GEOLOGICAL SURVEY OF CANADA
COMMISSION GEOLOGIQUE DU CANADA

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PALYNOLOGICAL DATA FROM THE KASKAPAU, BAD HEART, AND PUSKWASKAU FORMATIONS (SMOKY GROUP: UPPERMOST TURONIAN–UPPER SANTONIAN), SMOKY RIVER, ALBERTA, CANADA

by
K. Núñez-Betelu, C.J. Collom, and L.V. Hills

Geological Survey of Canada (Calgary), 3303 - 33 Street N.W.
Calgary, Alberta T2L 2A7

December 1999

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K. Núñez-Betelu (1), C.J. Collom (2) and L. V. Hills (2)

(1) Dept. of Stratigraphy and Paleontology
University of the Basque Country
P. O. Box 644, 48080 Bilbao, Basque Country

(2) Dept. of Geology and Geophysics
University of Calgary
2500 University Drive N. W.
Calgary, Alberta, Canada
T2N 1N4

Preface

The Geological Survey of Canada involvement in this project began with the recognition by Dave McIntyre that the suite of samples collected by Christopher Collom from the west-central Alberta, Smoky River Section of the Kaskapau through Puskwaskau would provide a valuable palynological resource for comparative purposes. A double set of slides were prepared with one set residing at the Geological Survey of Canada, Calgary and the second to eventually be deposited at the same location. The publication of this Open File Report provides a permanent record of the stratigraphic position of the palynological samples, their relationship with an ammonite based biozonation and, a composite list of dinoflagellates and miospores present in the samples. The section ranges from Turonian to Santonian in age. The presented relative abundances of dinoflagellates out of the total assemblage provides a sense of the transgresive-regressive sequences present in the section.

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ACKNOWLEDGEMENTS

Thanks are given to the University of the Basque Country and the Dept. of Education, Universities and Research of the Basque Government for economic support (K. Núñez-Betelu) and to NSERC (L.V. Hills). C.J.Collom thanks D. McIntyre (Geological Survey of Canada, emeritus) for processing of the palynological slides, and R.L. Hall for NSERC funding of field and laboratory research.

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INTRODUCTION

General Remarks

This document presents palynological data on 26 samples collected from the uppermost Kaskapau (uppermost Turonian–Middle Coniacian), Bad Heart (Upper Coniacian), and Puskwaskau (Santonian) formations. These samples were collected at 3.0 m intervals on the Smoky River (55°33'00"N, 118°11'45"W), west-central Alberta, Canada (Fig. 1). The section here is almost vertical and approximately 150 m high, but complete. Less complete but more easily accessible exposures of the same interval can be found less than 6.0 km to the south, along the banks of the Smoky River, and to the west (Bad Heart River and Kakut Creek). Due to analytical and time constraints, and thermal maturation overprinting (from Cordilleran tectonisms), no samples from the coeval Wapiabi Formation of the Foothills were analyzed for microfossils.

Stratigraphy

As the marine and shoreface stratigraphic units of the Colorado Group and equivalents are laterally extensive, and can be correlated throughout western North America based on their invertebrate fossils, it is possible to list strata in Alberta and eastern British Columbia coeval to those present in the Smoky River region (Figure 2). The Kaskapau Formation at the studied locality is correlative with the Leyland and Sturrock members of the Cardium Formation (*Scaphites preventricosus* Zone) of the Rocky Mountain Foothills,

farther to the south. The upper Kaskapau Formation is correlative with the Muskiki Member of the Wapiabi Formation (*Scaphites ventricosus* Zone) of the NNW-SSE trending Foothills region. The overlying Bad Heart Formation (Smoky Group) is correlative with the Marshybank Member of the Wapiabi Formation (Alberta Group: *Scaphites depressus* Zone) of the Foothills region. The Puskwaskau Formation is correlative to the Dowling, Thistle, and Hanson members of the Wapiabi Formation (*Clioscaphites vermiformis* and *Scaphites novimexicanus* Zones; Collom, in prep.). The contact between the Puskwaskau Fm. and the overlying Wapiti Fm. is not preserved at Smoky River (3-2-76-2W6), due to Quaternary glacial erosion (Figure 3). This lithological contact, however, records the transition from marine mudstones to nonmarine fluvial sandstones and carbonaceous facies. The Wapiti Formation is partly correlative to the Belly River and Brazeau formations in the southern Foothills, based on both palynological (Dawson *et al.*, 1994) and magnetostratigraphic data (Leahy and Lerbekmo, 1995).

Lithology

The Kaskapau and Puskwaskau formations are composed mainly of dark, jarositic marine mudstone (Fig. 2). The lower and upper contacts of the Kaskapau Fm. are sharp, and marked by regionally-correlative chert pebble conglomerate beds less than 20 cm thick (the upper one containing phylosillicate ooids). The lower of these pebble beds is correlative to the Cardinal Mbr., whereas the upper pebble bed represents the Sturrock Mbr. of the Cardium Fm. (southern Foothills), respectively. Unlike their thicker, more proximal, cross-bedded siltstone and sandstone counterparts to the south, these chert pebble "lags" are thought to record more distal, sediment-starved depositional environments.

The contact between the Kaskapau and Bad Heart formations is gradational, marked by a grain-size increase from mudstone to muddy siltstone, to fine, medium and coarse-grained bioturbated sandstone. The top of the Bad Heart Fm. is marked by a thin, discontinuous chert and quartzite pebble/cobble conglomerate. The Puskwaskau Formation is a dark mudstone, but contains a prominent fossiliferous concretionary horizon approximately 40.0 m above the top of the Bad Heart Fm. This is referred to as the "First White Specks" interval, and may readily be correlated to the Thistle Member, Wapiabi Fm. and Medicine Hat Fm. elsewhere in the province of Alberta (Schröder-Adams *et al.*, 1996). The Bad Heart Fm. and First White Specks interval are interpreted to represent regressive episodes (or falls of relative sea level) during the Upper Cretaceous of the Western Interior seaway. Regressive and transgressive facies are separated by surfaces of marine erosion, characterized by coarse-grained clastics with abundant chert pebbles derived from source areas to the west of the seaway and the WCSB.

