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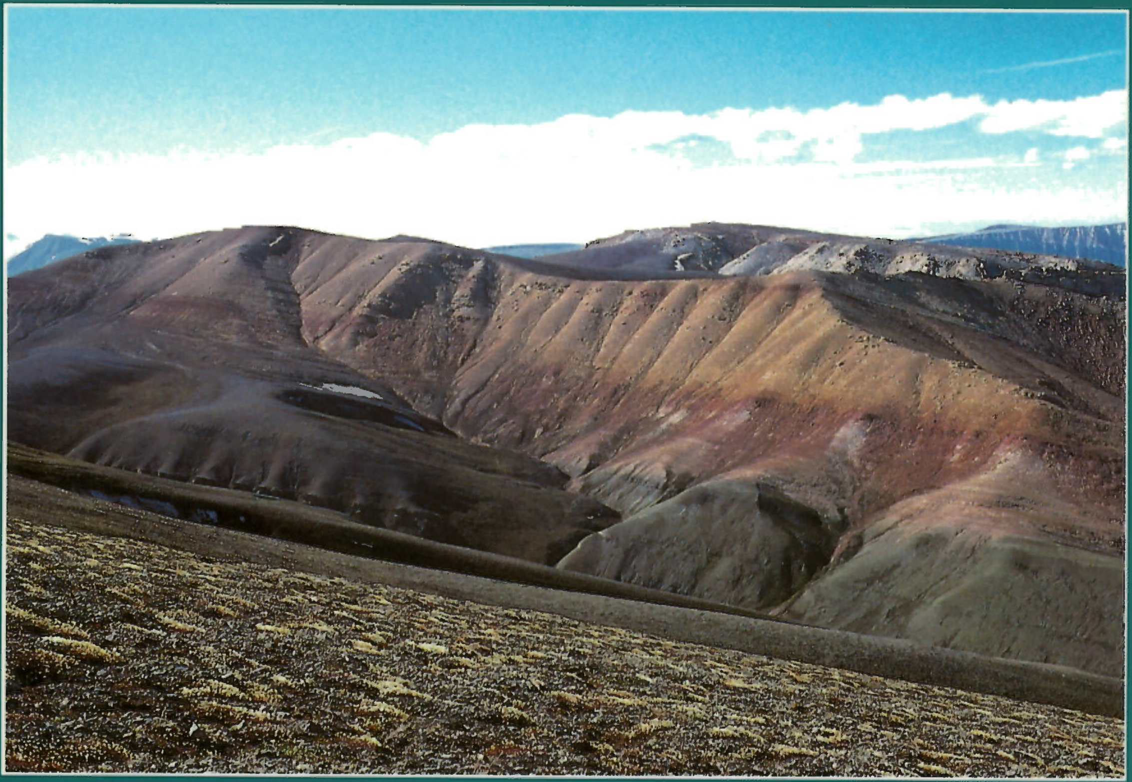
PALYNOSTRATIGRAPHY OF PERMIAN AND LOWER TRIASSIC ROCKS, SVERDRUP BASIN, CANADIAN ARCTIC ARCHIPELAGO

J. Utting



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Cover Illustration

Permian/Triassic contact, Hamilton Peninsula, Ellesmere Island. Upper Permian Trold Fiord Formation (green-grey) overlain by Lower Triassic Blind Fiord Formation (red-brown) and Bjorne Formation (buff).

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PREFACE

Permian and Lower Triassic rocks of the Sverdrup Basin, Canadian Arctic Archipelago have considerable potential as a source of mineral, and oil and gas deposits. As active exploration in that area increases, the palynological zonation presented in this bulletin will enable accurate and precise surface and subsurface biostratigraphic correlations to be made.

The detailed study (including taxonomic descriptions) of pollen and spores from numerous sections has resulted in the establishment of a biostratigraphic zonation for the Permian and Lower Triassic of the Sverdrup Basin. This zonation can be applied to marine and nonmarine facies and to intervals where macrofossils are lacking. Palynostratigraphic correlation is now possible with other circumpolar areas of the world including Western Canada, Alaska, Greenland, Svalbard, Bjørnøya, the Pechora Basin of Russia, and the Northern Russian Platform. Studies of this nature are essential for the calibration of a regional geological time scale, which is necessary for precise dating and correlation. In addition, the study provides data for this part of Canada on the floral province, paleoenvironments and paleoclimates in the Permian and Early Triassic.

E.A. Babcock
Assistant Deputy Minister
Geological Survey of Canada

PRÉFACE

Les roches du Permien et du Trias inférieur du bassin de Sverdrup, dans l'archipel Arctique canadien, ont un potentiel considérable en tant que source de minéraux et de gisements de pétrole et de gaz. À mesure que s'intensifiera l'activité d'exploration dans ce secteur, la zonation palynologique décrite dans le présent bulletin permettra d'établir des corrélations biostratigraphiques exactes et précises tant en surface qu'en subsurface.

L'étude détaillée (comprenant des descriptions taxonomiques) des pollens et des spores de nombreuses coupes a permis de définir une zonation biostratigraphique du Permien et du Trias inférieur dans le bassin de Sverdrup. Cette zonation peut s'appliquer aux faciès marins et non marins de même qu'aux intervalles dépourvus de macrofossiles. Il est maintenant possible d'établir une corrélation palynostratigraphique avec d'autres régions circumpolaires du monde, notamment l'Ouest canadien, l'Alaska, le Groenland, le Svalbard, la Bjørnøya, le bassin de la Pechora (en Russie) et la plate-forme russe septentrionale. Des études de ce type sont essentielles à l'établissement d'une échelle chronostratigraphique régionale, un outil indispensable pour obtenir des datations et des corrélations précises. Le présent bulletin constitue en outre une source de données sur la province floristique, les paléoenvironnements et les paléoclimats du Permien et du Trias précoce dans cette partie du Canada.

E.A. Babcock
Sous-Ministre adjount
Commission géologique du Canada

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Abstract

Nine outcrop sections of Permian and Lower Triassic rocks were studied in the basin-margin and basin-centre facies of the Sverdrup Basin. Abundant, well preserved palynomorphs occur in samples from many basin-margin facies. Palynomorph assemblages in samples from deeper marine basin-centre sediments generally lack diversity of taxa and are poorly preserved.

Two palynomorph zones have been established in the Permian (Roadian and Wordian) and one in the Lower Triassic (Griesbachian). Comparison of taxa in the zones shows some zones have many genera in common, although some genera are restricted. There is almost a complete change of species between the Permian and Triassic. This, and major quantitative differences, suggest a significant hiatus between the Permian and Triassic, and probable climatic differences.

Permian and Lower Triassic palynological assemblages of the Sverdrup Basin may be assigned to the Subangaran floral province. However, comparison of the Wordian assemblages of the Sverdrup Basin with those from the Kazanian stratotype west of the Urals indicates marked differences. This may be due to different paleoclimates and environments of deposition, incorrect stratigraphic correlations, or a combination of several factors.

Thirty-nine miospore species are newly described: ***Ahrensisporites multifloridus, A. thorsteinssonii, Apiculatisporis melvillensis, Cladaitina kolodae, Convolutispora arctica, C. perplexa, Corisaccites stradivarii, Crinalites sabinensis, Cyclogranisporites franklinii, Diatomozonotriletes hypenetes, D. igluanus, Dictyotriletes bamberi, Dyupetalum vesicatum, Gondisporites nassichukii, Gordonispora obstaculifera, Grandispora jansonii, Granulatisporites munitus, Hamiapollenites erebi, Jugasporites compactus, Kraeuselisporites sverdrupensis, Leiotriletes ulutus, Lophotriletes parryensis, Lunatisporites arluki, L. beauchampii, Neoraistrickia caudicea, N. delicata, Pallidosporites multiradiatus, Piceapollenites nookapii, Protohaploxypinus kayaki, P. panaki, Raistrickia enervata, Scutasporites nanuki, Striatoabieites borealis, Striatopodocarpites circulus, Sverdrupollenites agluatus, S. connudatus, Verrucosisporites christiei, Vittatina heclae,*** *and* ***Weylandites segmentatus****. Two new genera,* ***Crinalites*** *and* ***Sverdrupollenites****, are described. Descriptions are given of all Permian pollen and spore taxa found. Seven new combinations are made for Permian and Triassic taxa (****Cordaitina vulgaris, Pakhapites rotundus, Weylandites cincinnatus, W. striatus, Lunatisporites albertae, Simeonospora minuta*** *and* ***Uvaesporites imperialis****).*

Résumé

Neuf affleurements de roches du Permien et du Trias inférieur ont été étudiés dans les faciès de la marge et du centre du bassin de Sverdrup. Des palynomorphes bien conservés et abondants ont été identifiés dans des échantillons provenant de nombreux faciès de marge de bassin. Les associations de palynomorphes observées dans les échantillons de sédiments de milieu marin plus profond (centre du bassin) se caractérisent généralement par une absence de diversité des taxons et sont mal conservées.

On a établi deux zones de palynomorphes dans le Permien (Roadien et Wordien) et une dans le Trias inférieur (Griesbachien). La comparaison des taxons présents dans ces zones montre que certaines d'entre elles ont de nombreux genres en commun, mais que certains genres ont une distribution restreinte. On observe un changement presque total des espèces entre le Permien et le Trias. Ces faits, conjugués à d'autres différences majeures d'ordre quantitatif, suggèrent un hiatus majeur entre le Permien et le Trias, mais peut-être aussi des climats qui n'étaient pas les mêmes.

On peut placer les associations palynologiques du Permien et du Trias inférieur du bassin de Sverdrup dans la province floristique subangarienne. Toutefois, une comparaison des associations du Wordien observées dans le bassin de Sverdrup avec celles du stratotype du Kazanien à l'ouest des monts Oural indique des différences marquées. La raison en est peut-être des différences dans les paléoclimats et les milieux de sédimentation, des corrélations stratigraphiques incorrectes, ou une combinaison de plusieurs facteurs.

Trente-neuf espèces de miospores ont été nouvellement décrites : ***Ahrensisporites multifloridus, A. thorsteinssonii, Apiculatisporis melvillensis, Cladaitina kolodae, Convolutispora arctica, C. perplexa, Corisaccites stradivarii, Crinalites sabinensis, Cyclogranisporites franklinii, Diatomozonotriletes hypenetes, D. igluanus, Dictyotriletes bamberi, Dyupetalum vesicatum, Gondisporites nassichukii, Gordonispora obstaculifera, Grandispora jansonii, Granulatisporites munitus, Hamiapollenites erebi, Jugasporites compactus, Kraeuselisporites sverdrupensis, Leiotriletes ulutus, Lophotriletes parryensis, Lunatisporites arluki, L. beauchampii, Neoraistrickia caudicea, N. delicata, Pallidosporites multiradiatus, Piceapollenites nookapii, Protohaploxypinus kayaki, P. panaki, Raistrickia enervata, Scutasporites nanuki, Striatoabieites borealis, Striatopodocarpites circulus, Sverdrupollenites agluatus, S. connudatus, Verrucosisporites christiei, Vittatina heclae*** *et* ***Weylandites segmentatus****. Deux nouveaux genres,* ***Crinalites*** *et* ***Sverdrupollenites,*** *font l'objet d'une description, tout comme tous les taxons de pollens et de spores du Permien qui ont été identifiés. Sept nouvelles combinaisons sont établies pour les taxons du Permien et du Trias (****Cordaitina vulgaris, Pakhapites rotundus, Weylandites cincinnatus, W. striatus, Lunatisporites albertae, Simeonospora minuta*** *et* ***Uvaesporites imperialis****).*

Summary

The aim of this project was to establish a palynological zonation for correlating Permian and Lower Triassic strata within the Sverdrup Basin of the Canadian Arctic Archipelago. No previous detailed palynological study of Permian and Lower Triassic rocks has been carried out. Nine outcrop sections were sampled, including the type sections of six formations. Material was collected from both shallow and deep basinal facies in order to make palynological correlations across lithofacies boundaries.

Abundant, diverse, well preserved palynomorph assemblages with low thermal maturity occur in samples from many basin-margin facies. However, in samples from deeper marine, basin-centre sediments, assemblages generally lack diversity of taxa, and specimens are poorly preserved due to high thermal maturity and corrosion by the growth of sulphide crystals on the spore and pollen exines.

Two palynomorph zones have been established in the Permian (*Alisporites plicatus–Jugasporites compactus* Concurrent Range Zone and *Ahrensisporites thorsteinssonii–Scutasporites nanuki* Concurrent Range Zone), and one in the Early Triassic (*Tympanicysta stoschiana–Striatoabieites richteri* Assemblage Zone). The ages of the three zones are based largely on data published by previous workers concerning marine macro- and microfaunal groups, especially ammonoids, brachiopods, and conodonts. Ages are given in terms of North American stages (Roadian, Wordian and Griesbachian), and correlations with the Russian Permian stratotypes (Ufimian and Kazanian) are tentative. The *Alisporites plicatus–Jugasporites compactus* Concurrent Range Zone is Roadian (Ufimian?), the *Ahrensisporites thorsteinssonii–Scutasporites nanuki* Concurrent Range Zone is Wordian (Kazanian?), and the *Tympanicysta stoschiana–Striatoabieites richteri* Assemblage Zone is Griesbachian.

Comparison of the Upper Permian *Ahrensisporites thorsteinssonii–Scutasporites nanuki* Concurrent Range Zone with the Early Triassic *Tympanicysta stoschiana–Striatoabieites richteri* Assemblage Zone indicates that many genera are common to both zones, although a significant number are restricted in occurrence. For example, *Weylandites*, *Vittatina* and *Scutasporites* are

present in the former, but not in the latter. Conversely *Uvaesporites*, *Tympanicysta stoschiana* and *Ephedripites* are present in the Griesbachian zone, but not in the Permian zones. In addition, there is virtually a complete change of species between the Permian and the Triassic. These differences along with major quantitative differences in the palynological record suggest both a significant hiatus between the Wordian and Griesbachian and probable climatic differences.

Sequence stratigraphy indicates the possibility of younger Permian (Wordian or post-Wordian) chert and cherty shale beds in the basin centre, but these contain long-ranging taxa and species similar to those found in the *Ahrensisporites thorsteinssonii–Scutasporites nanuki* Concurrent Range Zone. Until more is known about Capitanian and Tatarian assemblages of Subangara, it is not possible to rule out a post-Wordian, but pre-Griesbachian age, for this material.

Diversity of assemblages in the Roadian suggests relatively humid climate, but an increase in the proportion of disaccates in some Wordian beds, may indicate drier periods. In basal beds of the Blind Fiord Formation of Early Triassic age, abundance of a single species of trilete spores may indicate the development of coastal marsh conditions at the beginning of the Triassic transgression, most Lower Triassic samples lack assemblage diversity and the climate may have been arid.

Palynostratigraphic correlations are now possible with Permian and Lower Triassic assemblages in other parts of the world. This is especially true of present day circumpolar areas, which were in the Subangaran floral province, such as Alberta and British Columbia of western Canada, Alaska, Greenland, Svalbard, Bjørnøya, the Barents Sea, the Pechora Basin, and the Northern Russian Platform. However, comparison of the Wordian assemblages of the Sverdrup Basin with those from the Kazanian stratotype located west of the Urals in Russia indicates marked qualitative and quantitative differences, which may be due to different paleoclimate, environment of deposition, facies, floral province, or even incorrect stratigraphic correlation. The differences may also be the result of a combination of several of these factors. Comparison with other, more distant, Subangaran parts of the world indicates similarities with assemblages from the northwestern part of the People's Republic of China (Xinjiang). However, Cathaysian assemblages from north and south China are very different, as are those from the Zechstein of Western Europe (Euramerica). There are a number of similarities at the generic level between the Sverdrup Basin material and assemblages from parts of Gondwana, but there are marked differences at the specific level.

Thirty-nine miospore species are newly described: *Ahrensisporites multifloridus, A. thorsteinssonii, Apiculatisporis melvillensis, Cladaitina kolodae, Convolutispora arctica, C. perplexa, Corisaccites stradivarii, Crinalites sabinensis, Cyclogranisporites franklinii, Diatomozonotriletes hypenetes, D. igluanus, Dictyotriletes bamberi, Dyupetalum vesicatum, Gondisporites nassichukii, Gordonispora obstaculifera, Grandispora jansonii, Granulatisporites munitus, Hamiapollenites erebi, Jugasporites compactus, Kraeuselisporites sverdrupensis, Leiotriletes ulutus, Lophotriletes parryensis, Lunatisporites arluki, L. beauchampii, Neoraistrickia caudicea, N. delicata, Pallidosporites multiradiatus, Piceapollenites nookapii, Protohaploxypinus kayaki, P. panaki, Raistrickia enervata, Scutasporites nanuki, Striatoabieites borealis, Striatopodocarpites circulus, Sverdrupollenites agluatus, S. connudatus, Verrucosisporites christiei, Vittatina heclae,* and *Weylandites segmentatus.* Two new genera *Crinalites* and *Sverdrupollenites* are described. Descriptions are given of all Permian pollen and spore taxa found. Seven new combinations are made for Permian and Triassic taxa (*Cordaitina vulgaris, Pakhapites rotundus, Weylandites cincinnatus, W. striatus, Lunatisporites albertae, Simeonospora minuta* and *Uvaesporites imperialis).*

Sommaire

Le but du présent projet était l'établissement d'une zonation palynologique permettant de corréler les strates du Permien et du Trias inférieur du bassin de Sverdrup dans l'archipel Arctique canadien. Aucune étude palynologique détaillée des roches du Permien et du Trias inférieur n'avait été faite auparavant. Neuf affleurements ont été échantillonnés, dont notamment les coupes types de six formations. Du matériel a été recueilli dans des faciès de bassins profonds et peu profonds, afin d'en arriver à des corrélations palynologiques de part et d'autre des limites des lithofaciès.

Il existe des associations de palynomorphes abondants, variés et bien conservés présentant une faible maturité thermique dans des échantillons qui proviennent de nombreux faciès de marge de bassin. Toutefois, dans les échantillons de sédiments de milieu marin plus profond (centre du bassin), les associations sont généralement caractérisées par une absence de diversité des taxons; de plus, les spécimens sont mal conservés en raison du degré élevé de maturité thermique et de la corrosion causée par la croissance de cristaux de sulfures sur les spores et les exines de pollen.

On a établi deux zones de palynomorphes dans le Permien (zone d'extension concomitante à *Alisporites plicatus–Jugasporites compactus* et zone d'extension concomitante à *Ahrensisporites thorsteinssonii–Scutasporites nanuki*) et une dans le Trias précoce (cénozone à *Tympanicysta stoschiana–Striatoabieites richteri*). Les âges des trois zones ont été assignés en grande partie en se basant sur des données publiées auparavant à propos de groupes de la macrofaune et de la microfaune marines, notamment les ammonoïdés, les brachiopodes et les conodontes. Les âges sont indiqués selon les étages nord-américains (Roadien, Wordien et Griesbachien) et les corrélations avec les stratotypes du Permien de Russie (Ufimien et Kazanien) sont provisoires. La zone d'extension concomitante à *Alisporites plicatus–Jugasporites compactus* est du Roadien (Ufimien?), celle à *Ahrensisporites thorsteinssonii–Scutasporites nanuki* est du Wordien (Kazanien?) et la cénozone à *Tympanicysta stoschiana–Striatoabieites richteri* est du Griesbachien.

La comparaison entre la zone d'extension concomitante à *Ahrensisporites thorsteinssonii–Scutasporites nanuki* du Permien supérieur et la cénozone à *Tympanicysta stoschiana–Striatoabieites richteri* du Trias précoce indique que de nombreux genres sont communs aux deux zones, bien qu'un nombre significatif d'entre eux aient une distribution restreinte. Par exemple, *Weylandites*, *Vittatina* et *Scutasporites* s'observent dans la première zone, mais pas dans la seconde. Inversement, *Uvaesporites*, *Tympanicysta stoschiana* et *Ephedripites* existent dans la zone du Griesbachien, mais pas dans les zones du Permien. En outre, on note un changement pratiquement complet des espèces entre le Permien et le Trias. Ces faits, conjugués à d'autres différences majeures d'ordre quantitatif, suggèrent un hiatus notable entre le Wordien et le Griesbachien, mais peut-être aussi des climats qui n'étaient pas les mêmes.

La stratigraphie séquentielle indique la possibilité de l'existence de couches de chert et de shale cherteux du Permien plus récent (du Wordien ou postérieures au Wordien) au centre du bassin, lesquelles contiennent des taxons et des espèces de longue durée semblables à ceux rencontrés dans la zone d'extension concomitante à *Ahrensisporites thorsteinssonii–Scutasporites nanuki*. Jusqu'à ce que l'on en sache davantage sur les associations du Capitanien et du Tatarien de la Subangara, il est impossible d'écarter l'hypothèse que ce matériel soit postérieur au Wordien mais antérieur au Griesbachien.

La diversité des associations du Roadien suggère un climat relativement humide; cependant, un accroissement de la proportion des spores à deux sacs dans certaines couches du Wordien pourrait indiquer des périodes de climat plus sec. Dans les couches basales de la Formation de Blind Fiord (Trias précoce), l'abondance d'une seule espèce de spores trilètes pourrait être le signe de la formation d'un milieu de marais littoral au début de la transgression triasique; la plupart des échantillons du Trias inférieur ne présentent pas de diversité dans les associations, ce qui signifie que le climat était peut-être aride.

Il est maintenant possible d'établir des corrélations palynostratigraphiques avec des associations du Permien et du Trias inférieur d'autres parties du monde. Cela est d'autant plus vrai dans les régions circumpolaires actuelles qui se trouvaient dans la province floristique subangarienne, comme l'Alberta et la Colombie-Britannique dans l'Ouest du Canada, l'Alaska, le Groenland, le Svalbard, la Bjørnøya, la mer de Barents, le bassin de la Pechora, et la plate-forme russe septentrionale. Toutefois, la comparaison entre les associations du Wordien observées dans le bassin de Sverdrup et celles du stratotype du Kazanien, situé à l'Ouest des monts Oural en Russie, fait ressortir des différences qualitatives et quantitatives marquées, peut-être dues à des différences dans le paléoclimat, les milieux de sédimentation, les faciès, les provinces floristiques, ou même à une corrélation stratigraphique incorrecte. Les différences peuvent aussi résulter d'une combinaison de ces facteurs. La comparaison avec d'autres régions subangariennes du monde indique des ressemblances avec des associations de la partie nord-ouest de la République populaire de Chine (Xinjiang). Toutefois, les associations cathaysiennes du nord et du sud de la Chine sont très différentes, comme celles du Zechstein en Europe de l'Ouest (Euramérique). Au niveau générique, il y a plusieurs ressemblances entre le matériel du bassin de Sverdrup et les associations de certaines parties du Gondwana; au niveau spécifique cependant, il y a des différences marquées.

Trente-neuf espèces de miospores ont été nouvellement décrites : *Ahrensisporites multifloridus, A. thorsteinssonii, Apiculatisporis melvillensis, Cladaitina kolodae, Convolutispora arctica, C. perplexa, Corisaccites stradivarii, Crinalites sabinensis, Cyclogranisporites franklinii, Diatomozonotriletes hypenetes, D. igluanus, Dictyotriletes bamberi, Dyupetalum vesicatum, Gondisporites nassichukii, Gordonispora obstaculifera, Grandispora jansonii, Granulatisporites munitus, Hamiapollenites erebi, Jugasporites compactus, Kraeuselisporites sverdrupensis, Leiotriletes ulutus, Lophotriletes parryensis, Lunatisporites arluki, L. beauchampii, Neoraistrickia caudicea, N. delicata, Pallidosporites multiradiatus, Piceapollenites nookapii, Protohaploxypinus kayaki, P. panaki, Raistrickia enervata, Scutasporites nanuki, Striatoabieites borealis, Striatopodocarpites circulus, Sverdrupollenites agluatus, S. connudatus, Verrucosisporites christiei, Vittatina heclae,* et *Weylandites segmentatus*. Deux nouveaux genres, *Crinalites* et *Sverdrupollenites,* font l'objet d'une description, tout comme tous les taxons de pollens et de spores d'âge permien qui ont été identifiés. Sept nouvelles combinaisons sont établies pour les taxons du Permien et du Trias (*Cordaitina vulgaris, Pakhapites rotundus, Weylandites cincinnatus, W. striatus, Lunatisporites albertae, Simeonospora minuta* et *Uvaesporites imperialis*).

INTRODUCTION

The purpose of this study was to establish a palynological zonation that could be used to correlate Permian and Lower Triassic strata within the Sverdrup Basin. No previous detailed palynological study of this area has been published. Nine outcrop sections were sampled, including all the type sections of the formations studied. Material was collected from both shallow and deep basinal facies to make palynological correlations across lithofacies boundaries.

The ages of the three palynological zones established were based mainly on ages determined from marine macro and microfaunal groups, especially ammonoids, brachiopods, and conodonts. Palynostratigraphic comparisons have been made with other parts of the world, including the Kazanian stratotype of Russia.

In this paper, the stages of the Permian in Russia and, in part, the stages of the Permian of North America, have been used (Fig. 1). It should be stressed, however, that these have yet to be reliably correlated, and there are numerous conflicting views about which correlations are valid. This paper follows the proposal by Dickins et al. (1989) that the Roadian of the United States may be correlated with the Ufimian of Russia, and the Wordian and Capitanian? (Guadalupian) of the United States may be correlated with the Kazanian of Russia. The location of the Lower Permian/Upper Permian boundary between the Roadian and Wordian is that used by Trettin (1991). This classification will require further revision if the proposal by Glenister et al. (1992) to recognize the Guadalupian as Middle Permian is accepted by the Permian Subcommission on Stratigraphy.

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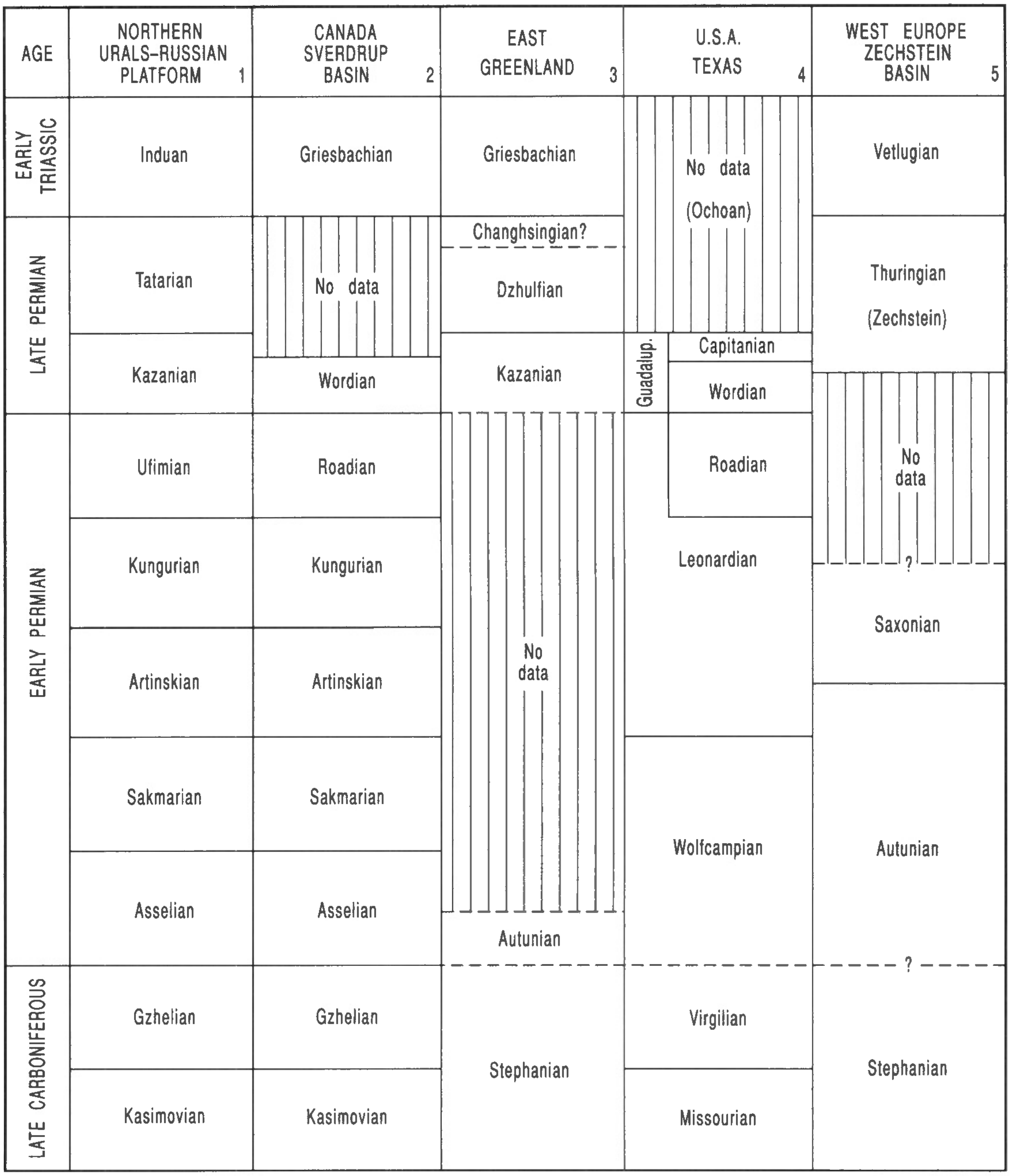
STRATIGRAPHIC SEQUENCES AND FORMATIONS

The Sverdrup Basin is a rift basin 1000 km long and 400 km wide, underlying the northernmost islands of the Canadian Arctic Archipelago (Fig. 2). The basin, as a whole, formed following extension, faulting, and collapse of Proterozoic to Devonian rocks in the underlying Franklinian Mobile Belt, after the latest Devonian to earliest Carboniferous Ellesmerian Orogeny (Thorsteinsson and Tozer, 1970; Davies and Nassichuk, 1990). Carboniferous and Permian rocks were deposited in several deep-water basins surrounded by shallow-water platform areas (Nassichuk and Davies, 1980; Beauchamp et al., 1989a).

In the Upper Paleozoic of the basin there are eight long-term transgressive–regressive sequences, separated by major unconformities at the basin margin that pass basinward into equivalent conformities (Beauchamp et al., 1989b). The sequences encompass the following time intervals: 1. Viséan, 2. Serpukhovian, 3. Bashkirian–Gzhelian, 4. Asselian–Sakmarian, 5. Artinskian, 6. Kungurian?–Roadian, 7. Roadian–Wordian, and 8. Wordian or younger (Beauchamp et al., 1989b; Beauchamp, in press, a; Fig. 3). The Permian sequences studied palynologically are 6, 7 and 8.

