conf. to 1 Aug. 1979

STRATIGRAPHIC CORRELATION
BIOSTRATIGRAPHIC ZONATION

IMP. IVIK K-54

69° 33' 36" N. LAT.; 134° 29' 01" W. LONG.
NORTHWEST TERRITORIES

AUSTIN & CUMMING EXPLORATION CONSULTANTS
CALGARY, ALBERTA
MAY, 1977

C O N T E N T S

SUMMARY AND CONCLUSIONS

Discussion of Zonation Correlations

BY

L. W. CUMMING, P. GEOL.

IMP. IVIK K-54

SUMMARY AND CONCLUSIONS

Biostratigraphic analysis of Imp. Ivik K-54 is comprised of a palynological analysis carried out by Dr. Geoffrey Norris, and a micropaleontological study by Drs. M. Brooke and W. Braun.

One hundred and thirty (130) palynomorph slides, prepared from ditch samples and cores (as shown in Fig. 1), were provided by the operator.

Fifty six (56) terrestrial palynomorph species and three marine dinoflagellate species were identified indicating three Neogene and four Paleogene palynozones.

One hundred and sixty nine (169) microfaunal slides, prepared from 34 sidewall cores and 128 ditch cuttings and 7 cores were provided by the operator. Diagnostic microfossil material was recovered only within the upper 1,000 feet (Neogene) and the lowermost 2,920 feet (Upper Eocene-Oligocene?).

Palynological zones are picked on the basis of first occurrences of a characteristic microflora or assemblage of microflora. Direct correlation of the microfloral zones with physical stratigraphic units cannot be made due to recycling of flora derived from older beds, and the limited knowledge of absolute range of each species. However, used in conjunction with lithological microfaunal and mechanical log data, correlative stratigraphic units can be established and carried from well to well as shown in Tables 1 and 2.

Microfossil material is particularly sparse in this well, with no diagnostic material recovered through the interval 1,000-7,400 feet. Recoveries of poorly developed Assemblage 1 fauna supports the palynological zonation, and the presence of Alveophragmium 154, Bathysiphon 52 and Haplophragmoides 53 through the lower 2900 feet support the Middle Eocene-Oligocene age interpreted for this interval.

A summary of the palynological and micropaleontological zonation showing relation of zones to interpreted stratigraphic units is presented in Table 1 following.

Interpretive correlation of this well with Imp. Nuktak C-22 is presented in Table 2.

TABLE 1

ZONATION SUMMARY

AGE	STRATIGRAPHIC UNIT	PALYNOLOGICAL UNIT	MICROFOSSIL ASS
NEOGENE			
Miocene to Pliocene	Coarse Clastic Unit	*Laevigatosporites*-1 IVK-1 (120-1380')	Assemblage I (Surface-1,000'
	Coarse Clastic & Mudstone Unit	*periporate*-1 IVK-2 (1380-2100')	
Miocene	Tsuga Mudstone Unit (2100-3320)	*Tsuga*-1 IVK-3 (2100-2460')	
PALEOGENE			
Oligocene	Ericaceae Sand Unit (3320-5340)	*Ericaceae*-1 IVK-4 (2460-5340')	
Upper Eocene to Oligocene	Lycopodiumsporites Sand & Mud Unit (5340-7920)	*Lycopodiumsporites*-1 IVK-5 (5340-7110')	
	*Osmundacidites? Mudstone & Sandstone Unit (7920-8700)		Alveophragmium Haplophragmoide Bathysiphon 52 (7400-10,320')
Upper Eocene	PJ-1 "overpressured" Shale Unit (8700-10,320)	*Parviprojectus*-1 IVK-6 (7110-10,320')	

*A single occurrence of *Osmundacidites*-1 at 7920 feet suggests the presence of the *Osmundacidites*-1 zone normally encountered above the PJ-1 zone, e.g., Pullen E-17, Nuktak C-22.

DISCUSSION OF ZONATION

NEOGENE

The Neogene in this well is divided into three palynozones, that, with modification, are supported by the physical stratigraphy. The two upper zones (IVK-1 and 2) are tentatively placed in the Upper Miocene to Pliocene, whereas IVK-3 or the Tsuga Mudstone Unit is placed in Miocene. The base of the Miocene is placed stratigraphically at 3,320 feet where mudstones are in possible unconformable contact with an underlying, predominantly sandstone unit.