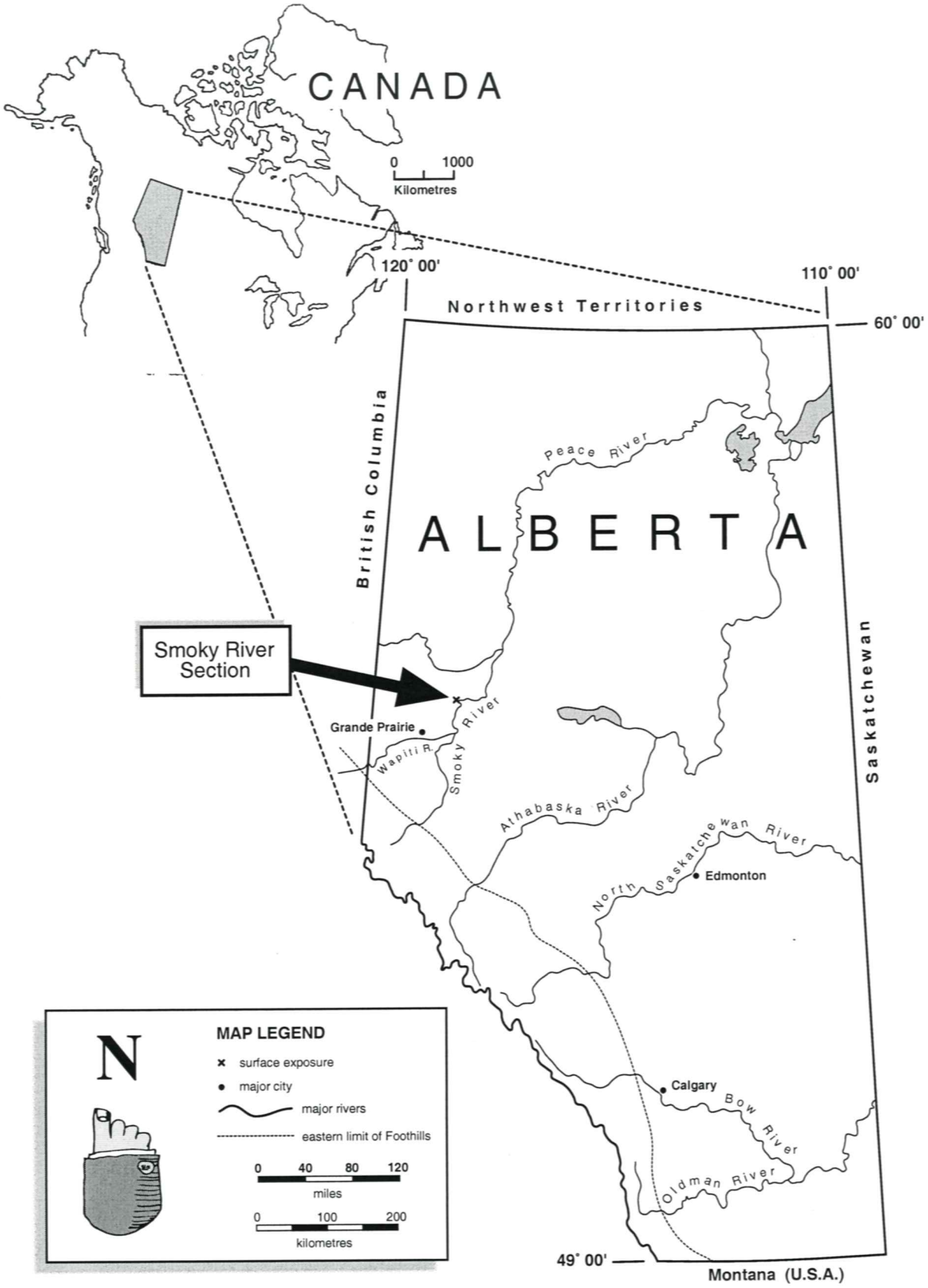

Figure 1. Map of Alberta, indicating location of the Smoky River section.

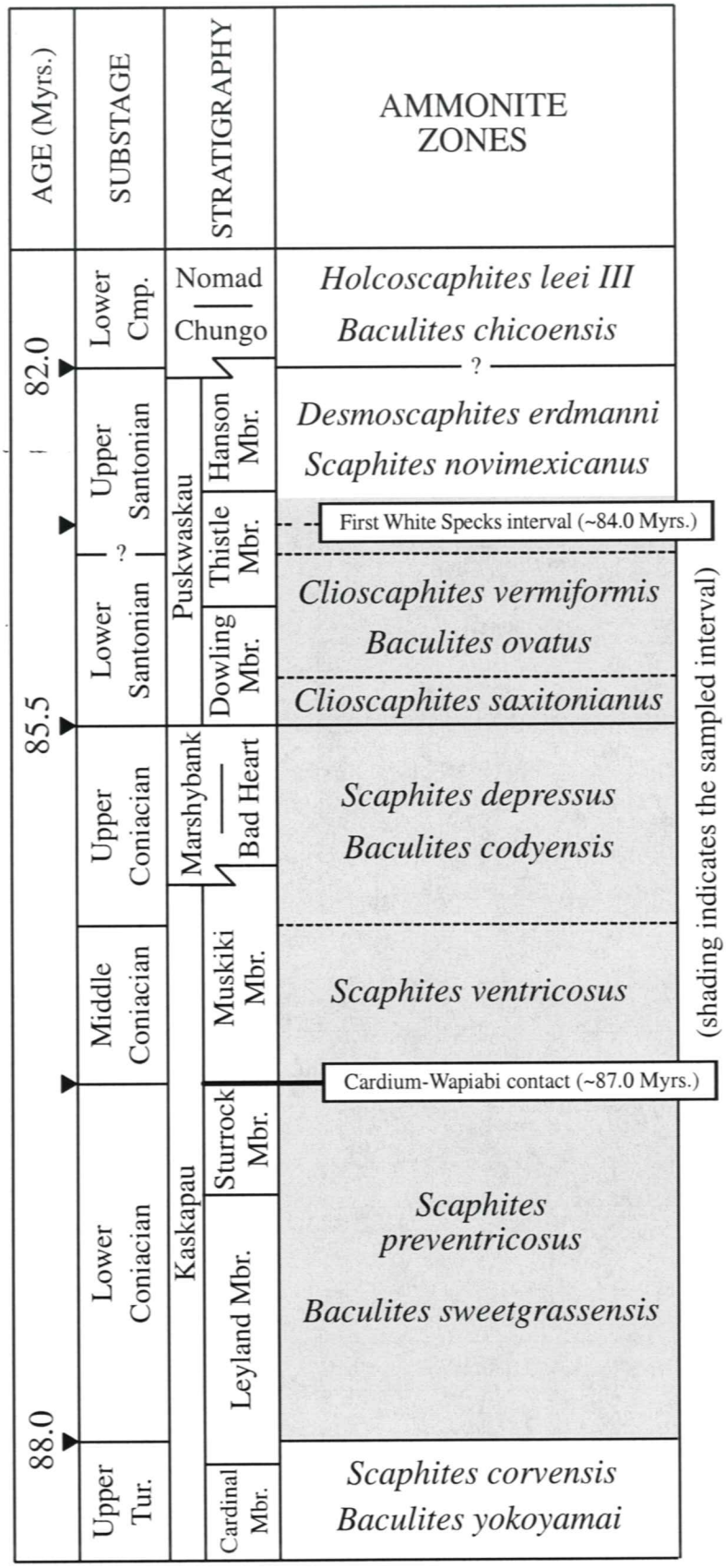

Figure 2. Litho- and biostratigraphic chart of the Cardium and Wapiabi formations.

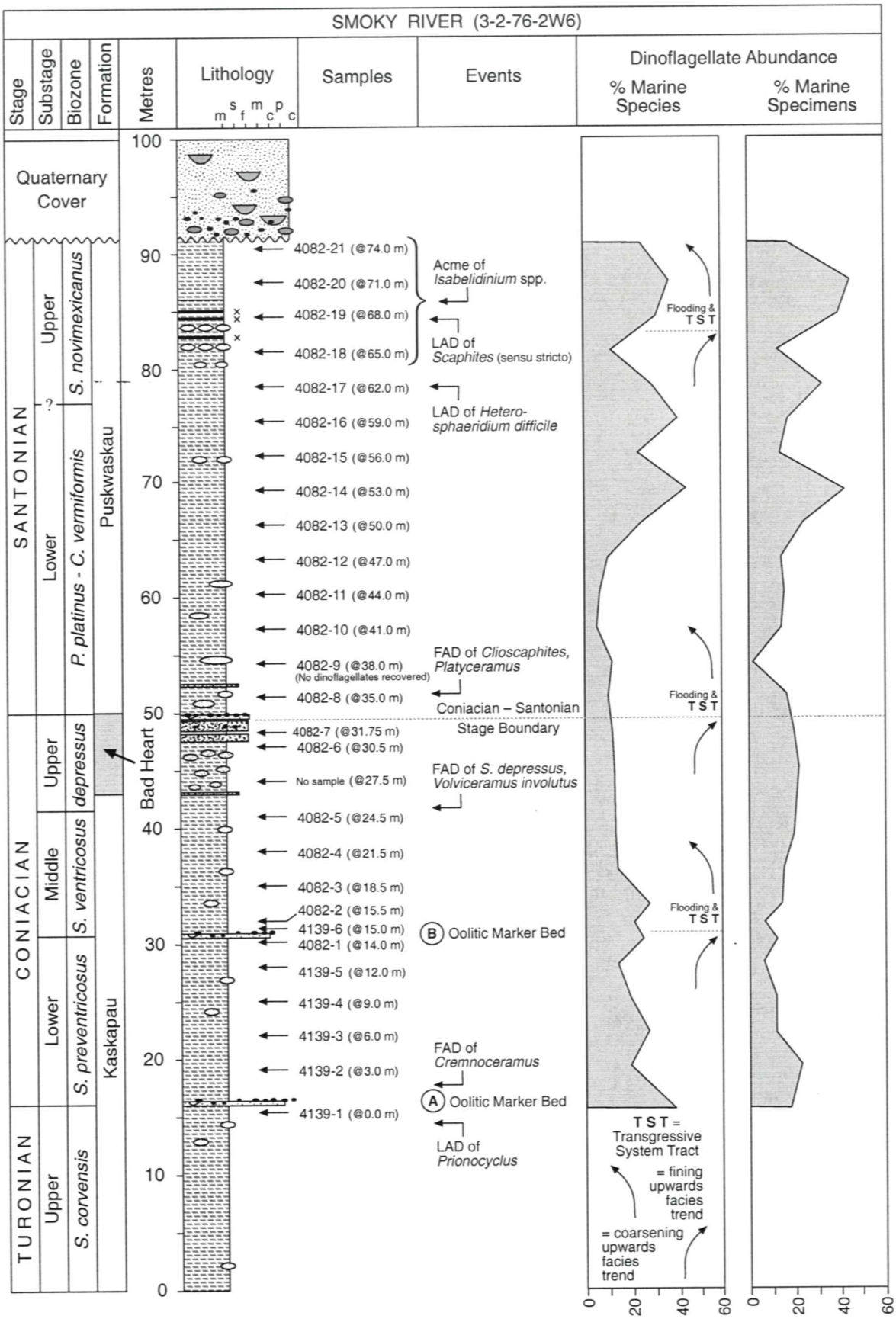

Figure 3. Stratigraphy, sample numbers, and dinoflagellate data of the Smoky River section.