Overlying the Permian are Triassic rocks that may be up to 4000 m thick (Embry, 1988). Nine transgressive–recessive cycles have been recognized in the basin (Embry, 1988, 1991). This report concerns the basal part of the first cycle, which is Griesbachian (Fig. 3).



AGE		NORTHERN URALS-RUSSIAN PLATFORM 1	CANADA SVERDRUP BASIN 2	EAST GREENLAND 3	U.S.A. TEXAS 4		WEST EUROPE ZECHSTEIN BASIN 5
EARLY TRIASSIC		Induan	Griesbachian	Griesbachian	No data (Ochoan)		Vetlugian
LATE PERMIAN		Tatarian	No data	Changhsingian? Dzhulfian			Thuringian (Zechstein)
		Kazanian	Wordian	Kazanian	Guadalup.	Capitanian Wordian	No data
EARLY PERMIAN		Ufimian	Roadian	No data		Roadian	
		Kungurian	Kungurian		Leonardian		? Saxonian
		Artinskian	Artinskian				
		Sakmarian	Sakmarian		Wolfcampian		Autunian
		Asselian	Asselian	Autunian			
LATE CARBONIFEROUS		Gzhelian	Gzhelian	Stephanian	Virgilian		? Stephanian
		Kasimovian	Kasimovian		Missourian		

Figure 1. *Correlation of stages of: 1. Commonwealth of Independant States, Northern Urals–Russian platform; 2. Canada, Sverdrup Basin; 3. East Greenland; 4. U.S.A., Texas; 5. West Europe, Zechstein Basin (after Utting and Piasecki, in press).*

KUNGURIAN(?)–ROADIAN

Sequence 6, represented at the basin margin by the Sabine Bay Formation, unconformably overlies the Great Bear Cape Formation of Beauchamp and Henderson (in press, Fig. 3). The Sabine Bay Formation was probably deposited relatively rapidly in response to the Melvillian disturbance (Beauchamp et al., 1989b). It is a dominantly sandstone unit, but intercalations of shale, and rare coaly and carbonaceous shale intercalations are present.

Near the base of the Sabine Bay Formation, Nassichuk (1970) recorded the ammonite *Sverdrupites* sp., and proposed an Artinskian age. More recent work indicates that these beds, in present day stratigraphic terminology, are Roadian (Nassichuk, in press). However, Henderson (1988) and Beauchamp

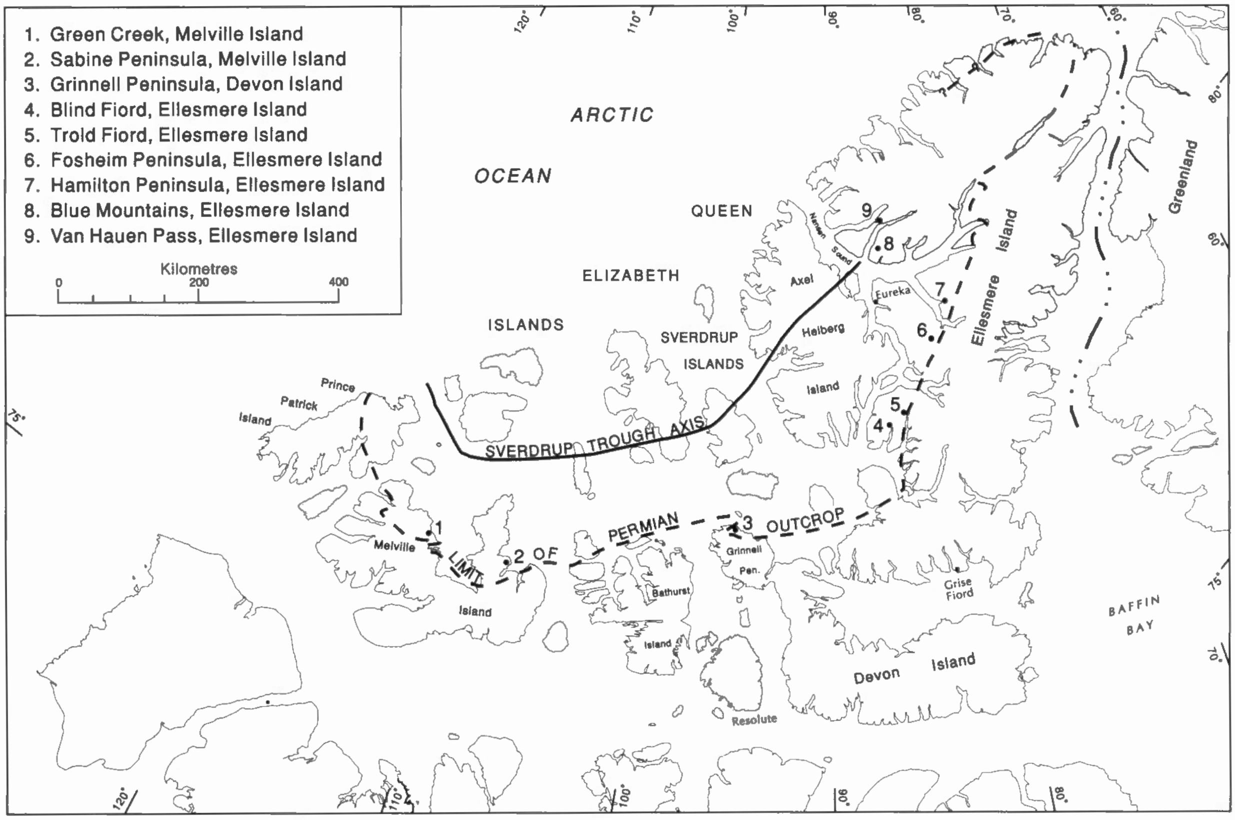


Figure 2. Outline of the Sverdrup Basin and position of trough axis (after Beauchamp, in press, a). Location of localities 1 to 9.

et al. (1989b), proposed a tentative Kungurian age for rocks near the top of the Sabine Bay Formation at McKinley Bay, northern Ellesmere Island, based on the conodonts *Neostreptognathodus prayi* and *Neogondolella idahoensis*. These are younger than typical Artinskian conodonts, but older than Roadian conodonts, and were assigned to Zone P10 (Henderson, 1988; Beauchamp et al., 1989b). Similar conodonts were also found in the basal part of the type section of the Sabine Bay Formation, Melville Island (Henderson, pers. comm., 1993). In this paper, the age determined by ammonoids is preferred to that of conodonts because more is known about the stratigraphic ranges of Permian ammonoids throughout the world than those of the relatively little-studied conodonts.

The Sabine Bay Formation can be traced into a very thin interval at the base of the van Hauen Formation toward the basin axis. It is possible that this unit, which has not yet been studied palynologically, is Kungurian (Beauchamp et al., 1989a, b; Beauchamp, in press, a).

ROADIAN-WORDIAN

Sequence 7 includes rocks belonging to the Assistance, Trold Fiord, and Degerböls formations, and part of the van Hauen Formation. The sequence forms a broad transgressive-regressive package, with the transgressive strata contained in the Assistance Formation (fossiliferous sandstone) and regressive strata in the Trold Fiord (fossiliferous glauconitic sandstone) and Degerböls (fossiliferous limestone) formations. These formations pass laterally into the deeper-water, dark-coloured, spiculitic cherts and shales of the van Hauen Formation.

The Assistance Formation contains a marine fauna of ammonoids, corals, scaphopods, gastropods, bryozoans, conularids, brachiopods, elasmobranch shark parts, and conodonts (Harker and Thorsteinsson, 1960; Nassichuk, 1970, 1971; Nassichuk and Spinosa, 1970; Nassichuk and Hodgkinson, 1976; Henderson, 1981, 1988; Beauchamp et al., 1989a). Age diagnostic fossils (Fig. 4, locs. 1-9) including ammonoids and scaphopods (Nassichuk et al., 1965;

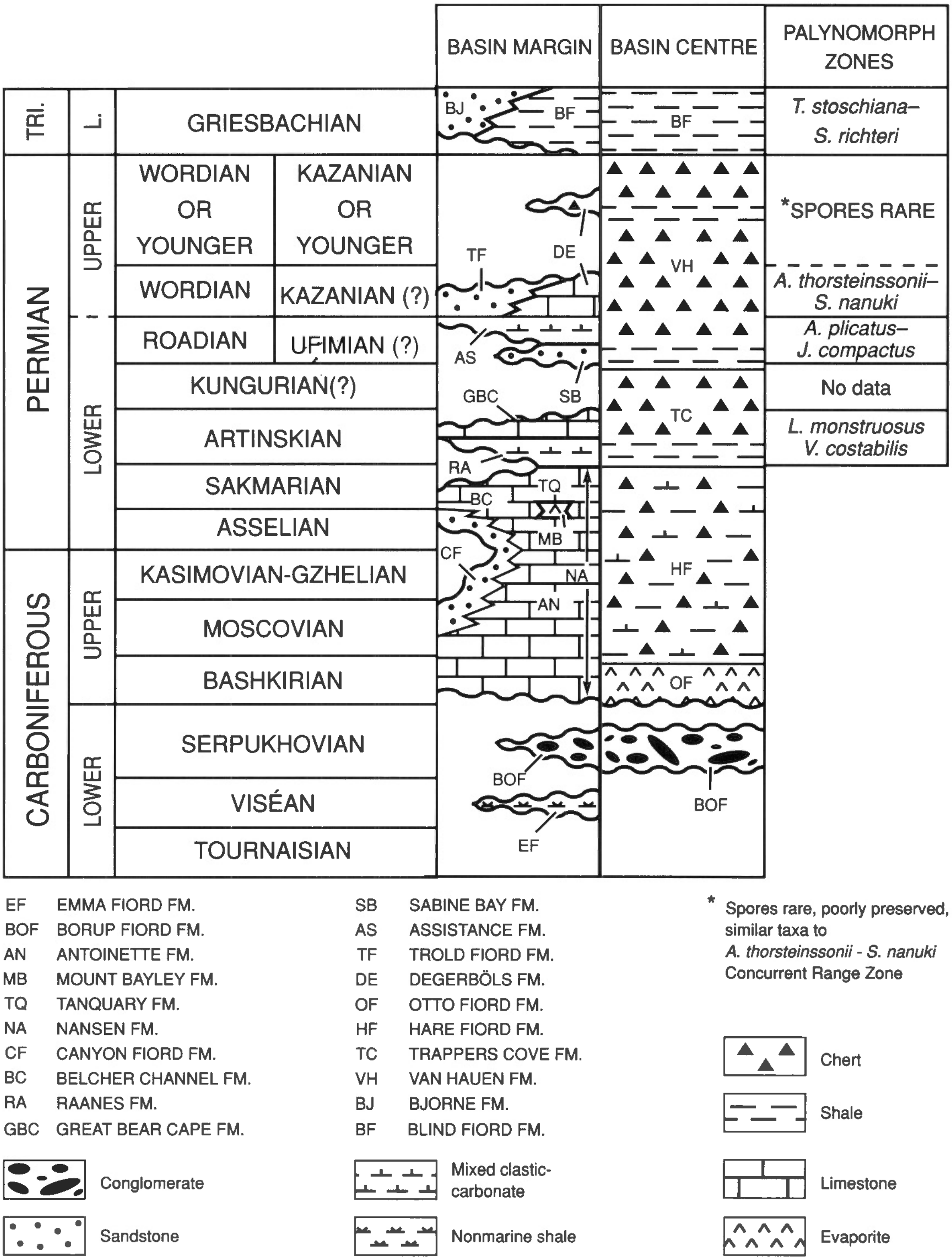


Figure 3. *Upper Paleozoic and Lower Triassic rock units of the Sverdrup Basin, showing unconformities at the basin margin and correlative conformities at the basin centre (modified from Beauchamp, in press, a). Also shown are palynomorph zones.*

Nassichuk, 1975), brachiopods (Waterhouse, 1969) and conodonts (Henderson, 1981, 1988; Beauchamp et al., 1989a, b), indicate a Roadian age. Dickins et al. (1989) suggested an early Ufimian age (= Solikamsk?) based on the ammonoids, and pointed out the close similarity of the ammonoids to those of the Kungurian of Western Australia.

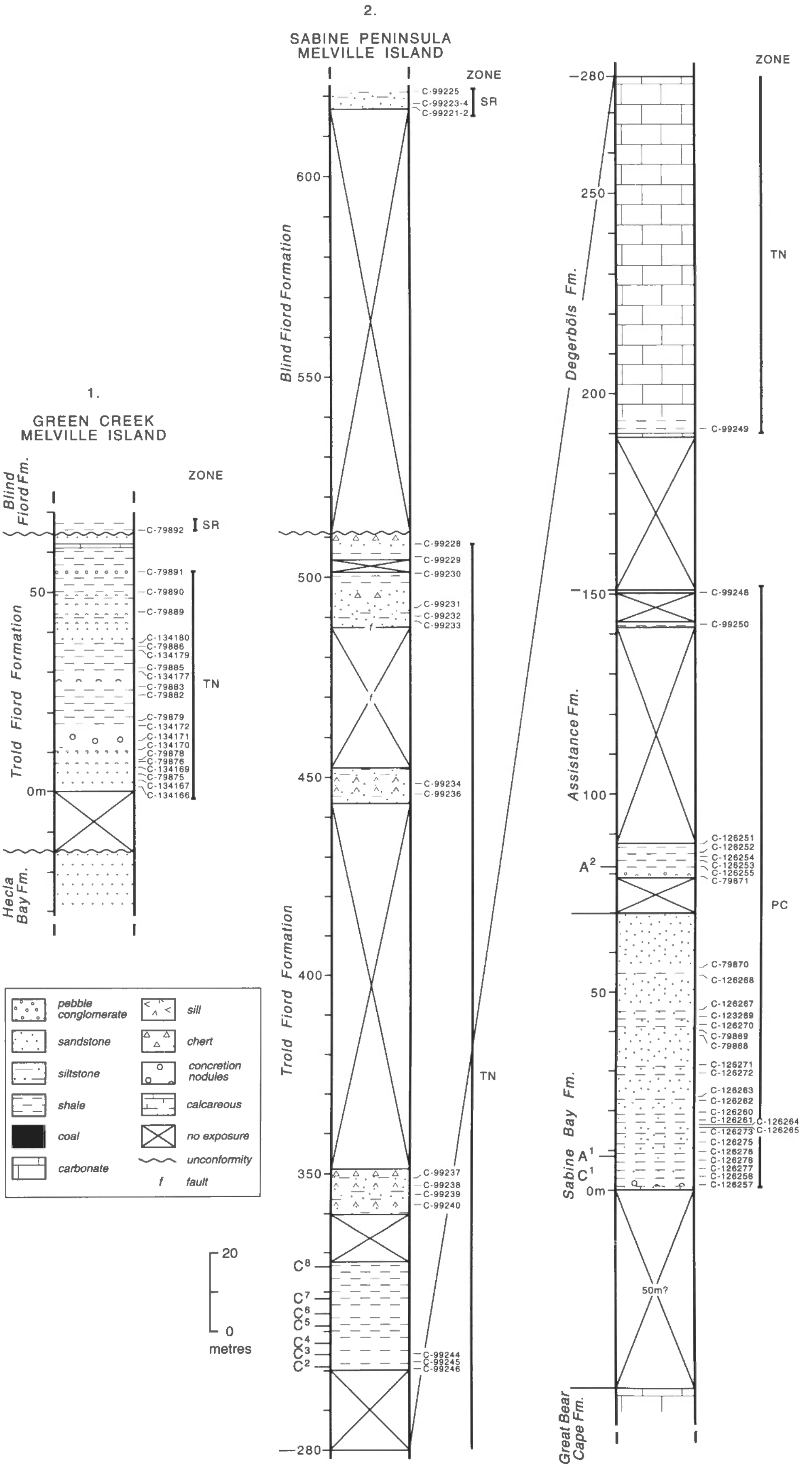
The Trold Fiord Formation contains brachiopods that indicate an early Guadalupian (Wordian) age (Waterhouse, 1969; Waterhouse, *in* Thorsteinsson, 1974; Nassichuk et al., 1973). The ammonoid *Neogeoceras macnairi*, documented from an unknown stratigraphic level in this formation on Cameron Island, also indicates an early Guadalupian or Wordian age (Nassichuk et al., 1965; Nassichuk, in press). A Wordian age is supported by the conodont data (Henderson, 1981, 1988, pers. comm., 1988; Beauchamp et al., 1989a, b). Thus, the contact between the Trold Fiord Formation and the Assistance Formation is approximately equated with the Roadian-Wordian boundary. Nassichuk (1975, in press) considered the Trold Fiord Formation is restricted to the Wordian based largely on ages derived from work on ammonoids and brachiopods. However, Nakamura et al. (1992) and Henderson (1993) proposed a possible Wordian to Capitanian age based mainly on unpublished brachiopod and conodont work.

The Degerböls Formation, a lateral correlative of the Trold Fiord Formation (Nassichuk et al., 1973; Beauchamp et al., 1989a, b; Fig. 3), contains brachiopods, bryozoans, conodonts, corals, sponges, pelecypods, and crinoid columnals. A Guadalupian age (Wordian in present day terminology) was suggested by Thorsteinsson (1974) on the basis of brachiopods identified by J.B. Waterhouse. Conodont data suggest a tentative late Roadian to early Wordian age (Henderson, pers. comm., 1988). The Degerböls Formation passes laterally into the van Hauen Formation (Fig. 3), a relationship demonstrated both physically (Beauchamp, in press, a) and seismically (Harrison, 1991).

The van Hauen Formation contains a sparse fauna. However, in the Blue Mountains, Ellesmere Island (Figs. 2, 4, loc. 8), 360 m below the top of the formation, the ammonoids *Daubichites fortieri* and *Sverdrupites harkeri* have been recorded (Nassichuk, 1975) indicating a Roadian age. According to J.B. Waterhouse (unpublished GSC report to W.W. Nassichuk, 1974), brachiopods from the van Hauen Formation 6.4 km south of the head of Blind Fiord include orthotetaceans, *Spiriferella, Waagenoconcha*, and *Kuvelousia*. They were assigned an age equivalent to the Trold Fiord Formation. Thus it is probable that part of the lower van Hauen Formation is Roadian and at least part of the upper part of the formation is Wordian.

Figure 4. *Rock types and sample localities at localities 1–9.*

GSC locality numbers of palynological samples (C-nos.) are given on right hand side of columns. Location of stratigraphically diagnostic marine fossil groups are shown on left side of columns. A = ammonoids, S = scaphopods, C = conodonts, (A) = ammonoids from talus. ***Locality 1.*** *Green Creek, Melville Island. No stratigraphically diagnostic marine fossils identified.* ***Locality 2.*** *Sabine Peninsula, Melville Island.* ***Sabine Bay Formation.*** *A^1 =* ***Sverdrupites*** *sp.; GSC loc. 67255, Nassichuk (1970); Roadian. C^1 =* ***Neogondolella idahoensis–Neostreptognathodus prayi*** *P10 Zone of Beauchamp et al. (1989a); Roadian to Kungurian.* ***Assistance Formation.*** *A^2 =* ***Daubichites fortieri*** *(Harker); GSC loc. C-462, Nassichuk (1970); Roadian.* ***Degerböls Formation.*** *No stratigraphically diagnostic marine fossils identified.* ***Trold Fiord Formation.*** *C^2 =* ***Neogondolella*** *spp.; GSC loc. C-114943, 0.5 m above base, Henderson (pers. comm., 1988); Wordian. C^3 =* ***Neogondolella*** *spp.,* ***Xaniognathus*** *sp.; GSC loc. C-114942, 6.5 m above base, Henderson (pers. comm., 1988); Wordian. C^4 =* ***Neogondolella*** *sp., ?**Merillina** sp.; GSC loc. C-114941, 7.0 m above base, Henderson (pers. comm., 1988); Wordian. C^5 =* ***Neogondolella*** *sp.; GSC loc. C=114940, 11.5 m above base, Henderson (pers. comm., 1988); Wordian? C^6 =* ***Neogondolella*** *aff.* ***phosphoriensis*** *subsp. A; GSC loc. C-114938, 14.0 m above base, Henderson (pers. comm., 1988); Wordian. C^7 =* ***Neogondolella*** *aff.* ***phosphoriensis****, ?**Xaniognathus** sp.; GSC loc. C-114937, 18.0 m above base, Henderson (pers. comm., 1988); Wordian. C^8 =* ***Neogondolella*** *aff.* ***phosphoriensis, Hindeodus*** *sp.; GSC loc. C-114936, 28.3 m above base, Henderson (pers. comm., 1988); Wordian.* ***Blind Fiord Formation.*** *No stratigraphically diagnostic marine fossils identified.* ***Locality 3.*** *Grinnell Peninsula, Devon Island.* ***Assistance Formation.*** *A^3 =* ***Daubichites fortieri*** *(Harker),* ***Sverdrupites harkeri*** *(Ruzhencev)* ***Sverdrupites*** *sp.,* ***Popanoceras*** *cf.* ***P. sobolewskyanum*** *(Verneuil) GSC loc. 26406, Nassichuk (1970). S^1 =* ***Prodentalium belcheri*** *Nassichuk and Hodgkinson, 1976, Nassichuk and Hodgkinson (1976); Roadian.* ***Blind Fiord Formation.*** *No stratigraphically diagnostic marine fossils identified.* ***Locality 4.*** *Blind Fiord, Ellesmere Island.* ***Van Hauen Formation.*** *No stratigraphically diagnostic marine fossils identified.* ***Blind Fiord Formation.*** *A^4 =* ***Otoceras boreale*** *Tozer, 1967, p. 52–53; Griesbachian.* ***Locality 5.*** *Trold Fiord, Ellesmere Island.* ***Trold Fiord Formation.*** *No stratigraphically diagnostic marine fossils identified.* ***Blind Fiord Formation.*** *Shale bed of unknown thickness (at present unexposed) at base. A^5 =* ***Otoceras boreale;*** *GSC loc. 68350, E.T. Tozer (1967), p. 53; Griesbachian.* ***Locality 6.*** *Fosheim, Ellesmere Island. No stratigraphically diagnostic marine fossils identified.* ***Locality 7 supplemented by Locality 7a.*** *Hamilton Peninsula, Ellesmere Island.* ***Sabine Bay Formation.*** *No stratigraphically diagnostic marine fossils identified.* ***Assistance Formation.*** *A^6 =* ***Daubichites fortieri*** *Nassichuk, 1975b; Roadian.* ***Trold Fiord Formation.*** *No stratigraphically diagnostic marine fossils identified.* ***Blind Fiord Formation.*** *No stratigraphically diagnostic marine fossils identified.* ***Locality 8.*** *Blue Mountains, Ellesmere Island.* ***Van Hauen Formation.*** *A^7 =* ***Sverdrupites harkeri, Daubichites fortieri*** *Nassichuk, 1975; Roadian.* ***Locality 9.*** *Van Hauen Pass, Ellesmere Island. No stratigraphically diagnostic marine fossils identified. Section from point X–Y from W.W. Nassichuk (pers. comm., 1992).*


1.
GREEN CREEK
MELVILLE ISLAND
ZONE
Blind Fiord Fm.
Trold Fiord Formation
Hecla Bay Fm.
50
0m
C-79892
SR
C-79891
C-79890
C-79889
C-134180
C-79886
C-134179
C-79885
C-134177
C-79883
C-79882
C-79879
C-134172
C-134171
C-134170
C-79878
C-79876
C-134169
C-79875
C-134167
C-134166
TN
2.
SABINE PENINSULA
MELVILLE ISLAND
ZONE
Blind Fiord Formation
Trold Fiord Formation
600
550
500
450
400
350
—280
C-99225
C-99223-4
C-99221-2
SR
C-99228
C-99229
C-99230
C-99231
C-99232
C-99233
f
C-99234
C-99236
C-99237
C-99238
C-99239
C-99240
C-99244
C-99245
C-99246
TN
C⁸
C⁷
C⁶
C⁵
C⁴
C³
C²
—280
250
200
150
100
50
0m
Degerböls Fm.
Assistance Fm.
Sabine Bay Fm.
Great Bear Cape Fm.
ZONE
TN
C-99249
C-99248
C-99250
C-126251
C-126252
C-126254
C-126253
C-126255
C-79871
A²
PC
C-79870
C-126268
C-126267
C-123269
C-126270
C-79869
C-79868
C-126271
C-126272
C-126263
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C-126260
C-126261
C-126264
C-126265
C-126273
C-126275
C-126276
C-126278
C-126277
C-126258
C-126257
A¹
C¹
50m?
pebble conglomerate
sandstone
siltstone
shale
coal
carbonate
sill
chert
concretion nodules
calcareous
no exposure
unconformity
f fault
20
0
metres