Miocene-Pliocene

Laevigatosporites-1 (120-1380)

The presence of *Laevigatosporites*-1 and *Sigmopollis hispidus* in this uppermost interval strongly supports correlation with the *Laevigatosporites*-1 palynozone in other wells. A poorly developed Assemblage I Fauna, encountered through the interval 0-1,000 feet, supports this correlation. This unit is composed of vari-coloured "gravels" deposited with poorly consolidated mudstones.

periporate-1 (1380-2100)

The appearance of *Betulaceoipollenites*-1 at 1380 feet indicates the presence of beds equivalent to the *periporate*-1 palynozone of other wells, (Norris) and the *Betulaceoipollenites*-1 zone (Rouse).

Lithologically, this zone is similar to the overlying *Laevigatosporites*-1 zone with a gradational increase of mudstone, and consequent decrease of gravels toward the base. The base of this zone is placed palynologically at 2100 feet at the first appearance of the underlying *Tsuga*-1 flora.

Miocene

Tsuga-1 (2100-2460)

Tsuga Mudstone Unit (2100-3320)

Common occurrences of the *Tsuga*-1 and *Corylus*-1 flora through the interval (2100-2460) clearly indicates a correlation with the *Tsuga*-1 zone at Imp. Nuktak C-22 and other wells (Table 2). Lithological correlations suggest this zone should also include the upper portion of the *Ericaceae*-1 palynozone from 2100-3320 feet, which we have termed the Tsuga Mudstone Unit.

Ericaceae-1 flora is commonly associated with beds containing *Tsuga*-1 and *Corylus*-1 palynomorphs, suggesting an upper range for *Ericaceae*-1 more or less coincident with that of the Tsuga assemblage. It is, therefore, proposed that the Tsuga mudstone unit includes the

Tsuga-1 palynozone (2100-2460) plus the interval (2460-3320) assigned to the *Ericaceae*-1 zone. The latter includes a mixture of *Tsuga*-1, *Corylus*-1 and *Ericaceae*-1 and coincides with the lower portion of a mudstone lithological unit. The base of this unit is placed at the unconformable(?) contact of the predominantly mudstone unit with underlying sandstones that commonly contain *Ericaceae*-1 in combination with *Pterocarya levis* flora.

The presence of *Ericaceae*-1 flora within the Tsuga mudstone might alternatively be interpreted as recycling of the *Ericaceae* flora into the younger *Tsuga*-1 deposits immediately above the unconformity(?) tentatively placed at 3,320.

PALEOGENE

Oligocene

Ericaceae-1 (2460-5340)

Ericaceae Sandstone Unit (3320-5340)

In that the uppermost range of the *Ericaceae*-1 flora appears inconsistent and in some wells coincident with the *Tsuga*-1 flora, it is proposed that the top of the *Ericaceae*-1 Sandstone Unit be picked at 3,320 feet on the basis of lithology and/or mechanical logs. The first occurrence of the *Pterocarya levis* flora (commonly associated with *Ericaceae*-1 flora) at 3360 in combination with *Ericaceae*-1 and *Abies*-1 flora may be useful in identifying this unit. The upper portion of this sandstone unit appears relatively impoverished of pollen, a feature that may prove useful in identifying these beds. The base of the *Ericaceae*-1 sandstone unit is placed at 5340 feet on the first occurrence of the *Lycopodiumsporites*-1 microfloral assemblage.

Upper Eocene-Oligocene

Lycopodiumsporites-1 (5340-7110)

Altnerate Interpretation (5340-7920)

The first appearance of *Lycopodiumsporites*-1 flora at 5340 marks the top of this unit. The base is chosen palynologically to coincide with the single occurrence of *tetrad*-1 at 7110, followed by a single *Parviprojectus*-1 species at 7200 feet. A single occurrence of *Osmundacidites*-1 in the 7920 foot sample indicates a reversal of normal sequence, where *Osmundacidites*-1 normally extends upward beyond the PJ-1 and tetrad flora. Consequently, the *Osmundacidites*-1 fauna is recognized for correlation (Table 2) and the PJ-1 and *tetrad* flora considered out of place, either through recycling upwards at a possible unconformity at 8700± feet, or to be longer ranging than previously indicated. Correlations to other wells (e.g., Nuktak - Table 2) are more straight forward with the latter interpretation.

This unit consists of alternating fine grained sandstone and mudstones.

Osmundacidites-1 (7920-8700) Alternate Interpretation

The top of this zone is picked on a single occurrence of *Osmundacidites*-1 in the 7920 foot sample. The base is chosen to coincide with the basal contact of a well developed sand (8490-8700± feet), which is tentatively interpreted as a basal sand overlying the PJ-1 mudstone unit.

