	(63)	15	(191)	2	(2)	-	-
21 Nechelik No. 1	13	2	(2)	12	(52)	1	(1)	-	-
22 Neve No. 1	35	9	(9)	26	(152)	2	(2)	1	(1)
23 Temptation No. 1	19	8	(19)	18	(235)	14	(23)	-	-
24 Thetis Island No. 1	13	2	(2)	13	(105)	5	(6)	-	-
25 Till No. 1	17	10	(14)	16	(244)	9	(15)	-	-
Totals	442	165	(338)	373	(5935)	145	(247)	11	(46)
Percent of samples with reworked palynomorphs			37.33%		84.39%		32.80%		2.49%
No. of wells with reworked palynomorphs in samples	25		22		24		24		5

D--Devonian (may include Mississippian)

C--Carboniferous (predominantly Mississippian)

P-Tr--Permian-Triassic

E J--Early-middle Jurassic

(*)--Number of specimens

Sample Summary in a Stratal Unit (tables 7-9)

Each stratigraphic interval (Oxfordian, Valanginian, and Hauterivian) has a summary of reworked palynomorphs for the 25 wells in this study.

Each well has the following:

- a) Total samples in the interval
- b) The number of samples containing reworked forms and the estimated counts of reworked specimens for each age category.

In the summary for all wells the following is calculated:

- a) Total number of samples
- b) The total number of samples containing re-

worked forms and the total counts of reworked specimens for each age category.

- c) Percentage of samples containing reworked forms from each age category.

- d) Number of wells in the study that contain any reworked taxa.

Semi-log Plot of Summary Data (figs. 2-4)

The calculated percentage of samples containing reworked palynomorphs by age categories is displayed in a semi-log plot for each stratal interval. This graphic display provides a sense of the frequency of reworked forms occurring in the wells.

Table 8. Presence of reworked palynomorphs in Valanginian (Mihveach Formation and Lower Kuparuk Formation) strata

Well name	Samples containing reworked palynomorphs										
	Samples	D	(*)	C	(*)	P-Tr	(*)	E J	(*)	L J	(*)
1 Alpine No. 1	5		0	4	(46)		0		0	1	(1)
2 Alpine No. 3	0		0		0		0		0		0
3 Bergschrund No. 1	7	1	(1)	5	(30)		0		0	1	(1)
4 Bergschrund No. 2	7	2	(3)	7	(53)		0		0	1	(1)
5 Colville No. 1 (Sinclair)	10	4	(5)	4	(7)		0		0	2	(2)
6 Colville Delta No. 1 (Am Hess)	12	5	(7)	8	(63)		0		0	1	(1)
7 Colville Delta No. 1/1a	3		0		0		0		0		0
8 Colville Delta No. 2	5	2	(2)	4	(4)	1	(1)		0	1	(1)
9 Colville Delta No. 3	4	2	(2)	4	(9)		0		0		0
10 Colville River No. 1 (ARCO)	7	6	(8)	7	(55)	1	(1)		0		0
11 East Harrison Bay No. 1	4		0		0		0		0	1	(9)
12 Fiord No. 1	3	1	(1)	2	(3)		0		0		0
13 Fiord No. 2	6	1	(2)	4	(15)		0		0	1	(9)
14 Fiord No. 3	5	3	(4)	3	(18)	2	(2)		0	1	(1)
15 Itkillik River No. 1 (ARCO)	5		0		0	1	(2)		0		0
16 Kalubik No. 1	6	1	(1)	2	(5)	2	(2)		0	1	(1)
17 Kalubik Creek No. 1	4		0		0		0		0		0
18 Kookpuk No. 1	5		0		0		0		0	1	(2)
19 Kuukpik No. 3	3		0	2	(5)	1	(1)	1	(1)		0
20 Nanuk No. 1	5	3	(5)	5	(44)		0		0	1	(1)
21 Nechelik No. 1	0		0		0		0		0		0
22 Neve No. 1	9	4	(6)	9	(73)	2	(2)		0	2	(3)
23 Temptation No. 1	0		0		0		0		0		0
24 Thetis Island No. 1	2		0	1	(2)		0		0	2	(2)
25 Till No. 1	6	3	(5)	5	(38)	3	(5)		0	1	(1)
Totals	123	38	(46)	76	(470)	14	(17)	1	(1)	18	(36)
Percent of samples with reworked palynomorphs			30.89%		61.79%		11.38%		0.81%		12.20%
No. of wells with reworked palynomorphs in samples	22		14		17		8		1		15