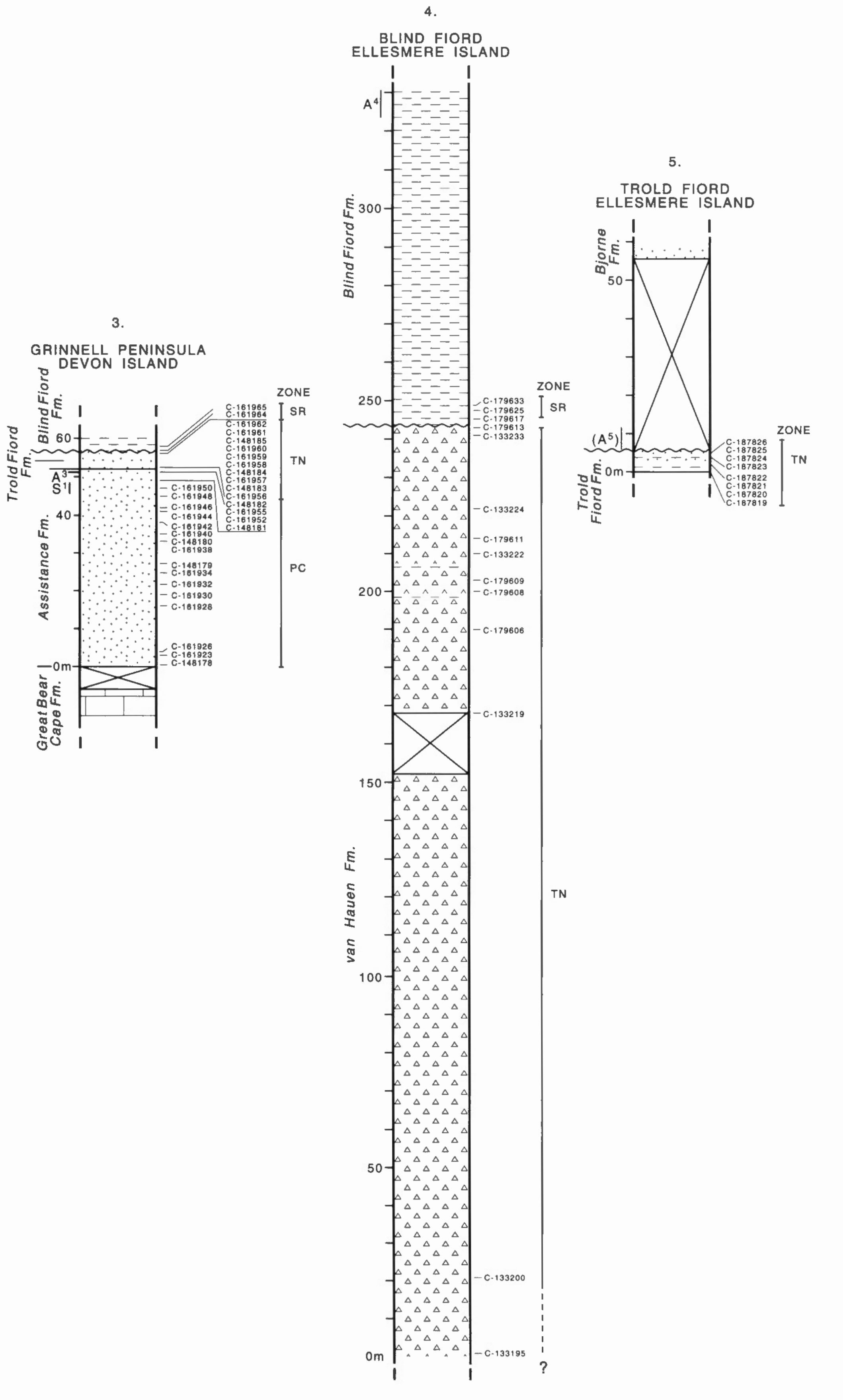

Figure 4. *(cont'd.)*

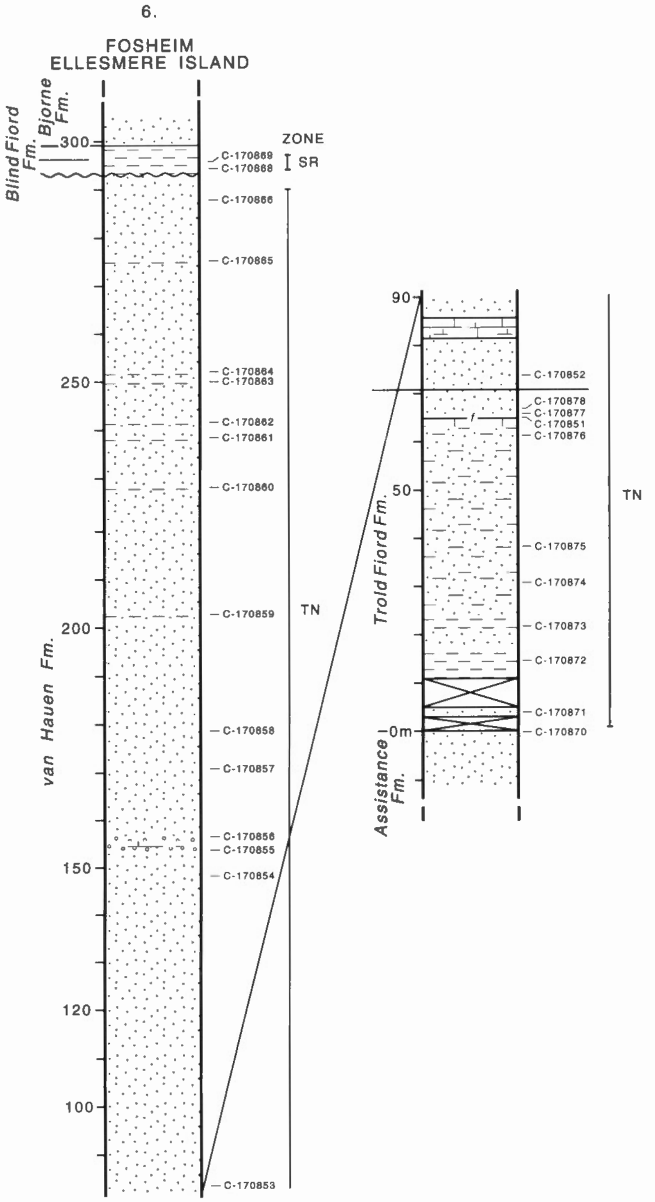

***Figure 4.** (cont'd.)*

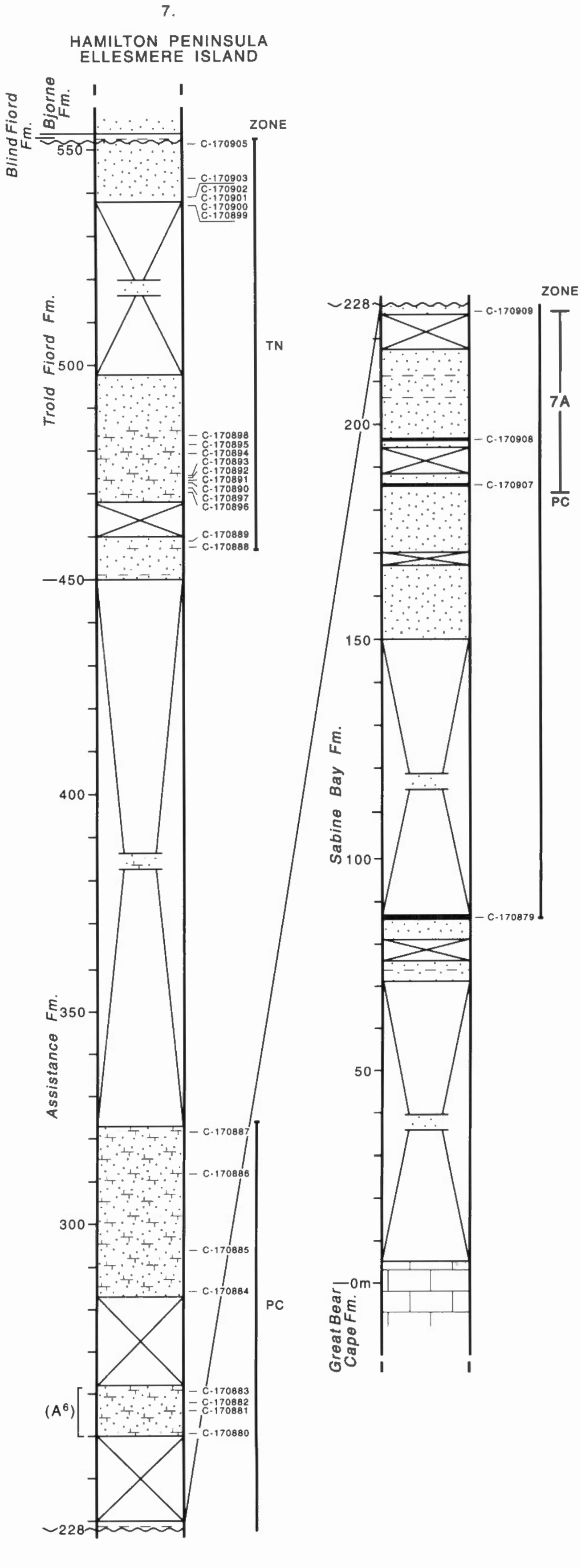

***Figure 4.** (cont'd.)*

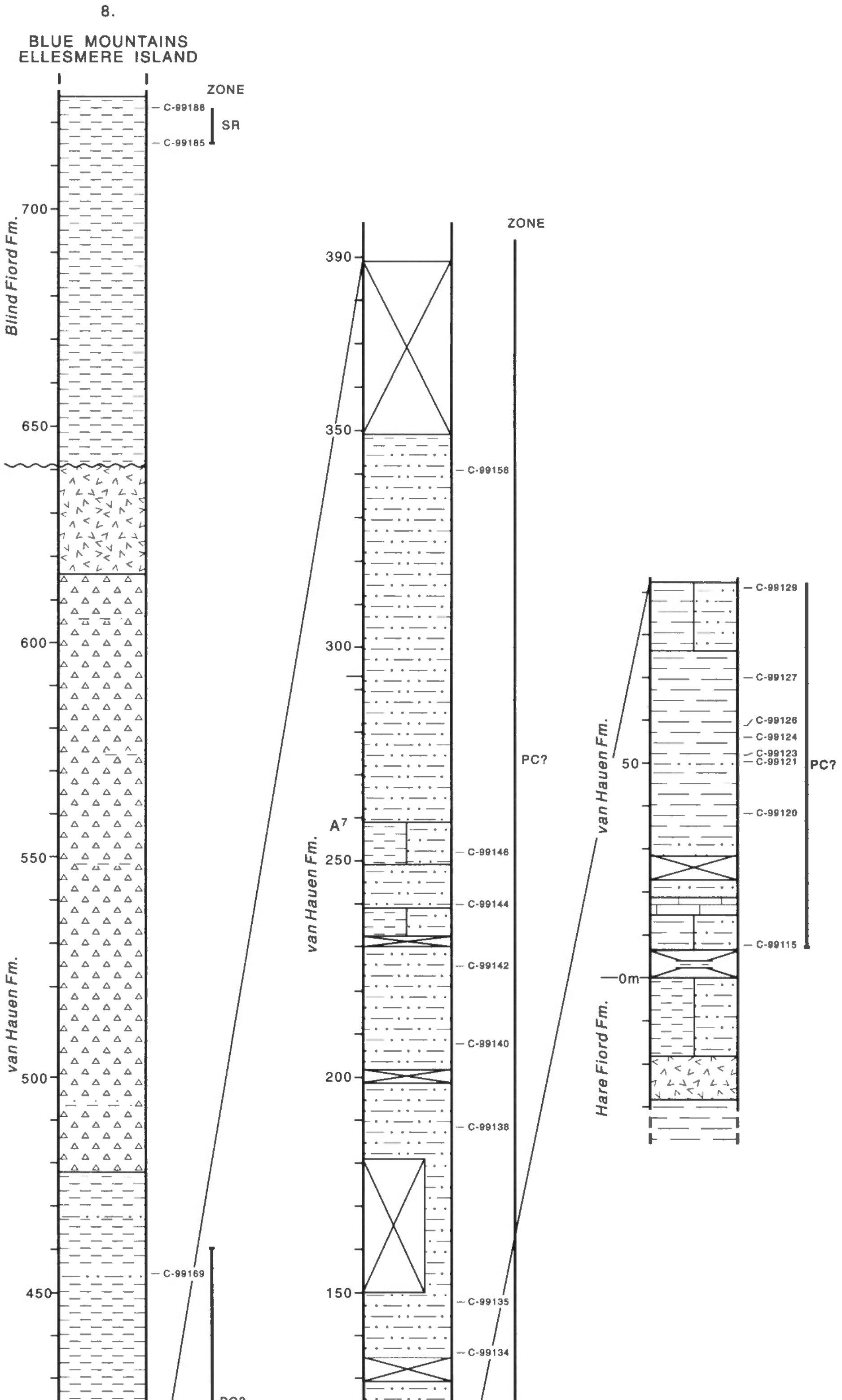

Figure 4. *(cont'd.)*

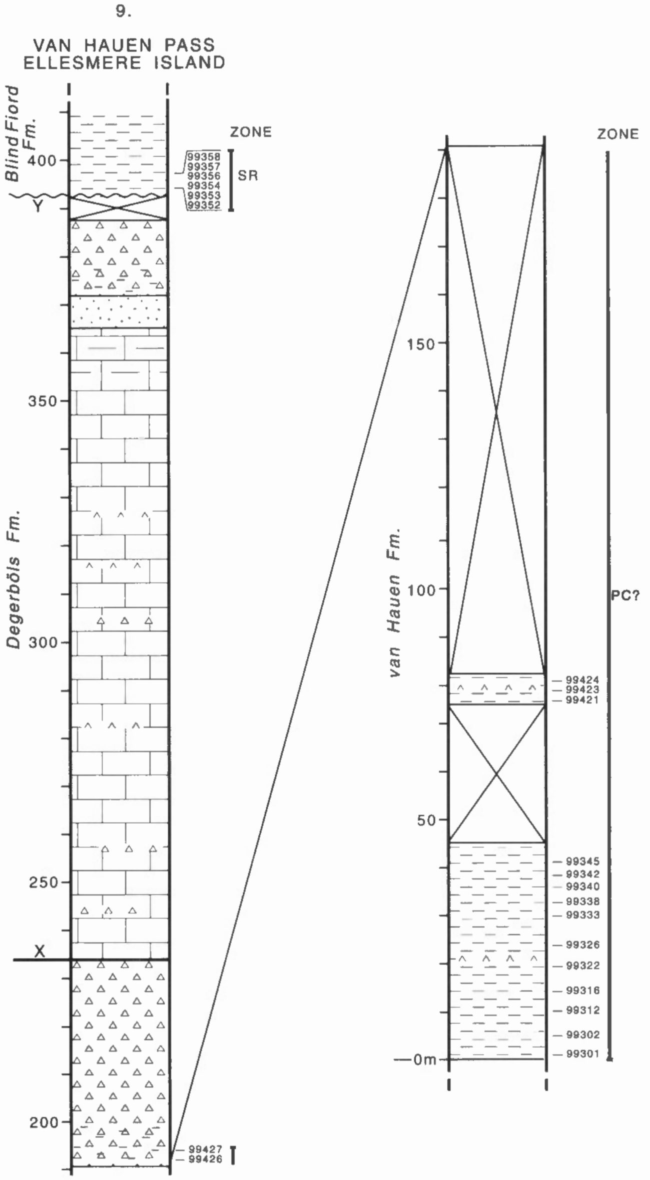

Figure 4. *(cont'd.)*

WORDIAN OR YOUNGER(?)

Sequence 8 comprises spiculitic chert and shale that are contained in the upper part of units previously mapped as the Degerböls and van Hauen formations (Thorsteinsson, 1974). These rocks, which form a broad wedge (up to 400 m in thickness), stratigraphically overlie the youngest prograding clinoforms of the Degerböls Formation and underlie the shales of the Blind Fiord Formation (Beauchamp, in press, a). In the basin centre, this chert is overlain directly by the Blind Fiord Formation, suggesting no erosional break and therefore no unconformity at the contact, although a submarine hiatus may exist between the two formations. This sequence has not been dated using marine fossils, and in the opinion of Beauchamp (pers. comm., 1993), falls within the age range of Wordian to Griesbachian inclusive. Beauchamp et al. (1989a, b), expressed the view that the chert is of post Wordian, but pre-Triassic age, and probably correlates with the Tatarian Stage. However, there is as yet little biostratigraphic evidence to support this claim. Calcareous chert overlying the sandy carbonate facies in the East Girty Creek section, Ellesmere Island, contains small foraminifers (*Agathammina*), which may indicate a post-Wordian age (Desrochers et al., 1993). As described in this report, the palynological assemblages obtained from a section that was measured in the upper part of this chert (very close to the Degerböls shelf edge) contain taxa similar to taxa found in the Trold Fiord, Assistance, and Sabine Bay formations.

GRIESBACHIAN

The nearshore to continental Lower Triassic sand-dominated Bjorne Formation named by Tozer (1961, *in* Fortier et al., 1963) consists of fine- to coarse-grained sandstone with minor red shale and siltstone interbeds; the deposits are mainly of braided stream origin, although delta-front sediments also occur (Embry, 1991). The type section of the Bjorne Formation, located in northwestern Bjorne Peninsula, is approximately 518 m thick (Tozer *in* Fortier et al., 1963). The formation contains a fauna that includes lingulid brachiopods, and an unidentifiable smooth ammonoid (Tozer, 1961).

The coeval deeper water and more basinal marine facies is represented by the shale–siltstone dominated Blind Fiord Formation named by Tozer (1961, *in* Fortier et al., 1963). The beds mainly lack macrofossils, but contain the important species *Otoceras concavum* that is similar in age to the *Otoceras woodwardi* Zone of the Himalayas. The *O. woodwardi* Zone is generally accepted as the basal Triassic zone (Tozer, 1967). At the type section of the Blind Fiord Formation at Blind Fiord (Fig. 2, loc. 4; Fig. 4, loc. 4), the ammonoid *Otoceras boreale* occurs 80 to 87 m above the base of the formation, and has also been recorded at the head of Trold Fiord (Tozer, 1967). Along the southern and eastern margins of the basin, the Blind Fiord Formation forms a thin, basal interval of medium to dark grey-green shale and siltstone, which are considered to be of offshore shelf origin (Embry, 1988, 1991).

PREVIOUS PALYNOLOGICAL WORK ON PERMIAN AND LOWER TRIASSIC ROCKS OF N. AMERICA

The following section contains a summary of previous work about rocks of approximately Artinskian to Griesbachian age. A more detailed review of Permian and Lower Triassic rocks is given elsewhere (Utting and Piasecki, in press).

CANADA

Arctic Archipelago, Sverdrup Basin

Little has been published previously on the palynology of Permian or Lower Triassic rocks of the Sverdrup Basin. Barss (1967) illustrated and identified specimens from the Sabine Bay Formation, and McGregor (1965) illustrated assemblages from the lowest Triassic Bjorne Formation. Utting (1985, 1989, 1991) and Utting and Piasecki (in press) summarized preliminary palynological work on Upper Carboniferous, Lower and Upper Permian and Lower Triassic rocks with special attention given to Melville Island in the western Arctic. The following zones were proposed for Artinskian to Griesbachian rocks:

The **Limitisporites monstruosus–Vittatina costabilis** *Assemblage Zone*

This zone is dominated by polyplicate (*Weylandites* and *Vittatina*) and taeniate disaccate (*Protohaploxypinus, Striatoabieites*) pollen suggesting deposition in an arid climate. The zone contains *Weylandites striatus, Vittatina vittifera, Vittatina costabilis, Vittatina* spp., *Vittatina minima, Vittatina subsaccata, Protohaploxypinus perfectus, Protohaploxypinus* spp., *Striatoabieites elongatus, Striatoabieites sedovae, Striatoabieites* spp., *Limitisporites monstruosus, Cordaitina marginata, Cordaitina* sp., and *Discernisporites* sp. (Utting, 1991). The assemblage occurs in the Great Bear Cape Formation of Beauchamp and Henderson (in press) that underlies unconformably the Sabine Bay Formation. The Great Bear Cape Formation is of Artinskian age based on ammonoids, brachiopods, and conodonts (Beauchamp, in press, a).

The **Alisporites insignis–Triadispora** *sp.* *(***Alisporites plicatus–Jugasporites compactus** *of this paper) Assemblage Zone*

This zone comprises a diverse assemblage of trilete spores, taeniate and nontaeniate disaccate pollen, polyplicate pollen and occasional monosaccate pollen. Trilete spores include those assigned to: *Apiculatisporis, Calamospora, Convolutispora, Diatomozonotriletes, Kraeuselisporites, Leiotriletes, Lophotriletes, Lundbladispora* (reworked *Geminospora* of this paper), *Neoraistrickia, Nevesisporites* (*Gordonispora* of this paper), *Punctatisporites, Raistrickia*, and *Verrucosisporites*. Also present are polyplicate pollen (*Weylandites striatus, Vittatina simplex*, and *V. vittifera*; taeniate disaccate pollen *Lueckisporites* (*Corisaccites* of this paper), *Protohaploxypinus perfectus, P.* spp., *Striatoabieites* sp., and *Hamiapollenites bullaeformis*; and nontaeniate disaccate pollen *Vitreisporites pallidus, Triadispora* sp. (*Jugasporites compactus* of this paper) and *Alisporites insignis* (*A. plicatus* of this paper). Colpate pollen include *Cycadopites follicularis*, and *Marsupipollenites retroflexus* (*Sverdrupollenites agluatus* of this paper). Monosaccate grains are rare, but include *Florinites luberae* and *Cordaitina* sp. Acritarchs present in this zone include *Micrhystridium* and *Veryhachium*. The assemblage occurs in the Sabine Bay and Assistance formations, and the lower part of the van Hauen Formation. It is of Roadian age based on ammonoids (Nassichuk, 1970, and pers. comm.), and Kungurian to Roadian age based on conodonts (Beauchamp et al., 1989a, b).

The **Taeniaesporites** *Assemblage Zone* *(***Ahrensisporites thorsteinssonii–Scutasporites nanuki** *of this paper)*

This zone contains many species in common with the underlying zone, but this zone includes the first appearance of *Lunatisporites* spp. (*Taeniaesporites* is a junior synonym of *Lunatisporites*, Foster 1979). Acritarchs include *Veryhachium* and *Micrhystridium*. The assemblage occurs in the Trold Fiord Formation, and is of Wordian age based on brachiopods and conodonts (Thorsteinsson, 1974; Beauchamp et al., 1989a, b).

The **Tympanicysta stoschiana–Striatoabieites richteri** *Assemblage Zone*

This zone contains assemblages markedly different from those of the Upper Permian (Utting, 1989). The zone contains *Tympanicysta stoschiana, Taeniaesporites noviaulensis* (*Lunatisporites noviaulensis* of this paper), *Gnetaceaepollenites steevesii* (*Ephedripites steevesii* of this paper), and *Lundbladispora obsoleta*. According to Fisher (1979), the Bjorne Formation

(Griesbachian) at the head of Trold Fiord contains cavate trilete spores *Densoisporites complicatus, D. playfordii, Lundbladispora obsoleta,* and *L. willmottii*; acavate spores *Iraquispora labrata, Nevesisporites fossulatus,* and *Uvaesporites* sp. (*U. imperialis* in this paper), which often occurs in tetrads. Taeniate disaccate pollen includes *Lueckisporites singhii, Lunatisporites novimundii, L. transversundatus, Protohaploxypinus bharadwajii, P. pellucidus P. samoilovichii, Striatoabieites duivenii, S. richteri, Striatopodocarpites pantii,* and *Striatisaccus noviaulensis*. Polyplicate grains include *Gnetaceaepollenites multistriatus, G. paenesaccatus* and *G. steevesii*. Many of the taxa listed by Fisher (1979) have been described from Gondwana assemblages. The duplication of taxa, however, does not indicate a sudden change in floral province of the Sverdrup Basin from Subangara to Gondwana, but rather reflects the lack of detailed systematic description of the Lower Triassic of northern continents at the time Fisher wrote his report. The assemblage zone is of early Triassic (Griesbachian) age based on ammonoids (Tozer, 1967).

Alberta and British Columbia

Jansonius (1962) described assemblages from the Permian Belloy Formation and the Lower Triassic Toad and Grayling formations in the Peace River area of Alberta and British Columbia. He proposed a Leonardian to Guadalupian age for the Permian Belloy assemblages, and a Scythian to Anisian age for the Triassic Toad and Grayling material. Nassichuk (1969) suggested an Artinskian age for the upper part of the Belloy Formation based on ammonoids, and Henderson (1989) summarized biostratigraphic data that indicated the formation as a whole is Asselian to Artinskian. Generally, the Belloy assemblages described by Jansonius (1962) are characterized by an abundance and variety of *Vittatina* along with common nontaeniate disaccate pollen (*Pityosporites* and *Alisporites*), taeniate disaccate pollen (*Protohaploxypinus* and *Hamiapollenites*), and monocolpate pollen (*Cycadopites*). Jansonius (*in* Naqvi, 1972) also recorded the presence of *Vittatina striata, V. minima*, and *V.* spp. close to the top of the Belloy Formation in the subsurface, along with *Limitisporites, Klausipollenites staplinii*, and *Cycadopites* sp. The Triassic assemblages contain small amounts of acritarchs, abundant taeniate (*Protohaploxypinus, Lunatisporites, Striatoabieites*) and nontaeniate (*Platysaccus* and *Alisporites*) disaccate pollen, colpate pollen (e.g., *Ephedripites* and *Cycadopites*), and some trilete spores.

U.S.A.

Alaska

On the North Slope, Balme (1980b) summarized palynomorph assemblages from the lower part of the Sadlerochit Formation of Kazanian age (based on invertebrate fauna) that resemble those of the Zechstein type of Euramerica. That is the main components are *Lueckisporites virkkiae, Klausipollenites schaubergeri, Striatoabieites richteri*, and *Protohaploxypinus samoilovichii*. This is the only published record to date of this type of assemblage in arctic U.S.A. and Canada, although assemblages in Greenland (Balme, 1980a) and Oklahoma (Wilson, 1962; Clapham, 1970a, b) have some Zechstein affinities. The lowest Triassic (lowermost Griesbachian) contains abundant *Protohaploxypinus, Striatoabieites richteri, Lunatisporites, Ephedripites*, and *Cycadopites*. These predominantly gymnosperm associations are replaced in overlying Griesbachian strata by assemblages dominated by *Lunatisporites* and large numbers of lycopsid spores.

Oklahoma and Kansas

In Oklahoma and Kansas, the Wellington Formation of early Leonardian (Artinskian?) age (Wilson, 1962; Shaffer, 1964; Hedlund, 1965; Bond, 1968) contains assemblages dominated in some samples by saccate pollen and minor amounts of trilete spores, whereas others are dominated by trilete spores. Variations in ecological conditions were believed to have been the main cause of these differences. The microflora contains a number of stratigraphically important taxa, including *Potonieisporites simplex, Hamiapollenites saccatus, Thymospora, Vittatina costabilis*, and *Lueckisporites*. Bond (1968) recorded *Lueckisporites virkkiae*, but the specimen illustrated appears to be closer to *Striatopodocarpites*.

Oklahoma

From the Upper Permian of Oklahoma, Wilson (1962) described assemblages from the Flowerpot Formation. The Flowerpot Formation was assigned a Wordian age and tentatively correlated with the Ufimian to early Kazanian of the Commonwealth of Independent States (C.I.S.); reptile fossils indicate a Kazanian age (Chudinov, 1965; Olson, 1975). The palynological assemblages however, are very different from those of similar age described from the Sverdrup Basin. Most of the Flowerpot microflora consist of taeniate disaccate pollen, the most abundant being *Lueckisporites virkkiae*, followed by *Protohaploxypinus*. Other important genera include *Vittatina, Potonieisporites, Nuskoisporites, Ephedripites*, and *Hamiapollenites*. On the basis of abundant conifer pollen and *Ephedra*-type pollen, Wilson (1962) suggested deposition in a semi-arid climate, and pointed out that the assemblage resembled those from the Zechstein of Europe. Further work on the Flowerpot Formation indicated two different assemblages in the uppermost part of the formation; one is dominated by *Lueckisporites virkkiae* and represents an upland flora dominated mainly by conifers. The other is rich in cryptogamic spores, both trilete and monolete, that were derived from a salt marsh or swamp flora, which included abundant gymnosperms (Clapham, 1970a, b).

Utah

In Utah, Jacobson, Wardlaw, and Saxton (1982) recorded acritarch assemblages from the Phosphoria and Park City formations of Roadian (late Leonardian or Ufimian?) and Wordian (early Guadalupian or Kazanian) age. Genera include *Leiosphaeridia, Micrhystridium*, and *Unellium*.

GREENLAND

From East Greenland, Balme (1980a) recorded three assemblages from the Upper Permian (*Vittatina* Association) and Triassic (*Protohaploxypinus* and *Lunatisporites* associations).

In the *Vittatina* association of the Upper Permian, diversity is low, and identifiable trilete spores are extremely rare. Present in all samples are *Pilasporites* sp., *Vittatina striata*, *V. subsaccata*, and *Alisporites* spp. Species restricted to this association are *Inaperturopollenites nebulosus*, *Vittatina minima*, *Alisporites* sp. cf. *A. nuthallensis*, *Florinites* sp. cf. *F. luberae*, *Falcisporites* sp. cf. *F. zapfei*, *Scutasporites* sp. cf. *S. unicus*. Quantitatively, this assemblage is distinguished by the high content of various species of *Vittatina*; spinose acritarchs are present. Balme (1980a) suggested that the assemblage may be Dzhulfian age (Upper Permian), but this conclusion is largely based on the chronostratigraphic implications of the cyclolobid ammonoid *Godthaabites kullingi* Frebold, which occurs in the Foldvik Creek beds. Nassichuk (pers. comm., 1991) is currently reviewing the Permian ammonoids of East Greenland and has concluded that the Dzhulfian strata are indeed contained within the Foldvik Creek Formation. This is based on the presence of *Episageceras, Eumedlicottia* and *Godthaabites* in the Kap Stosch area. The range of *Episageceras* is Dzhulfian to Triassic.

The *Protohaploxypinus* Association (Lower Triassic) includes *Lundbladispora obsoleta*, *Densoisporites playfordii*, *Kraeuselisporites apiculatus*, and *Proprisporites pocockii*. The following pollen occur in all the samples: *Cycadopites follicularis* Wilson and Webster, *Ephedripites* spp., *Protohaploxypinus samoilovichii*, *P. jacobii*, *Striatoabieites richteri* (Klaus) Balme, and *Lunatisporites noviaulensis*. Assemblages in samples from this association show considerable variation. For example, *Ephedripites* spp. was abundant in some samples, but a minor component in others.

The *Lunatisporites* Association (Lower Triassic) is characterized by a high content of *Lunatisporites noviaulensis* and (*Taeniaesporites*) *pellucidus*. Other species characteristic of the association are *Lundbladispora obsoleta, Cycadopites follicularis, Ephedripites* spp., and *Klausipollenites staplinii*. Spinose acritarchs (*Veryhachium, Baltisphaeridium* and *Micrhystridium*) are abundant.

Piasecki (1984), who also studied the upper Carboniferous, Permian and lower Triassic of East Greenland, recognized four assemblages: *Potonieisporites, Vittatina, Protohaploxypinus*, and *Lunatisporites*. Similar associations to those of Balme (1980a) were recorded by Piasecki (1984) from the southern part of the basin in Jameson Land of East Greenland, and a supplementary "transitional assemblage" between the *Vittatina* assemblage and the Lower Triassic *Protohaploxypinus* and *Lunatisporites* floras was included. Since then, more data have become available (Utting and Piasecki, in press). Poorly preserved palynomorphs similar to those of the Zechstein palynofacies occur in the Karstryggen Formation. They include *Klausipollenites schaubergeri*, early forms of *Lueckisporites virkkiae, L. tattooensis, Jugasporites delasauceri, J. paradelasauceri, J. lueckoides, Lunatisporites noviaulensis, Perisaccus granulatus, Protohaploxypinus samoilovichii, Vittatina costabilis*, and *W. striatus*. As with most Zechstein deposits, trilete spores are absent. The main difference between the Zechstein and Greenland floras is that in the latter, *Inaperturopollenites nebulosus* is very common, and *Vittatina* is common and diverse. The typical dominant species of the Zechstein are absent, or rare to subordinate in East Greenland; for example, *Nuskoisporites dulhuntyi* is absent. In one bed of this formation, *Tympanicysta stoshiana*, an algal or fungal cyst of uncertain affinity (Balme, 1980a), is abundant (Utting and Piasecki, in press).

The marine carbonate platforms and build-ups of the Upper Permian Wegener Halvø Formation and the shales of the basinal equivalent Ravnefjeld Formation contain the *Vittatina* Association of Balme (1980a). Abundant taxa include *Weylandites striatus, Vittatina vittifer, V. costabilis, V. subsaccata, V. minima* and *V. persecta*. The only other palynomorph very commonly observed is *Inaperturopollenites nebulosus*. The remaining flora comprise badly preserved taeniate and nontaeniate disaccate pollen, many of which are mentioned above. *Scutasporites* sp., *Protohaploxypinus samoilovichii, P. marginalis*, and *P. limpidus* become more common, and *Veryhachium, Micrhystridium*, and *Tasmanites* appear. *Veryhachium* sp. cf. *V. rhomboides* is restricted to this formation (Utting and Piasecki, in press).

The overlying Upper Permian unit, the Schuchert Dal Formation, includes sandstone and coarse conglomerate along the basin margins. The coarse clastics interfinger basinward with grey shales of the Oksedal Member. The palynoflora of the Oksedal Member is characterized by many of the same species that occur in the underlying unit, but the genus *Vittatina* decreases rapidly in importance; both taeniate and nontaeniate disaccate forms become dominant (Utting and Piasecki, in press). Species of *Alisporites, Scutasporites, Falcisporites, Sulcatisporites, Vesicaspora, Paravesicaspora*, and *Labiisporites* become more common. A variety of species of *Protohaploxypinus* are present. *Lunatisporites* is rare. *Tympanicysta stoschiana* occurs regularly, but is rare. In addition, rare trilete spores and acritarchs occur. In the uppermost few metres of the Oksedal Member, the gradual appearance of small trilete spores heralds floristic changes at the Permian–Triassic boundary. *Apiculatisporis, Anapiculatisporites*, and *Proprisporites* increase toward the boundary, which is clearly marked by the first appearance of many species. The typical (Upper) Permian *Lueckisporites virkkiae* and the Upper Carboniferous and Permian *Vittatina* almost disappear at the boundary, but some specimens occur in the lower few metres of the Triassic (Utting and Piasecki, in press).

In the Lower Triassic Wordie Creek Formation of Jameson Land, there are three stratigraphic cycles that as a whole contain a spore-dominated assemblage gradually replaced by disaccate pollen (Utting and Piasecki, in press). The disaccate pollen of the two lower cycles consist mainly of *Protohaploxypinus*, followed in the upper cycle by *Lunatisporites*. The spore assemblages include *Lundbladispora obsoleta, L. brevicula, Densoisporites nejburgii, D. playfordii, Kraeuselisporites, Proprisporites, Uvaesporites imperialis*, and *Maculatasporites*. Their appearance, along with the common occurrence of *Tympanicysta stoschiana*, marks the base of the Triassic. The common disaccate pollen are mainly taxa known to occur elsewhere in the world in the Upper Permian. *Striatoabieites richteri* and *Crustaesporites globosus* are common in the earliest strata and are followed by a variety of other taeniate disaccate pollen. Rare pollen types comprise *Pretricolpipollenites* and cf. *Cordaitina*, although *Cycadopites* and *Ephedripites* are restricted to the northern part of the basin (Utting and Piasecki, in press).

PALYNOSTRATIGRAPHY

LOCALITIES SAMPLED

Palynological samples were collected from nine outcrop sections (Fig. 2, locs. 1–9; Fig. 4, locs. 1–9; Fig. 5). These nine include all of the type sections of the respective formations. In some cases, reference sections sampled are better exposed than the type sections [e.g., Trold Fiord Formation on Fosheim Peninsula, Ellesmere Island (Fig. 1, loc. 4)].