Parviprojectus-1 (7110-10,320)

Palynologically, the top of the PJ-1 zone is chosen at 7110 feet on a single occurrence of *tetrad*-1 followed by a single occurrence of *Parviprojectus*-1 at 7200. The presence of *Pluricellaesporites*-3 at 9720 suggests a correlation with Imp. Pullen E-17 where this species is found in association with *tetrad*-1, *Fungiscissa*-1 and *Pluricellaesporites*-2, which are characteristic of the *Parviprojectus*-1 in other wells. As noted by Norris, *Pluricellaesporites*-3 is commonly found within the *Pesavis tagluensis* zone, however, this species also was recognized in the *Tilia*-1 zone (*Parviprojectus*-1 equivalent) at Ya Ya A-28, indicating an upward range of Upper Eocene for this formation. The absence of species such as *Azolla*-1, *Astrocysta*-1 and *Wetzeliella hampdenensis* indicates this well failed to penetrate the lower portion of the PJ-1 zone. Norris, however, suggests the possibility of *Pesavis tagluensis* through the interval 9072-10,320 feet due to the presence of *Pluricellaesporites*-3 and *Multicellaesporites*-5, but mechanical log and lithological correlations tend to support the former interpretation.

Parviprojectus "overpressured" shale (8700-10,320)

Lithologically the top of this unit can be placed at 8700 feet. The presence of *tetrad*-1 and PJ-1 flora at 7110 and 7200 respectively is credited either to recycling of material into beds above a possible unconformity at 8700, or to a range extended beyond that previously considered for these flora.

Mechanical logs indicate that beds below 8700 feet contain "overpressure" conditions that appear to correlate directly to similar beds near the base of Imp. Pullen E-17.

An interpretive correlation of Imp. Ivik K-54 with Imp. Nuktak C-22, based on an interpretation of Biostratigraphic results in combination with mechanical log and lithology is shown in Table 2, following.

The presence of the microfaunal indicators Alveophragmium 154, Bathysiphon 52 and Haplophragmoides 53 through the interval 7400-10,320 also suggests a correlation with the *Osmundacidites*-1 and PJ-1 zones at both Imp. Nuktak C-22 and Imp. Pullen E-17 which are presently considered to be of Upper Eocene to Oligocene age.

CORRELATIONS

We have attempted a correlation between Ivik K-54 and Nuktak C-22 using palynostratigraphic zones which are a refinement of the palynozones using recognizable lithologic units (Table 2). This interpretation is favoured over that of Norris which would suggest on tenuous grounds that the well bottomed in *Pesavis tagluensis*.

TABLE 2

PALYNOSTRATIGRAPHIC CORRELATION IMP. IVIK K-54 WITH NUKTAK C-22

IMP. NUKTAK C-22		PALYNOLOGICAL ZONE OR * STRATIGRAPHIC UNIT	IMP. IVIK K-54	
MIOCENE TO PLIOCENE	950'	LAEVIGATOSPORITES-1	1380'	MIOCENE TO PLIOCENE
	2370'	BETULA-1 (PERIPORATE-1)	2100'	
MIOCENE	2920'	* TSUGA MUDSTONE UNIT	3320'	MIOCENE
OLIGOCENE	5370'	* ERICACEA SANDSTONE UNIT	5340'	OLIGOCENE
UPPER EOCENE TO OLIGOCENE	7682'	LYCOPODIUMSPORITES-1	7920'	UPPER EOCENE TO OLIGOCENE
	8695'	*OSMUNDACIDITES-1 ? ALVEOPHRAGMIUM 154	8700'	
UPPER EOCENE	11,160'	* PARVIPROJECTUS "OVERPRESSURED" SHALES	10,330'	UPPER EOCENE
MIDDLE TO LOWER EOCENE	12,600'	PESAVIS TAGLUENSIS		

* Based on Lithology

Vertical Scale: 1" = 2000'