PALYNOLOGICAL ANALYSES

Methodology

The palynological analyses included identification of taxa and counting. A minimum of 400 specimens were counted in every sample to ensure that most taxa present in the samples were included in the statitical analyses. A similar methodology has been previously suggested by Newell (1965), where it is shown that these amounts are sufficient to avoid sampling and research biases. However, due to the richness of the samples, in most of them about 600 specimens were counted to guarantee that rare species were also part of the statistical analyses.

Specimens that were broken, torn, folded, or corroded beyond species-recognition were also counted and recorded in generalized categories that included "dinocysts", "acritarchs", "spores", "pollen", and "bisaccates" but were not credited to the overall species counts. This offers information on the overall composition of the assemblage, such as, the relative abundance of marine versus terrestrial palynomorphs and gives information about the state of preservation in the sample. Since the various groups of palynomorphs react differently to biological and chemical alterations, some palynological groups would be greatly misrepresented if only those taxa that are well preserved are included in the counts. For instance, within the studied material bisaccate pollen grains are the most susceptible to corrosion and damage from the impingement of mineral grains and to thermal maturation whereas dinocysts and miospores appear to be far more resistant. Therefore, if only the well-preserved palynomorphs were counted, the relative proportions would be highly biased against bisaccates.

Results

All 26 samples are very rich in palynomorphs, both marine and terrestrial (Figure 3). These palynomorphs are well preserved, except for reworked Paleozoic spores wich tend to be coalified. Among the marine palynomorphs there are dinoflagellate cysts and acritarchs. The terrestrial forms comprise miospores and pollen grains, including bisaccates. This portion of the study includes identification (see the systematics below) and counting of specimens (Table 1) and species (Table 2). A total of 16,783 palynomorphs were counted (Table 1). Of these, 13,124 (78.20 %) were marine and 3,659 (21.80 %) were terrestrial. This represents and average of 645.5 specimens/sample, including an average of 504.8 marine specimens and 140.7 terrestrial individuals per sample. A total of 129 marine species and 55 terrestrial species were identified (Table 2). The number of species is variable from sample to sample, ranging from 20 to 70 marine species, and from 4 to 17 terrestrial species. In terms of

relative proportions, the percentage of marine species per sample varies between 56.10 % and 97.30 %, with an average of 80.56 % (most samples around 80 %). The perponderence of marine palynomorphs in all 26 samples indicates that the section is principally marine, with minor regressive pulses indicated by increases in terrestrial taxa.

SYSTEMATIC PALYNOLOGY

Because the environment of deposition was exclusively marine, dinocysts and acritarchs species are listed first followed by terrestrial taxa (miospores, pollen, and bisaccates). Marine taxa are arranged following the scheme proposed by Fensome et al. (1993) for dinoflagellates and their cysts, and that by Downie et al. (1963) for acritarchs. The listing includes all known taxonomic categories pertaining to the identified taxa. Terrestrial taxa are listed following Potonié (1956, 1970) and Dettmann (1963). The author citation follows each taxon in the list.

SUBDIVISION DINOKARYOTA Fensome et al. 1993

CLASS DINOPHYCEAE Pascher 1914

SUBCLASS GIMNODINIPHYCIDAE Fensome et al. 1993

ORDER PTYCHODISCALES Fensome et al. 1993

FAMILY PTYCHODISCACEAE Willey and Hickson 1909

SUBFAMILY DINOGYMNIOIDEAE (Sarjeant and Downie 1974) Fensome et al. 1993

Genus *Alysogymnium* Lentin and Vozzhennikova 1990
Alysogymnium euclaense (Cookson and Eisenack 1970) Lentin and Vozzhennikova 1990

Genus *Dinogymnium* Evitt et al. 1967
Dinogymnium acuminatum Evitt et al. 1967
Dinogymnium sibiricum (Vozzhennikova 1967) Lentin and Williams 1973
Dinogymnium westralium (Cookson and Eisenack 1958) Evitt et al. 1967; emend. May 1977

SUBCLASS PERIDINIPHYCIDAE Fensome et al. 1993

ORDER GONYAULACALES Taylor 1980

SUBORDER CLADOPYXIINEAE Fensome et al. 1993

FAMILY CLADOPYXIACEAE Stein 1883

Genus *Microdinium* Cookson and Eisenack 1960a
Microdinium distinctum Davey 1969a
Microdinium ornatum Cookson and Eisenack 1960a

FAMILY PAREODINIACEAE Gocht 1957

SUBFAMILY BROOMEOIDEAE (Eisenack 1969) Fensome et al. 1993

Genus *Batioladinium* Brideaux 1975
Batioladinium jaegeri (Alberti 1961) Brideaux 1975

Genus *Broomea* Cookson and Eisenack, 1958
Broomea sp. 1 McIntyre, 1975

FAMILY UNCERTAIN

Genus *Rhiptocorys* Lejeune-Carpentier and Sarjeant 1983
Rhiptocorys veligera (Deflandre 1937) Lejeune-Carpentier and Sarjeant 1983

SUBORDER GONYAULACINEAE (Autonym)

FAMILY GONYAULACEAE Lindemann 1928

SUBFAMILY LEPTODINIOIDEAE Fensome et al. 1993

Genus *Endoscrinium* (Klement 1960) Vozzhennikova 1967
Endoscrinium campanula Gocht 1959 Vozzhennikova 1967

Genus *Leptodinium* Klement 1960
Leptodinium delicatum (Davey 1969a) Sarjeant in Davey et al. 1969

Genus *Oligosphaeridium* Davey and Williams 1966a
Oligosphaeridium albertense (Pocock 1962) Davey and Williams 1969
Oligosphaeridium complex (White 1842) Davey and Williams 1966b
Oligosphaeridium pulcherrimum (Deflandre and Cookson 1955) Davey and Williams 1966b
Oligosphaeridium totum Brideaux 1971

Genus ?*Stiphrosphaeridium* Davey 1982
?*Stiphrosphaeridium anthophorum* (Cookson and Eisenack 1958) Lentin and Williams 1985

SUBFAMILY CRIBROPERIDINIOIDEAE Fensome et al. 1993

Genus *Apteodinium* Eisenack 1958b
Apteodinium deflandrei (Clarke and Verdier 1967) Lucas-Clark 1987
Apteodinium maculatum grande Eisenack and Cookson 1960

Genus *Cribroperidinium* Neale and Sarjeant 1962
Cribroperidinium edwardsii (Cookson and Eisenack 1958) Davey 1969a

Genus *Cordosphaeridium* Eisenack 1963b
Cordosphaeridium inodes (Klumpp 1953) Eisenack 1963b

Genus *Florentinia* Davey and Verdier 1973
Florentinia cooksoniae (Singh, 1971) Duxbury, 1980
Florentinia mantellii (Davey & Williams 1966b) Davey & Verdier, 1973
Florentinia verdieri Singh 1983

Genus *Hystrichokolpoma* Klumpp 1953
Hystrichokolpoma cf. *rigaudiae* Deflandre and Cookson 1955

Genus *Kallosphaeridium* de Coninck 1969
Kallosphaeridium ringnesiorum (Manum and Cookson 1964) Helby 1987

Genus *Operculodinium* Wall 1967
Operculodinium centrocarpum (Deflandre and Cookson 1955) Wall 1967

Genus *Spongodinium* Deflandre 1936b
Spongodinium delitiense (Ehrenberg 1838) Deflandre 1936b

SUBFAMILY GONYAULACOIDEAE (Autonym)

Genus *Achomosphaera* Evitt 1963
Achomosphaera ramulifera (Deflandre 1937) Evitt 1963

Genus *Hystrichosphaeropsis* Londeix and Jan du Chêne 1988
Hystrichosphaeropsis sp.