Sabine Bay Formation

The type section, proposed by Tozer and Thorsteinsson, 1964, is located 1.6 km northwest of Tingmisut Lake, Melville Island (Fig. 2, loc. 2; Fig. 4, loc. 2). The main rock type is medium grained, generally grey to buff, crossbedded, quartzose sandstone, but the section also contains rare thin beds of carbonaceous mudstone and coal up to 0.05 m thick; varicoloured chert pebbles are common. The lower part of the formation is distinctive because the medium and coarse sandstone intervals are loosely consolidated and uncemented. Near the base of the exposed part of the formation (Fig. 4, loc. 2), a bed occurs with large (0.8 m) calcareous nodular concretions that in places contain brachiopods and trace fossils (*Zoophycos*); the latter also are found near the top of the formation (Utting, 1985). In the upper part, coarse sandstone selectively cemented with calcite forms prominent cliffs. Neptunian dykes occur in some localities (Harrison, 1990). The unit is approximately 120 m thick (Nassichuk, 1965) at the type section, but thins to approximately 19 m in the southwest (Harrison, 1990). There is no thick, continuously exposed section of the Sabine Bay Formation in the type area, but rather the outcrop consists of small discontinuous exposures in the channel of Hiccles Creek and its numerous minor tributaries.

LOCALITY NO.	NAME	LATITUDE/ LONGITUDE	REFERENCE	FORMATION					
				Sabine Bay	Assistance	van Hauen	Degerböls	Trold Fiord	Blind Fiord
1	Green Creek, Melville Island	76° 00' 30" N 112° 18' 00" E	Locality 79 Tozer and Thorsteinsson, (1964)					●	●
2	Sabine Peninsula, Melville Island	76° 00' 20" N 108° 00' 00" E to 75° 57' 30" N 107° 55' 00" E	Locality 73-76 Tozer and Thorsteinsson, (1964)	●	●		●	●	●
3	Grinnell Peninsula, Devon Island	76° 57' 00" N 96° 20' 00" E	Locality 5 Harker and Thorsteinsson, (1960)		●			●	●
4	Blind Fiord, Ellesmere Island	78° 23' 40" N 86° 03' 00" E	Locality 61 Thorsteinsson (1974)			●			●
5	Trold Fiord, Ellesmere Island	78° 34' 15" N 84° 43' 00" E	Locality 64 Thorsteinsson (1974)					●	
6	Fosheim Peninsula, Ellesmere Island	79° 41' 40" N 82° 43' 00" E	Locality 170 Thorsteinsson (1974)					●	●
7	Hamilton Peninsula, Ellesmere Island	A 80° 02' 15" N 81° 47' 30" E B 80° 03' 20" N 81° 41' 00" E	Locality 72 Thorsteinsson (1974) Except Sabine Bay Fm. (C-170879 – C-170909)	● ●	●			●	
8	Blue Mountains, Ellesmere Island	80° 43' 25" N 85° 40' 00" E	Locality 68B Thorsteinsson (1974)			●			●
9	van Hauen Pass, Ellesmere Island	81° 04' 00" N 85° 40' 00" E	Locality 69 Thorsteinsson (1974)			●	●		●

Figure 5. *Geographic location of localities 1–9 and respective formations sampled.*

The composite section presented in Figure 4, loc. 2 was compiled from these numerous outcrops; stratigraphic order was established with the aid of general field relations observed on the ground and air photo interpretation. It is possible that some of the beds were duplicated in the sampling. In addition to the type section, a 228 m thick section of the Sabine Bay Formation was sampled on Hamilton Peninsula, Ellesmere Island (Fig. 2, loc. 7; Fig. 4, loc. 7). The rock types are remarkably similar to the type section, and there is more continuous exposure.

Assistance Formation

The type section on Grinnell Peninsula, Devon Island (Fig. 2, loc. 3; Fig. 4, loc. 3) is about 50 m thick. Medium bedded, fine grained sandstone is interbedded with thin silt and clay intercalations, variably calcareous and glauconitic. Fresh surfaces are medium grey, weathering to yellowish orange and medium greyish green. Dusky red ironstone and calcareous sandstone concretions, rich in fossils, occur in the upper part of the formation (Harker and Thorsteinsson, 1960; Fortier et al., 1963; Thorsteinsson, 1974; Nassichuk, 1975). In addition to those from the type section, samples were collected from Hamilton Peninsula, Ellesmere Island (Fig. 2, loc. 7; Fig. 4, loc. 7) where the formation attains a thickness of approximately 173 m. On Melville Island, near Hiccles Creek (Fig. 2, loc. 2; Fig. 4, loc. 2), the formation consists of approximately 80 m of weakly compacted, recessive, greenish grey and dark-grey-weathering glauconitic, argillaceous, and fine grained sandstone and siltstone. In the lower part of the section, purplish red, brown, pebbly sandstone intercalations occur. The contact with the Sabine Bay Formation is not well exposed at this locality, and is arbitrarily placed at a point where sandstone becomes the dominant rock type and the greenish grey colouring disappears. In the southwest part of Sabine Peninsula, thin intercalations of dusky red-weathering pebbly mudstone occur in the upper part (Harrison, 1990).

Trold Fiord Formation

The type section is located on an unnamed tributary of the East Cape River that flows into the northeast side of Cañon Fiord, Hamilton Peninsula, Ellesmere Island (Fig. 2, loc. 7; Fig. 4, loc. 7). It consists of 151 m of friable to soft quartzose sandstone that is grey, green, or brown, fine to coarse textured, thin to thick bedded and massive, variably calcareous and glauconitic. The uppermost sandstone unit (15 m) lacks marine fauna.

In addition to the type section, other sections sampled were a 6 m section at the northwestern extremity of Trold Fiord, Ellesmere Island (Fig. 2, loc. 5; Fig. 4, loc. 5), a 296 m section on Fosheim

Peninsula, Ellesmere Island (Fig. 2, loc. 6; Fig. 4, loc. 6), and a 3 m section on Grinnell Peninsula, Devon Island (Fig. 2, loc. 3; Fig. 4, loc. 3). The formation is well exposed on Melville Island and samples were recovered from Green Creek (80 m) and Hiccles Creek, on Sabine Peninsula (230 m) (Fig. 2, locs. 1, 2; Fig. 4, locs. 1, 2). The formation at the Green Creek locality consists of green, glauconitic sandstone, black spiculitic chert and minor limestone bands and shaly intercalations. It was considered to belong to the Assistance Formation by Tozer and Thorsteinsson (1964), but the high glauconite content of the rocks in this section suggests that it would be more appropriate to include the Green Creek section in the Trold Fiord Formation (Harrison, pers. comm., 1991).

Degerböls Formation

The type section is approximately 1.6 km east of van Hauen Pass, Ellesmere Island (Fig. 2, loc. 9; Fig. 4, loc. 9). It consists of 183 m of alternating units of light grey to medium grey, medium bedded, coarse grained to fine grained limestone that weathers to various shades of grey and yellow. Grey and blue chert is common throughout the section. In addition to the type section, samples were also collected from rocks tentatively assigned to the Degerböls Formation (Harrison, pers. comm., 1993) on Melville Island (Fig. 2, loc. 2; Fig. 4, loc. 2). Here, disconformably overlying the Assistance Formation, is an approximately 130 m (Harrison, 1991) thick bioclastic limestone (''Unit A'' of Nassichuk, 1975) of Wordian age (Nassichuk, 1975; Beauchamp et al., 1989b) containing an abundant fauna of brachiopods, fenestellid bryozoans, conodonts, and *Zoophycos*. Harrison (1991) interpreted that ''Unit A'' grades laterally into the Trold Fiord Formation from seismic data.

Van Hauen Formation

The type section is approximately 870 m thick, and is located approximately 1.6 km northeast of van Hauen Pass, Ellesmere Island (Fig. 2, loc. 9; Fig. 4, loc. 9). The lower member, which overlies the Trappers Cove Formation (Beauchamp and Henderson, in press; Beauchamp, in press, a), consists of 635 m of interbedded shale and siltstone, and relatively small amounts of chert and sandstone, and rare bioclastic limestone. The shale is dark grey to black, and commonly fissile and sooty (Thorsteinsson, 1974). The upper member is a uniform succession of approximately 235 m of intergrading chert and subordinate siltstone, dark grey to black, thin to medium bedded, hard and brittle. The chert contains abundant sponge spicules. Other sections sampled include 250 m of spiculitic chert at Blind Fiord (Fig. 2, loc. 4; Fig. 4, loc. 4). Also studied were 32 samples from a 222 m section of the lower part of the van Hauen Formation 7 km to the south. Unfortunately, these samples were barren of palynomorphs, although they contained abundant fusain fragments. Also sampled was the complete exposure of approximately 615 m of the van Hauen Formation in the Blue Mountains (Fig. 2, loc. 8; Fig. 4, loc. 8).

Blind Fiord Formation

The Blind Fiord Formation was sampled in order to compare the contained palynomorphs with their Permian counterparts, but the assemblages were not subjected to the same detailed systematic investigation as were those from the Permian. The type section of the Blind Fiord, situated northwest of Blind Fiord (Fig. 2, loc. 4; Fig. 4, loc. 4), consists of approximately 1128 m green and grey, partly micaceous siltstone (Tozer, 1963, *in* Fortier et al., 1963). The siltstones are grey and green, medium to thin bedded, commonly micaceous, weakly calcareous to noncalcareous, and they weather to reddish brown. In some areas, grey shales are interbedded with the siltstone. The Blind Fiord Formation was also sampled at the following locations on Ellesmere Island: Green Creek, Melville Island (Fig. 2, loc. 1; Fig. 4, loc. 1), Sabine Peninsula, Melville Island (Fig. 2, loc. 2; Fig. 4, loc. 2), Grinnell Peninsula, Devon Island (Fig. 2, loc. 3; Fig. 4, loc. 3), Fosheim Peninsula (Fig. 2, loc. 6; Fig. 4, loc. 6), Blue Mountains (Fig. 2, loc. 8; Fig. 3, loc. 8), van Hauen Pass (Fig. 2, loc. 9; Fig. 4, loc. 9).

PALYNOLOGICAL ASSEMBLAGES AND ZONES

Preservation

In many of the shallow-water platform facies (Sabine Bay, Assistance, Degerböls, and Trold Fiord formations), palynomorphs are abundant and well preserved. Pollen, spores, and acritarchs are well preserved and common in grey, shaly rock types, carbonaceous shale, greenish (glauconitic) siltstone, and argillaceous carbonate; pollen and spores are often rare to absent in the carbonate facies containing little argillaceous material.

In deeper water basinal facies (grey to black shales and spiculitic cherts of the van Hauen Formation), preservation is generally poor due to the growth of sulphide crystals on the pollen and spore exines. This, in association with abundant organic matter and dark colouration of the sediments, indicates deposition under anoxic conditions.

A further factor influencing preservation is thermal maturity (Utting, Goodarzi, Dougherty, and Henderson, 1989). For example, in the shallow-water platform facies along the southern outcrop margin, the pollen and spores are yellow-orange to light brown, and the thermal maturity is low (T.A.I. 2- to 2). However, in the van Hauen Formation at van Hauen Pass, and in the Blue Mountains, pollen and spores are dark brownish black to black, and the thermal maturity is high (T.A.I. 4- to 4). This thermally altered material is sometimes unidentifiable. In contrast, the thermal maturity of the van Hauen Formation in more marginal parts of the basin is relatively low. For example, T.A.I. 3- to 3 in the Blind Fiord area (Fig. 2, loc. 4; Utting, Goodarzi, Dougherty, and Henderson, 1989), and T.A.I. 2 to 3 in many subsurface localities of the western Arctic on Melville Island (Utting, 1989).

Palynomorph zones

Palynomorph zones were established from vertical distribution data obtained in the nine outcrops studied (Appendix Figs. 1-16; Fig. 6). The vertical distribution of the zones in each outcrop is shown in Figure 4, loc. 1-9 on the right hand side of the column.

For the Permian strata studied, two concurrent range zones are formally proposed, the *Alisporites plicatus–Jugasporites compactus* Zone and the *Ahrensisporites thorsteinssonii–Scutasporites nanuki* Zone. In the Triassic strata studied, one assemblage zone is proposed (*Tympanicysta stoschiana–Striatoabieites richteri* Assemblage Zone). The zones along with their characteristic taxa are summarized below:

Alisporites plicatus–Jugasporites compactus *Concurrent Range Zone*

Characteristic taxa. Sverdrupollenites agluatus, S. connudatus, Cladaitina kolodae.

Occurrence. Throughout Sabine Bay and Assistance formations; lower part of van Hauen Formation. Present in only a few samples of the Sabine Formation is *Crinalites sabinensis*.

Ahrensisporites thorsteinssonii–Scutasporites nanuki *Concurrent Range Zone*

Characteristic taxa. Lunatisporites beauchampii, Scutasporites nanuki, Ahrensisporites floridus, A. thorsteinssonii, Piceapollenites nookapii, Striatoabieites borealis.

Occurrence. Throughout Trold Fiord and Degerböls formations; upper part of van Hauen Formation.

Tympanicysta stoschiana–Striatoabieites richteri *Assemblage Zone*

Characteristic taxa. Uvaesporites imperialis, Simeonospora minuta, Gordonispora sp., *Proprisporites pocockii, Kraeuselisporites spinosus, Falcisporites zapfei, Klausipollenites staplinii, Chordasporites* sp., *Lunatiporites noviaulensis, Striatoabieites richteri, Protohaploxypinus samoilovichii, Ephedripites steevesii, Maculatasporites* sp., *Tympanicysta stoschiana.*

Occurrence. Lower part of Blind Fiord Formation.

The lowest and highest occurrences of taxa throughout the Sverdrup Basin have been established from the data obtained in the nine outcrops, and are presented in summary form in Appendix Figure 7. The criteria on which the concurrent range zones are based requires explanation. Beds underlying the *Alisporites plicatus–Jugasporites compactus* Zone, belonging to the *Limitisporites monstruosus–Vittatina costabilis* Assemblage Zone of Artinskian age, have yet to be studied in detail, although the general assemblage characteristics are known (Utting, 1989, 1991). This older assemblage is dominated by taeniate disaccate (*Protohaploxypinus*) and polyplicate (*Weylandites* and *Vittatina*) pollen. Monosaccate pollen (*Limitisporites monstruosus*) are present, and trilete spores are rare. The abrupt and marked difference in taxa in these two assemblages suggests a hiatus (part of Kungurian and part of Artinskian?), or a marked climatic change — or a combination of both. The possibility of a hiatus is also suggested by data from other fossil groups (e.g., conodonts), and the presence of a major sequence boundary at the base of the Sabine Bay Formation (Beauchamp et al., 1989b; Beauchamp, in press, a). Additional evidence in favour of climatic change includes differences in rock types and biota at the boundary (Beauchamp, in press, b; see Paleoclimate and paleoenvironment).

A number of species have their lowest occurrence at the base of the *Alisporites plicatus–Jugasporites*

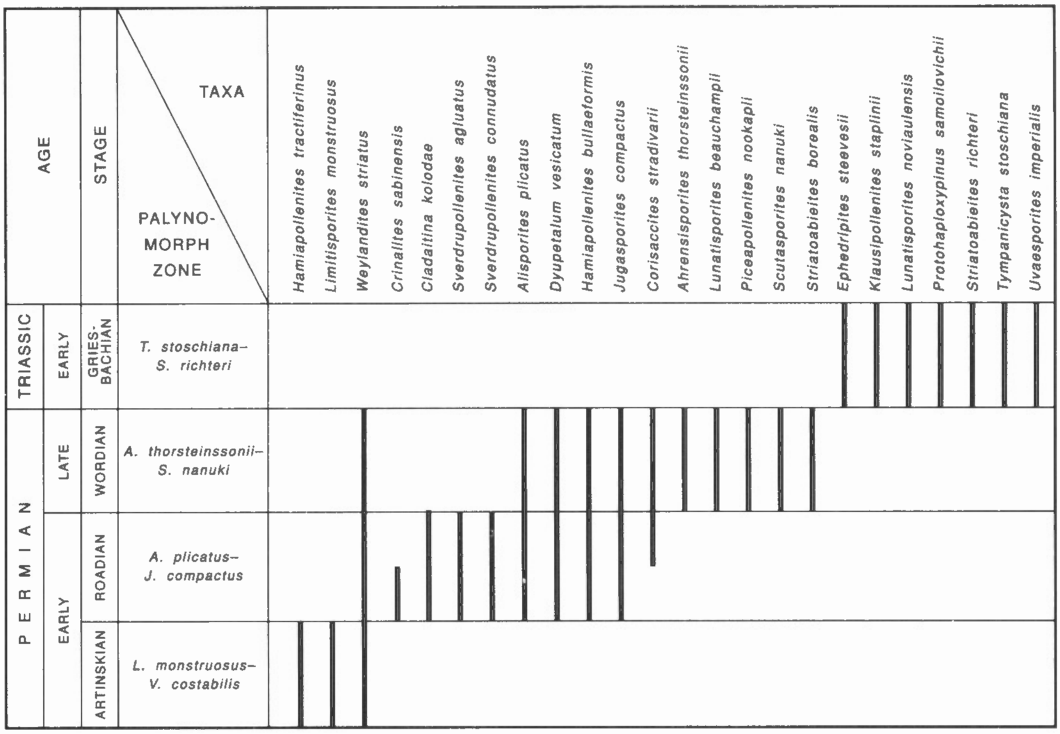

Figure 6. *Occurrence of stratigraphically significant taxa in* ***Limitisporites monstruosus–Vittatina costabilis, Alisporites plicatus–Jugasporites compactus, Ahrensisporites thorsteinssonii–Scutasporites nanuki,*** *and* ***Tympanicysta stoschiana–Striatoabieites richteri*** *zones.*

compactus Zone. However, if a hiatus were present, the base of this zone may not coincide with the first appearance of these species elsewhere in the circumpolar region — some species may be present in older rocks elsewhere. Similarly, if a hiatus exists in the marginal facies of the basin between the Trold Fiord and the Blind Fiord (representing the Capitanian?, Dzhulfian, and Changhsingian), then the "highest occurrence" of some species in the *A. thorsteinssonii-S. nanuki* Zone, which is based largely on data from this facies, may be apparent rather than real. The top of the *A. plicatus-J. compactus* Zone, and the base of the *A. thorsteinssonii-S. nanuki* Zone, are based on the lowest and highest occurrences of certain taxa, respectively, and according to these criteria they are concurrent range zones. Assemblages from the overlying Griesbachian beds of the Blind Fiord Formation (*Tympanicysta stoschiana-Striatoabieites richteri* Assemblage Zone) are markedly different from the Permian assemblages (Figs. 6, 7). However, as only the lowest beds have been studied, the vertical distribution of taxa is unknown; this zone is therefore termed an assemblage zone.

AGE INTERPRETATIONS OF PALYNOMORPH ZONES BASED ON MARINE FAUNA

In the following section, the ages given for the palynomorph zones are based on the marine fauna, especially ammonoids, summarized above (Fig. 4, locs. 2-5, 7, 8). Unfortunately, in many of the units sampled, ammonoids are rare; significant intervals exist where none have been found. In addition, their precise stratigraphic position in the section is not always known, as some were found in talus rather than *in situ*. More detailed sampling has been carried out for conodonts, but other than the initial work of Henderson (1981) on the Assistance and Trold Fiord formations in northern Ellesmere, and work summarized by Beauchamp et al. (1989a, b), most of the detailed data from the sections described in the present paper are unpublished. Thus, conodont information data summarized in Figure 4 are mainly from unpublished Geological Survey of Canada reports or personal communication (e.g., Henderson, pers. comm.). The corals have not yet been studied in detail

(Bamber, pers. comm., 1993), and the brachiopods, although described and illustrated in a preliminary fashion, have not been studied in a modern taxonomic context.

From the data so far available the ages of the zones are as follows:

Alisporites plicatus–Jugasporites compactus Concurrent Range Zone: Roadian.

Ahrensisporites thorsteinssonii–Scutasporites nanuki Concurrent Range Zone: Wordian.

Tympanicysta stoschiana–Striatoabieites richteri Assemblage Zone: Griesbachian.

COMPARISON OF PERMIAN AND TRIASSIC ASSEMBLAGES

Permian and Triassic assemblages differ markedly from one another, but have some important features in common. Many of the same pollen genera are present in both the *Ahrensisporites thorsteinssonii–Scutasporites nanuki* and the *Tympanicysta stoschiana–Striatoabieites richteri* zones.

A number of genera appear for the first time in the lowest Triassic, including *Chordasporites, Ephedripites, Klausipollenites, Simeonospora, Tympanicysta, Proprisporites*, and *Uvaesporites*. Furthermore, a number of genera, commonly present in the Permian, do not continue into the Triassic, e.g., *Ahrensisporites, Cordaitina, Corisaccites, Dyupetalum, Hamiapollenites, Sverdrupollenites, Vittatina*, and *Weylandites*. In contrast, some genera occur in both the Permian and the Triassic, e.g., *Protohaploxypinus, Striatoabieites, Lunatisporites, Cycadopites, Kraeuselisporites*, and *Gordonispora*. Significant suprageneric quantitative differences also exist between Permian and Triassic genera (Fig. 7). For example, in the Permian, polyplicate pollen are common, whereas monosaccate pollen are consistently present in small amounts, and monosulcates occur rarely in some beds. The lowest Triassic beds however, contain fungal cysts (*Tympanicysta stoschiana*), but lack monosaccate pollen; polyplicate and monosulcate pollen are rare. These differences may partly reflect the age difference between the two units, but may also be a response to climatic differences between the Wordian and the Griesbachian.

COMPARISON WITH SELECTED LOCALITIES AND AGE INTERPRETATIONS BASED ON PALYNOLOGICAL DATA

Localities believed to have been in the same macrofloral province as the Sverdrup Basin in Roadian to Griesbachian time are discussed first. Although no macroflora specimens are available, the Sverdrup Basin is assigned to the Permian Subangaran province of Meyen (1987), because the microflora is similar to those of the Pechora Basin and Subangara areas of Russia and Kazakhstan (Utting and Piasecki, in press). Comparisons are also made with selected localities in other macrofloral provinces of Laurasia (Angara, Euramerica, Cathaysia), and Gondwana.

Subangara

Alberta and British Columbia

In Alberta and British Columbia, assemblages described by Jansonius (1962) from the upper Belloy Formation are similar to material from the "un-named" formation or Great Bear Cape Formation of late Sakmarian to Artinskian age (Nassichuk and Wilde, 1977; Beauchamp et al., 1989a; Utting, 1989, 1991; Beauchamp, in press, a). Belloy species show limited diversity and are dominated by *Vittatina, Weylandites*, and *Protohaploxypinus*. However, the assemblages described by Jansonius (1962) from the Toad and Grayling formations in northeastern British Columbia have many features in common with the Griesbachian *Tympanicysta stoschiana–Striatoabieites richteri* Assemblage Zone and are believed to be approximately the same age.

Greenland

The *Vittatina* Association of Late Permian Dzhulfian? age (Balme, 1980a) has a low diversity of taxa, but is similar in some respects to the *Ahrensispoprites thorsteinssonii–Scutasporites nanuki* Concurrent Range Zone. Significant is the presence of *Scutasporites* sp. cf. *S. unicus* (*Scutasporites nanuki* of this paper), a characteristic taxon of the *Ahrensisporites thorsteinssonii–Scutasporites nanuki* Zone, but the Sverdrup material lacks the important species *Lueckisporites virkkiae*. The absence of *L. virkkiae* may be because the Sverdrup material is older, or because this species merely indicates the Zechstein affinities of the Greenland material. Assemblages from the Upper Permian Oksedal Member of the Schuchert

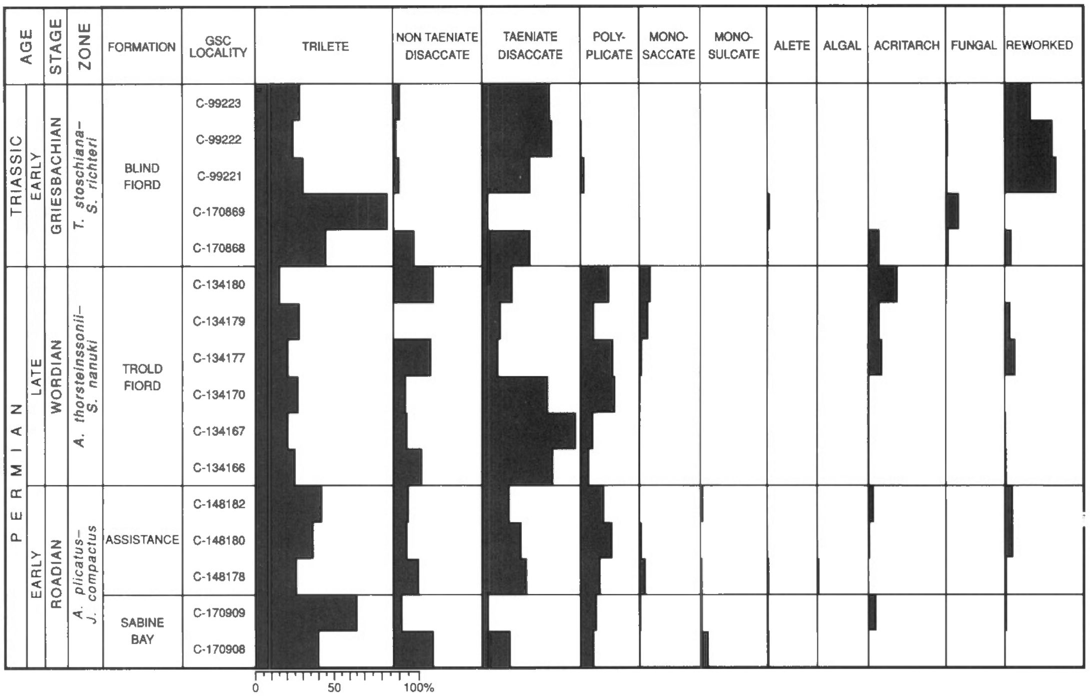

Figure 7. *Relative quantitative changes in suprageneric groups in selected samples of Sabine Bay, Assistance, Trold Fiord, and Blind Fiord formations.*

Dal Formation are younger. They contain *Tympanicysta stoschiana* and *Proprisporites* near the Permian-Triassic contact (Utting and Piasecki, in press).

The *Protohaploxypinus* Association of Greenland resembles that known from the Sverdrup Basin *Tympanicysta stoschiana-Striatoabieites richteri* Assemblage Zone of Griesbachian age, but the overlying *Lunatisporites* (*Taeniaesporites* of Balme 1980a) Association, with its high content of *Lunatisporites*, may be slightly younger than the *Tympanicysta stoschiana-Striatoabieites richteri* Assemblage Zone.

Svalbard, Bjørnøya, and Barents Sea

Assemblages described by Mangerud and Konieczny (1991) from the upper part of the Nordenskiöldbreen Formation, Gipshuken Formation, and the lowermost part of the Kapp Starostin Formation from Nordaustlandet, Svalbard, are probably older than material described here, and possibly of late Sakmarian to Kungurian age (Nakrem et al., 1992). However, Nakamura et al. (1992), suggested (based mainly on brachiopod data) that the lowermost part of the Kapp Starostin Formation is of Kungurian age. Assemblages from the basal Svenskegga Member of the Kapp Storostin Formation contain abundant acritarchs (*Micrhystridium*, *Veryhachium*, and *Unellium*). Throughout the Svenskegga Member and the overlying Hovtinden Member of Ufimian and Kazanian age, acritarchs, taeniate disaccate pollen (including *Lueckisporites virkkiae*) and polyplicate pollen (*Vittatina*) are abundant (Nakrem et al., 1992). The presence of *L. virkkiae* distinguishes this assemblage from the material described here. Griesbachian assemblages from the Barents Sea resemble those from the Sverdrup Basin (Hochuli et al., 1989).

Russia and Kazakhstan

Correlation with Permian stratotypes in the Urals is difficult because of the different zonal concepts employed by scientists in the former Soviet Union. In the C.I.S., zones are based on general characteristics of assemblages from a particular rock interval i.e., "suites", rather than the concurrent range zones — independent of lithostratigraphy — currently used in western Europe, North America, Australia, and elsewhere. The C.I.S. also uses a different taxonomic procedure (Balme, 1970; Warrington *in* Smith et al., 1974). Nevertheless, some general similarities are clear. For example, the three main assemblage groups recorded by Faddeyeva (1980) in the Permian stratotype areas in the Urals are present in the

Sverdrup Basin. The oldest group occurs in the Gzhelian and is not discussed here. The miospores of the Asselian (from the lower zone of the *Schwagerina* horizon), to the top of the Aktastinskian of the Artinskian lack variety; they are dominated by *Vittatina, Cordaitina, Potonieisporites, Florinites*, and taeniate disaccates. These characteristics are partly shared with the *Weylandites striatus–Protohaploxypinus perfectus* and *Limitisporites monstruosus–Vittatina costabilis* assemblage zones of the Sverdrup Basin (Utting, 1989).

At the base of the Baigendzhinian substage in the upper part of the Artinskian stage, the microflora becomes more diverse and new species of *Spinosisporites, Cordaitina,* and taeniate disaccates appear. This flora persists to the top of the Sheshma horizon of the Ufimian. It resembles in general terms the *Alisporites plicatus–Jugasporites compactus* Concurrent Range Zone described in this paper.

At the base of the Kazanian stage, new species appear and there is an increase in the percentage of taeniate disaccates and nontaeniate disaccates. The polyplicate pollen *Vittatina* is common, but represented by only a few species. Important are *Vesicaspora, Lueckisporites*, and *Lunatisporites* (*Taeniaesporites*). This assemblage group may also include the Tatarian, although data are not available from the actual type area, and the precise boundary between the Kazanian and Tatarian is not defined palynologically. This assemblage group differs from the *Ahrensisporites thorsteinssonii–Scutasporites nanuki* Concurrent Range Zone, as in the latter, *Vesicaspora* and *Lueckisporites* are absent.

The *Alisporites plicatus–Jugasporites compactus* Zone and the *Ahrensisporites thorsteinssonii–Scutasporites nanuki* Zone have many species in common with Kungurian, Ufimian, and Kazanian successions at Kolguyev Island in the southern Barents Sea (work in progress). Assemblages from the upper Tatarian of the Pechora Basin and Northern Russian Platform differ qualitatively and quantitatively from the Sverdrup Basin material because in the former, *Lueckisporites virkkiae* and *Lunatisporites* sp. are common (Varyukhina, 1971; Molin and Koloda, 1972; Faddeyeva, 1980; Tuzhikova, 1985; N. Koloda, L. Fefilova, and L. Medvedeva, pers. comm., 1991). Palynomorphs from the upper Kazanian stratotype on the Volga River near Pechischi (Solodukho et al., 1993), and from localities in the Kama River area are very different from those of the Barents Sea. They differ also from those in the *Ahrensisporites thorsteinssonii–Scutasporites nanuki* Zone of the Sverdrup Basin (Fig. 8). Samples from the "Podboi" bed of the Pechischinskian horizon in the stratotype of the upper Kazanian substage near Pechischi are dominated by taeniate disaccate (*Protohaploxypinus perfectus*, *Hamiapollenites tractiferinus*, and *Striatopodocarpites* spp.) and polyplicate pollen (*Pakhapites rotundus, Weylandites striatus, Vittatina connectivalis, Vittatina vittifera*). The following nontaeniate disaccate pollen are present: *Limitisporites monstruosus*, *Alisporites plicatus*, and the monosaccate pollen *Florinites luberae*, *Cordaitina rotata* (Luber) Samoilovich, 1953, *Cordaitina subrotatus* Luber var. *subisopolaris* Varyukhina, 1971. Trilete spores are rare, but include *Calamospora* sp., *Cyclogranisporites franklinii, Lophotriletes parryensis*, *Neoraistrickia* sp., and *Gondisporites* sp. Similar assemblages occur in rocks assigned to the Kazanian of the Kama River area, where in some samples *Limitisporites monstruosus* is common. *Cordaitina rugulifer* (Luber) var. *rarus* Varyukhina, 1971 is also present. Genera diagnostic of the Wordian, including *Scutasporites* and *Lunatisporites,* and species of *Ahrensisporites* are absent.