Interpretation by: L.W. CUMMING

PALYNOSTRATIGRAPHIC STUDY

BY

G. NORRIS, Ph.D.

TABLE 3
PALYNOLOGICAL ZONATION
IMP. IVIK K-54

	WELL ZONE	DESCRIPTIVE PALYNOMORPH	ENVIRONMENT	AGE	ORG. MAT.
1000	IVK-1 1380'	LAEVIGATOSPORITES-1	TERRESTRIAL WITH RESTRICTED MARINE INTERVALS	PLIOCENE	1-2
2000	IVK-2 2100'	PERIPORATE-1 (BETULA-1)	RESTRICTED MARINE	UPPER MIOCENE TO L. PLIOCENE	
	IVK-3 2460'	TSUGA-1		MIDDLE MIOCENE	
3000	IVK-4 5340'	ERICACEAE-1	TERRESTRIAL	OLIGOCENE	2-3
6000	IVK-5 7110'	LYCOPODIUMSPORITES-1		UPPER EOCENE TO OLIGOCENE	3-4
8000	IVK-6 10,320'	PARVIPROJECTUS-1		UPPER EOCENE	
10,000					

IMP. IVIK K-54

SUMMARY

One hundred and thirty samples from the subject well yielded 56 terrestrial spore species and 3 marine dinoflagellate species. Three Neogene and four Paleogene zones are recognized, with an apparent break in the section at 7,110 feet. Terrestrial conditions of deposition dominated, with weak marine influence indicated in the approximately upper 3,000 feet of the well. Spore colours range from light yellow at the top to amber at the bottom of the well.

ZONATION

Zone IVK-1 *Laevigatosporites*-1 (120-1380 feet)

Characterized by:

1 *Stereisporites antiquasporites*
2 *Taxodiaceaepollenites hiatus*
407 *Laevigatosporites*-1
287 *Alnipollenites*-1
409 *Stereisporites*-2
570 *Lycopodiumsporites*-2
229 *Sigmopollis hispidus*
326 *Pinus*-1 (at bottom)
401 *Picea*-1 (possibly recycled)

Zone IVK-2 *periporate*-1 (1380-2100 feet)

220 *Betulaceoipollenites*-1
581 *Tricolporopollenites*-9
576 *Diporisporites*-1
M242 *Korojonia*-1

Zone IVK-3 *Tsuga*-1 (2100-2460 feet)

371 *Tsuga*-1
395 *Corylus*-1
324 *Carpinus subtriangula* (possibly recycled)
411 *Abies*-1
M242 *Korojonia*-1 remains common

Zone IVK-4 *Ericaceae*-1 (2460-5340 feet)

34 *Laevigatosporites ovatus*
377 *Ericaceae*-1
582 *Onagraceae*-1
323 *Pterocarya levis*

408 *periporate*-1
282 *Caryapollenites paleocenicus*
19 *Osmundacidites wellmanii* (at bottom)
413 *Stereisporites*-3 (at bottom)

The upper 1,000 feet of this zone are characterized by common M242 *Korojonia*-1

Zone IVK-5 *Lycopodiumsporites*-1 (5340-7110 feet)

412 *Lycopodiumsporites*-1
370 *Tiliapollenites*-1
583 *Dicellaesporites*-3
854 *Polypodiisporites*-2
585 *Multicellaesporites*-3
394 *Corylus granilabrata*
586 *Leptolepidites*-2
374 *Granatisporites*-1
567 *periporate*-3
22 *Cyathidites minor*
320 *Ulmus*-1 (at bottom)
587 *Urnaspora*-2
588 *Striadiporites*-4
42 *Araucariacities australis*
578 *Dicellaesporites*-2
M233 *Horologinella*-1

Zone IVK-6 *Parviprojectus*-1 (7110-10,320 feet)

Characterized by these sparsely distributed species:

419 *tetrad*-1
422 *Parviprojectus*-1
31 *Lycopodiumsporites austroclavatidites*
421 *Leptolepidites*-1
589 *Granatisporites*-3
391 *Striadiporites sanctaebarbarae*
291 *Tricolpites hians*
416 *Osmundacidites*-1
183 *Baculatisporites comaumensis*
590 *Multicellaesporites*-5
415 *Aquilapollenites* cf. *murus*
591 *Multicellaesporites*-9
549 *Pluricellaesporites*-3

ENVIRONMENT OF DEPOSITION

A restricted dinoflagellate flora comprising M242 *Korojonia*-1 in the upper part of Zone IVK-4, IVK-3, IVK-2, and IVK-1 indicates weak marine influence in this interval.

The remaining zones are essentially non-marine, except for the rare presence of M233 *Horologinella*-1 in Zone IVK-5 which may be marine, although it is possible that it is a lacustrine algal type.

AGE AND CORRELATION

Ages and correlations are summarized in the accompanying tables.