Genus *Impagidinium* Stover and Evitt 1978
Impagidinium sp.

Genus *Pterodinium* Eisenack 1958a
Pterodinium aliferum Eisenack 1958a
Pterodinium cingulatum (Wetzel 1933b) Below, 1981

Genus *Spiniferites* Mantell 1850
Spiniferites porosus (Manum and Cookson 1964) Harland 1973
Spiniferites ramosus (Ehrenberg 1838) Mantell 1854
Spiniferites scabrosus (Clarke & Verdier 1967) Lentin & Williams 1975
Spiniferites wetzelii (Deflandre 1937) Sarjeant 1970

SUBFAMILY UNCERTAIN (Family Gonyaulacaceae)

Genus *Cometodinium* Deflandre and Courteville 1939
Cometodinium ? whitei (Deflandre & Courteville 1939) Stover & Evitt 1978

Genus *Coronifera* Cookson and Eisenack 1958
Coronifera oceanica Cookson and Eisenack 1958

Genus ?*Discorsia* Duxbury 1977, emend. Khowaja-Ateequzzaman et al. 1985
?*Discorsia nanna* (Davey 1974) Duxbury 1977, emend. Khowaja-Ateequzzaman et al. 1985

Genus *Escharisphaeridia* Erkmen and Sarjeant 1980
Escharisphaeridia sp.

Genus *Fibrocysta* Stover and Evitt 1978
Fibrocysta sp.

Genus *Hystrichodinium* Deflandre 1935
Hystrichodinium pulchrum Deflandre 1935

Genus *Kiokansium* Stover and Evitt 1978
Kiokansium polypes (Cookson and Eisenack 1962) Below, 1982

Genus *Pervosphaeridium* Yun 1981
Pervosphaeridium cf. *truncatum* (Davey 1969a) Below 1982

Genus *Stephodinium* Deflandre 1936a
Stephodinium cf. *australicum* Cookson and Eisenack 1962

Genus *Surculosphaeridium* Davey et al. 1966
Surculosphaeridium ? longifurcatum (Firtion 1952) Davey et al. 1966

Genus *Trichodinium* Eisenack and Cookson 1960
Trichodinium castanea (Deflandre 1935) Clarke and Verdier 1967

FAMILY AREOLIGERACEAE Evitt 1963

Genus *Adnatosphaeridium* Williams and Downie 1966
Adnatosphaeridium sp.

Genus *Areoligera* Lejeune-Carpentier 1938
Areoligera guembelii Kirsch 1991
Areoligera senonensis Lejeune-Carpentier 1938

Genus *Canningia* Cookson and Eisenack 1960b
Canningia minor Cookson and Eisenack 1960b

Genus *Circulodinium* Alberti 1961
Circulodinium distinctum (Deflandre and Cookson 1955) Jansonius 1986

Genus *Glaphyrocysta* Stover and Evitt 1978
Glaphyrocysta ordinata Stover and Evitt 1978

FAMILY CERATIACEAE Willey and Hickson 1909

Genus *Odontochitina* Deflandre 1935
Odontochitina costata Alberti 1961, emend. Clarke and Verdier 1967
Odontochitina operculata (Wetzel 1933a) Deflandre and Cookson 1955

SUBORDER GONIODOMINAE Fensome et al. 1993

SUBFAMILY PYRODINIOIDEAE Fensome et al 1993

Genus *Dinopterygium* Deflandre 1935
Dinopterygium cladoides Deflandre 1935

Genus *Hystrichosphaeridium* Deflandre 1937
Hystrichosphaeridium tubiferum (Ehrenberg 1838) Deflandre 1937

FAMILY UNCERTAIN (Order Gonyaulacales, Suborder uncertain)

Genus *Caligodinium* Drugg 1970
Caligodinium aceras (Manum & Cookson 1964) Lentin & Williams 1975

Genus *Chlamydophorella* Cookson and Eisenack 1958
Chlamydophorella discreta Clarke and Verdier 1967
Chlamydophorella ? grossa Manum and Cookson 1964
Chlamydophorella nyei Cookson and Eisenack 1958

Genus *Cleistosphaeridium* Davey et al. 1966
Cleistosphaeridium ? aciculare Davey 1969a
Cleistosphaeridium ? multispinosum (Singh 1964) Brideaux 1971

Genus *Dapsilidinium* Bujak et al. 1980
Dapsilidinium marinum Singh 1983

Genus *Desmocysta* Duxbury 1983
Desmocysta sp.

Genus *Dorocysta* Davey 1970
Dorocysta litotes Davey 1970

Genus *Elytrocysta* Stover and Evitt 1978
Elytrocysta druggii Stover and Evitt 1978

Genus *Exochosphaeridium* Davey et al. 1966
Exochosphaeridium bifidum (Clarke and Verdier 1967) Clarke et al. 1968
Exochosphaeridium striolatum (Deflandre 1937) Davey 1969a

Genus *Heterosphaeridium* Cookson and Eisenack 1968
Heterosphaeridium difficile (Manum and Cookson 1964) Ioannides 1986

Genus *Impletosphaeridium* Morgenroth 1966
Impletosphaeridium sp.

Genus *Membranilarnacia* Eisenack 1963a
Membranilarnacia polycladiata Cookson and Eisenack in Eisenack 1963a

Genus *Raphidodinium* Deflandre 1936b
Raphidodinium sp.

Genus *Tanyosphaeridium* Davey and Williams 1966b
Tanyosphaeridium salpinx Norvick in Norvick and Burger 1976

ORDER PERIDINIALES Haeckel 1894

SUBORDER PERIDINIINEAE (Autonym)

FAMILY PERIDINIACEAE Ehrenberg 1831

SUBFAMILY PALAEOPERIDINIOIDEAE (Vozzhennikova 1961) Bujak and Davies 1983

Genus *Ginginodinium* Cookson and Eisenack 1960a
Ginginodinium ornatum (Felix & Burbridge 1973) Lentin & Williams 1976

Genus *Laciniadinium* McIntyre 1975
Laciniadinium arcticum (Manum & Cookson 1964) Lentin & Williams 1980
Laciniadinium biconiculum McIntyre 1975
Laciniadinium williamsii Ioannides 1986

Genus *Luxadinium* Brideaux and McIntyre 1975
Luxadinium primulum Brideaux and McIntyre 1975

Genus *Palaeohystrichophora* Deflandre 1935
Palaeohystrichophora infusorioides Deflandre 1935

Genus *Palaeoperidinium* Deflandre 1934
Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967

Genus *Subtilisphaera* Jain and Millepied 1973
Subtilisphaera foliacea (Eisenack & Cookson 1960) Stover & Evitt 1978
Subtilisphaera pontis-mariae (Deflandre 1936b) Lentin and Williams 1976

SUBFAMILY DEFLANDREOIDEAE Bujak and Davies 1983

Genus *Alterbidinium* Lentin and Williams 1985
Alterbidinium minor (Alberti 1959) Lentin and Williams 1985, emend. Khowaja-Ateequzzaman et al. 1991

Genus *Chatangiella* Vozzhennikova 1967
Chatangiella decorosa (McIntyre 1975) Lentin and Williams 1976
Chatangiella ditissima (McIntyre 1975) Lentin and Williams 1976
Chatangiella granulifera (Manum 1963) Lentin and Williams 1976
Chatangiella spectabilis (Alberti 1959) Lentin and Williams 1976
Chatangiella verrucosa (Manum 1963) Lentin and Williams 1976

Genus *Hexagonifera* Cookson and Eisenack 1961
Hexagonifera sp.