DIAGNOSTIC TAXA	KAZANIAN STRATOTYPE	*A. thorsteinssonii–S. nanuki* Zone
Protohaploxypinus perfectus	●	●
Hamiapollenites tractiferinus	●	
Striatopodocarpites spp.	●	●
Weylandites striatus	●	●
Vittatina connectivalis	●	●
Vittatina vittifera	●	●
Pakhapites rotundus	●	●
Limitisporites monstruosus	●	
Alisporites plicatus	●	●
Florinites luberae	●	●
Cordaitina rotata	●	
Cordaitina subrotatus var. *subisopolaris*	●	
Cyclogranisporites franklinii		●
Lophotriletes parryensis		●
Ahrensisporites multifloridus		●
Ahrensisporites thorsteinssonii		●
Diatomozonotriletes hypenetes		●
Grandispora jansonii		●
Piceapollenites nookapii		●
Scutasporites nanuki		●
Lunatisporites beauchampii		●
Lunatisporites arluki		●
Hamiapollenites erebi		●

Figure 8. *Comparison of stratigraphically diagnostic taxa in Kazanian stratotype and* ***A. thorsteinssonii–S. nanuki.*** *Concurrent Range Zone of the Sverdrup Basin.*

The reasons for these marked differences are not clear. One reason could be incorrect correlations. Perhaps the stratotype for the Kazanian is older than rocks assigned to the "Kazanian" in the Barents Sea area and to the Wordian of the Sverdrup Basin. Based on the Sverdrup Basin material, the assemblages more closely resemble those from the *Limitisporites monstruosus-Vittatina costabilis* Assemblage Zone of late Sakmarian to Artinskian age. Another factor could be that the stratotype near Kazan is in the Euramerican floral province rather than the Subangara province. Reconstructions by Meyen (1982, textfigs. 36, 39) suggest that this is not the case, and show that the Kazan and Kama River localities are within the Subangara area, albeit close to the border of Euramerica. If the stratotype were in the Euramerican floral province, then one would expect more similarities with the Wordian material summarized above from the Flower Pot Formation of Oklahoma, or the Kazanian and/or Tatarian Zechstein of Western Europe. The absence of *Lueckisporites virkiiae* in the Kazan material, which is dominant in both the Flower Pot Formation and the Zechstein, does not support inclusion in the Euramerican floral province. Another possibility is that due to marked climatic differences, the microflora is different. Quite clearly, the gypsiferous facies of the stratotype area was deposited in a hotter, more arid climate than that of the Trold Fiord of the Sverdrup Basin, or the Kazanian sediments in the Barents Sea area. Such a hot, dry climate is more reminiscent of the Zechstein facies of Europe. Clearly, additional work on other fossil groups is needed in the stratotype area and elsewhere before this problem can be resolved.

People's Republic of China

The assemblages that most closely resemble those of the Sverdrup Basin are from Xinjiang in northwest China (Utting and Piasecki, in press). In the late Early to early Late Permian, gymnosperm pollen are predominant (Yang et al., 1986; Hou and Wang, 1990). Main taxa comprise *Cordaitina, Hamiapollenites* and *Striatoabieites elongatus*. In the Late Permian (Kazanian), the assemblage is dominated by gymnosperm pollen including *Cordaitina uralensis, C. ornata, Hamiapollenites bullaeformis, H. tractiferinus, Striatoabieitites multistriatus, Platysaccus, Vittatina*, *Protohaploxypinus*, and *Gardenasporites*, and some pteridophyte spores including *Apiculatisporis, Kraeuselisporites* sp., and *Tuberculatisporites* sp. This assemblage differs from the *Ahrensisporites thorsteinssonii-Scutasporites nanuki* Assemblage Zone, which lacks *H. tractiferinus, Cordaitina*, and *Gardenasporites*.

In the latest Permian, there is a predominance of gymnosperm pollen in which nontaeniate pollen is most abundant e.g., *Alisporites, Pteruchipollenites*, and *Klausipollenites*. Taeniate pollen consists mainly of *Protohaploxypinus limpidus, P.* sp., and *Lueckisporites virkkiae*. *Cordaitina* is common. Pteridophyte spores are less common and include *Apiculatisporis, Limatulasporites fossulatus, Kraeuselisporites* sp., and *Lundbladispora*. The common occurrence of *Lueckisporites virkkiae* is similar to its representation in the Zechstein of western Europe, and to its occurrence in material described from the Kazanian of Alaska by Balme (1980b). Its absence from the *Scutasporites nanuki-Ahrensisporites thorsteinssonii* Assemblage Zone may be of age significance, or reflect a different climate.

Euramerica

Western Europe

Upper Permian "Zechstein" assemblages of Kazanian to Tatarian age (Visscher, 1971, 1980; Warrington, *in* Smith et al., 1974) are very different from those described in this report. For example, absent in the Sverdrup Permian material is *Lueckisporites virkkiae, Nuskoisporites dulhuntyi, Lunatisporites noviaulensis, Striatoabieites richteri*, and *Klausipollenites schaubergeri*, although *L. noviaulensis* and *S. richteri* occur in the Triassic Blind Fiord Formation.

Cathaysia

People's Republic of China

In the Lungtan Formation of South China (Ouyang and Li, 1980; Ouyang, 1982), where ammonoids indicate an early Late Permian (Dzhulfian) age, the assemblages are very different from those found in the *Ahrensisporites thorsteinssonii-Scutasporites nanuki* Zone. South China assemblages contain many genera similar to the Carboniferous and Lower Permian of Europe, e.g., *Raistrickia, Knoxisporites, Triquitrites, Ahrensisporites, Tripartites, Lycospora, Crassispora, Densosporites, Rotaspora, Proprisporites, Torispora*, and *Vesicaspora*, but in addition contain many Cathaysian or endemic elements (Ouyang, 1982).

The overlying Changhsing Formation is quantitatively monotonous, and contains mainly acritarchs. Present also are *Tympanicysta stoschiana*, acid resistant foraminiferal tests, scolecodonts and rare pollen and spores. Cathaysian elements are increasingly important, and the assemblage has little in common with those of the Sverdrup Basin (Ouyang and Utting, 1990).

Griesbachian assemblages in southeast China differ from those of the Sverdrup Basin, but some taxa occur in both, e.g., *Tympanicysta stoschiana* and *Ephedripites steevesii.*

Gondwana

The Gondwana microflora has been studied by various workers in Africa, Australia, India, Antarctica, and South America, and was reviewed by Schopf and Askin (1980), Truswell (1980) and Anderson (1981). The precise age of many Gondwana rocks is uncertain because of the lack of marine fossils at many localities and in many horizons. In many areas, age determinations are based on data from plant macrofossils, pollen and spores, and vertebrates. Although these are extremely useful for biostratigraphic correlation within and between sedimentary basins, precise correlation with the stratotypes of Russia and Kazakhstan remains largely uncertain.

A number of paleobotanical similarities exist between certain parts of northern Gondwana and selected areas of Laurasia. Meyen (1982) believed the similarities between Gondwana and Subangara of Meyen (1987) were due to parallelism of the parent flora; the abundant taeniate and nontaeniate disaccate pollen of the Subangaran area were derived from pteridosperms (mostly Peltaspermales) and not conifers as often stated. Typical *Glossopteris* flora were produced by another group of pteridosperms called the Glossopteridales, thus the parent flora was different, but related. Although parallelism may have been a factor in some cases, so many pollen and spore genera occur in both the Subangaran and Gondwanan provinces that it seems probable that some plants were more cosmopolitan than one might suspect from the limited macrofloral record (Utting and Piasecki, in press).

Whatever the explanation, there are a number of palynological features in common between the Permian Sverdrup Basin material and those parts of Gondwana that may have occupied a similar latitude and climatic belt in the Southern Hemisphere as the Sverdrup Basin did in the north. According to paleogeographic reconstructions of Lottes and Rowley (1990), Central Africa occupied just such a southern latitude. Features in common with the Sverdrup Basin assemblages include a dominance of monosaccate pollen in uppermost Carboniferous to lower Lower Permian rocks, but this is also commonly a feature of these rocks in other parts of Gondwana (Truswell, 1980). In both areas, there is an increasing abundance of disaccate pollen throughout the Lower Permian.

Many similarities occur at the generic level between the *Alisporites plicatus–Jugasporites compactus* Zone and the Ecca assemblages of Zambia (Utting, 1978). For example, common to both localities are *Acanthotriletes, Apiculatisporis, Cyclogranisporites, Leiotriletes, Lophotriletes, Neoraistrickia, Punctatisporites, Raistrickia, Verrucosisporites, Gondisporites, Laevigatosporites, Alisporites, Pityosporites, Vitreisporites, Hamiapollenites, Protohaploxypinus, Striatopodocarpites Cycadopites, Vittatina*, and *Weylandites*. In the Upper Permian in Central Africa in the *Cistecephalus* vertebrate zone of Zambia (Utting, 1979) and Zimbabwe (Falcon, 1975), and the *Cistecephalus* and *Daptocephalus* zones of South Africa (Anderson, 1977), the assemblages differ from the *Ahrensisporites thorsteinssonii–Scutasporites nanuki* Concurrent Range Zone. Nevertheless, present in both areas are *Vittatina, Weylandites, Protohaploxypinus, Alisporites, Striatopodocarpites*, and *Corisaccites*, but "Gondwana" genera such as *Dulhuntyispora, Densipollenites* and *Guttulapollenites* are lacking in the Sverdrup Basin. No marine fauna are known in the Karoo of Central Africa, but in Namibia in southwest Africa, the goniatite *Eoasianites* sp. and bivalve *Eurydesma mytiloides* (Martin et al., 1970) occur in marine Dwyka beds (Upper Carboniferous and Lower Permian). Brachiopods and ammonoids occur in the Upper Permian of East Africa in Madagascar in the lower Sakamena Formation. Furnish (1966) listed a number of ammonoids, including *Xenaspis* in lower beds, and *Cyclolobus* in the upper. He suggested a Capitanian to Chhidruan age for the marine strata in Madagascar. These beds may therefore be slightly younger than the Wordian *Ahrensisporites thorsteinssonii–Scutasporites nanuki* Zone of the Sverdrup Basin. These lower Sakemena Formation beds, with Upper Permian palynomorph assemblages similar to those of the *Cistecephalus* and *Daptocephalus* zones of central and southern Africa, are dominated by the taeniate disaccate (*Guttulapollenites hannonicus* and *Lueckisporites virkkiae*) and polyplicate (*Vittatina*) pollen (Goubin, 1965; Wright and Askin, 1987; Anderson, 1977; Utting, 1979). The *Daptocephalus* zone may be of similar age to the Late Tatarian, where *Daptocephalus* was recorded (Lozovsky, 1991), but Late Tatarian palynological assemblages are poorly known.

The lowermost Triassic of Madagascar (Wright and Askin, 1987) contains a typical Gondwana assemblage including trilete cavate spores (*Densoisporites, Lundbladispora, Kraeuselisporites*) and taeniate disaccate pollen (*Lunatisporites* spp.). This assemblage differs from the *Tympanicysta stoschiana–Striatoabieites richteri* Assemblage Zone that lacks *Densoisporites* and *Lundbladispora*.

In Eastern and Western Australia, where a number of palynological zones have been established, there is stratigraphic control from marine fauna at some horizons (Archbold and Dickins, 1991). Foraminifers, crinoids, bryozoans, molluscs, and brachiopods of Asselian age occur in the Grant Formation of the Canning Basin of Western Australia (Foster and Waterhouse, 1988). Correlation of the pollen and spore zones between Eastern and Western Australia is not certain, but broad correlations are possible (Kemp et al., 1977; Truswell, 1980; Backhouse, 1991). Only the zones from the Canning Basin of Western Australia, of approximately similar age to the Sverdrup Basin material, have been discussed in any detail here. Assemblages of Artinskian age belong to units IV to VI of Kemp et al. (1977). Unit IV of Aktastinian (early Artinskian) age (Backhouse, 1991), has moderate diversity; *Indotriradites* (a genus similar to *Kraeuselisporites*) is common, as are other spores of lycopsid aspect, *Microbaculispora tentula* Tiwari is abundant. In the Sverdrup Basin, trilete spores are rare in the Artinskian (*Limitisporites monstruosus*–*Vittatina costabilis* Assemblage Zone). In Unit V of late Artinskian age (Backhouse, 1991), disaccate pollen is abundant, especially haploxylonoid, taeniate forms and the nontaeniate *Scheuringipollenites maxima* (Hart) Tiwari and *Scheuringipollenites ovatus* (Balme and Hennelly) Foster (Kemp et al., 1977). *Marsupipollenites triradiatus* is common. *Marsupipollenites* and *Scheuringipollenites* are absent in the Sverdrup Permian material, but haploxylonoid taeniate forms (*Protohaploxypinus*) are common. Unit VI Baigendzhinian (late Artinskian) is similar to unit V except there is a sudden increase in *Granulatisporites trisinus* Balme and Hennelly, a species not found in the Permian of the Sverdrup Basin. In unit VII of ?Ufimian age (Backhouse, 1991), taeniate disaccate pollen grains including haploxylonoid and diploxylonoid forms are dominant. In Unit VIII, of Guadalupian age, a number of species are common including *Weylandites lucifer* (Bharadwaj and Srivastava) Foster, *Vitreisporites pallidus* (Reissinger) Nilsson, nontaeniate pollen such as *Falcisporites*, and trilete spores resembling *Lophotriletes novicus* Singh, and *Kraeuselisporites rallus* Balme (Kemp et al., 1977). *Vitreisporites pallidus* and species closely related to *W. lucifer* are present in the Sverdrup material. In general, the Australian assemblages differ from the Sverdrup Basin assemblages at the specific level, but there are some genera in common. However, *Dulhuntyispora*, *Scheuringipollenites* and *Marsupipollenites* are lacking from the Sverdrup Basin assemblages.

In the Permian and Triassic of West Pakistan, there are many genera in common with the Sverdrup Basin, but like other Gondwanan assemblages, few species occur in both localities. Late Permian assemblages of West Pakistan are similar to those from Madagascar, and Triassic assemblages resemble those of the Perth Basin, Western Australia (Balme, 1970).

PALEOCLIMATE AND PALEOENVIRONMENT

Qualitative and quantitative palynological data at the suprageneric level from selected localities (Fig. 7) were used to help determine paleoclimates. Paleoenvironments were determined from overall assemblage composition, and the relative proportions of organic matter constituents.

PALEOCLIMATE

According to recent paleogeographic reconstructions (Lottes and Rowley, 1990), the Sverdrup Basin in the Early Permian was situated between 30° and 45° north; the climate was therefore probably warm. Ziegler (1990) proposed that the region was part of a desert in the Sakmarian and Kazanian, and this is supported by the palynological data (Utting, 1989). Beauchamp (in press, b) suggested that the climate evolved toward much colder conditions from the Early to the Late Permian. He pointed out that this amount of change was greater than would be expected from the 10 to 15° of northerly migration inferred for Pangea during the Permian. In the beds of Artinskian age underlying the *Alisporites plicatus*–*Jugasporites compactus* Concurrent Range Zone, there is evidence to suggest that an arid climate prevailed during deposition. The palynomorph assemblages lack qualitative diversity and are dominated by taeniate disaccate and polyplicate pollen (Utting, 1989, 1991). Beauchamp (in press, b) presented data from the biotic succession (Bryonoderm–extended) and lithological criteria (pseudomorphs after gypsum, redbeds and caliche) that suggest a dry, temperate, warm climate in the Artinskian.

In the *Alisporites plicatus*–*Jugasporites compactus* Concurrent Range Zone, the variety and abundance of pteridophyte spores, and gymnosperm and pteridosperm pollen of the Sabine Bay Formation (Figs. 6, 7) suggests that the assemblages were derived from a diverse vegetation growing in a humid climate; thin coaly and carbonaceous shale intercalations in parts of the Sabine Bay Formation support this suggestion (Utting, 1989). Beauchamp (in press, b) proposed a humid temperate cold climate, based on the biotic (Bryonoderm) succession and lithological criteria (coal seams). There are fewer trilete spores and more taeniate disaccate pollen (Fig. 7) in assemblages from the Assistance Formation than from the Sabine Bay Formation. These slight differences may suggest a trend toward less humid conditions, or they could be the result of differential transport between the two facies.

In the *Ahrensisporites thorsteinssonii–Scutasporites nanuki* Concurrent Range Zone, some samples in the Trold Fiord Formation contain abundant taeniate disaccate and polyplicate pollen (Fig. 7) possibly indicating a trend to a more arid climate on land. Other samples contain common trilete spores, suggesting that there may have been humid periods. Alternatively, these variations could be the result of differential transport and sorting of the palynomorphs. Beauchamp (in press, b) proposed a return to arid conditions in view of the lack of coal seams, and the reappearance of red-weathering units in the Trold Fiord Formation. In the Trold Fiord Formation, he also recorded the presence of dropstones, and suggested that these were dropped from floating ice. According to Beauchamp (in press, b) there is evidence of post-Kazanian deposition of spiculitic chert (Hyalosponge association) and Bryonoderm carbonates. These associations may have been deposited under a permanent to semipermanent ice cover in a dry polar climate. One such section where spiculitic chert occurs is the upper part of the van Hauen Formation at Blind Fiord (Fig. 2, loc. 4; Fig. 4, loc. 4) that contains a palynomorph assemblage assigned to the *Ahrensisporites thorsteinssonii–Scutasporites nanuki* Concurrent Range Zone. If this unit was deposited in a dry polar climate, the extreme cold could explain the relative lack of pollen and spore species diversity. However, the lack of diversity may be partly due to the basinal facies being far from land. Facies-controlled diversity is supported by the fact that not even Roadian parts of the van Hauen Formation have diverse assemblages. If the climate were polar, one might anticipate a closer similarity to the Upper Permian assemblages from the colder parts of Angara where monosulcates (mainly *Cycadopites*) become abundant (Dibner, 1971). Monosulcates, however, are rare in the Sverdrup Basin material.

In the Griesbachian, Embry (1991) suggested that during the earliest Triassic, the Canadian Arctic Archipelago was approximately 40°N, and based on lithological criteria (red shale and siltstone of overbank origin), the climate was probably seasonally dry, hot, subtropical, savanna-type. In some of the meandering-river sediments, rare paleosols are indicated by massive horizons of rhizoliths (root casts) and a sparse amount of small (1 cm) carbonate nodules, the latter suggesting poorly developed caliches of a semiarid paleoclimate (Devaney, 1991).

Near the base of the Griesbachian at some localities, assemblages are dominated by a single species of the trilete spore *Uvaesporites imperialis*, suggesting the possibility of arid conditions (see also Paleoenvironment section below). Many samples contain assemblages with abundant taeniate disaccate pollen, which may indicate a vegetation growing on the nearby land well adapted to periods of aridity.

PALEOENVIRONMENT

In the Sabine Bay Formation, the samples contain mainly pollen and spores (Fig. 7), but in some shaly beds spinose acritarchs (*Micrhystridium*) and rare scolecodonts (jaw apparatus of polychaete worms) are present suggesting a probable nearshore shallow marine environment, such as a delta front or estuary. *Crinalites sabinensis*, the possible algal spore or cyst, has been found rarely, but exclusively, in this formation. The organic matter consists of mainly woody and coaly fragments (50 to 75%), some exinous fragments, and rare finely dispersed debris. The woody and coaly fragments are medium to large (up to 200 μm).

In the Assistance Formation, the samples contain palynomorph groups and organic matter similar to those of the Sabine Bay Formation (Appendix Fig. 7, Fig. 19) although *Crinalites sabinensis* is absent (Fig. 6). Spinose acritarchs include *Micrhystridium*, *Unellium*, and *Veryhachium*.

In the Trold Fiord Formation, the samples contain palynomorph groups and organic matter proportions similar to those of the Assistance Formation, although in some samples, spinose acritarchs are slightly more common, suggesting periods of deeper water and/or greater distance from land. There is also a lack of sulcate grains, although the environmental significance of this is not known. In the Degerböls Formation, there is a similar abundance of acritarchs. The organic matter does not show any major differences from that described above, although the proportion of finely dispersed organic debris is relatively high (approximately 30%). In the type Degerböls Formation, there is an abundance of coaly (fusain) fragments in the lower cherty units.

In the van Hauen Formation, which is in part the lateral equivalent of the Sabine Bay, Assistance, Degerböls, and Trold Fiord formations, spores and pollen are rare. Acanthomorph acritarchs are more common (e.g., *Micrhystridium*, *Veryhachium*, and *Unellium*). Spores and pollen, and to a lesser extent acritarchs, are often corroded by the growth of pyrite on the exines, indicative of an anoxic environment at the sediment–water interface. The organic matter consists of abundant amorphous (finely dispersed organic debris), common coaly fragments, and less common woody and exinous material. The abundance of large angular coaly or fusain fragments, and the lack of exinous and woody fragments, suggest significant distance from land. This may be because fusain (or charcoal) floats, and may have been transported a considerable distance prior to deposition in relatively deep water.

In the Blind Fiord Formation, the organic matter varies significantly in composition from one locality to another, reflecting the different environments present during early Triassic transgression. Most samples contain extremely variable proportions of amorphous, fungal, exinous, woody, and coaly fragments; the coaly fragments are mainly angular, but include some more abraded rounded particles. In some samples (e.g., C-170869 from Fosheim Peninsula), fungal material (*Tympanicysta stoschiana*) is common (approximately 10%). Small spinose acritarchs (*Filisphaeridium setasessitante, Wilsonastrum colonicum*) are common in some Blind Fiord samples, possibly reflecting a more open-marine paleoenvironment. Near the base of the formation, some palynomorph assemblages are dominated by a single trilete spore species (*Uvaesporites imperialis*), suggesting possible deposition in a nearshore environment such as a coastal marsh (Ouyang and Utting, 1990).

Reworking (generally 2 to 8% in most samples) is a common feature of all Permian assemblages studied from the Roadian and Wordian (Fig. 7). Most of the reworked material is of late Devonian age, with, less commonly, material from the Early Carboniferous (Viséan). Reworking of Permian material into the lowest Triassic was rare, in spite of the significant hiatus between the two systems, and the fact that a major transgression took place at the beginning of the Triassic. Nevertheless, Late Devonian reworking is common, and comprises up to 34% in one sample (Fig. 7). The fact that reworking is present in most Permian and lowest Triassic samples indicates that erosion of the Franklinian Mobile Belt (especially late Devonian rocks), and less commonly of the oldest Carboniferous rocks (Viséan) of the Sverdrup Basin, took place from the Roadian to the Griesbachian. Erosion of late Devonian rocks appears to have been especially active in the Griesbachian. In some cases, for example, in the deep water basinal facies of the van Hauen Formation, preservation of reworked material is better than that of the *in situ* material, which is corroded. This is probably due to the fact that the spores were enclosed in indurated rock particles, and were thus protected from the growth of sulphide crystals. In shallow water facies, where *in situ* and reworked material are well preserved, some of the latter may be slightly darker, although this is because many of the taxa recorded have thicker exines. In a few cases, it is difficult to determine if some simple trilete spore species are reworked, but have not been recorded in the Devonian and Viséan literature, or whether they are in fact Permian, for example, *Convolutispora perplexa* sp. nov., described in the systematic palynology section.

CONCLUSIONS

1. Two palynological zones have been established for the Permian; the older is Roadian, and the younger Wordian and possibly younger.

2. One palynological zone of Griesbachian age was established for the Triassic.

3. No evolutionary lineages were apparent in the taxa described from the Permian. Thus the "lowest" and "highest" occurrence of taxa could be the result of environmental or climatic changes. The true stratigraphic ranges can ultimately only be accurately determined when data are available from numerous other circumpolar Upper Paleozoic and Lower Mesozoic basins within the Subangaran floral province.

4. Permian (Wordian) and Triassic (Griesbachian) palynomorph assemblages are very different qualitatively and quantitatively, reflecting the hiatus present and possible climatic changes between the Wordian and the Griesbachian.

5. Palynomorphs from the uppermost Permian (Wordian and post-Wordian?) spiculitic chert unit near the basin centre are poorly preserved and lack diversity. Other than sponge spicules and small foraminifers, palynomorphs are the only fossils recorded. The palynomorph assemblages contain mostly long-ranging species, although some diagnostic taxa characteristic of the Wordian *Ahrensisporites thorsteinssonii–Scutasporites nanuki* Concurrent Range Zone are rare. Until Capitanian and younger Permian assemblages are known, however, it is not possible to determine more precisely the age of these uppermost Permian beds.

6. Paleoclimatic interpretations from the palynological data indicate that the climate, which was humid in the Roadian, became increasingly arid in the Wordian, although there were periods of humidity. In the Griesbachian, the climate was probably arid.

7. Palynofacies data support the anticipated variety of marine sedimentary facies from the basin margin to the basin centre in the Permian. Local nonmarine environments may have existed during deposition of the Sabine Bay Formation. In the Griesbachian, the quantitative variety in the assemblages may reflect the diverse environments that were colonized during the basal Triassic transgression. Dominance by a single species of the trilete spore *Uvaesporites imperialis* may indicate that in some intervals these environments included coastal marsh.

8. Correlation with the stratotypes in the Urals and adjacent areas is hampered by the fact that data are not available, or are difficult to interpret due to different taxonomic treatment. Different zonal concepts have also been applied (Utting and Piasecki, in press). In the case of the Kazanian, stratotype assemblages were very different from Wordian (Kazanian) assemblages of the Sverdrup Basin. There are many similarities with assemblages described by Varyukhina (1971) and Molin and Koloda (1972) from Timan-Pechora and the northern Russian platform. Comparison with these areas indicates that the *Alisporites plicatus-Jugasporites compactus* Concurrent Range Zone is generally most similar to the Russian Ufimian; the *Ahrensisporites thorsteinssonii-Scutasporites nanuki* Concurrent Range Zone to the Kazanian to early Tatarian; and the *Tympanicysta stoschiana-Striatoabieites richteri* Assemblage Zone to the Induan. The presence in the *Ahrensisporites thorsteinssonii-Scutasporites nanuki* Concurrent Range Zone of taxa such as *Lunatisporites arluki* and *L. beauchampii*, are reminiscent of the Tatarian species identified by Varyukhina (1971) as *Taeniaesporites substriata nomen nudum* (see Systematic Palynology section).

9. The *Ahrensisporites thorsteinssonii-Scutasporites nanuki* Concurrent Range Zone has some features in common with post-Wordian assemblages elsewhere in the world. The distincitive genus *Scutasporites* was recorded by Balme (1980a) from possible Dzhulfian beds at Kap Stosch in East Greenland.

SYSTEMATIC PALYNOLOGY

All Permian pollen and spore taxa observed during the course of this study are described in the Systematic Palynology section and illustrated in Plates 1-9. Lower Triassic palynomorphs (Pl. 10) were not studied in detail and, with the exception of *Uvaesporites imperialis* (Pl. 10, figs. 1-3) and *Simeonospora minuta* (Pl. 10, figs. 6, 7) were not described or discussed. Acritarchs have been identified mainly to generic level only, and were not studied in detail; scolecodonts and scytinasciae (acid resistant tests of foraminifers) were recorded but not described (Appendix Figs. 8-16). In the descriptions given below the GSC locality number is followed by the slide number, stage co-ordinates and GSC type number, e.g., C-126264, 3, 19.2 x 95.7, GSC 105392.

All holotypes and figured specimens are in the collections of the Geological Survey of Canada, Ottawa.

The classification used is based on that of various authors, especially Potonié and Kremp (1954), Dybová and Jachowicz (1957), Dettmann (1963), and Neves and Owens (1966).

Anteturma SPORITES H. Potonié, 1893

Turma TRILETES Reinsch emend.
Dettmann, 1963

Suprasubturma ACAVATITRILETES
Dettmann, 1963

Subturma AZONOTRILETES Luber emend.
Dettmann, 1963

Infraturma LAEVIGATI (Bennie and Kidston)
R. Potonié, 1956

Genus *Calamospora* Schopf, Wilson,
and Bentall, 1944

Type species. Calamospora hartungiana Schopf in Schopf, Wilson, and Bentall, 1944.

Calamospora brunneola Virbitskas, 1983

Plate 1, figures 1-3

Synonymy. Calamopsora brunneola Virbitskas, 1983, p. 135, 136, Pl. 37, figs. 2-6.

Figured specimens. C-126264, 3, 19.2 x 95.7, GSC 105392; C-126264, 3, 26.8 x 106.0, GSC 105393; C-126264, 3, 43.3 x 110.0, GSC 105394.

Occurrence. Sabine Bay, Assistance, Degerböls, Trold Fiord, and van Hauen formations.

Description. Spores radial trilete. Amb circular to subcircular in unfolded specimens. Laesurae one quarter to one third of radius, straight. Darkened contact area in some specimens. Exine thin (0.5 μm) laevigate to minutely granulate. Lateral and oblique compression common with haptotypic mark off-centre; secondary folding of exine common.

Dimensions. (10 specimens), 34 to 53 μm, mean 44 μm.

Remarks. Virbitskas (1983) described *C. brunneola* from Artinskian–Kazanian beds of the Pechora Basin. The size range given is 37–53 μm, thickness of exine 0.5–1 μm and length of laesurae is one third of radius. *Calamospora breviradiata* Kosanke, 1950 differs in that it has distinct and elevated labra and is generally larger (52–71 μm). *Calamospora microrugosa* (Ibrahim) Schopf, Wilson, and Bentall, 1944 and *C. parva* Guennel, 1958 are similar, but have longer laesurae.

Genus *Leiotriletes* (Naumova) Potonié and Kremp, 1954

Type species. Leiotriletes sphaerotriangulus (Loose) Potonié and Kremp, 1954.

Leiotriletes ulutus sp. nov.

Plate 1, figures 4–8

Holotype. C-126269, 4, 39.7 x 103.0, GSC 105395.