Zone IVK-1 *Laevigatosporites*-1 Zone

This zone is clearly correlated with the *Laevigatosporites*-1 zone (Pliocene) on the basis of the presence of the nominal species and 229 *Sigmopollis hispidus*.

Zone IVK-2 *periporate*-1 Zone

The well defined top of 220 *Betulaceaeoipollenites*-1 indicates a correlation with the *periporate*-1 zone (upper Miocene-lower Pliocene). The nominal species, however, does not occur in this zone but a single specimen of it occurs lower at 3360 feet, presumably by caving from above.

Zone IVK-3 *Tsuga*-1 Zone

The co-occurrence and well defined tops of 371 *Tsuga*-1 and 395 *Corylus*-1 indicates a correlation with the *Tsuga*-1 zone (Middle Miocene), additionally characterized by common *Betulaceoipollenites*-1.

Zone IVK-4 *Ericaceae*-1 Zone

The co-occurrence and tops of 377 *Ericaceae*-1 and 411 *Abies*-1 indicates a correlation with the *Ericaceae* zone (Oligocene). Additionally, 323 *Pterocarya levis* occurs in this zone as in NT-4 and NI-2.

Zone IVK-5 *Lycopodiumsporites*-1 Zone

The clearly defined top of 413 *Lycopodiumsporites*-1 suggests a correlation with the *Lycopodiumsporites*-1 zone (Upper Eocene-Lower Oligocene).

The slides used in this study were marked (?by the operating company palynologists) "PJ-1", presumably in reference to *Parviprojectus* sp. PJ-1 described by Staplin (1976). None of the specimens on the slides could be identified as this species. However, the top of the PJ-1 interval in the subject well is at 6,270 feet (in the middle of the *Lycopodiumsporites*-1 zone) which correlates with the top of the PJ-1 interval in IOE Nuktak C-22 (also identified by the operator's palynologists in a similar way) at 5,626 feet (in the upper half of the NT-5 *Lycopodiumsporites*-1 zone). Staplin (1976) notes the top of this interval in the upper part of his Zone T-3B and favours a middle-late Eocene age, although indicating the possibility of an Oligocene age.

It is worth noting that *Parviprojectus* sp. PJ-1 is not the same as 422 *Parviprojectus*-1 which occurs lower in this zone and other wells at the top of the *tetrad*-1 zone.

Zone IVK-6 *Parviprojectus*-1 Zone

The top of the range of 419 *tetrad*-1 suggests a correlation with the *tetrad*-1 zone (Upper Eocene). The rare presence of 422 *Parviprojectus*-1 at the top of IVK-6 correlates with a similar occurrence at the top of NT-7 (also *tetrad*-1 zone). The presence of 391 *Striadiporites sanctaebarbarae* towards the top of IVK-6 may be due to recycling.

At 9,072 (core) and lower, 590 *Multicellaesporites*-5 occurs which has been previously reported in the *Pesavis tagluensis* zone.

549 *Pluricellaesporites*-3 occurs at 9,720 feet in Ivik which is present in the *Pesavis tagluensis* zone in some wells. This species, however, ranges into the *Parviprojectus*-1 (*Tilia*-1) zone at Gulf Mobil Ya Ya A-28 and occurs near the top of the zone at Pullen E-17. Thus, a tentative correlation with the *Pesavis tagluensis* zone of the interval 9072 feet to T.D. in Ivik could be suggested, although many biostratigraphically significant species for this zone are absent.

ORGANIC MATURATION

Spore colours increase steadily from light yellow at the top of the well to amber at the bottom of the well as indicated in the paleo-log.

REFERENCE

Staplin, F.L. (ed.), 1976. Tertiary biostratigraphy, Mackenzie Delta Region, Canada. Bull. Can. Petrol. Geol., vol. 24, No. 1, 117-36.