Genus *Isabelidinium* Lentin and Williams 1977
Isabelidinium acuminatum (Cookson & Eisenack 1958) Stover & Evitt 1978
Isabelidinium ? *amphiatum* (McIntyre 1975) Lentin and Williams 1977
Isabelidinium cooksoniae (Alberti 1959) Lentin and Williams 1977

Genus *Spinidinium* Cookson and Eisenack 1962
Spinidinium ? *clavus* Harland 1973
Spinidinium uncinatum May 1980

Genus *Trithyrodinium* Drugg 1967
Trithyrodinium fragile Davey 1969b
Trithyrodinium suspectum (Manum and Cookson 1964) Davey 1969b

FAMILY CONGRUENTIDIACEAE Schiller 1935

SUBFAMILY CONGRUENTIDIOIDEAE (Autonym)

Genus *Phelodinium* Stover and Evitt 1978
Phelodinium cf. *pentagonale* (Corradini 1973) Stover and Evitt 1978

ORDER UNCERTAIN (class Dinophyceae, subclass Peridiniphycidae)

FAMILY UNCERTAIN

Genus *Palaeotetradinium* Deflandre 1936b; emend. Deflandre and Sarjeant 1970; emend. Stover and Evitt. 1978
Palaeotetradinium silicorum Deflandre 1936b; emend. Deflandre & Sarjeant 1970

ORDER UNCERTAIN (class Dinophyceae, subclass uncertain)

FAMILY UNCERTAIN

Genus *Prolixosphaeridium* Davey et al. 1966
Prolixosphaeridium granulosum (Deflandre 1937) Davey et al. 1966

OTHER POSSIBLE DINOCYSTS

The following taxa are listed as dinoflagellate cysts by Lentin and Williams (1993) but not as such by Fensome et al. (1993):

Genus *Bosedinia* He Chengquan 1984
Bosedinia laevigata (Jiabo 1978) He Chengquan 1984

Genus *Fromea* Cookson and Eisenack 1958
Fromea amphora Cookson and Eisenack 1958
Fromea chytra (Drugg 1967) Stover and Evitt 1978
Fromea fragilis Cookson and Eisenack 1962) Stover and Evitt 1978
Fromea glabella (Singh 1971) Lentin and Williams 1981

Genus *Palaeostomocystis* Deflandre 1937
Palaeostomocystis sp.

Genus *Wallodinium* Loeblich Jr. and Loeblich III 1968
Wallodinium anglicum (Cookson & Hughes 1964) Lentin & Williams 1973

Wallodinium luna (Cookson and Eisenack 1960a) Lentin and Williams 1973

GROUP ACRITARCHA Evitt, 1963

SUBGROUP ACANTHOMORPHITAE

Genus *Baltisphaeridium* Eisenack 1958a, emend. Downie and Sarjeant 1963b
Baltisphaeridium sp.

Genus *Micrhystridium* Deflandre, 1937, emend. Lister 1970
Micrhystridium breve Jansonius 1962
Micrhystridium fragile Deflandre 1947
Micrhystridium recurvatum forma *brevispinosa* Valensi 1953
Micrhystridium stellatum Deflandre 1945

SUBGROUP POLYGONOMORPHITAE

Genus *Veryhachium* Deunff 1958; emend. Downie and Sarjeant 1963a; emend. Turner 1984
Veryhachium reductum (Deunff 1958) Downie and Sarjeant 1965
Veryhachium rhomboidium Downie 1959
Veryhachium valiente Cramer 1964

SUBGROUP PTEROMORPHITAE

Genus *Pterospermella* Eisenack 1972
Pterospermella aureolata (Cookson and Eisenack 1958) Eisenack 1972
Pterospermella australiensis (Deflandre and Cookson 1955) Eisenack et al. 1973
Pterospermella hartii (Sarjeant 1960) Eisenack et al. 1973

INCERTAE SEDIS

Genus *Crassosphaera* Cookson and Manum 1960
Crassosphaera papillata Singh 1971

Genus *Leiofusa* Eisenack 1938, emend. Eisenack 1965, emend. Combaz et al. 1967
Leiofusa jurassica Cookson and Eisenack 1958

Genus *Leiosphaeridia* Eisenack 1958a; emend. Downie and Sarjeant 1963a
Leiosphaeridia sp.

Genus *Nummus* Morgan 1975; emend. Backhouse 1988
Nummus monoculatus Morgan 1975

Genus *Palambages* Wetzel, 1961
Palambages morulosa Wetzel, 1961

Genus *Scuticabolus* Loeblich III 1967
Scuticabolus lapidaris (Wetzel, 1933a) Loeblich III 1967

Genus *Tasmanites* Newton 1875
Tasmanites suevicus (Eisenack 1957) Wall 1965

Genus *Wuroia* Stover and Helby 1987
Wuroia sp.

MIOSPORES AND POLLEN

ANTETURMA SPORITES Potonié 1931

TURMA TRILETES Reinsch 1884; emend. Dettmann 1963

SUPRASUBTURMA ACAVATITRILETES Dettmann 1963

SUBTURMA AZONOTRILETES Luber emend. Dettmann 1963

INFRATURMA LAEVIGATI Bennie and Kidston 1886; emend. Potonié 1956

Genus *Cyathidites* Couper 1953
Cyathidites australis Couper 1953
Cyathidites minor Couper 1953

Genus *Deltoidospora* Miner 1935; emend. Potonié 1956
Deltoidospora hallii Miner 1935
Deltoidospora juncta (Kara-Murza) Singh 1964
Deltoidospora psilostoma Rouse 1959

Genus *Dictyophyllidites* Couper 1958; emend. Dettmann 1963
Dictyophyllidites harrisii Couper 1958

Genus *Todisporites* Couper 1958
Todisporites minor Couper 1958

Genus *Stereisporites* Pflug in Thomson and Pflug 1953
Stereisporites antiquasporites (Wilson and Webster 1946) Dettman 1963
Stereisporites regium Drugg 1967

INFRATURMA APICULATI Bennie and Kidston 1886; emend. Potonié 1956

Genus *Baculatisporites* Pflug and Thomson in Thomson and Pflug 1953
Baculatisporites comaumensis (Cookson 1953) Potonié 1956

Genus *Ceratosporites* Cookson and Dettmann 1958
Ceratosporites equalis Cookson and Dettmann 1958

Genus *Concavissimisporites* Delcourt and Sprumont 1955
Concavissimisporites minor (Pocock 1962) Delcourt et al. 1963
Concavissimisporites variverrucatus (Couper 1958) Brenner 1963

Genus *Liburnisporis* Srivastava 1972
Liburnisporis adnacus Srivastava 1972

Genus *Neoristrickia* Potonié 1956
Neoraistrickia truncata (Cookson 1953) Potonié 1956

Genus *Osmundacidites* Couper 1953
Osmundacidites wellmanii Couper 1953

INFRATURMA MURONATI Potonié and Kremp 1955

Genus *Cicatricosisporites* Potonié and Gelletich 1933
Cicatricosisporites australiensis (Cookson 1953) Potonié 1956
Cicatricosisporites aff. *baconicus* Brenner 1963
Cicatricosisporites hallei Delcourt and Sprumont 1955
Cicatricosisporites potomacensis Brenner 1963

Genus *Costatoperforasporites* Deák 1962
Costatoperforasporites foveolatus Deák 1962

Genus *Hamulatisporites* Krutzsch 1959
Hamulatisporites amplus Stanley 1965

Genus *Ischyosporites* Balme 1957
Ischyosporites sp.

Genus Klukisporites Couper 1958
Klukisporites sp.

Genus *Lycopodiumsporites* Thiergart 1938; ex Delcourt and Sprumont 1955
Lycopodiumsporites crassimacerius Hedlund 1966
Lycopodiumsporites marginatus Singh 1964

Genus *Retitriletes* van der Hammen 1956; ex Pierce 1961; emend. Döring 1965
Retitriletes sp.

Genus *Tigrisporites* Klaus 1960; emend. Singh 1971
Tigrisporites reticulatus Singh 1971

Genus *Trilobosporites* Pant 1954
Trilobosporites sp.

SUBTURMA ZONOTRILETES Dettmann 1963

INFRATURMA AURICULATI Schopf et al. 1944; emend. Dettmann 1963

Genus *Appendicisporites* Weyland & Krieger 1953; emend. Burden & Hills 1989
Appendicisporites bilateralis Singh 1971

INFRATURMA TRICRASSATI Dettmann 1963

Genus *Camarozonosporites* Pant 1954 ex Potonié 1956; emend. Klaus 1960
Camarozonosporites insignis Norris 1967

Genus *Gleichniidites* Ross, 1949 ex Delcourt and Sprumont, 1955;
emend. Dettmann 1963
Gleichniidites senonicus Ross 1949

INFRATURMA CINGULATI Potonié and Klaus 1954; emend. Dettmann 1963

Genus *Distaltriangulatisporites* Singh 1971
Distaltriangulatisporites perplexus (Singh 1964) Singh 1971

TURMA MONOLETES Ibrahim 1933

SUPRASUBTURMA ACAVATOMONOLETES Dettmann 1963

SUBTURMA AZONOMONOLETES Dettmann 1963

INFRATURMA LAEVIGATOMONOLETI Dybova and Jachowicz 1957

Genus *Laevigatosporites* Ibrahim 1933; emend. Schopf et al. 1944
Laevigatosporites ovatus Wilson and Webster 1946

GYMNOSPERM POLLEN

ANTETURMA POLLENITES Potonié 1931

TURMA SACCITES Erdtman 1947

SUBTURMA DISACCITES Cookson 1947

INFRATURMA DISACCIASTRILETI Leschik 1955; emend. Potonié 1958

Genus *Abiespollenites* Thiergart 1938; emend. Potonié 1958
Abiespollenites sp.