Figured specimens. C-126269, 3, 33.0 x 100.5, GSC 105396; C-79879, 3a, 9.0 x 98.0, GSC 105397; C-134172, 3, 30.2 x 101.7, GSC 105398; C-161948, 3, 55.5 x 94.4, GSC 105399.

Occurrence. Sabine Bay, Assistance, Trold Fiord, Degerböls, and van Hauen formations.

Diagnosis. Spores radial, trilete. Amb subtriangular with straight to concave inter-radial margins. On some specimens, angular junction with flatly rounded to convex radial extremities, thus forming prominent 'shoulders' approximately 20 μm apart. Laesurae distinct, straight, length approximately three quarters of radius. Exine laevigate to punctate, approximately 0.5 μm thick. Contact area slightly darker than remainder of proximal surface. This darker area often subtriangular with apices at tips of laesurae, strongly concave sides. Surface laevigate. Exine approximately 1 μm thick.

Dimensions. (40 specimens), 33 to 49 μm, mean 41 μm.

Remarks. There is continuous variation between specimens with straight sides and those with concave sides; some extreme forms of the latter could arguably be included in the genus *Waltzispora* Staplin, 1960, but subdivision into two taxa would be very subjective and serve little purpose. Concave-sided specimens differ from *W. albertensis* Staplin, 1960, in that the former have less tangential expansion at the radial margins. *Leiotriletes subintortus* (Waltz) Ishchenko, 1952 var. *rotundatus* Waltz, 1941 lack the darkened contact area. The specimens described here resemble *Trachytriletes* sp., illustrated, but not described, by Varyukhina (1971, Pl. 7, fig. 1).

Derivation of name. Apices resemble the *ulut*, Inuit, a curved knife used by Inuit people.

Genus *Punctatisporites* (Ibrahim) Potonié and Kremp, 1956

Type species. Punctatisporites punctatus Ibrahim, 1933.

Punctatisporites glaber (Naumova) Playford, 1962

Plate 1, figures 9, 10

Synonymy. Puncatatisporites glaber (Naumova) Playford, 1962, p. 576, 577, Pl. 78, figs. 15, 16.

Figured specimens. C-99250, 3, 15.5 x 108.8, GSC 105400; C-161961, 3, 10.1 x 94.5, GSC 105401.

Occurrence. Sabine Bay, Assistance, Trold Fiord, and Degerböls formations.

Description. Spores radial, trilete. Approximately circular to rounded subtriangular trilete spores. Laesurae straight, unornamented, extend approximately three quarters radius of spore. Exine relatively thick (1–2 μm), laevigate.

Dimensions. (40 specimens), 35 to 66 μm, mean 46 μm.

Infraturma APICULATI (Bennie and Kidston) Potonié, 1956

Subinfraturma GRANULATI Dybová and Jachowicz, 1957

Genus *Cyclogranisporites* Potonié and Kremp, 1956

Type species. Cyclogranisporites leopoldi (Kremp, 1952) Potonié and Kremp, 1954.

Cyclogranisporites franklinii sp. nov.

Plate 1, figures 11–13

Holotype. C-126264, 3, 26.5 x 99.1, GSC 105402.

Figured specimens. C-126264, 3, 21.0 x 101.6, GSC 105403; C-126261, 3, 43.4 x 95.1, GSC 105404.

Occurrence. Sabine Bay, Assistance, Degerböls, Trold Fiord, and van Hauen formations.

Diagnosis. Spores radial, trilete. Amb subcircular, but generally irregular due to secondary folding. Laesurae straight, extending approximately seven eighths of radius, generally bordered by labra with irregular margins, each 1 μm wide. Ornament of grana and coni 0.25 to 1 μm high, and 0.5 to 1 μm apart. Exine 0.5 μm thick. Curvaturae imperfectae on some specimens.

Dimension. (25 specimens), 35 to 54 μm, mean 46 μm.

Remarks. Differs from *Apiculatisporis melvillensis*, which has a thicker exine and an ornament of more widely spaced scattered spinae, coni, and bacula. *Cyclogranisporites commodus* Playford, 1964 lacks labra, and has an ornament of grana only. *Azonotriletes polygyrenus* Luber and Waltz, 1941 differs in having laesurae extending one half the radius and lacking labra. *Apiculatisporites dilucidus* (McGregor) McGregor, 1964 from the Upper Devonian of Melville Island, differs in that it is generally larger (51–67 μm), has a thicker exine (1 μm), and coarser ornament, but the species may be closely related. It is possible that the specimens described here are reworked from the Devonian.

Derivation of name. Sir John Franklin, who led an ill-fated expedition (1845–1847) to the Canadian Arctic Archipelago; tragically there were no survivors.

Genus *Granulatisporites* (Ibrahim) Potonié and Kremp, 1954

Type species. Granulatisporites granulatus Ibrahim, 1933.

Granulatisporites munitus sp. nov.

Plate 1, figures 14–16

Holotype. C-134170, 3, 19.6 x 99.6, GSC 105405.

Figured specimens. C-134171, 3, 7.8 x 93.7, GSC 105406; C-134171, 3, 20.0 x 95.9, GSC 105407.

Occurrence. Sabine Bay, Assistance, and Trold Fiord formations.

Diagnosis. Spores radial, trilete. Amb rounded-triangular, sides straight to slightly concave to slightly convex. Laesurae extend to approximately three quarters of radius, trilete, often gaping. Ornament on proximal and distal surfaces of closely spaced grana less than 0.25 to 0.5 μm high and has a basal diameter of less than 0.25 to 0.5 μm. Exine thick (2.5 μm).

Dimensions. (10 specimens), 36 to 44 μm, mean 39 μm.

Remarks. Differs from *Leiotriletes nigrans* Naumova, 1953, by its ornament of grana and thick exine. Differs from *Leiotriletes egregius* Virbitskas, 1983, which is smooth or punctate.

Derivation of name. Latin, *munitus*, fortified.

Granulatisporites sp. A

Plate 1, figures 17, 18

Figured specimen. C-161956, 3b, 37.7 x 109.4, GSC 105408; C-161956, 3b, 34.7 x 111.0, GSC 105409.

Occurrence. Trold Fiord Formation.

Diagnosis. Spore radial, trilete. Amb rounded triangular, sides convex. Laesurae simple, straight, extend almost to equator; bordered by secondary folds up to 6 μm high. Exine 1 μm thick. Ornament of small grana (0.25 μm or less in diameter and less than 0.25 μm high) on proximal and distal surfaces. Space between grana 0.5 to 1 μm.

Dimensions. (2 specimen), 34 to 40 μm.

Remarks. Granulatisporites sp. differs from *G. munitus* in having a thinner exine and smaller grana. *Granulatisporites trisinus* Balme and Hennelly, 1956, is larger (45–110 μm), and has larger grana (1 μm diameter and 1 μm apart).

Genus *Waltzispora* Staplin, 1960

Type species. Waltzispora lobophora (Waltz) Staplin, 1960.

Waltzispora sp. A

Plate 1, figure 19

Figured specimens. C-170874, 3, 33.6 x 103.4, GSC 105417.

Occurrence. Trold Fiord Formation.

Diagnosis. Spores radial, trilete. Amb semitriangular. Sides concave. Laesurae approximately two thirds of radius, with associated folds up to 1.5 μm. Ornament on part of distal surface of irregularly scattered low coni of variable dimensions; largest with basal diameter of 1 μm and 0.5 μm high, and smallest with basal diameter and height less than 0.25 μm. Space between elements varies from 0.5 μm to 3 μm. Ornament covers distal apical and polar areas, but in interapical areas is very sparse approximately midway between the pole and the equator. The contact between well ornamented and sparsely ornamented area is sharp, producing a strongly concave outline. Exine approximately 1 μm thick.

Dimensions. (1 specimen), 49 μm.

Remarks. This species is assigned to *Waltzispora* because it has the markedly concave sides with radial angles reflexed and expanded into a saddle-shaped outline. However, *Waltzispora* normally is either laevigate or may have fine ornament, whereas the specimens described here have a distinctive distribution of coni on the distal surface.

Subinfraturma VERRUCATI Dybová and Jachowicz, 1957

Genus *Verrucosisporites* (Ibrahim) Smith and Butterworth, 1967

Type species. Verrucosisporites verrucosus (Ibrahim) Ibrahim, 1933.

Verrucosisporites christiei sp. nov.

Plate 1, figures 20, 21, 25

Holotype. C-99249, 3, 8.2 x 99.4, GSC 105410.

Figured specimens. C-126267, 4, 25.0 x 101.3, GSC 105411; C-170909, 3, 37.5 x 98.4, GSC 105412.

Occurrence. Sabine Bay, Assistance, Trold Fiord, and van Hauen formations.

Diagnosis. Spores radial, trilete. Amb rounded-triangular, sides straight to slightly convex. Laesurae extending almost to equator. Ornament on distal surface of small (up to 2 μm diameter), rounded, closely spaced verrucae (0.25 to 1 μm apart) of irregular shape and size. Some elements on a single specimen have rounded bases, others have polygonal; diameter varies from 0.25 to 2 μm with majority approximately 1.5 μm; height varies from 0.25 μm to up to 1 μm, tops of verrucae rounded. Space between elements varies from 0.25 μm to 1.5 μm. Similar, but reduced, ornament on proximal surface.

Dimensions. (5 specimens), 52 to 76 μm, mean 62 μm.

Remarks. Differs from other species of *Verrucosisporites* by its rounded-triangular shape and the small size of the verrucae. *Verrucosisporites naumovae* Hart, 1963, is generally larger (74–83 μm) and has larger verrucae. *Granulatisporites micronodosus* Balme and Hennelly, 1956, differs in that the ornament is sparser.

Derivation of name. R.L. Christie, Geological Survey of Canada, in recognition of his contribution to Arctic geology, and the assistance provided the author concerning Inuit names used for new spore species.

Genus *Simeonospora* Balme, 1970

Type species. Simeonospora khlonovae, Balme, 1970.

Simeonospora minuta (Jansonius) comb. nov.

Plate 10, figures 6, 7

Synonymy. Dulhuntyispora? *minuta* Jansonius, 1962, p. 48, 49, Pl. 11, figs. 1–5.

Figured specimens. C-79892, 4, 25.1 x 108.2, GSC 105627; C-79892, 3, 21.7 x 97.7, GSC 105628.

Occurrence. Blind Fiord Formation.

Remarks. Balme, 1970 suggested that *Dulhuntyispora*? *minuta* Jansonius may be more appropriately assigned to *Simeonospora* than *Dulhuntyispora*, because it lacks the characteristic exoexinal "blisters" of *Dulhuntyispora*. The specimens illustrated here (Pl. 10, figs. 6, 7), and those described by Jansonius (1962), have the characteristic radial alignment of proximal structural elements in the centre of each contact depression typical of *Simeonospora*. However, as Balme (1970) pointed out, *Dulhuntyispora*? *minuta* Jansonius has annular distal thickenings that are not a characteristic of *Simeonospora*. *Gordonispora* is similar to *Simeonospora* in that it has a distal polar thickening, although this is not annular, and it differs by having a cingulum and lacking proximal structural elements with radial alignment.

Genus *Apiculatisporis* Potonié and Kremp, 1954

Type species. Apiculatisporis aculeatus, Ibrahim, 1933.

Apiculatisporis melvillensis sp. nov.

Plate 1, figures 22–24, 26–29

Holotype. C-170863, 3, 27.7 x 93.6, GSC 105418.

Figured specimens. C-79869, 3, 44.3 x 104.2, GSC 105590; C-161956, 3a, 40.6 x 109.0, GSC 105420; C-79890, 3, 28.0 x 108.5, GSC 105421; C-170871, 3, 10.9 x 99.8, GSC 105422; C-161952, 3, 15.2 x 99.7, GSC 105423; C-126269, 3, 9.2 x 97.6, GSC 105419.

Occurrence. Sabine Bay, Assistance, van Hauen, and Trold Fiord formations.

Diagnosis. Spores radial, trilete. Amb subtriangular. Sides convex to straight. Laesurae three quarters to seven eighths of radius, labra 0.5 μm wide. Ornament on proximal and distal surfaces of scattered spinae, coni, and bacula; proportions of individual elements variable. Coni approximately 1 to 2 μm high with a basal diameter of approximately 1 to 1.5 μm, acicular spinae similar height, but basal diameter less than 1 μm. Bacula approximately 2 μm high and 1 μm diameter, tips both rounded and conical; space between elements 2 to 5 μm. Exine approximately 1 μm thick. Lateral compressions and secondary folding common.

Dimensions. (25 specimens), 32 to 61 μm, mean 47 μm.

Remarks. Apiculatisporis melvillensis differs from *Granulatisporites absonus* Foster, 1979 in that the latter has verrucae and bacula confined mainly to the equatorial region, and thicker labra. *Azonotriletes spinosellus* Waltz, 1941 differs in that it appears from the line drawing to have a sparser ornament of spinae, rather than spinae, coni, and bacula. It also is slightly larger (66 μm) than *Apiculatisporis melvillensis*.

Derivation of name. Melville Island, Canadian Arctic Archipelago.

Genus *Lophotriletes* (Naumova) Potonié and Kremp, 1959

Type species. Lophotriletes gibbosus (Ibrahim) Potonié and Kremp, 1954.

Lophotriletes parryensis sp. nov.

Plate 2, figures 1–3

Holotype. C-126261, 3, 7.7 x 96.8, GSC 105424.

Figured specimens. C-126261, 3, 33.5 x 95.4, GSC 105425; C-126261, 3, 26.4 x 95.8, GSC 105426.

Occurrence. Sabine Bay, Assistance, Trold Fiord, and van Hauen formations.

Diagnosis. Spores radial, trilete. Amb triangular. Sides concave. Laesurae simple straight, extending approximately seven eighths of radius. Exine approximately 0.75 μm thick. Ornament on proximal and distal surfaces of scattered coni, occasionally with slightly expanded bases, approximately 0.5 μm in diameter and 0.5 μm high; generally 2 to 3 μm apart.

Dimensions. (26 specimens), 29 to 44 μm, mean 34 μm.

Remarks. The specimens identified as *Granulatisporites gibbosus* (Ibrahim) Varyukhina, 1971 (p. 74, Pl. v, fig. 3) are similar, but this species has an ornament of larger and more closely spaced coni than *L. parryensis*. *Granulatisporites microgranifer* Ibrahim, 1933 is similar to *L. parryensis*, but has a more closely spaced ornament. *Lophotriletes parryensis* also resembles *Azonotriletes spinellosus* Luber, 1941, but the latter has angular apices and an ornament of narrow, short spinae. *Granulatisporites parviverrucosus* (Waltz) Virbitskas, 1983 is similar, but from the brief description given originally by Waltz (*in*

Luber and Waltz, 1941) it is difficult to determine if *L. parryensis* is conspecific. However, the laesurae of the former are generally shorter, and the ornament on the line drawing of *Azonotriletes pariverrucosus* by Waltz (op. cit.) and from the description and illustrations by Virbitskas (1983), appears to be larger. *Lophotriletes novicus* Singh, 1964 has more prominent and sparser ornament than *L. parryensis*.

Derivation of name. Parry Islands, Canadian Arctic Archipelago.

Infraturma BACULATI Dybová and Jachowicz, 1957

Genus *Neoraistrickia* Potonié, 1956

Type species. Neoraistrichia truncatus (Cookson) Potonié, 1956.

Neoraistrickia caudicea sp. nov.

Plate 2, figures 4–12

Holotype. C-79890, 3, 21.0 x 93.0, GSC 105427.

Figured specimens. C-134177, 3, 6.4 x 99.3, GSC 105428; C-79879, 3, 33.4 x 95.9, GSC 105429; C-170909, 3, 42.2 x 96.0, GSC 105434; C-126269, 3, 35.0 x 97.0, GSC 105435; C-79890, 3, 25.0 x 104.8, GSC 105436; C-99248, 3, 10.7 x 102.3, GSC 105440; C-161944, 3, 15.0 x 97.2, GSC 105441; C-79878, 3, 22.3 x 105.4, GSC 105442.

Occurrence. Sabine Bay, Assistance, Trold Fiord, and van Hauen formations.

Diagnosis. Spores radial, trilete. Amb mostly subtriangular to subcircular, sides convex to concave. Laesurae straight, extend to equator, bordered by labra, each labrum up to 2 μm wide. Variable ornament on proximal and distal surfaces of widely scattered, stout to slender bacula of variable shape, with rare short (2–3 μm) coni, spinae and cristae. Space between elements up to 5 μm. Bacula are up to 5 to 6 μm high, and in some specimens up to 7 μm broad. Some bacula have secondary coni less than 1 μm high at the tip. Remainder of spore exine laevigate.

Dimensions. (25 specimens), 29 to 45 μm, mean 33 μm.

Remarks. Neoraistrickia caudicea is assigned to *Neoraistrickia* because most specimens are subtriangular. Some are subcircular and could be included in *Raistrickia*, but this differentiation would be arbitrary and serve no useful purpose. There is considerable variety in the ornament of this species, but there appears to be continuous variation between the specimens observed. *Spinosisporites cornata* (Kara–Murza) Varyukhina, 1971 is generally larger and has coni rather than bacula. Ornament of *N. caudicea* is more closely spaced than that of *Horriditriletes ramosus* (Balme and Hennelly) Bharadwaj and Salujha, 1964. Some specimens within the broad range circumscribed by *N. caudicea* resemble *Raistrickia ifanovi* Virbitskas, 1983, but the laesurae of the latter extend two thirds to three quarters of the radius rather than extending to the equator.

Derivation of name. Latin, *caudicius*, trunk-like.

Neoraistrickia delicata sp. nov.

Plate 2, figures 13–16

Holotype. C-126269, 3, 21.1 x 103.0, GSC 105430.

Figured specimens. C-170909, 3, 23.2 x 92.4, GSC 105431; C-170909, 3, 23.3 x 95.1, GSC 105432; C-126261, 3, 18.2 x 96.4, GSC 105433.

Occurrence. Sabine Bay, Assistance, Trold Fiord, and van Hauen formations.

Diagnosis. Spores radial, trilete. Amb rounded triangular to subcircular. Laesurae extend almost to equator. Ornament of scattered parallel-sided, to tapering bacula, and rare spinae and coni on distal, and more sparsely on proximal surface; length of bacula generally 2 to 3 μm, rarely as low as 1 μm and rarely as high as 7 μm; width 1 to 2 μm; elements approximately 3 μm apart. Spinae up to 7 μm high, but generally less. Coni vary from 0.25 to 5 μm high. Space between elements generally 2 to 3 μm, but sometimes up to 5 μm. Remainder of exine laevigate, thin (approximately 0.25 μm).

Dimensions. (25 specimens), 25 to 51 μm, mean 33 μm.

Remarks. The ornament of *Neoraistrickia delicata* sp. nov. is very variable. Study of the total population, however, indicates continuous variation. The ornament is more delicate than that of *Neoraistrickia caudicea*; the latter has stouter bacula. *Neoraistrickia delicata* is similar to *Selaginella* sp. 3 Zauer, 1965 and *Spinosisporites* sp. of Varyukhina, 1971 (Pl. 13, fig. 8), *Spinosisporites cornata* (Kara–Murza) Varyukhina, 1971 has stouter ornament, although one specimen illustrated (Pl. III, fig. 6b) is not unlike *N. delicata*. *Spinosisporites rectispinosus* (Luber) Varyukhina, 1971 has an ornament of spinae rather than bacula. *Raistrickia obtusosetosa* (Luber) Sivertseva, 1966 has a stouter ornament. *Acanthotriletes tereteangulatus* Balme and Hennelly, 1956 has a similar delicate ornament, but predominantly of coni and spinae. *Horriditriletes ramosus* (Balme and Hennelly) Bharadwaj and Salujha, 1964 has a more robust ornament. *Acanthotriletes superbus* Foster, 1979 has a thicker exine (1-2.5 μm), and generally denser ornament.

Derivation of name. Latin, *delicata*, delicate.

Genus *Raistrickia* (Schopf, Wilson, and Bentall) Potonié and Kremp, 1954

Type species. Raistrickia grovensis Schopf *in* Schopf, Wilson, and Bentall, 1944.

Raistrickia enervata sp. nov.

Plate 2, figures 17-19

Holotype. C-99228, 10, 38.2 x 106.5, GSC 105437.

Figured specimens. C-79879, 3, 43.2 x 100.1, GSC 105438; C-134171, 3, 6.4 x 93.8, GSC 105439.

Occurrence. Sabine Bay, Assistance, and Trold Fiord formations.

Diagnosis. Spores radial, trilete. Amb subcircular. Laesurae extend two thirds of radius, bordered by labra 1 μm wide. Ornament on distal surface of scattered (2 to 4 μm apart), narrow bacula and subsidiary coni. Bacula up to 2 μm high, and has diameter of 1 μm, coni 0.25 to 1.5 μm high, and has basal diameter of 0.25 to 1.5 μm. Ornament reduced on proximal surface. Remainder of exine laevigate, approximately 0.5 μm thick.

Dimensions. (7 specimens), 36 to 56 μm, mean 46 μm.

Remarks. Some specimens have an ornament approaching that of *N. delicata*, but the latter is subtriangular.

Derivation of name. Latin, *enervata*, weakened.

Raistrickia sp. A

Plate 2, figures 20-22

Holotype. C-134171, 3, 20.6 x 96.0, GSC 105443.

Figured specimens. C-126265, 3, 38.8 x 95.8, GSC 105444; C-134172, 3, 22.6 x 95.0, GSC 105445.

Occurrence. Assistance and Trold Fiord formations.

Diagnosis. Spores radial, trilete. Amb rounded triangular, sides convex. Laesurae extend three quarters of radius, generally bordered by labra approximately 1 μm wide. Exine approximately 1.5 μm thick. Ornament on distal surface of pilate and spatulate bacula and coni. Pila approximately 1.25 μm high, basal diameter 0.5 to 1 μm, with expanded tips. Coni up to 1 μm high with basal diameter of similar dimensions. Elements either in contact at their bases or up to 1 μm apart.

Dimensions. (6 specimens), 39 to 59 μm, mean 41 μm.

Infraturma MURORNATI Potonié and Kremp, 1954

Genus *Convolutispora* Hoffmeister, Staplin, and Malloy, 1955

Type species. Convolutispora florida.

Convolutispora arctica sp. nov.

Plate 2, figures 23-25

Holotype. C-126269, 3, 19.5 x 103.0, GSC 105446.

Figured specimens. C-134169, 3, 37.1 x 100.8, GSC 105447; C-134169, 3, 32.4 x 103.1, GSC 105448.

Occurrence. Sabine Bay, Assistance, and Trold Fiord formations.

Diagnosis. Spores radial, trilete. Amb almost circular to rounded subtriangular. Trilete, laesurae extend two thirds of radius. Proximal and distal ornament of muri of irregular shape and size, generally no more than 3 μm across and up to 12 μm in length; majority are less (approximately 5 μm). Smallest may approach verrucae and be as small as 1 μm in diameter. Lacunae are also very irregular in shape and may be up to 4 μm wide; majority are less. On some specimens, the relative proportion of the spore covered by muri and lacunae may be approximately equal. Rare clavae approximately 1 μm high occur on some specimens. Ornament generally reduced on proximal surface near laesurae. Exine thick (approximately 1.5 μm). Secondary folding common.

Dimensions. (25 specimens), 34 to 66 μm, mean 46 μm.

Remarks. This species is distinguished from other species of *Convolutispora* by the small size of the muri. It has been assigned to *Convolutispora* rather than *Verrucosisporites* because although some of the smaller muri approach verrucae, the ornament is more generally murornate.

Derivation of name. The arctic region.

Convolutispora perplexa sp. nov.

Plate 2, figures 26–29

Holotype. C-134171, 4, 14.1 x 100.1, GSC 105449.

Figured specimens. C-126253, 3, 38.7 x 95.7, GSC 105450; C-126269, 3, 8.6 x 97.0, GSC 105451; C-170909, 3, 22.5 x 112.7, GSC 105452.

Occurrence. Sabine Bay, Assistance, and Trold Fiord formations.

Diagnosis. Spores radial, trilete. Amb rounded triangular, subcircular to circular, trilete. Laesurae straight. Often barely visible as obscured by ornament of irregularly shaped muri and cristae of irregular outline and width (up to 5 μm, but generally less than 0.25 μm on a single specimen). Exine 3 μm thick, lacunae 0.25 to 1 μm.

Dimensions. (12 specimens), 49 to 93 μm, mean 70 μm.

Remarks. Convolutispora perplexa is similar to some Carboniferous taxa. For example, *C. tessellata* Hoffmeister, Staplin, and Malloy, 1955 is similar, but has larger and less variable muri; *C. ampla* Hoffmeister, Staplin, and Malloy, 1955 is also similar, but has smaller muri. It is possible that the specimens described here are reworked from the Upper Devonian or Lower Carboniferous.

Derivation of name. Latin, *perplexa*, tangled, puzzling.

Genus *Dictyotriletes* (Naumova) Butterworth and Smith, 1954

Type species. Dictyotriletes bireticulatus (Ibrahim) Potonié and Kremp, 1954.

Dictyotriletes bamberi sp. nov.

Plate 2, figure 30; Plate 3, figures 1–2

Holotype. C-161952, 3, 32.3 x 101.7, GSC 105453.

Figured specimens. C-148178, 3, 16.7 x 95.0, GSC 105454; C-134177, 3, 10.6 x 93.7, GSC 105455.

Occurrence. Sabine Bay, Assistance, and Trold Fiord formations.

Diagnosis. Spores radial, trilete. Amb subcircular. Laesurae straight, extend two thirds of radius. Fine reticulum on proximal and distal surface. Muri 0.25 to 0.5 μm wide, and 0.25 to 0.5 μm high; polygonal laevigate lumina from 0.5 to 4 μm diameter. Exine thickness approximately 1 μm.

Dimensions. (7 specimens), 38 to 49 μm, mean 42 μm.

Remarks. Dictyotriletes bireticulatus (Ibrahim) Smith and Butterworth, 1967 is similar, but has wider muri and larger lumina.

Derivation of name. After Dr. E.W. Bamber, in recognition of his major contribution to the geology of western and arctic Canada.

Genus *Uvaesporites* Döring, 1965

Type species. Uvaesporites glomeratus Döring, 1965.

Uvaesporites imperialis (Jansonius) comb. nov., emend.

Plate 10, figures 1–3

Synonymy. Lycospora imperialis Jansonius, 1962, Pl. 11, fig 15. *Rewanispora* sp. cf. *R. vermiculatus* Hochuli, Colin, and Vigran, 1989, Fig. 4; 3, 4.

Figured specimens. C-170869, 3, 28.2 x 93.0, GSC 105622; C-170869, 3, 32.1 x 96.8, GSC 105623; C-170869, 3, 8.7 x 94.4, GSC 105624.

Occurrence. Blind Fiord Formation.

Description. Spores radial, trilete. Amb rounded triangular to subrounded; exine approximately 0.5 µm. Laesurae distinct, bordered by labra 0.5 to 1 µm thick. Flange simple, carina-shaped; generally 2.5 to 5 µm wide, rarely up to 10 µm. Proximal surface laevigate. Distal surface with variably dense ornament of coarse elements that are globular, uvate, and reniform; smallest of these have diameters of 1 µm, and largest are up to 10 µm; most are in the 3 to 6 µm range. In places, in proximodistal compressions the distal surface may slightly overlap the equatorial margin, suggesting it is relatively more inflated than the proximal surface. In some specimens, withdrawal of intexine (approximately 0.25 µm thick) is visible.

Dimensions. (25 specimens), 34 to 55 µm, mean 42 µm.

Remarks. The distal ornament of coarse elements that are globular, uvate, and reniform favours the inclusion of this species in *Uvaesporites* rather than *Lycospora*. In the former, there is also some thickening of the exine equatorially producing a flange, although the genus is not cingulate or cingulizonate like *Lycospora*. *Rewanispora* De Jersey, 1970 is cingulate with foveolate-vermiculate sculpture rather than verrucate. The ornament shows considerable variation in density. The specimens commonly occur in tetrads.

Subturma ZONOTRILETES Waltz, 1935

Infraturma AURICULATI (Schopf) Dettmann, 1963

Genus *Ahrensisporites* Potonié and Kremp, 1954

Type species. Ahrensisporites guerickei (Horst) Potonié and Kremp, 1954.

Ahrensisporites multifloridus sp. nov.

Plate 3, figure 3–7

Holotype. C-134172, 4, 19.4 x 95.1, GSC 105456.

Figured specimens. C-134171, 4, 10.4 x 105.5, GSC 105457; C-134171, 4, 11.2 x 109.3, GSC 105458; C-134177, 5, 16.1 x 98.1, GSC 105459.

Occurrence. Trold Fiord Formation.

Diagnosis. Spores radial, trilete. Amb subtriangular to triangular, sides slightly convex to straight. Laesurae extend almost to apices. Proximal surface laevigate. Exine approximately 1 to 2 µm thick. On distal surface, close to or at equator in interapical region, is band of poorly defined exinal thickening (kyrtome), which terminates in apical region. The apices of the kyrtome project 1–2 µm beyond the equator at apical region; on some specimens they overlap on to the proximal surface at the apical region. Inner sides of kyrtomes have small (approx. 0.25 to 0.5 µm) vacuoles. Distal surface of spore has ornament of irregularly shaped verrucae and less common rugulae. Closely spaced (2 to 3 µm) verrucae 3 to 5 µm diameter, and 2 µm high, often linked by rugulae approximately 2 µm wide; elements sparser and smaller toward the equator where they consist of coni 1 µm high. Punctae approximately 0.5 µm in diameter and elongate holes up to 2 µm long occur between ornament.

Dimensions. (10 specimens), 50 to 83 µm, mean 68 µm.

Remarks. Ahrensisporites multifloridus is distinguished from other species of *Ahrensisporites* by its distinct distal ornament of verrucae and rugulae. *Ahrensisporites ornatus* (Neves) Ravn, 1986, possesses less prominent irregular, wart-like thickenings on the distal surface, and a more distinctive kyrtome.

Derivation of name. Latin, *multus*, many; *floridus* flowery.

Ahrensisporites thorsteinssonii sp. nov.

Plate 3, figures 8–11

Holotype. C-134170, 3, 39.0 x 97.3, GSC 105460.

Figured specimens. C-134172, 3, 41.3 x 107.6, GSC 105461; C-134177, 3, 28.1 x 96.4, GSC 105462; C-79890, 3, 12.4 x 106.9, GSC 103894.

Occurrence. Trold Fiord and Degerböls formations and upper part of van Hauen Formation.