D-Devonian (may include Mississippian)
 C-Carboniferous (predominantly Mississippian)
 P-Tr-Permian-Triassic
 E J-Early-middle Jurassic
 L J-Late Jurassic
 (*)-Number of specimens

For each stratigraphic interval there is:

- a) The number of wells containing the reworked palynomorphs
- b) The percentage of samples in which the reworked specimens occur.

Bar Graph Summary Plot (fig. 5)

A single bar graph plot summarizes the percentage of samples within each stratal unit that contain reworked palynomorphs. These reworked forms are separated into their recognized age categories.

RESULTS

Inspection of the data presented in tables 1–9, indicate that the Oxfordian interval consistently contains the most frequent occurrences and the greatest abundance of reworked palynomorphs. A progressive decrease in reworked palynomorphs is evident in younger intervals. The uppermost interval, the Barremian–early Albian, is essentially devoid of reworked palynomorphs (tables 1–6). These strata are rich in amorphous organic material and are associated with a decrease in clastic input, resulting in the near absence of reworked palynomorphs. This uppermost interval is shown

Table 9. Presence of reworked palynomorphs in Hauterivian (upper Kuparuk Formation) strata

Well name	Samples containing reworked palynomorphs												
	Samples	D	(*)	C	(*)	P-Tr	(*)	E J	(*)	L J	(*)	V	(*)
1 Alpine No. 1	7	—	—	4	(291)	1	(1)	—	—	—	—	—	—
2 Alpine No. 3	5	—	—	1	(2)	1	(1)	1	(1)	1	(2)	—	—
3 Bergschrund No. 1	8	—	—	5	(10)	—	—	—	—	—	—	1	(1)
4 Bergschrund No. 2	5	—	—	1	(3)	1	(1)	—	—	—	—	—	—
5 Colville No. 1 (Sinclair)	8	—	—	—	0	1	(1)	—	—	—	—	—	—
6 Colville Delta No. 1 (Am Hess)	6	—	—	—	—	—	—	—	—	1	(1)	—	—
7 Colville Delta No. 1/1a	3	—	—	—	—	—	—	—	—	—	—	—	—
8 Colville Delta No. 2	4	—	—	—	—	—	—	—	—	—	—	—	—
9 Colville Delta No. 3	7	—	—	1	(2)	—	—	—	—	—	—	—	—
10 Colville River No. 1 (Arco)	6	1	(2)	2	(4)	—	—	—	—	—	—	—	—
11 East Harrison Bay No. 1	6	—	—	—	—	—	—	—	—	—	—	—	—
12 Fiord No. 1	8	—	—	—	—	—	—	—	—	—	—	—	—
13 Fiord No. 2	11	1	(1)	6	(69)	—	—	—	—	3	(4)	—	—
14 Fiord No. 3	5	—	—	—	—	—	—	—	—	—	—	—	—
15 Itkillik River No. 1 (Arco)	5	—	—	—	—	—	—	—	—	—	—	—	—
16 Kalubik No. 1	5	—	—	—	—	—	—	—	—	—	—	—	—
17 Kalubik Creek No. 1	3	—	—	—	—	—	—	—	—	—	—	—	—
18 Kookpuk No. 1	3	—	—	—	—	—	—	—	—	—	—	—	—
19 Kuukpik No. 3	9	—	—	3	(58)	—	—	—	—	3	(4)	—	—
20 Nanuk No. 1	6	1	(1)	2	(3)	—	—	—	—	1	(1)	—	—
21 Nechelik No. 1	4	—	—	—	—	—	—	—	—	1	(1)	—	—
22 Neve No. 1	5	—	—	2	(3)	—	—	—	—	—	—	—	—
23 Temptation No. 1	4	—	—	—	—	—	—	—	—	—	—	—	—
24 Thetis Island No. 1	4	—	—	2	(3)	—	—	—	—	—	—	—	—
25 Till No. 1	3	—	—	—	—	—	—	—	—	1	(2)	—	—
Totals	140	3	(4)	29	(451)	4	(4)	1	(1)	11	(15)	1	(1)
Percent of samples with reworked palynomorphs			2.14%		20.71%		2.86%		0.71%		7.86%		0.71%
No. of wells with reworked palynomorphs in samples	25		3		11		4		1		7		1