Genus *Alisporites* (Daugherty 1941) Somers 1968; emend. Potonié 1970
Alisporites bilateralis Rouse 1959
Alisporites cf. *grandis* (Cookson 1953) Dettmann 1963

Genus *Phyllocaldidites* Cookson 1947
Phyllocaldidites sp.

Genus *Pityosporites* Seward 1914
Pityosporites constrictus Singh 1964
Pityosporites verus Seward 1914

Genus *Podocarpidites* Cookson 1947 ex Couper 1953
Podocarpidites rugulosus Cookson 1947

Genus *Pristinuspollenites* Tschudy 1973
Pristinuspollenites microsaccus (Couper 1958) Tschudy 1973

Genus *Vitreisporites* Leschik 1955; emend. Jansonius 1962
Vitreisporites pallidus sp.

SUBTURMA STRIATITES Potonié 1931

Genus *Striatisaccus* Mädler 1964
(S) *Striatisaccus rhaeticus* Mädler 1964

TURMA ALETES Ibrahim 1933

SUBTURMA AZONALETES Potonié and Kremp 1955

INFRATURMA PSILONAPITI Erdtman 1947

Genus *Laricoidites* Potonié et al. 1950 ex Potonié 1958
Laricoidites magnus (Potonié 1931) Potonié et al. 1950

Genus *Taxodiaceaepollenites* Kremp 1949 ex Potonié 1958
Taxodiaceaepollenites hiatus Kremp 1949 ex Potonié 1958

INFRATURMA TUBERINI Potonié 1970

Genus *Sequoiapollenites* Thiergart 1938
Sequoiapollenites pusillus Singh 1983

ADVANCED GYMNOSPERM AND ANGIOSPERM POLLEN

TURMA MONOSULCATES Potonié 1970

Genus *Monosulcites* Cookson 1947 ex Couper 1953
Monosulcites sp.

SUBTURMA MONOCOLPATES Iversen and Troels-Smith 1950

Genus *Cycadopites* Wodehouse 1933
Cycadopites carpentieri (Delcourt and Sprumont 1955) Singh 1964

SUBTURMA TRICOLPATES Potonié 1970

Genus *Retitricolpites* (van der Hammen 1956) Pierce 1961
Retitricolpites maximus Singh 1971

Genus *Tricolpites* Cookson 1947 ex Couper 1953; emend. Belsky et al. 1965
Tricolpites sp.

SUBTURMA TRIPROJECTATITES Mtchedlishvili in Samoilovitch & Mtchedlishvili 1961

Genus *Aquilapollenites* Rouse 1957; emend. Funkhouser 1961
Aquilapollenites formosus Srivastava and Rouse 1970
Aquilapollenites pumilis Srivastava 1969

Genus *Fibulapollis* Khlonova 1961
Fibulapollis sp.

FUNGAL SPORES

Genus *Pluricellaesporites* van der Hammen 1954
Pluricellaesporites psilatus Clarke 1965

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Data on palynological specimens, Smoky River section

Sample No.	Dinoc.	Acrit.	Spores	Pollen	Bisacc.	Total Marine	Total Ter.	Total specimens	% Mar. specimens
1	359	38	87	114	44	397	245	642	61.84
2	441	29	15	87	23	470	125	595	79.00
3	451	27	60	102	21	478	183	661	72.31
4	463	39	29	88	13	502	130	632	79.43
5	592	28	32	59	16	620	107	727	85.28
6	409	85	34	113	30	494	177	671	73.62
7	523	28	36	90	26	551	152	703	78.38
8	346	16	57	58	25	362	140	502	72.11
9	431	18	33	17	9	449	69	518	86.68
10	456	26	38	10	20	482	68	550	87.64
11	381	14	36	6	9	395	51	446	88.57
12	553	26	35	12	21	579	68	647	89.49
13	547	27	17	11	23	574	51	625	91.84
14	577	32	25	38	11	609	74	683	89.17
15	587	23	20	8	15	610	43	653	93.42
16	530	15	24	6	16	545	46	591	92.22
17	564	30	25	10	30	594	65	659	90.14
18	523	31	70	41	83	554	194	748	74.06
19	330	27	76	75	137	357	288	645	55.35
20	493	40	47	85	21	533	157	690	77.25
21	389	32	171	66	52	421	289	710	59.30
22	428	33	96	26	76	461	198	659	69.96
23	566	19	14	14	45	585	73	658	88.91
24	367	29	45	74	66	396	185	581	68.16
25	385	28	111	68	78	413	257	670	61.65
26	683	10	49	103	72	693	224	917	75.57

Summary of previous data (No. of specimens)

	Dinoc.	Acrit.	Spores	Pollen	Bisacc.	Total Marine	Total Ter.	Total Palyn.	% Mar. specimens
Total	12374	750	1282	1381	982	13124	3659	16783	78.20
Mean	476	29	49	53	38	504.8	140.7	645.5	78,51
Med.	460	28	36	59	24	498	135	656	78,69
Max.	683	85	171	114	137	693	289	917	75.58
Min.	330	10	14	6	9	357	43	446	80.04

Table 1. Smoky River Section. Raw Palynological Data (No. of specimens).

Data on palynological species, Smoky River section

Sample No.	Dinoc.	Acrit.	Spores	Pollen	Bisacc.	Total Marine	Total Ter.	Total species	% Mar. species
1	39	8	5	3	3	47	11	58	81.03
2	38	7	9	2	1	45	12	57	78.95
3	44	10	3	3	2	54	8	62	87.10
4	48	12	4	2	1	60	7	67	89.55
5	44	9	2	2	0	53	4	57	92.98
6	28	6	3	2	0	34	5	39	87.18
7	40	8	2	2	0	48	4	52	92.31
8	32	7	5	1	1	39	7	46	84.78
9	40	9	6	2	2	49	10	59	83.05
10	50	11	10	3	2	61	15	76	80.26
11	51	7	13	3	1	58	17	75	77.33
12	52	10	11	2	2	62	15	77	80.52
13	53	11	9	2	2	64	13	77	83.12
14	44	11	5	3	0	55	8	63	97.30
15	44	9	5	3	1	53	9	62	85.48
16	43	4	7	1	1	47	9	56	83.93
17	57	13	8	3	2	70	13	83	84.34
18	37	8	7	5	2	45	14	59	76.27
19	17	3	7	5	3	20	15	35	57.14
20	50	10	6	3	1	60	10	70	85.71
21	23	8	5	2	0	31	7	38	81.58
22	21	2	9	2	0	23	11	34	67.65
23	32	5	2	2	1	37	5	42	88.10
24	16	4	8	3	2	20	13	33	60.60
25	19	4	10	5	3	23	18	41	56.10
26	41	5	6	2	2	46	10	56	82.14

Summary of previous data (No. of species)

	Dinoc.	Acrit.	Spores	Pollen	Bisacc.	Total Marine	Total Ter.	Total Palyn.	% Mar. species
Total	110	19	35	10	10	129	55	184	70.11
Mean	38.58	7.73	6.42	2.62	1.35	46.31	10.81	57.12	80.56
Med.	40.5	8	6	2	1	47.5	10	47.5	83.00
Max.	57	13	13	5	3	70	17	83	83.34
Min.	16	2	2	1	0	20	4	33	60.61

Table 2. Smoky River Section. Raw Palynological Data (No. of species).