Diagnosis. Spores radial, trilete. Amb subtriangular, sides slightly convex to straight. Laesurae extend almost to apices, bordered by thin associated folds 1–3 µm high. Proximal surface laeviate. Exine approximately 1 µm thick. Subtriangular, concave-sided exinal swelling on distal surface, bordered by narrow arcuate folds or kyrtome 1.25 µm thick, and 1 to 2 µm wide. Location of kyrtome interapically from distal pole varies from half of spore radius (Pl. 3, figs. 11, 12) to almost complete radius (e.g., Pl. 3, fig. 13). The apices of the kyrtome project 1-2 μm beyond the equator in the apical region; in some specimens they overlap on to the proximal surface up to 3 μm. Outer side of kyrtome wavy with relief up to 1 μm; inner sides of kyrtomes with small (approx. 0.25 μm) vacuoles. On exine within kyrtome, on most specimens there is an ornament of low scattered coni approximately 0.5 μm high, and 0.5 to 1 μm diameter; elements 1 to 2 μm apart.

Dimensions. (23 specimens), 32 to 57 μm, mean 44 μm.

Remarks. Ahrensisporites thorsteinssonii is distinguished from other species of *Ahrensisporites* by its relatively narrow, wavy kyrtome with vacuoles, and by the ornament of low scattered coni within the kyrtome. *Azonotriletes tristichus* Luber, 1941 lacks coni within the kyrtome.

Derivation of name. After Dr. R. Thorsteinsson, in recognition of his major contribution to the geology of the Canadian Arctic Archipelago.

Genus *Tripartites* (Schemel) Potonié and Kremp, 1954

Type species. Tripartites vetustus Schemel, 1950.

Tripartites sp. A

Plate 3, figure 12

Figured specimen. C-79871, 2, 29.4 x 98.3, GSC 105463.

Occurrence. Assistance Formation.

Diagnosis. Spores radial, trilete. Amb subtriangular, with sides strongly concave. Apices expanded to form bulbous terminations in outer one third. Distal and equatorial ornament of scattered (approximately 1 μm apart) coni, from 0.5 to 1 μm high, and with basal diameter of 0.5 to 1 μm. Laesurae extend three quarters of radius, bordered by labra approximately 1 μm wide. Exine approximately 0.5 μm thick.

Dimensions. (1 specimen), 29 μm.

Genus *Triquitrites* (Wilson and Coe) Potonié and Kremp, 1954

Type species. Triquitrites arculatus Wilson and Coe, 1940.

Triquitrites sp. A

Plate 3, figure 13

Figured specimen. C-134171, 3, 23.5 x 96.0, GSC 105464.

Occurrence. Trold Fiord Formation.

Diagnosis. Spores radial, trilete. Amb triangular. Apices rounded, sides concave. Laesurae straight bifurcate at tip, extend to margin of spore body. Spore surrounded by crassitude of variable width, but widest (up to 4 μm) at apices. On cingulum, rare conical projections from 1 to 2 μm high occur. On distal surface are cristae up to 2 μm high and 7 μm long, and irregularly shaped exinal thickenings.

Dimensions. (1 specimen), 36 μm.

Remarks. In some respects, *T.* sp. A is similar to *T. comptus* Williams, 1973 (*in* Neves et al., 1973) described from the Namurian of Northern England, but the latter has a crassitude of more constant width and a variable ornament on the proximal and distal surfaces of grana, verrucae and cristae. It is possible that the specimen is reworked from the Lower Carboniferous, but similar material was not found in the Viséan Emma Fiord Formation of the Sverdrup Basin (Utting, Jachowicz, and Jachowicz, 1989). *Triquitrites proratus* Balme, 1970, described from the Upper Permian of the Salt Range, has more pronounced auriculae.

Infraturma TRICRASSATI Dettmann, 1963

Genus *Diatomozonotriletes* (Naumova) Playford, 1963

Type species. Diatomozonotriletes saetosus (Hacquebard and Barss) Hughes and Playford, 1961 (by subsequent designation of Playford, 1963).

Diatomozonotriletes hypenetes sp. nov.

Plate 3, figures 14-17

Holotype. C-99245, 3, 41.2 x 101.4, GSC 105465.

Figured specimens. C-99245, 3, 30.3 x 98.4, GSC 105466; C-99246, 3, 37.2 x 95.0, GSC 105467; C-170852, 3, 34.5 x 99.3, GSC 105468.

Occurrence. Trold Fiord and Degerböls formations.

Diagnosis. Spores radial, trilete. Amb rounded triangular. Sides straight to convex. Laesurae faint, extend approximately two thirds of radius; on some specimens accompanying folds up to 2 μm high. Proximal surface laevigate. Ornament of echini on distal surface comprising tapered cones with expanded bases, approximately 2 to 3 μm high, and basal diameter 1 to 1.5 μm. At equatorial margin in interapical area, are closely spaced narrow tapered spinae up to 9 μm high, with basal diameter approximately 0.5 μm; spinae become gradually shorter toward the smooth apices. Spinae rest on expanded bases 1 μm high and 1 μm diameter. Distance between elements approximately 0.5 μm. Exine thickness 1 μm.

Dimensions. (5 specimens), 41 to 50 μm, mean 46 μm.

Remarks. Differs from *D. rarus* Playford, 1963 in lacking labra and possessing narrower spinae in the interapical area. *Diatomozonatriletes birkheadensis* Powis, 1984, has thicker spinae (approximately 1.5 μm basal diameter).

Derivation of name. Greek, *hypenetes*, one who is getting a beard.

Diatomozonotriletes igluanus sp. nov.

Plate 3, figures 18–21

Holotype. C-170908, 3, 38.2 x 107.7, GSC 105415.

Figured specimens. C-161946, 3, 44.2 x 98.3, GSC 105414; C-99248, 3, 17.8 x 102.2, GSC 105413; C-126264, 3, 39.9 x 108.2, GSC 105416.

Occurrence. Sabine Bay, Assistance, Trold Fiord, and Degerböls formations.

Diagnosis. Spores radial, trilete. Amb triangular to rounded triangular. Sides straight to slightly convex. Laesurae straight, extend almost to equator, with associated folds up to 6 μm. Ornament on distal surface, barely extending on to proximal surface, of irregularly scattered low rounded coni (0.5–3 μm diameter; 0.5–2 μm high). Coni vary in size between specimens, but also on a single specimen. Size of elements generally increases toward equator where they may coalesce, but they are up to 3 μm apart elsewhere. Coni decrease in size and number toward the apices. Exine approximately 1 μm thick, laevigate on most of proximal surface except at equatorial margins, where there may be a few tubercles.

Dimensions. (10 specimens), 29 to 41 μm, mean 34 μm.

Remarks. The species has been assigned to *Diatomozonotriletes* because of the triangular shape, and the fact that the tubercles at the equatorial margin show a gradual diminution in size toward the apices. *Diatomozonotriletes townrowii* Segroves, 1970, differs from *D. igluanus* by its more prominent ornament of bacula rather than tubercles. *Reinchospora plumsteadii* Hart, 1963 has two series of "lateral projections" in the interapical area, one on the distal lateral margin, and the other on the proximal lateral margin.

Derivation of name. Inuit, *iglu*, snow house.

Diatomozonotriletes sp. A

Plate 3, figure 22

Figured specimen. C-134179, 3, 30.5 x 99.0, GSC 105469.

Occurrence. Trold Fiord Formation.

Diagnosis. Spores radial, trilete. Amb triangular, sides concave. Laesurae extend to equatorial margin, bordered by labra 1 μm wide and secondary folds up to 3 μm high. Exine thin, approximately 1 μm, laevigate. Distal surface with triangular-shaped area of closely spaced, stout bacula, up to 2 μm high and 1.5 μm broad, and occasional verrucae with polygonal and rounded bases from 1 to 2 μm diameter. Elements smaller toward the apices. Triangular-shaped ornamented area with apices close to the apices of the spore margin. Sides concave, leaving approximately half interradial distal surface nearest to equatorial margin unornamented. A single line of bacula occurs at the equatorial margin, or subequatorially, in the interapical region. The bacula are approximately 3 μm high in the central part, but become gradually smaller toward the smooth apices. Space between bacula bases less than 0.5 μm.

Dimensions. (1 specimen), 40 μm.

Remarks. The ornament of *Diatomozonotriletes* sp. A is more robust than that of *D. rarus* Playford, 1963, which has an echinate to conate ornament on the distal surface and lacks the triangular-shaped area of baculate ornament. *Diatomozonotriletes* sp. A lacks the coni and echini on the distal surface.

Infraturma CINGULATI (Potonié and Klaus) Dettmann, 1963

Genus *Gordonispora* Van der Eem, 1983

Type species. Gordonispora fossulatus (Balme) Van der Eem, 1983.

Synonymy. Nevesisporites fossulatus Balme, 1970, p. 355, Pl. 3, figs. 1-5. *Limatulasporites fossulatus* (Balme) Foster, 1979, p. 51, Pl. 13, figs. 1-3.

Gordonispora obstaculifera sp. nov.

Plate 3, figures 23-25

Holotype. C-134171, 3, 20.0 x 107.0, GSC 105470.

Figured specimens. C-134171, 3, 24.6 x 99.4, GSC 105471; C-79890, 3, 28.2 x 102.6, GSC 105472.

Occurrence. Sabine Bay, Assistance, Trold Fiord, and van Hauen formations.

Diagnosis. Spores radial, trilete. Amb subcircular. Laesurae straight to sinuous, extend almost to equator. Bordered by labra approximately 1 μm broad. Exine differentially thickened at equatorial margin to form a cingulum approximately 3 μm broad and 2.5 μm thick, inner margin generally wavy. Proximal surface laevigate. On distal surface, approximately mid-way between pole and margin is a concentric band, sometimes discontinuous, of thickened exine; width variable due to wavy inner margin, but approximately 1 to 5 μm broad; on some specimens, the thickened exine may extend in irregularly shaped patches on to polar area.

Dimensions. (26 specimens), 29 to 41 μm, mean 35 μm.

Remarks. Gordonispora fossulatus (Balme) Van der Eem, 1983 has scattered sparse grana on the proximal surface; these are lacking on *G. obstaculifera*.

Derivation of name. Latin, *obstaculum*, hindrance.

Genus *Kraeuselisporites* Leschik emend. Jansonius, 1962

Type species. Kraeuselisporites dentatus Leschik, 1956.

Kraeuselisporites sverdrupensis sp. nov.

Plate 3, figures 26-28

Holotype. C-79879, 3, 21.6 x 96.0, GSC 105473.

Figured specimens. C-79879, 3, 19.2 x 97.6, GSC 105474; C-79876, 3, 16.1 x 104.8, GSC 105475.

Occurrence. Sabine, Assistance, Trold Fiord, Degerböls, and van Hauen formations.

Diagnosis. Spores radial, trilete. Amb rounded-triangular. Laesurae extend to equator, associated folds up to 2 μm high. Exine of spore body approximately 2.25 μm; intexine very thin (less than 0.25 μm). On distal surface of spore body, is ornament of closely spaced to scattered echini with acicular to pilate tips, spinae and coni up to 6 μm high. Surrounding flange up to 10 μm wide is very thin (less than 0.25 μm), finely granulose with sparse ornament of echini generally smaller than on body. Small vacuoles (with diameter of approximately 0.25 μm) visible at base of flange on some specimens. Secondary folding at margin of spore body common.

Dimensions. (20 specimens), 46 to 73 μm, mean 58 μm.

Remarks. Many specimens have only one layer of the flange preserved as the result of corrosion. *Kraeuselisporites sverdrupensis* may be distinguished from *K. apiculatus* Jansonius, 1962 and *K. spinosus* Jansonius, 1962 recorded from the lower Triassic, in that *K. sverdrupensis* has vacuoles near the base of the flange and the laesurae extend to the equatorial margin of the spore rather than to the base of the flange. *Kraeuselisporites papulatus* Smirnova ex Virbitskas, 1983 is more rounded in shape, has a well defined central body, and a distinctly granulose flange with elements up to 0.5 to 0.6 μm high. *Kraeuselisporites niger* Segroves, 1970 also has a thicker intexine (0.5 μm).

Kraeuselisporites is used here in the sense of Balme (1970) to include cavate and acavate species.

Derivation of name. Sverdrup Basin, Canadian Arctic Archipelago.

Suprasubturma LAMINATITRILETES Smith and Butterworth, 1967

Subturma ZONOLAMINATITRILETES Smith and Butterworth, 1967

Infraturma CINGULICAVATI Smith and Butterworth, 1967

Genus *Gondisporites* Bharadwaj, 1962

Type species. Gondisporites raniganjensis Bharadwaj, 1962.

Gondisporites nassichukii sp. nov.

Plate 3, figure 29; Plate 4, figures 1-3

Synonymy. cf. *Granizonospora granifer* (Luber) Varyukhina, 1971 (*nom. nud.*), pars (Pl. 10, fig. 17), no description.

Holotype. C-79879, 3, 10.2 x 96.6, GSC 105476.

Figured specimens. C-79879, 3, 33.3 x 110.0, GSC 105477; C-79889, 3, 9.9 x 98.0, GSC 105478; C-79879, 3, 28.7 x 102.0, GSC 105479.

Occurrence. Sabine Bay, Assistance, Trold Fiord, and van Hauen formations.

Diagnosis. Spores radial, trilete. Amb rounded-triangular. Cavate, with narrow zona. Laesurae straight, extending to inner margin of zona, with associated folds up to 4 μm high, extending to equator. Exoexine punctate, approximately 1 μm thick. Inner body clearly visible, subcircular, rounded-triangular, intexine approximately 0.25 μm thick. Ornament on distal surface (including zona) of widely scattered echini; elements generally up to 2.5 μm high and 4 to 8 μm apart. Base of echini conical shaped and up to 1 μm high, aciculate spinose tip up to 1 μm. In some specimens (Pl. 4, fig. 3) larger elements occur and they may be up to 6 μm high, with the aciculate tip 1 μm long, the diameter at the base of the echini may be up to 4 μm. Also present are low coni up to 1.5 μm high with a basal diameter of 3.5 μm. Zona up to 7 μm wide; inner margin of zona is distinctly thickened; at equator is limbus approximately 1.5 μm wide.

Dimensions. (8 specimens), 51 to 71 μm, mean 59 μm.

Remarks. Some species of the invalid genus *Granizonospora* Luber, 1966 in Pokrovskaya (see Jansonius and Hills, card 1174, 1976), resemble *Gondisporites nassichukii*. The ornament of *Granizonospora spinosa* (Naumova) *in* Molin and Koloda (1972) (*nom. nud.*; illustrated but not described) is denser than that of *Gondisporites nassichukii*. Similar to specimens of *Gondisporites nassichukii* that possess larger ornamental elements is cf. *Granizonospora granifer* (Luber) Varyukhina, 1971 (*nom. nud.*). *Gondisporites raniganjensis* Bharadwaj, 1962 differs from *G. nassichukii* in that the former has an ornament of grana and bacula (2-3 μm high). *Gondisporites baradwajii* Foster, 1979, differs in that it has an ornament of cristae and rugulae. *Lundbladispora iphilegna* Foster, 1979 has an equatorial thickening (1.5-3 μm) that is narrower than the zona of *G. nassichukii*. The ornament of *Indotriradites reidii* Foster, 1979 is composed of spinae and mammoid processes rather than echini and low coni.

Derivation of name. Named for W.W. Nassichuk, in recognition of his contribution to arctic geology.

Subturma SOLUTITRILETES Neves and Owens, 1966

Infraturma DECORATI Neves and Owens, 1966

Genus *Grandispora* (Hoffmeister, Staplin, and Malloy) Neves and Owens, 1966

Type species. Grandispora spinosa Hoffmeister, Staplin, and Malloy, 1955.

Grandispora jansonii sp. nov.

Plate 4, figures 4-8

Holotype. C-134171, 4, 28.0 x 105.3, GSC 105480.

Figured specimens. C-134167, 5, 29.9 x 97.0, GSC 105481; C-170891, 3, 10.2 x 95.8, GSC 105482; C-134171, 4, 24.1 x 101.3, GSC 105483; C-134177, 4, 42.6 x 97.1, GSC 105484.

Occurrence. Trold Fiord Formation.

Diagnosis. Camerate spores radial trilete. Amb subcircular. Laesurae wavy extending almost to equator; associated sinuous folds up to 2 μm high. Outline of 0.5 μm thick intexine, or spore body, well defined, mainly with secondary folds subparallel to equatorial margin. Diameter of inner body approximately 50% overall diameter. Exoexine finely granulose, very thin (0.25 μm), often with secondary folds; ornament on distal surface of scattered coni; elements 3 to 7 μm apart, up to 1.5 μm diameter, and up to 1 μm high; tips of coni rounded or pointed; rare echini, of similar height to coni.

Dimensions. (10 specimens), diameter 80 to 95 μm, mean 87 μm.

Remarks. Grandispora segrovesii Foster, 1979 also is camerate and has a distal ornament of coni, but the elements are more closely spaced than in *G. jansonii*, and the inner body is much larger. *Grandispora notensis* Playford, 1971 has a larger ornament of coni-spinae, a relatively larger inner body, and thicker exoexine (2.5–3 μm).

Derivation of name. Named for J. Jansonius for his contribution to Permian and Triassic palynology of Canada.

Turma MONOLETES Ibrahim, 1933

Suprasubturma ACAVATOMONOLETES Dettmann, 1963

Subturma AZONOMONOLETES Luber, 1935

Infraturma LAEVIGATOSPORITES Ibrahim, 1933

Genus *Laevigatosporites* Ibrahim, 1933

Type species. Laevigatosporites vulgaris Ibrahim, 1933.

Laevigatosporites minor Loose, 1934

Plate 4, figure 9

Synonymy. Laevigatosporites minor (Loose) Potonié and Kremp; Bharadwaj, p. 109, Pl. 29, figs. 8, 9.

Figured specimen. C-134170, 3, 36.2 x 100.8, GSC 105485.

Occurrence. Sabine Bay, Assistance, and Trold Fiord formations.

Description. Spores monolete, amb oval, shape in meridian plane phaseolate. Laesurae simple up to two thirds of length. Exine approximately 1 μm thick, laevigate. Secondary folding common.

Dimensions. (9 specimens), length 34 to 76 μm, mean 54 μm. Width in equatorial view 32 to 49 μm, mean 40 μm.

Remarks. Most of the specimens fall within the arbitrary size range of 35 to 64 μm given for *L. minor* by Smith and Butterworth (1967) and the mean length is within that size range. A few specimens are larger (up to 11 μm), and although these could theoretically be included in *L. vulgaris* Ibrahim, 1933 (size range 65–100 μm of Smith and Butterworth, 1967) they have been included with *L. minor* in this paper.

Anteturma POLLENITES Potonié, 1931

Turma SACCITES Erdtman, 1947

Subturma MONOSACCITES (Chitaley) Potonié and Kremp, 1954

Genus *Cordaitina* Samoilovich, 1953

Type species. Cordaitina uralensis (Luber, *in* Luber and Waltz, 1941).

Cordaitina vulgaris (Zauer) Varyukhina, 1971 ex. Utting comb. nov.

Plate 4, figures 10–13, 16, 20

Synonymy. Pseudocordaites vulgaris Zauer, 1965, *nom. nud.*, Pl. XXIX, figs. 4a–c (no description). *Pseudocordaites vulgaris* Varyukhina, 1971, *nom. nud.*, p. 98, 99, Pl. X, figs. 5a–b (with description but no holotype designated).

Holotype. C-99245, 3, 32.0 x 108.1, GSC 105486.

Figured specimens. C-126269, 3, 22.4 x 95.1, GSC 105487; C-79883, 3, 23.2 x 104.8, GSC 105488; C-134171, 4, 34.5 x 112.3, GSC 105489; C-99229, 5, 6.7 x 98.2, GSC 105490; C-99229, 5, 18.1 x 105.6, GSC 105491.

Occurrence. Sabine Bay, Assistance, and Trold Fiord formations.

Diagnosis. Monosaccate pollen. Amb subcircular to circular. Trilete to geniculate mark sometimes barely visible; laesurae short and of unequal length (3–10 μm). Inner body generally well defined, smooth, often with secondary arcuate folds, exine 1 μm thick. Saccus with vermiculate pattern on proximal and distal surfaces, producing irregular shaped botryoidal thickenings of elements with average diameter of 2 μm on smaller specimens, and up to 4 μm on larger. Saccus 1 μm thick. Width of overlap onto body 2 to 4 μm, radial brochi near equator (0.25 μm wide).

Dimensions. (12 specimens), 44 to 83 μm, mean 57 μm.

Remarks. *Pseudocordaites* Zauer ex. Varyukhina, 1971, was differentiated from *Cordaitina* by the presence of a trilete mark in the former. However, Hart (1965) suggested that *Cordaitina* should include species with a trilete mark, and Dibner (1971) emended the description of the genus to include trilete species. The specimens described here have therefore been included in *Cordaitina*. They are similar to *Pseudocordaites vulgaris* Zauer ex. Varyukhina, 1971, although some are smaller than the 70 to 85 μm size range given by Varyukhina (1971), and the body is more clearly defined.

Genus *Crustaesporites* Leschik, 1956

Type species. *Crustaesporites globosus* Leschik, 1956, p. 130, Pl. 21, fig. 2.

Crustaesporites sp. A

Plate 5, figures 5, 6

Figured specimens. C-79876, 3, 34.4 x 101.1, GSC 105503; C-134171, 4, 25.6 x 98.7, GSC 105504.

Occurrence. Trold Fiord Formation.

Diagnosis. Taeniate monosaccate, outline trilobate. Central body transversely oval. Cappa with transverse, narrow, parallel clefts, less than 0.25 μm wide, separating approximately 10 taeniae approximately 2 μm wide; taeniae are sometimes interrupted by narrow, vertical clefts dividing them into blocks. Sacci exine intrareticulate, approximately 1 μm thick; proximally attached near equator, distally not discernible.

Dimensions. (2 specimens), overall diameter 56 to 64 μm; central body from 35 to 43 μm; saccus offlap 12 to 20 μm.

Remarks. Appears to resemble specimen illustrated, but not described, by Molin and Koloda (1972, Pl. XIX, fig. 1), and identified as *Striatopodocarpites* sp., although their specimen has four lobes rather than trilobate structure of *Crustaesporites* sp. A.

Genus *Dyupetalum* Jansonius and Hills, 1979

Type species. *Dyupetalum fimbriatum* Jansonius and Hills, 1979 (originally assigned to invalid genus *Petalum* by Dyupina, 1974).

Dyupetalum vesicatum sp. nov.

Plate 4, figures 14, 15, 18, 19, 21

Holotype. C-126275, 3, 5.1 x 98.9, GSC 105492.

Figured specimens. C-126275, 3, 22.4 x 103.2, GSC 105493; C-126275, 3, 22.4 x 93.7, GSC 105494.

Occurrence. Sabine Bay, Assistance, and Trold Fiord formations.

Diagnosis. Monosaccate pollen. Amb subcircular to circular, trilete. Laesurae short approximately 25% of radius. One laesura generally shorter than others. Proximal surface of spore body with ornament of fine irregular rugulae less than 0.5 μm wide, lacunae up to 1 μm. In the immediate vicinity of the laesurae, the rugulae give way to a finely granulate surface. The distal surface has an ornament of rugulae, which are slightly narrower than those on the proximal surface. Saccus or velum with closely packed folds producing a fibrous radiating pattern at the margin. The velum is expanded to produce most frequently seven or eight irregularly spaced, thin, laevigate spatulate projections up to 7 μm high, and from 8 to 15 μm wide at the extremity. Velum offlap approximately one tenth to one seventh of radius of spore.

Dimensions. (10 specimens), 39 to 58 μm, mean 45 μm.

Remarks. *Latensina trileta* Alpern, 1958, which was described as having a "fibroradial zone", lacks the spatulate processes of *D. vesicatum*. *Dyupetalum vesicatum* bears some similarity to *Cordaitina subrotata* Luber var. *subisopolaris*, Varyukhina, 1971, although the latter lacks the spatulate process found on *D. vesicatum*. *Dyupetalum fimbriatum* (Dyupina) Jansonius and Hills, 1979, is generally larger (57-84 μm) and the velum offlap is wider (one fifth to one quarter).

Derivation of name. Latin, *vesica*, bladder.

Genus *Florinites* Schopf, Wilson, and Bentall, 1944

Type species. *Florinites pellucidus* (Wilson and Coe, 1940) Wilson, 1958.

Florinites luberae Samoilovich, 1953

Plate 4, figures 22, 23; Plate 5, figure 1

Synonymy. Samoilovich, 1953, op. 42, Pl. VIII, figs. 2a, b.

Figured specimens. C-134170, 3, 9.4 x 100.6, GSC 105497; C-126269, 6, 4.7 x 93.4, GSC 105498; C-79879, 3a, 20.4 x 110.1, GSC 105499.

Occurrence. Sabine Bay, Assistance, Degerböls, and Trold Fiord formations.

Description. Monosaccate pollen. Amb of saccus oval. Exoexine intrareticulate, thin (approx. 0.25 μm), often developing secondary folds during compression. Amb of centrally located body circular to oval, with long axis parallel to long axis of grain; intexine approximately 1 μm thick, intragranulate, grana less than 0.25 μm in diameter. Tetrad mark not seen. Close to the equatorial margin on the distal surface of the body occur exoexinal folds parallel to the equator of the body, producing a rim of unequal width (up to 3 μm) and continuity. Common also are arcuate folds at the equatorial margin of the body.

Dimensions. (25 specimens), total length 44.0 to 84.0 μm, mean 63 μm; total breadth 24.0 to 54.0 μm, mean 41 μm. Length of central body 26.0 to 49.0 μm, mean 36 μm; breadth 16.0 to 45.0 μm, mean 34 μm.

Remarks. The specimens described here resemble *Florinites luberae* Samoilovich, 1953. The "rimlet" mentioned by Samoilovich is here interpreted as secondary folding.

Florinites sp. A

Plate 5, figures 2, 3

Figured specimen. C-79876, 3, 23.3 x 104.8, GSC 105500; C-79876, 3, 18.4 x 99.2, GSC 105501.

Occurrence. Trold Fiord Formation.

Diagnosis. Monosaccate pollen. Amb subcircular to oval. Body circular to transversely oval, commonly with secondary folds subparallel to margin. Diameter of body approximately 50% that of saccus. Trilete mark not apparent. Central body exine laevigate approximately 1 μm thick. Distally(?) saccus overlaps body by up to 10 μm. Saccus intrareticulate with lumina elongate radially; lumina up to 2.5 μm wide and up to 1.5 μm long. Saccus exine about 0.5 μm thick.

Dimensions. (2 specimens), length and breadth 55 x 51; 34 x 31 μm; central body 34 x 41; 26 x 24 μm.

Genus *Potonieisporites* Bharadwaj, 1954

Type species. *Potonieisporites novicus* Bharadwaj, 1954, p. 520, fig. 10.

Potonieisporites sp. A

Plate 5, figure 4

Figured specimen. C-161940, 3, 26.9 x 104.1, GSC 105502.

Occurrence. Assistance Formation.

Diagnosis. Monosaccate pollen, elliptical in transverse plane. Inner body almost circular in outline. Monolete suture parallel to long axis, extends three quarters of body length; elliptical compressional folds running almost perpendicular to monolete mark. On distal surface of body is poorly developed irregular rugulate ornament, with reticuloid pattern and segments 3 to 5 μm diameter, lacunae less than 0.25 μm wide. Bladder intrareticulate covering distal side of body, attachment on proximal surface overlaps margin of body slightly (by up to 7 μm).

Dimensions. (1 specimen), overall size 173 x 57 μm; inner body dimensions 41 x 43 μm.

Genus *Striomonosaccites*

Type species. *Striomonosaccites ovatus* Bharadwaj, 1962.

Striomonosaccites sp. A

Plate 4, figures 17, 24

Figured specimens. C-126269, 4, 38.0 x 104.5, GSC 105495; C-161948, 3, 37.2 x 94.1, GSC 105496.

Occurrence. Sabine Bay and Assistance formations.

Diagnosis. Outline of saccus subcircular to oval, margin minutely indented. Body circular and occupying an eccentric position. Diameter of body slightly less than 50% that of saccus. Proximal cappa traversed by 4 to 5 subparallel clefts approximately 0.25 μm wide separating 5 to 6 taeniae 5 to 7 μm wide. Body exine infragranulate. Distally(?), saccus overlaps body by about 5 μm. Saccus intrareticulate with lumina elongate radially; lumina up to 4 μm wide and 12 μm long, muri approximately 0.5 μm wide. Saccus exine approximately 0.5 μm thick.

Dimensions. (2 specimens), overall diameter 93 to 100 μm; body diameter 38 to 51 μm.

Remarks. This species appears similar to *Walchiites* sp., illustrated, but not described, by Molin and Koloda (1972, Pl. XXIV, fig. 2). However, *Walchiites* Bolkhovitina, 1956, is a monocolpate group and not a valid genus (Jansonius and Hills, 1976).

Subturma DISACCITES Cookson, 1947

Infraturma DISACCIATRILETI Leschik emend. Potonié, 1958

Genus *Abiespollenites* Thiergart, 1937

Type species. Abiespollenites absolutus Thiergart ex Raatz, 1937.

Abiespollenites sp. A

Plate 5, figures 7, 8

Figured specimens. C-126252, 3, 34.7 x 107.2, GSC 105505; C-99250, 3, 26.5 x 93.8, GSC 105519.

Occurrence. Assistance and Trold Fiord formations.

Diagnosis. Disaccate haploxylonoid pollen grain. Corpus transversely elongate oval. Cappa thin, intrapunctate. Sacci slightly greater than semicircular in polar view; saccus exoexine thin, intrareticulate; brochi less than 0.5 μm diameter. Slight radial elongation at margin of cappa. Cappula with subparallel sides, breadth approximately one half that of corpus. Exine of cappula thin and without structure.

Dimensions. (3 specimens), total breadth 35 to 51 μm, mean 40 μm; saccus breadth 12 to 15 μm, mean 13 μm; corpus breadth 25 to 34 μm, mean 29 μm; cappula breadth 8 to 18 μm, mean 13 μm; saccus offlap 5 to 7 μm, mean 6 μm; saccus length 15 to 24 μm, mean 18 μm; corpus length 20 to 29 μm, mean 24 μm.

Genus *Alisporites* Daugherty emend. Nilsson, 1958

Type species. Alisporites opii Daugherty, 1941.

Alisporites plicatus Jizba, 1962

Plate 5, figures 12–14

Synonymy. Alisporites plicatus Jizba, 1962, p. 884, Pl. 124, figs. 51–53; *Lebachia insignis* Varyukhina, 1970, p. 45, 46, Pl. 1, figs. 8, 9.

Figured specimens. C-126253, 3, 30.8 x 109.1, GSC 105509; C-126269, 4, 19.6 x 102.7, GSC 105510; C-126254, 3, 22.7 x 104.7, GSC 105511.