D—Devonian (may include Mississippian)
 C—Carboniferous (predominantly Mississippian)
 P-Tr—Permian-Triassic
 E J—Early-middle Jurassic
 L J—Late Jurassic
 V—Valanginian
 (*)—Number of specimens

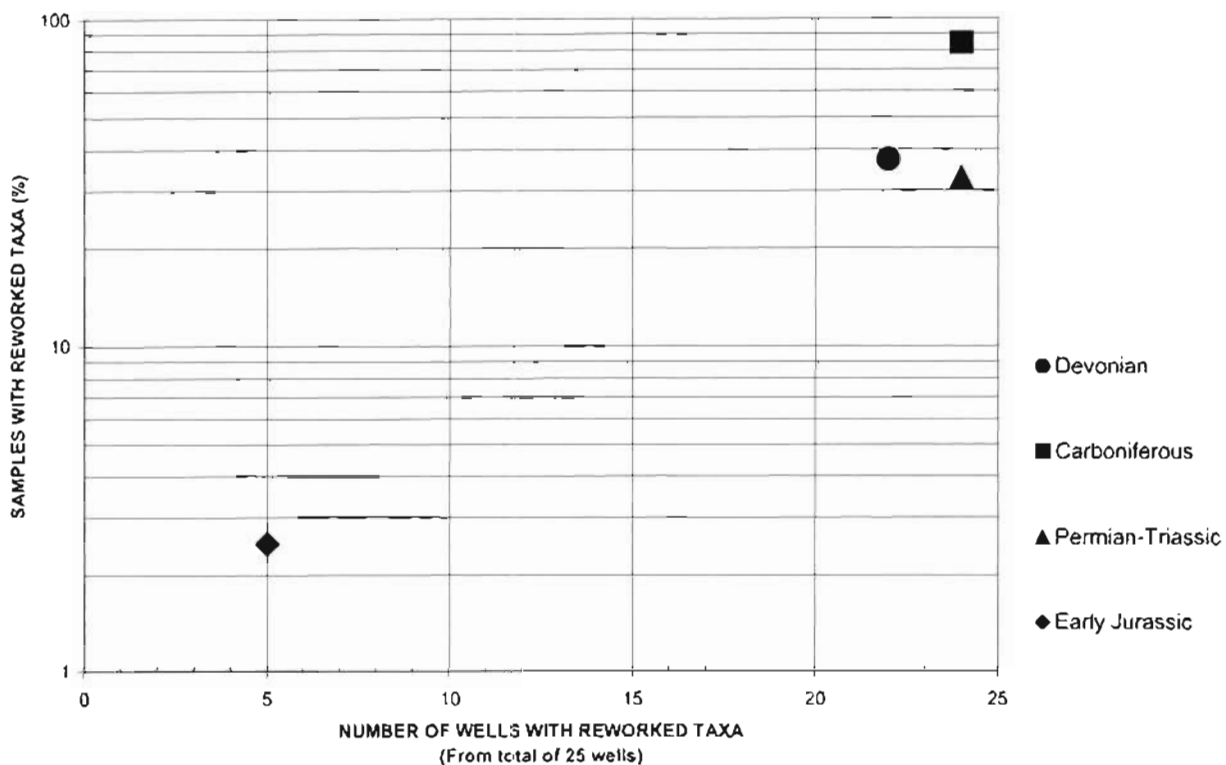


Figure 2. Reworked palynomorphs in Oxfordian (Kingak Formation) samples.