PALYNOLOGICAL DATA FROM THE KASKAPAU, BAD HEART, AND PUSKWASKAU FORMATIONS (SMOKY GROUP: UPPERMOST TURONIAN – UPPER SANTONIAN), SMOKY RIVER, ALBERTA, CANADA

K. Núñez-Betelu, C.J. Collom, and L. V. Hills

Table 3

Field Number	Metres above Base	Lab Prep Number	GSC Locality No.
26	74.0 m	4082-21	C–401283
25	71.0	4082-20	C–401282
24	68.0	4082-19	C–401281
23	65.0	4082-18	C–401280
22	62.0	4082-17	C–401279
21	59.0	4082-16	C–401278
20	56.0	4082-15	C–401277
19	53.0	4082-14	C–401276
18	50.0	4082-13	C–401275
17	47.0	4082-12	C–401274
16	44.0	4082-11	C–401273
15	41.0	4082-10	C–401272
14	38.0	4082-9	C–401271
13	35.0	4082-8	C–401270
12	31.75	4082-7	C–401269
11	30.5	4082-6	C–401268
10	24.5	4082-5	C–401267
9	21.5	4082-4	C–401266
8	18.5	4082-3	C–401265
7	15.5	4082-2	C–401264
6	15.0	4139-6	C–401263
5A	14.0	4082-1	C–401262
5	12.0	4139-5	C–401261
4	9.0	4139-4	C–401260
3	6.0	4139-3	C–401259
2	3.0	4139-2	C–401258
1	0.0	4139-1	C–401257

Plate 1

Dinoflagellates of the Smoky Group, Alberta
Smoky River (near JW58-3)

All Figures are Nomarski Interference Contrast Photographs

Figure 1. *Discorsia nanna* (Davey) – TMP 97.102.6 (x200); upper Kaskapau Formation (P4139-1: C-401257; GSC 116985).

Figure 2. *Broomea* sp. 1 (of McIntyre, 1974) – TMP 97.102.16 (x200); upper Kaskapau Formation (P4139-3: C-401259; GSC 116986).

Figure 3. *Dapsilidinium marinum* Singh – TMP 97.102.15 (x200); upper Kaskapau Formation (P4139-3: C-401259; GSC 116987).

Figure 4. *Pterospermella hartii* (Sarjeant) – TMP 97.102.25 (x200); upper Kaskapau Formation (P4139-4: C-401260; GSC 116988).

Figure 5. *Coronifera striolata* (Deflandre) – TMP 97.102.27 (x200); upper Kaskapau Formation (P4139-5: C-401261; GSC 116989).

Figure 6. *Hystrichosphaeropsis* sp. – TMP 97.102.37 (x200); upper Kaskapau Formation (P4139-6: C-401263; GSC 116990).

Figure 7. *Hystrichokolpoma* cf. *rigaudiae* Deflandre & Cookson– TMP 97.102.42 (x200); upper Kaskapau Formation (P4082-2: C-401264; GSC 116991).

Figure 8. *Laciniadinium arcticum* (Manum & Cookson) – TMP 97.102.52 (x200); upper Kaskapau Formation (P4082-4: C-401266; GSC 116992).

Figure 9. *Diatomozonotriletes saetosus* (Hacquebard & Barss) – TMP 97.102.55 (x200); upper Kaskapau Formation (P4082-5: C-401267; GSC 116993), reworked Lower Carboniferous spore.

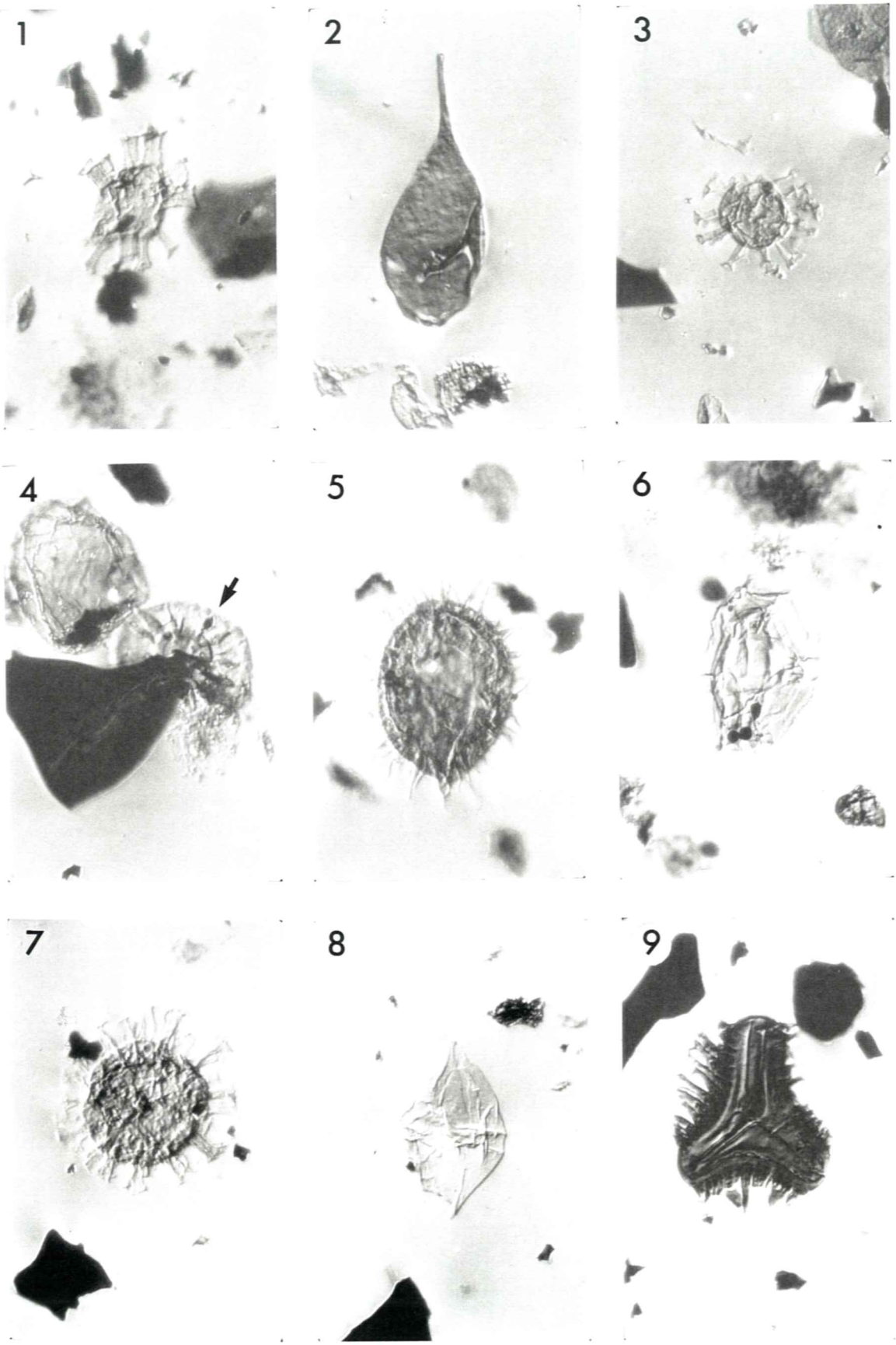
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Plate 2

Dinoflagellates of the Smoky Group, Alberta
Smoky River (near JW58-3)

All Figures are Nomarski Interference Contrast Photographs

Figure 1. *Palaeotetradinium silicorum* Deflandre – TMP 97.102.72 (x400); Bad Heart Formation (P4082-6: C-401268; GSC 116994).

Figure 2. *Alisogymnium euclaense* (Cookson & Eisenack) – TMP 97.102.58 (x400); Bad Heart Formation (P4082-6: C-401268; GSC 116995).

Figure 3. Densospore – TMP 97.102.71 (x200); Bad Heart Formation (P4082-6: C-401268; GSC 116996), reworked Paleozoic spore.

Figure 4. *Dinogymnium* cf. *sibiricum* (Vozzhennikova) – TMP 97.102.89 (x200); Bad Heart Formation (P4082-7: C-401269; GSC 116997).

Figure 5. *Exochosphaeridium* sp. [of Davey *et al.*, 1966] – TMP 97.102.86 (x200); Bad Heart Formation (P4082-7: C-401269; GSC 116998).

Figure 6. *Odontochitina costata* Alberti – TMP 97.102.107 (x200); basal Puskwaskau Formation (P4082-8: C-401270; GSC 116999).

Figure 7. *Exochosphaeridium striolatum* (Deflandre) – TMP 97.102.98 (x200); basal Puskwaskau Formation (P4082-8: C-401270; GSC 117000).

Figure 8. *Coronifera oceanica* Cookson & Eisenack – TMP 97.102.108 (x200); basal Puskwaskau Formation (P4082-8: C-401270; GSC 117001).