APPENDIX

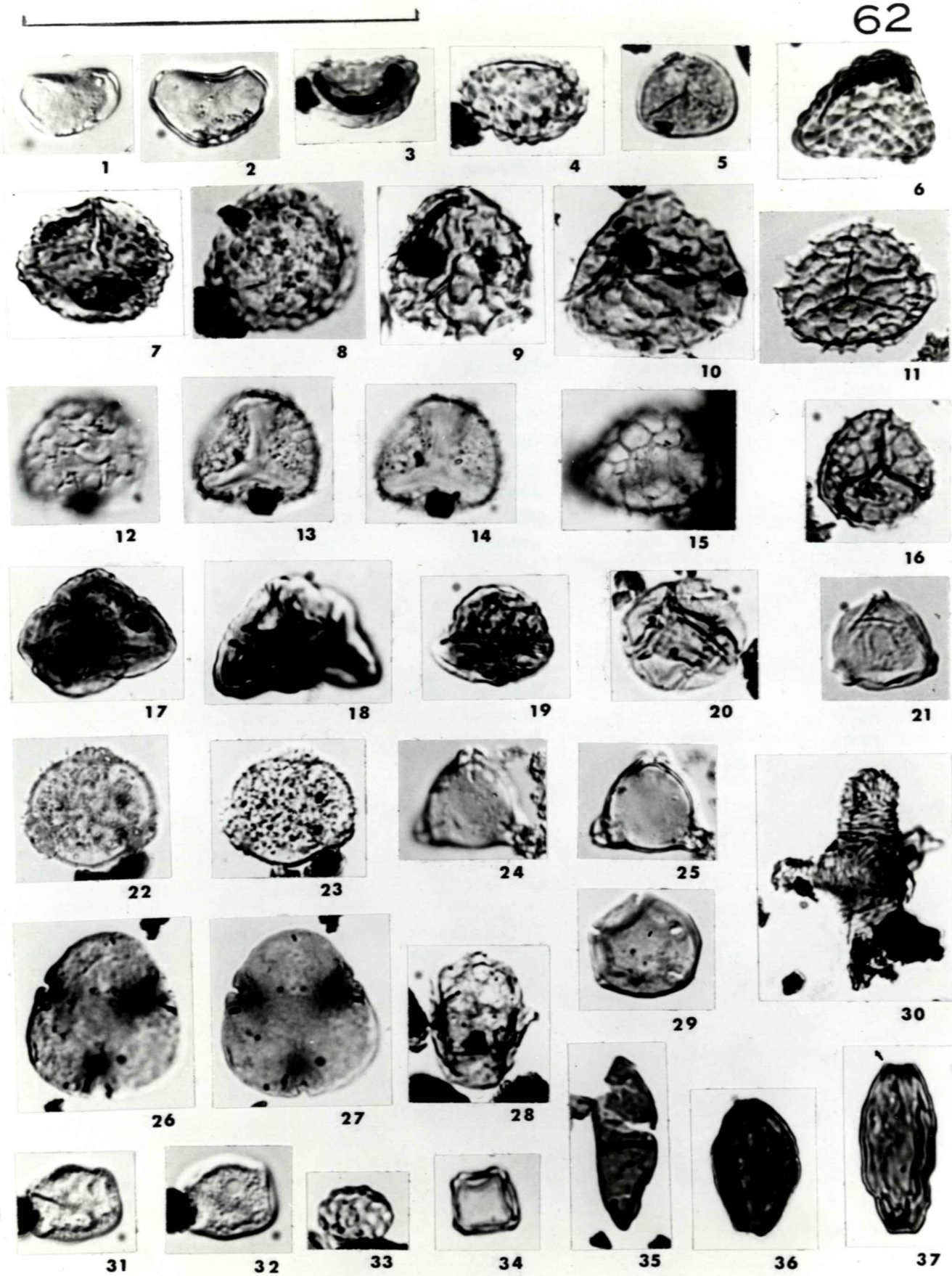
PALYNOLOGICAL PHOTOGRAPHS

(Plate numbering corresponds
to sequential numbering of
Austin & Cumming Arctic Flora
Photographic Library)

IMPERIAL IVIK K-54

PLATE 62

1-2	407	*Laevigatosporites*-1
3-4	584	*Polypodiisporites*-2
5	413	*Stereisporites*-3
6	586	*Leptolepidites*-2
7	416	*Osmundacidites*-1
8	421	*Leptolepidites*-1
9-10	412	*Lycopodiumsporites*-1
11-16	570	*Lycopodiumsporites*-2
17-19	419	*tetrad*-1
20	377	*Ericaceae*-1
21	220	*Betulaceoipollenites*-1
22-23	582	*Onagraceae*-1
24-25	581	*Tricolporopollenites*-9
26-27	370	*Tiliapollenites*-1
28	422	*Parviprojectus*-1
29	287	*Alnipollenites*-1
30	415	*Aquilapollenites* cf. *murus*
31-32	408	*periporate*-1
33	567	*periporate*-3
34	287	*Alnipollenites*-1
35	578	*Dicellaesporites*-2
36	391	*Striadiporites sanctaebarbarae*
37	588	*Striadiporites*-4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IMPERIAL IVIK K-54