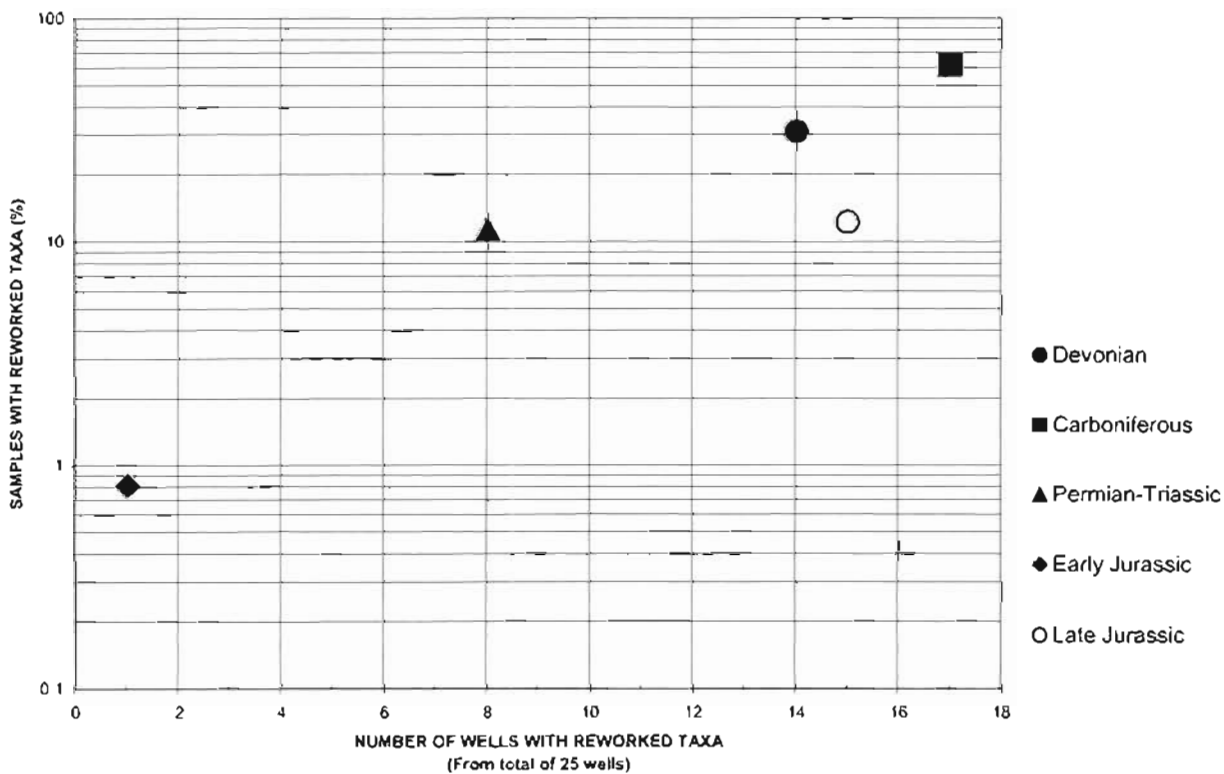


Figure 3. Reworked palynomorphs in Valanginian (Miluveach Formation and lower Kuparuk Formation) samples.