Figure 9. *Glaphyrocysta ordinata* Williams & Downie – TMP 97.102.118 (x200); Puskwaskau Formation (P4082-10: C-401272; GSC 117002).

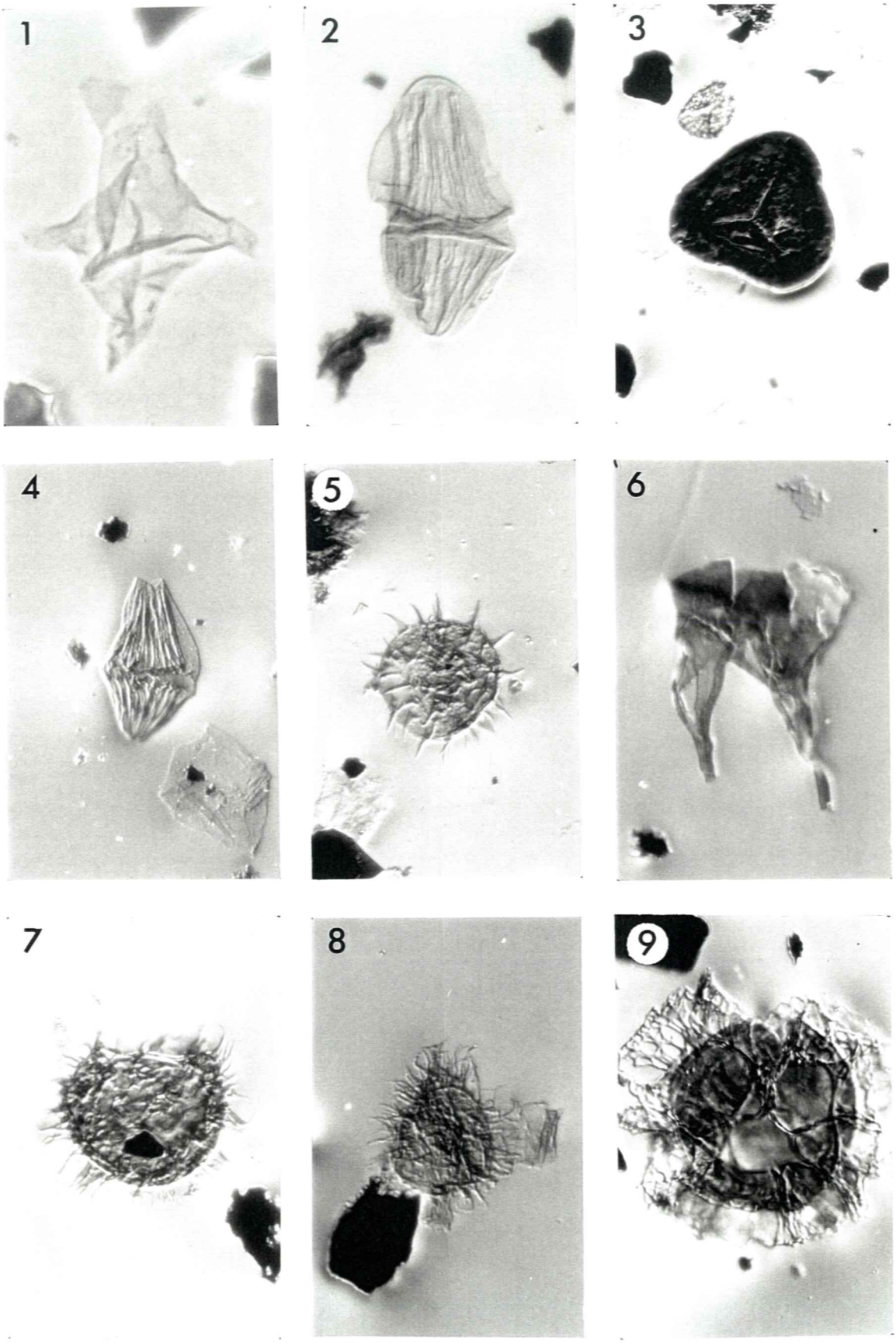
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Plate 3

Dinoflagellates of the Smoky Group, Alberta
Smoky River (near JW58-3)

All Figures are Nomarski Interference Contrast Photographs

Figure 1. *Dinogymnium sibiricum* (Vozzhennikova) – TMP 97.102.111 (x200); Puskwaskau Formation (P4082-10: C-401272; GSC 117003).

Figure 2. *Oligosphaeridium totum* Brideaux – TMP 97.102.117 (x200); Puskwaskau Formation (P4082-10: C-401272; GSC 117004).

Figure 3. *Dinogymnium acuminatum* Evitt *et al.* – TMP 97.102.136 (x200); Puskwaskau Formation (P4082-12: C-401274; GSC 117005).

Figure 4. *Dinogymnium* cf. *westralium* (Cookson & Eisenack) – TMP 97. 102.146 (x200); Puskwaskau Formation (P4082-14: C-401276; GSC 117006).

Figure 5. *Ischyosporites* cf. *disjunctus* Balme – TMP 97.102.148 (x200); Puskwaskau Formation (P4082-14: C-401276; GSC 117007).

Figure 6. *Crassosphaera papillata* Singh – TMP 97.102.152 (x200); Puskwaskau Formation (P4082-18: C-401280; GSC 117008).

Figure 7. *Concavissimisporites minor* (Pocock) – TMP 97.102.153 (x200); Puskwaskau Formation (P4082-19: C-401281; GSC 117009).

Figure 8. *Striatisaccus rhaeticus?* Maedler – TMP 97.102.155 (x200); Puskwaskau Formation (P4082-20: C-401282; GSC 117010), striate bissacate.

Figure 9. *Ginginodinium ornatum* (Felix & Burbridge) – TMP 97.102.157 (x200); Puskwaskau Formation (P4082-21: C-401283; GSC 117011).


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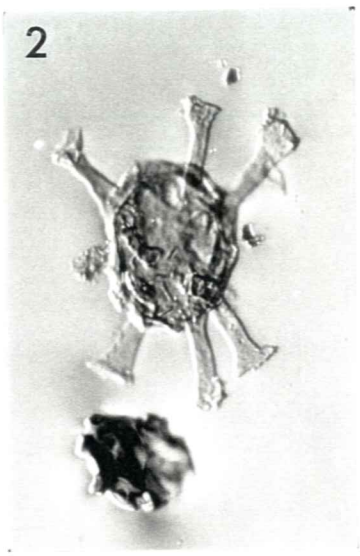
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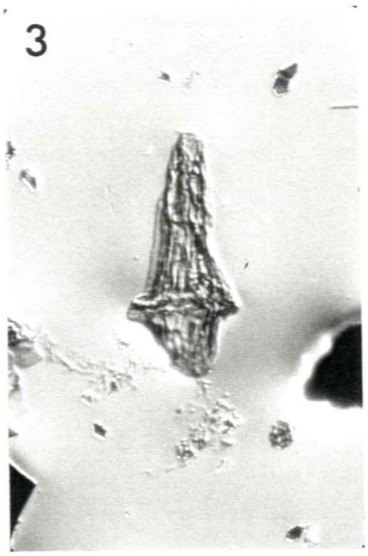
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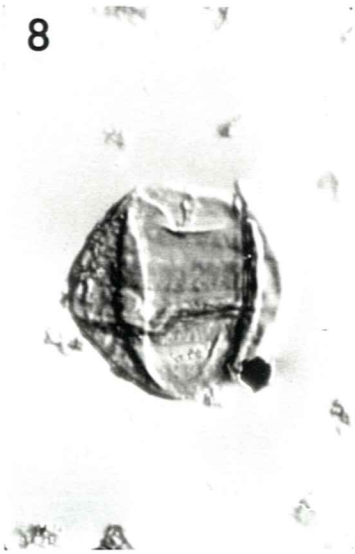
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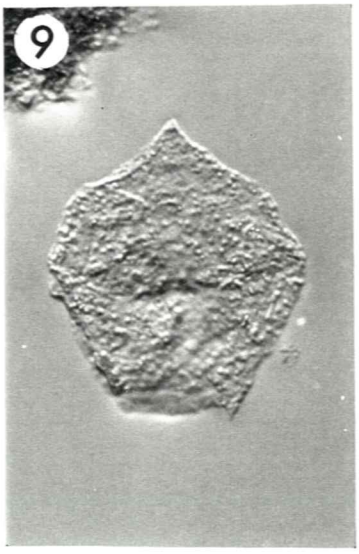
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