PLATE 63

38-39	576	*Diporisporites*-1
40-41	583	*Dicellaesporites*-3
42	589	*Granatisporites*-3
43-45	590	*Multicellaesporites*-5
46	591	*Multicellaesporites*-9
47	578	*Dicellaesporites*-2
48	587	*Urnaspora*-2
49	549	*Pluricellaesporites*-3
50	411	*Abies*-1
51-53	M242	*Korojonia*-1
54-56	M233	*Horologinella*-1


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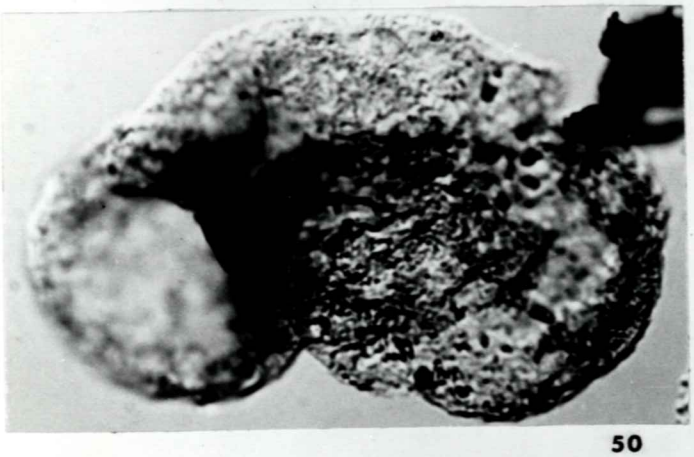
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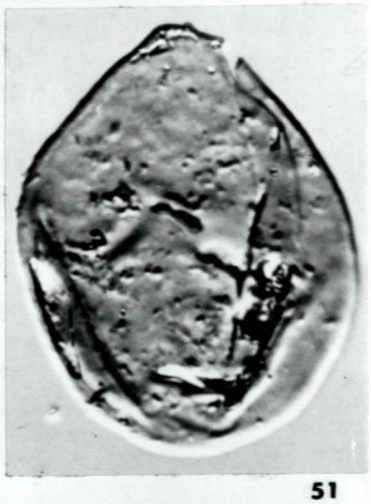
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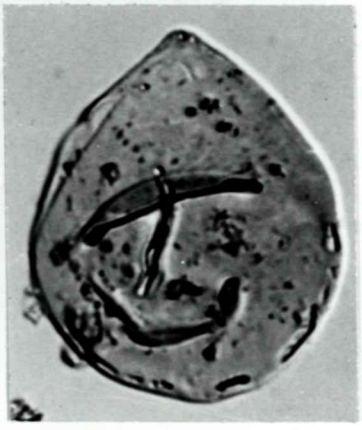
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MICROPALEONTOLOGICAL STUDY

BY

W. BRAUN, Ph.D.
&
M. BROOKE, Ph.D.

IMP. IVIK K-54

GENERAL REMARKS

One hundred and sixty nine (169) micropaleontological slides were submitted for study of which 128 were from drill-cuttings, 34 from sidewall cores (6489-9800 feet), and 7 from cores (9535-9607 feet). Unfortunately, none of the core samples contained any diagnostic microfossils.

All microfossils that could be identified, including characteristic fragments, were provided with species numbers, or they are listed simply as fragments. Their sequence and relative abundance is shown on the accompanying chart.

MICROFAUNAL ASSEMBLAGES

The rock sequence penetrated seem to be largely of terrestrial origin, and the marine faunas, therefore, are confined to two intervals. Bituminous and coaly fragments, plant debris, and many inorganic remains dominate the microfaunal spectrum.

NEOGENE ASSEMBLAGE 1

The uppermost 1,000 feet of the section penetrated contain some typical indicators of the Neogene Assemblage 1. The calcareous rotaliid Foraminifera, and ostracodes 1, 6 and 7 represent the marine component of this assemblage, whereas ostracode 2 and 11 (Iliocypris and Limnocythere) are typical freshwater representatives. This mixture of shallow-water, marine (inner to middle neritic) forms and intercalated freshwater species is typical of Assemblage 1 which is quite widespread in the Mackenzie Delta region.