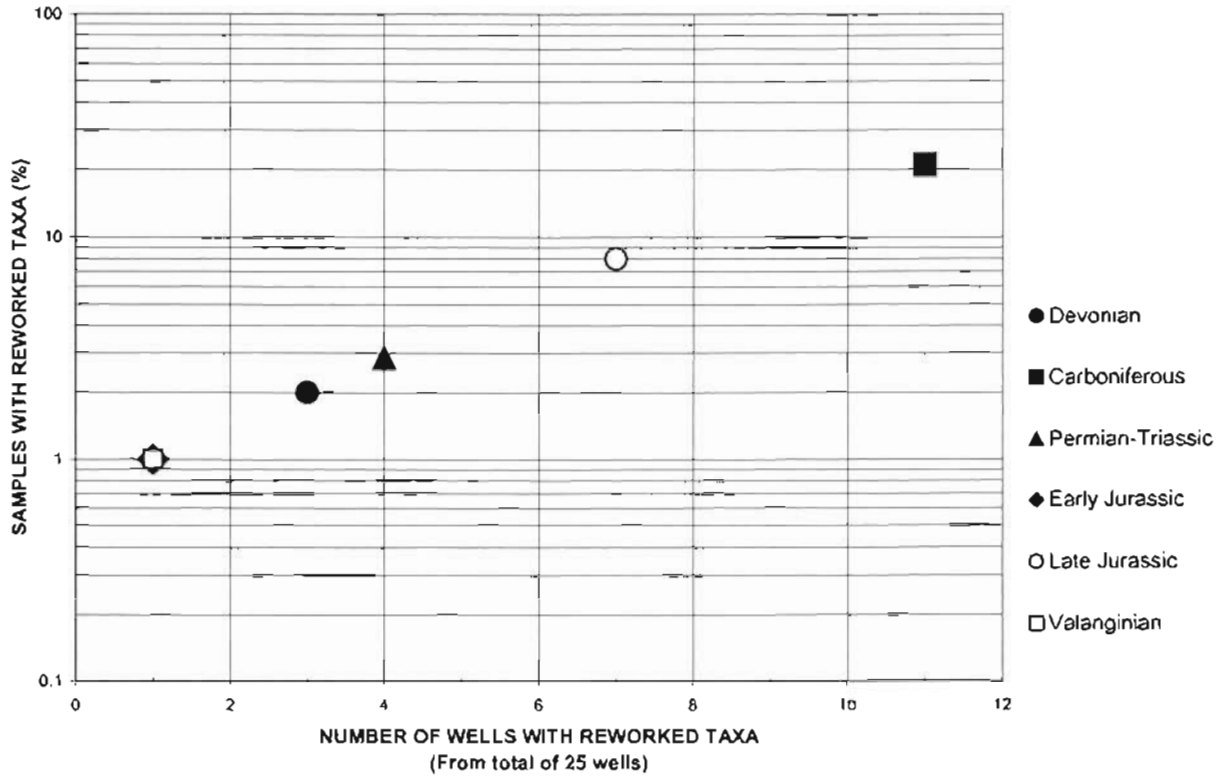


Figure 4. Reworked palynomorphs in Hauterivian (upper Kuparuk Formation) samples.