This fauna is not as highly diversified at Ivik as it is in other wells, and the species are represented with fewer specimens. This may indicate that there were strong terrestrial influences, as suggested by Norris, and that the marine or freshwater intercalations are relatively minor. The upper part is the more fossiliferous one; at this time the marine influences obviously were stronger. The lower part, in contrast, contains only undiagnostic fragments, most likely "derived", indicating prevailing terrestrial conditions. According to Norris, Assemblage 1 is about identical in position to his Pliocene IVK-1 zone.

IMPERIAL

TABLE 4

IVIK K-54

PALYNOLOGY Norris, 1976			MICROPALEONTOLOGY Braun & Brooke, 1977	
Zones	Environment	Age		
IVK-1 1380'	terrestrial with restricted marine intervals	PLIOCENE	NEOGENE ASSEMBLAGE I ≈1,000'	open, shallow-mari near-shore to lagoonal; some lacustrine intercalations
IVK-2 2100'	restricted marine	L. PLIOCENE TO U. MIOCENE		
IVK-3 2460'		M. MIOCENE		
IVK-4 5340'	terrestrial	OLIGOCENE	no diagnostic microfauna	
IVK-5 7110'		U. EOCENE TO OLIGOCENE	≈7,400'	
IVK-6 10,320'		UPPER EOCENE	ALVEOPHRAGMIUM 154 HAPLOPHRAGMOIDES cf 53 BATHYSIPHON 52 FAUNA 10,320'	restricted marine
T.D.				

Undiagnostic Interval

Except for a few undiagnostic foraminiferal fragments and very few species which may well be all contaminants, nothing is contained in between about 1,000 feet to 7,400 feet of the section penetrated that would permit an assessment of age or environment to be made. Norris suspects "restricted-marine" influences to have been present at the time of deposition of his IVK-2 and IVK-3 zone (Middle Miocene to Lower Pliocene) with terrestrial influences prevailing through the remainder of the section.

ALVEOPHRAGMIUM 154-FAUNA

Starting at about 7,400 feet, a low-diversity foraminiferal fauna appears, continuing to 10,320 feet T.D., and indicating marine influences, however weak. The main faunal components are Haplophragmoides specimens that are closely related or intermediate to species 53 and 67; they are not well enough preserved to identify precisely and seem to be transitional forms. However, the most diagnostic of all species within this interval is Alveophragmium 154 (formerly identified as "Haplophragmoides"), a very large species with complex wall structure. This species was to date found only at Nuktak C-22 as constituent part of the Haplophragmoides 53-Bathysiphon 52-Fauna of Upper Eocene-Oligocene age. At this time it was not used as a zonal indicator for only a few specimens were found. The appearance of this diagnostic species at Ivik in greater abundance and in about the same faunal combination, however, justifies its recognition as a marker species.

The Alveophragmium 154-Haplophragmoides of 53-Bathysiphon 52 assemblage spans the interval from approximately 7,400 feet to 10,320 feet T.D. It corresponds to Norris' IVK-6 zone of Upper Eocene age. Norris considers the section from about 3,000 feet to T.D. to be of terrestrial origin; however, the appearance of the Foraminifera signals the return of marginal marine conditions. This assemblage initiates within the lower portion of the Upper Eocene-Oligocene *Osmundacidites*-1 zone of the alternate interpretation (Cumming) and continues into beds indicated as Middle-Lower Eocene.

Foraminifera with complex and labyrinthic wall structures such as those of the Subfamily Cyclammininae (Cyclammina, Alveophragmium) are sometimes considered indicators of deeper-water and more off-shore conditions. Taking into account the general geologic setting of the Mackenzie Delta region at the time of deposition of these faunas, but foremost the paleontologic and palynologic evidence, the reverse assumption has to be made. The faunas are either monotypic or of low-diversity, lacking completely the variety one would expect of an open-marine assemblage. Also, terrestrial influences seem to be strong in these intervals according to palynological data. It would be more logical to postulate that such low-diversity or monotypic faunas were "pioneering" ones, occupying a particular niche in a marginal marine environment, such as would be the case in a deltaic setting.

The genus Alveophragmium is represented by species in the Arctic waters of the Sea of Japan; it is closely related to Haplophragmoides or even to Cyclammina.

The relationship between the Cyclammina 7-Fauna of Umiak J-37, Pullen E-17, and Taglu C-42, and the Alveophragmium 154-Fauna of Nuktak C-22 and Ivik is not quite clear. In general, they occur in about the same stratigraphic interval and could be considered, therefore, to be facies controlled and equivalent. The possibility, however, that they represent slightly different time intervals within Upper Eocene sequences cannot be ruled out either.