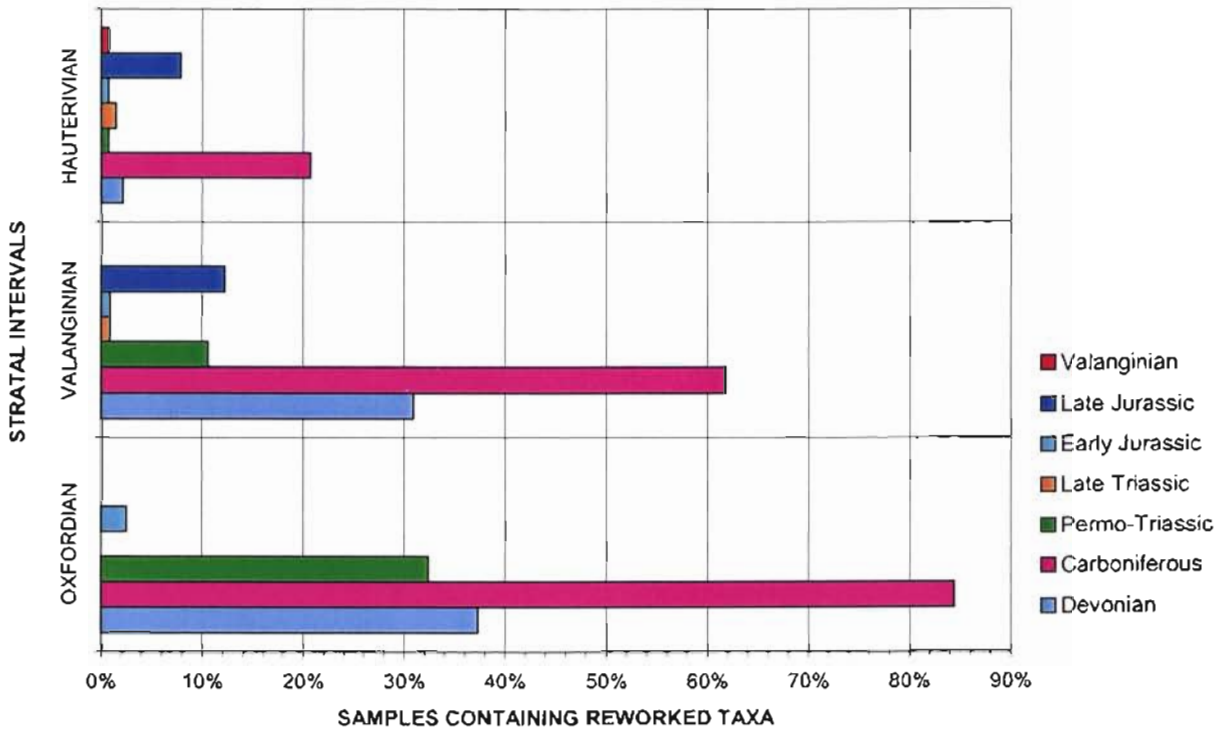


Figure 5. Summary of reworked palynomorph occurrences.

in the examples for comparative purposes, but is not relevant to the reworked palynomorph counts in this study.

Summaries of data for the Oxfordian, Valanginian, and Hauterivian intervals from the wells are tabulated in tables 7, 8, and 9, respectively. In these tables the percentage of samples within each time interval that contain age-specified reworked palynomorphs has been calculated. It is obvious that Carboniferous spores are the most common constituents of the reworked palynomorph suite. Devonian and Permian–Triassic palynomorphs make up the next most frequently reworked forms.

Graphic displays of the calculated percentages of samples containing reworked palynomorphs are presented in semi-log plots (figs. 2-4). These show a progressive decrease in the number of wells and a similar decrease in the percentage of samples containing reworked forms in each overlying younger stratal interval.

In the Oxfordian stratigraphic interval (fig. 2), over 80 percent of the samples in 24 wells contained reworked Carboniferous spores. Between 30 and 40 percent of the samples in most of the wells contained Devonian and Permian–Triassic palynomorphs. Early Jurassic dinocysts were a minor constituent of the reworked assemblage.

In the Valanginian interval (fig. 3), a decrease in the number of wells that contained reworked palynomorphs is noted. The most common reworked components are still the Carboniferous spores, which occur in over 60 percent of the samples in 17 wells. The Devonian spores are present in 30 percent of the samples in 14 wells. Late Jurassic dinocysts are present in 15 of the wells, but they occur in only about 12 percent of the samples. The presence of Permian–Triassic palynomorphs has decreased to about 10 percent of the samples in only eight wells.

The Hauterivian interval (fig. 4) exhibits a further decrease in numbers of samples containing reworked palynomorphs. The Carboniferous spores are still the most common constituents, but they are only present in about 20 percent of the samples in 11 wells. The other reworked age categories appear in less than 10 percent of the samples.

A summary of all the reworked occurrences within each stratigraphic unit is incorporated into a bar graph (fig. 5). This simplified format presents the percent of samples that contain the specific age categories of reworked palynomorphs in a single display.

CONCLUSIONS

The tracking of reworked palynomorphs is one method by which additional insight may be acquired regarding the provenance of rock units. The limited study for the Colville Delta region indicates that Carboniferous units (evidenced mainly by Kekiktuk Formation spores) were a major source of the detritus occurring in Oxfordian age strata. Devonian and Permian to Triassic formations were, to a lesser extent, also recognizable contributing sources.

During Valanginian deposition, the Carboniferous units were also the dominant detrital source, although their reworked palynomorph presence is less abundant than in Oxfordian strata. Evidence of palynomorph-bearing detritus sourced from other age units is likewise diminished. Hauterivian deposits exhibit a further decrease in recognizably reworked detritus, and the decreasing trend is maximized in the overlying Barremian–early Albian section, in which the non-siliciclastic component consists predominantly of amorphous organics. This Barremian–early Albian unit represents a low energy, marine, probably distal, environment with sparse detrital sediment input and, therefore, is nearly devoid of identifiable reworked detritus. This latter unit can include the Kalubik Formation and HRZ unit of Carman and Hardwick (1983), as well as part of the Hue Shale.

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