Occurrence. Sabine Bay, Assistance, Trold Fiord, and van Hauen formations.

Description. Disaccate pollen, haploxylonoid to slightly diploxylonoid. Amb of pollen laterally oval, although some specimens have slightly concave lateral sides. Sacci vary from greater than semicircular, to semicircular, to crescent shaped; exoexine thin, (approx. 0.25 μm), finely intrareticulate, brochi less than 1 μm diameter, slight radial elongation occurs toward proximal sacci base. Corpus longitudinally oval to semirhombic in shape, intexine approximately 1.0 μm thick, finely granulate. Cappula longitudinally oval, laevigate. Cappa thin laevigate to intrapunctate.

Dimensions. (25 specimens), total breadth 49 to 85 μm, mean 73 μm; saccus breadth 17 to 36 μm, mean 27 μm; corpus breadth 29 to 42 μm, mean 36 μm; cappula breadth 10 to 28 μm, mean 19 μm; saccus offlap 12 to 28 μm, mean 19 μm; saccus length 24 to 63 μm, mean 48 μm; corpus length 26 to 56 μm, mean 43 μm.

Remarks. Similar specimens to *A. plicatus* were illustrated and identified by Varyukhina (1971) as *Lebachia insignis* Varyukhina, 1970. *Alisporites* is used here in the sense of Balme (1970) for disaccate haploxylonoid to slightly diploxylonoid pollen that lack a clearly defined sulcus. The macrofloral genus *Lebachia* Florin, 1938 is not used because there is no evidence known to the present writer that spores of this type were derived from *Lebachia*.

Alisporites splendens (Leschik) Foster, 1979

Plate 5, figures 9–11

Synonymy. Sulcatisporites splendens Leschik, p. 137, Pl. 22, fig. 10; *Alisporites splendens* (Leschik) Foster, 1979, p. 73, 74, Pl. 25, figs. 9, 10.

Figured specimens. C-79868, 3, 13.6 x 104.2, GSC 105506; C-161952, 3, 29.2 x 94.8, GSC 105507; C-161946, 3, 59.6 x 97.0, GSC 105508.

Occurrence. Sabine Bay, Assistance, van Hauen, and Trold Fiord formations.

Description. Disaccate pollen, haploxylonoid, amb oval. Corpus poorly defined circular to slightly longitudinally elongate oval. Cappa thin, finely intrareticulate. Sacci semicircular to almost semicircular in polar view; often linked at longitudinal margin by thin band of exine; exine thickness 0.5 μm coarsely intrareticulate, brochi up to 3 μm diameter. Cappula thin, narrow, fusiform to elongate rectangular; breadth one quarter to one third of corpus.

Dimensions. (5 specimens), total breadth 60 to 71 μm, mean 63 μm; saccus breadth 24 to 28 μm, mean 25 μm; corpus breadth 31 to 43 μm, mean 36 μm; cappula breadth 10 to 20 μm, mean 14 μm; saccus offlap 13 to 15 μm, mean 14 μm; saccus length 45 to 50 μm, mean 48 μm; corpus length 45 to 50 μm, mean 48 μm.

Remarks. As pointed out by Foster (1979), *A. splendens* shows considerable variation in size and shape, but the specimens seen here do not appear to show continuous variation to *Alisporites plicatus* Jizba, 1962 as suggested by Foster (1979); the two have therefore been maintained as separate species. *Alisporites plicatus* is larger, has a well defined corpus, and a broader cappula. *Alisporites splendens* is similar to *Sulcatisporites ovatus* (Balme and Hennelly) Balme, 1970, but has a more fusiform cappa and no clear sulcus. *Alisporites tenuicorpus* Balme, 1970, is similar but has a broader cappula.

Genus *Jugasporites* Klaus, 1964

Type species. Jugasporites delasauciae (R. Potonié and Klaus) Leschik, 1956.

Jugasporites compactus sp. nov.

Plate 5, figures 15–17

Holotype. C-126269, 4, 22.5 x 102.3, GSC 105512.

Figured specimens. C-126269, 3, 31.8 x 96.8, GSC 105513; C-126269, 4, 8.4 x 97.6, GSC 105514.

Occurrence. Sabine Bay, Assistance, and Trold Fiord formations.

Diagnosis. Disaccate pollen, haploxylonoid, transversely oval to almost circular. Monolete mark or slightly geniculate laesurae of unequal length on proximal surface; mark up to 18 μm long. Corpus well defined, shape almost circular to slightly longitudinally or laterally oval; intexine 0.5 μm thick, laevigate, slightly darker than exoexine. Cappa 1 μm thick, finely intrapunctate. Proximal exoexinal operculum present and may be detached (e.g., Pl. 5, fig. 16). Exoexine of corpus not differentiated from that of sacci. Exoexine of sacci intrareticulate. Outline of sacci crescent-shaped, offlap narrow. Occasionally sacci in contact at lateral margin of corpus by a narrow (1–3 μm) band of exoexine. Most specimens have a distal longitudinal fold close to the point of the distal attachment of at least one of the sacci with the corpus. Cappula well defined, extending full length of corpus. Outline rectangular to oval; breadth approximately one third of corpus, surface thin and smooth.

Dimensions. (25 specimens), total breadth 32.0 to 50.0 μm, mean 44 μm; saccus breadth 13.0 to 20.0 μm, mean 16 μm; corpus breadth 30.0 to 41.0 μm, mean 36 μm; cappula breadth 10.0 to 20.0 μm, mean 14 μm; saccus offlap 2.0 to 9.0 μm, mean 4 μm; saccus length 31.0 to 44.0 μm, mean 37 μm; corpus length 28.0 to 41.0 μm, mean 36 μm.

Remarks. The species described here has been assigned to *Jugasporites*, as it possesses a monolete to geniculate mark. There are some features in common with *Triadispora* sp. cf. *T. epigona* Klaus, 1964 described by Foster, 1979, from the Baralaba Coal Measures of Chhidruan–Dzhulfian age, although the latter possesses a trilete or geniculate mark. *Jugasporites compactus* is within the lower part of the size range of *Triadispora* sp. cf. *T. epigona*, but *J. compactus* has less transverse elongation. Foster (1979, p. 72) discussed the apparent difference in exoexine between his specimens, the holotype of *T. epigona* (Klaus, 1964, Pl. 2, fig. 13), and those specimens illustrated by Scheuring (1970) where the exoexine may have a crumpled appearance. The significance of the difference is not certain; it may reflect a very thin layer, or be the result of corrosion. Foster (1983) also noted the presence of a proximal exoexinal operculum on *Jugasporites*. This feature apparently occurs in *J. compactus*. For example, in the specimen illustrated in Pl. 5, fig. 16, there is a transverse oval opening up to 15 μm long and 7 μm wide.

Derivation of name. Latin, *compactus*, compact.

Genus *Limitisporites* Leschik, 1956

Type species. Limitisporites rectus Leschik, 1956.

Limitisporites sp. A

Plate 5, figure 18

Figured specimen. C-161958, 3, 36.5 x 105.0, GSC 105515.

Occurrence. Trold Fiord Formation.

Diagnosis. Disaccate pollen, diploxylonoid. Corpus circular to laterally oval. Cappa approximately 1.25 μm thick, exine punctate; monolete mark 6 μm long. Sacci slightly greater than semicircular, distally inclined; joined equatorially by strips of exoexine. Saccus exoexine 0.5 μm thick, coarsely intrareticulate. Cappula elongate oval to subrectangular, extending full length of corpus.

Dimensions. (1 specimen), total breadth 50 μm; saccus breadth 19 μm; corpus breadth 30 μm; cappula breadth 14 μm; saccus offlap 10 μm; saccus length 37 μm; corpus length 24 μm.

Remarks. The specimens described here are similar to those recorded as *Limitisporites* sp. Balme, 1980a from the *Vittatina* (Dzhulfian?) and *Protohaploxypinus* (Griesbachian), Associations of East Greenland.

Genus *Piceapollenites* Potonié, 1931

Type species. Piceapollenites alatus R. Potonié, 1931.

Piceapollenites nookapii sp. nov.

Plate 5, figure 19–21

Holotype. C-99228, 10, 19.5 x 105.3, GSC 105516.

Figured specimens. C-99228, 15, 5.4 x 98.6, GSC 105517; C-99228, 12, 14.9 x 105.9, GSC 105518.

Occurrence. Trold Fiord and Degerböls formations.

Diagnosis. Disaccate pollen, haploxylonoid. Corpus laterally elongate to subrectangular. Cappa approximately 1.5 μm thick, exine punctate. Sacci smaller than corpus, semicircular to greater than semicircular in shape. Saccus exoexine thin (less than 0.25 μm) finely intrareticulate; crescent-shaped secondary fold commonly present near distal sacci base on at least one saccus. Brochi faint with radial elongation. Cappula subrectangular, extending full length of corpus.

Dimensions. (8 specimens), total breadth 63 to 80 μm, mean 69 μm; saccus breadth 20 to 31 μm, mean 26 μm; corpus breadth 46 to 65 μm, mean 55 μm; cappula breadth 20 to 60 μm, mean 33 μm; saccus offlap 6 to 20 μm, mean 14 μm; saccus length 26 to 42 μm, mean 33 μm; corpus length 41 to 51 μm, mean 46 μm.

Remarks. Piceapollenites nookapii is distinguished by its very thin sacci with poorly discernible distal attachment. In some specimens, only one sac remains. *Piceapollenites sublevis* (Luber and Waltz) Hart, 1965 has relatively larger sacci (with respect to the size of the corpus), which are coarsely intrareticulate. *Piceapollenites aligerus* (Luber and Waltz) Hart, 1965 has a fusiform-shaped sulcus, and the sacci unite laterally. *Striatoabieites borealis* differs in that it has faint clefts.

Derivation of name. Nookapingwa, a Greenlander. In 1929, with Inspector Joy of the Royal Canadian Mounted Police, he went on a patrol from Dundas Harbour, Devon Island, to Melville Island and back to Bache Peninsula, Ellesmere Island; a total distance of 2735 km.

Genus *Vitreisporites* (Leschik) emend. Jansonius, 1962

Type species. Vitreisporites pallidus Reissinger, 1940.

Vitreisporites pallidus (Reissinger) Nilsson, 1958

Plate 5, figures 22–24

Synonymy. Pityosporites pallidus Reissinger, 1940, *nom. nud.*; p. 14; *Pityosporites pallidus* Reissinger, 1950, p. 109, Pl. 15, figs. 1–5; *Vitreisporites signatus* Leschik, 1955, p. 53, 54, Pl. 8, fig. 10; *Vitreisporites pallidus* (Reissinger) Nilsson, 1958, p. 78, Pl. 7, figs. 12–14.

Figured specimens. C-134172, 3, 19.8 x 94.8, GSC 105520; C-79890, 3, 36.0 x 95.5, GSC 105521; C-161961, 3, 4.7 x 101.0, GSC 105522.

Occurrence. Assistance and Trold Fiord formations.

Description. Disaccate pollen, haploxylonoid. Corpus longitudinally elongate oval. Cappa thin intrapunctate. Sacci slightly greater than semicircular in polar view; saccus exoexine thin intrareticulate, brochi less than 0.5 μm in diameter. Slight radial elongation at margin of cappa. Cappula with subparallel sides, breadth approximately one quarter that of corpus. Exine of cappula thin and without structure.

Dimensions. (5 specimens), total breadth 22 to 27 μm, mean 24 μm; saccus breadth 7 to 12 μm, mean 10 μm;

corpus breadth 12 to 15 μm, mean 14 μm; cappula breadth 3 to 5 μm, mean 3 μm; saccus offlap 4 to 6 μm, mean 5 μm; saccus length 15 to 17 μm, mean 16 μm; corpus length 15 to 17 μm, mean 16 μm.

Infraturma STRIATITI Pant, 1954

Genus *Corisaccites* Venkatachala and Kar, 1966

Type species. Corisaccites alatus Venkatachala and Kar, 1966.

Corisaccites stradivarii sp. nov.

Plate 5, figures 25–28; Plate 6, figures 1, 2

Holotype. C-134167, 3, 40.5 x 103.0, GSC 105523.

Figured specimens. C-134177, 3, 38.2 x 94.4, GSC 105524; C-134171, 4, 15.5 x 96.1, GSC 105525; C-161940, 3, 22.0 x 97.6, GSC 105526; C-161950, 3, 23.7 x 99.8, GSC 105527; C-161938, 3, 22.0 x 95.0, GSC 103895.

Occurrence. Assistance and Trold Fiord formations.

Diagnosis. Disaccate taeniate pollen, slightly diploxylonoid. Corpus transversely elongate-oval. Cappa approximately 1 to 1.5 μm thick, divided by a transverse polar cleft 1 to 9 μm wide, in which thin translucent intexine may be exposed. Exoexine of cappa finely intrareticulate. Sacci crescent to hemispherical shape in polar view, with pronounced distal inclination. Saccus exoexine 1 μm thick, densely intrareticulate. Brochi 0.5 to 3.0 μm in diameter, are radially elongate near the proximal sacci roots. Sacci roots almost equal to length of corpus. Cappula breadth narrow to broad, varies from approximately one tenth of corpus breadth to approximately one half.

Dimensions. (12 specimens), total breadth 30 to 52 μm, mean 46 μm; saccus breadth 12 to 23 μm, mean 18 μm; corpus breadth 28 to 47 μm, mean 38 μm; cappula breadth 3 to 18 μm, mean 12 μm; saccus offlap 2 to 7 μm, mean 3 μm; cappula breadth 23 to 48 μm, mean 40 μm; corpus length 25 to 44 μm, mean 35 μm.

Remarks. Most specimens have a distorted shape, and the polar cleft is split open, making the grains asymmetrical. In one specimen (Pl. 5, fig. 26), there appears to be a transverse monolete mark (approx. 5 μm long). *Corisaccites stradivarii* has been assigned to the genus *Corisaccites* because of the broad cleft on the cappa and the slightly diploxylonoid shape. It was not included in *Lueckisporites* because it lacks a thick columellate cap-like exo-exinous layer. *Corisaccites stradivarii* differs from *C. alatus* Venkatachala and Kar, 1964 in that the former is smaller and has a wider polar cleft. Some specimens of *C. stradivarii* superficially resemble *Lueckisporites virkkiae* "norm Bc" of Visscher (1971) but lack the columellae on the cappa.

Derivation of name. In polar compression (Pl. 5, fig. 25), the overall shape resembles that of the body of a violin. Named for Antonio Stradivari (1644–1737) of Cremona, Italy, world-renowned for crafting violins of superb tonal quality.

Genus *Hamiapollenites* Wilson emend. Tschudy and Kosanke, 1966

Type species. Hamiapollenites saccatus Wilson, 1962.

Hamiapollenites bullaeformis (Samoilovich) Jansonius, 1962

Plate 6, figures 3–5

Synonymy. Protodiploxypinus bullaeformis Samoilovich, 1953, p. 33, 34, Pl. IV, figs. 1a, b; *Hamiapollenites bullaeformis* (Samoilovich) Jansonius, 1962, p. 72.

Figured specimens. C-126269, 3, 22.0 x 106.8, GSC 105528; C-79870, 1a, 35.3 x 98.8, GSC 105529; C-126270, 3, 36.4 x 93.6, GSC 105530.

Occurrence. Sabine Bay, Assistance, Trold Fiord, Degerböls, and van Hauen formations.

Description. Taeniate disaccate pollen, haploxylonoid. Corpus circular to laterally elongate. Cappa approximately 1 μm thick finely intrapunctate; divided by narrow (0.25 to 0.5 μm) transverse and oblique clefts into 9 to 10 taeniae, which are almost continuous across the full breadth of the cappa, although they may taper to wedge shapes toward the lateral margins. Sacci greater than semicircular in polar view, finely to coarsely intrareticulate. Cappula lateral margins approximately parallel, and bordered by narrow longitudinal intexinal folds lying below sacci bases. Single distal longitudinal band of thickened exoexine approximately 6–7 μm wide, intrapunctate, commonly bordered by longitudinal fold.

Dimensions. (6 specimens), total breadth 52 to 74 μm, mean 64 μm; saccus breadth 15 to 24 μm, mean 19 μm; corpus breadth 34 to 40 μm, mean 36 μm; cappula breadth 24 to 30 μm, mean 28 μm; saccus offlap 10 to 16 μm, mean 14 μm; saccus length 23 to 34 μm, mean 29 μm; corpus length 35 to 42 μm, mean 40 μm.

Hamiapollenites erebi sp. nov.

Plate 6, figures 6–9

Holotype. C-99228, 4, 30.3 x 108.7, GSC 105531.

Figured specimens. C-99228, 4, 27.3 x 107.1, GSC 105532; C-134169, 3, 14.9 x 97.8, GSC 105533; C-134171, 5 18.6 x 102.5, GSC 105534.

Occurrence. Trold Fiord Formation.

Diagnosis. Taeniate disaccate pollen, haploxylonoid. Corpus transversely elongate. Cappa approximately 1 μm thick, finely intrapunctate; divided by wide (approximately 4 μm) transverse clefts into 3 or 4 punctate to finely intrareticulate taeniae 4–6 μm wide, which are continuous across the full breadth of the cappa. Sacci greater than semicircular in polar view, finely to coarsely intrareticulate. Cappula lateral margins approximately parallel. Single distal longitudinal band of thickened exoexine approximately 8 to 14 μm wide, intrapunctate to intrareticulate, commonly bordered by longitudinal fold.

Dimensions. (6 specimens), total breadth 66 to 85 μm, mean 74 μm; saccus breadth 22 to 29 μm, mean 25 μm; corpus breadth 36 to 77 μm, mean 56 μm; cappula breadth 23 to 33 μm, mean 27 μm; saccus offlap 10 to 11 μm, mean 11 μm; saccus length 30 to 47 μm, mean 37 μm; corpus length 44 to 55 μm, mean 49 μm.

Remarks. Hamiapollenites erebi differs from *H. bullaeformis* by having fewer taeniae and wider clefts. It differs from *Paucistriatopinites tener* (illustrated, but not described by Zauer, 1965), which has relatively large crescent-shaped sacci and a circular corpus. *Hamiapollenites erebi* differs from *Paucistriatopinites septatus* Dyupina, 1975 in that the longitudinal band of thickened exoexine is generally wider, and it lacks a narrow fissure, also *H. erebi* lacks a monolete mark. Nevertheless, it would appear that *H. erebi* and *P. septatus* are closely related.

Derivation of name. After *Erebus*, one of the ships used for the ill-fated Franklin expedition of 1845.

Genus *Lunatisporites* Leschik emend Klaus, 1963

Type species. Lunatisporites acutus Leschik, 1955.

Remarks. As Scheuring (1970) pointed out, the type species of *Lunatisporites* and *Taeniaesporites* are conspecific, and most workers consider *Lunatisporites* to be the senior synonym (see summary by Foster, 1979). As a result *Taeniaesporites albertae* Jansonius, 1962, p. 62, Pl. 13, fig. 12 (Appendix Figs. 8, 13, 15) is here considered to be the basionym of *Lunatisporites albertae* (Jansonius) comb. nov.

Lunatisporites beauchampii sp. nov.

Plate 6, figures 10–13

Holotype. C-170905, 3, 10.0 x 106.7, GSC 105535.

Figured specimens. C-161961, 3, 4.4 x 100.8, GSC 105536; C-161957, 3, 39.0 x 103.2, GSC 105537; C-161959, 3, 41.1 x 108.7, GSC 105538.

Occurrence. Trold Fiord Formation and upper van Hauen Formation.

Diagnosis. Taeniate disaccate pollen, haploxylonoid. Corpus transversely elongate oval. Cappula traversed by three to four clefts approximately 1 to 5 μm wide, into four or five taeniae from 6 to 10 μm wide. Exoexine of cappa 1 to 2 μm thick, finely intrapunctate. Intexine very thin. Sacci greater than semicircular in polar view, smaller than corpus. Exoexine of sacci 0.5 μm thick, intrareticulate, brochi 1 to 3 μm in diameter, with radial elongation near sacci bases. On proximal surface, sacci attached near to or at equator. Cappula approximately one third as broad as corpus, outline rectangular.

Dimensions. (5 specimens), total breadth 53 to 60 μm, mean 57 μm; saccus breadth 18 to 20 μm, mean 19 μm; corpus breadth 35 to 50 μm, mean 43 μm; cappula breadth 10 to 20 μm, mean 16 μm; saccus offlap 4 to 12 μm, mean 7 μm; saccus length 30 to 40 μm, mean 38 μm; corpus length 30 to 45 μm, mean 39 μm.

Remarks. Lunatisporites beauchampii sp. nov. is more transversely elongate than the specimens of the *nomen nudum Taeniaesporites substriata* (Maljavkina) Varyukhina, 1971; the former also has sacci greater than semicircular, whereas in *T. substriata* they are crescent-shaped. In *Lunatisporites albertae* (Jansonius, 1962, p. 62, Pl. 13, figs. 12, 13.) comb. nov., the sacci are thinner and smaller relative to the central body than in *L. beauchampii*. The taeniae are also more uniform in appearance in the former. *Lueckisporites pellucidus* (Goubin) Balme, 1970 is larger (79 to 102 μm). *Taeniaesporites ovatus* Goubin, 1965 has a less transversely elongate corpus, and more crescent-shaped sacci.

Derivation of name. Named for Benoit Beauchamp, Geological Survey of Canada, for his contribution to the geology of the Sverdrup Basin.

Lunatisporites arluki sp. nov.

Plate 6, figures 14–16

Holotype. C-99228, 17, 35.0 x 107.0, GSC 105539.

Figured specimens. C-99228, 14, 14.5 x 100.4, GSC 105540; C-99228, 7, 25.4 x 100.0, GSC 105541.

Occurrence. Trold Fiord Formation.

Diagnosis. Taeniate disaccate pollen, haploxylonoid to slightly diploxylonoid. Corpus transversely elongate oval. Cappa traversed by three or four clefts approximately 1 to 5 μm wide, into four or five taeniae from 4 to 7 μm wide. Monolete mark within central cleft 6 to 10 μm long. Exoexine of cappa 1.5 μm thick, finely intrapunctate to intrareticulate. Intexine not visible. Sacci greater than semicircular in polar view, slightly larger than corpus. Exoexine of sacci 0.5 μm thick, intrareticulate, brochi 1–3 μm in diameter, with radial elongation near sacci bases. Crescentic fold at sacci bases. On proximal surface, sacci attached near to or at equator. Cappula approximately one quarter to one third as broad as corpus, outline rectangular.

Dimensions. (6 specimens), total breadth 60 to 78 μm, mean 72 μm; saccus breadth 25 to 32 μm, mean 30 μm; corpus breadth 33 to 44 μm, mean 38 μm; cappula breadth 10 to 15 μm, mean 13 μm; saccus offlap 16 to 20 μm, mean 18 μm; saccus length 37 to 41 μm, mean 40 μm; corpus length 35 to 49 μm, mean 39 μm.

Remarks. Taeniaesporites substriata (Maljavkina) Varyukhina, 1971 (*nom. nud.*) has smaller sacci, lacks the crescentic folds at the sacci bases, and the monolete mark. *Lunatisporites beauchampii* is smaller, has smaller sacci, and lacks the crescentic folds at the base of the sacci. The clefts on *Lunatisporites arluki* are broader than those of *Lunatisporites albertae* Jansonius, 1962 (p. 62, Pl. 13, figs. 12, 13). *Lunatisporites noviaulensis* (Leschik) Foster, 1979 is generally less diploxylonoid than *L. arluki*, but in other respects is similar.

Derivation of name. Inuit, *arluk*, killer whale.

Genus *Pallidosporites* Schaarschmidt, 1963

Type species. Pallidosporites minimus Schaarschmidt, 1963.

Pallidosporites multiradiatus sp. nov.

Plate 6, figures 17, 18, 22, 23

Synonymy. Florinites sp. Varyukhina, 1971, Pl. 25, fig. 10.

Holotype. C-126275, 3, 39.0 x 107.1, GSC 105542.

Figured specimens. C-126257, 3, 39.7 x 101.1, GSC 105543; C-126275, 3, 28.6 x 108.0, GSC 105544; C-126275, 3, 41.2 x 101.4, GSC 105545.

Occurrence. Sabine Bay, Assistance, and Trold Fiord formations.

Diagnosis. Taeniate disaccate pollen, haploxylonoid. Amb subcircular; corpus approximately circular to longitudinally oval. Cappa 1 to 2 μm thick, finely intrareticulate. Sacci almost semicircular in polar view; distally inclined. Saccus exoexine 0.25 μm thick, intrareticulate. Sacci continuous laterally with a band of exoexine approximately 2 μm wide. Brochi elongate, extending in a radial pattern from the proximal and distal sacci bases almost to margin of saccus. Near lateral margin they are approximately 1 μm long to 1 μm wide, but increase in length and width toward the transverse axis where they may be up to 5 μm long and 2.5 μm wide. On cappa, extending full breadth, is narrow central cleft, approximately 0.25 μm wide. Cappula not clearly visible, but thin and narrow.

Dimensions. (25 specimens), total breadth 26 to 44 μm, mean 39 μm; saccus breadth 14 to 22 μm, mean 17 μm; corpus breadth 20 to 39 μm, mean 29 μm; cappula breadth 1 to 8 μm, mean 5 μm; saccus offlap 2.5 to 7 μm, mean 5 μm; saccus length 29 to 39 μm, mean 34 μm; corpus length 24 to 41 μm, mean 32 μm.

Remarks. The clefts are very faint in many specimens. Pollen grains commonly split open at one or both extremities of the longitudinal axis. Varyukhina (1971, Pl. 25, fig. 10), illustrated, but did not describe, what appears to be a similar taxon in the Permian and

Lower Triassic, and identified it as *Florinites* sp. In *Pallidosporites minimus* Schaarschmidt, 1963 the breadth is greater than the length; also greater is the breadth of the cappula and the sacci. *Vesicaspora wilsonii* Schemel emend. Wilson and Venkatachala, 1963 lacks the narrow transverse cleft on the cappa but the overall size and shape are similar.

Derivation of name. Latin, *multus*, many; *radiatus*, provided with rays.

Genus *Protohaploxypinus* Samoilovich emend. Morbey, 1975

Type species. Protohaploxypinus latissimus (Luber) *in* Luber and Waltz, 1941.

Protohaploxypinus kayaki sp. nov.

Plate 6, figures 19–21, 24–26

Holotype. C-126275, 3, 20.3 x 99.8, GSC 105546.

Figured specimens. C-126275, 3, 28.0 x 98.7, GSC 105547; C-126275, 3, 7.0 x 99.7, GSC 105548.

Occurrence. Sabine Bay, Assistance, Trold Fiord, and van Hauen formations.

Diagnosis. Taeniate disaccate pollen, haploxylonoid, amb transversely oval. Corpus well defined, shape suboval with transverse elongation. Cappa approximately 1 μm thick, finely intrareticulate in proximal view; divided by narrow (less than 0.5 μm) transverse clefts. Taeniae each up to 8 μm wide, but may taper to 2 μm; approximately 6 taeniae, occasionally branched, with 1 to 2 taeniae extending part way. Sacci hemispherical to greater than hemispherical in polar view, discrete, but may be in contact at lateral margins. Exoexine thin (less than 1 μm) intrareticulate. Cappula breadth approximately one half of corpus; sacci bases poorly defined. On some specimens, longitudinal concentric intexinal folds occur close to sacci bases. Brochi elongate to radial pattern near sacci bases. Monolete, geniculate or unequal trilete (with short laesura parallel to longitudinal axis), haptotypic mark orientated parallel to transverse axis, 10 to 19 μm long.

Dimensions. (10 specimens), total breadth 49 to 66 μm, mean 54 μm; saccus breadth 18 to 22 μm, mean 16 μm; corpus breadth 32 to 42 μm, mean 35 μm; cappula breadth 12 to 20 μm, mean 17 μm; saccus offlap 7 to 10 μm, mean 9 μm; saccus length 29 to 40 μm, mean 32 μm; corpus length 30 to 42 μm, mean 34 μm.

Remarks. This species has features in common with *Protohaploxypinus minor* (Klaus) Clarke, 1965, but has fewer taeniae, and the corpus has a transverse elongation. It differs from *Protohaploxypinus chaloneri* Clarke, 1965, in lacking the distal attachment thickenings. It is similar to *Striatopodocarpites oblongus* Zauer, 1965, but differs in having a monolete or geniculate mark and poorly defined sacci bases. *Protohaploxypinus kayaki* is smaller than *P. perfectus*, generally has fewer taeniae, and has a more clearly defined haptotypic mark.

Derivation of name. Inuit, *kayak*, canoe.

Protohaploxypinus latissimus (Luber) Samoilovich, 1953

Plate 6, figures 27–29

Selected synonymy. Pemphygaletes latissimus Luber, Luber and Waltz, 1941, Pl. XIII, fig. 221; *Protohaploxypinus latissimus* (Luber) Samoilovich, 1953.

Figured specimens. C-126276, 3, 14.1 x 93.6, GSC 105549; C-126262, 3, 38.0 x 95.0, GSC 105550; C-79879, 3a, 9.5 x 96.4, GSC 105551.

Occurrence. Sabine Bay, Assistance, Trold Fiord, and van Hauen formations.

Description. Taeniate disaccate pollen, haploxylonoid, amb transversely oval. Corpus poorly defined, shape suboval. Cappa approximately 1 μm thick, finely intrareticulate in proximal view; divided by narrow (less than 0.5 μm) transverse clefts. Number of taeniae variable (7–12), each 3 to 7 μm wide; occasionally branched, with a few (1 to 4) of the taeniae extending part way. Sacci hemispherical to greater than hemispherical in polar view, distally inclined; exoexine thin (less than 1 μm) intrareticulate, sacci sometimes joined equatorially by strips of exoexine. Cappula oval, breadth approximately one half that of corpus.

Dimensions. (10 specimens), total breadth 66 to 110 μm, mean 82 μm; saccus breadth 24 to 44 μm, mean 39 μm; corpus breadth 42 to 63 μm, mean 49 μm; cappula breadth 7 to 24 μm, mean 18 μm; saccus offlap 10 to 22 μm, mean 15 μm; saccus length 49 to 64 μm, mean 51 μm; corpus length 27 to 64 μm, mean 45 μm.

Remarks. Protohaploxypinus latissimus differs from *P. perfectus* by its thin poorly defined cappa, relatively larger cappula and the lack of a haptotypic mark.

Protohaploxypinus varius (Bharadwaj) Balme, 1970 is similar, but has a broader cappula. *Protohaploxypinus limpidus* (Balme and Hennelly) Balme, 1970 differs in that it has a narrower cappula and is smaller (43–64 µm, mean 53 µm).

Protohaploxypinus panaki sp. nov.

Plate 6, figures 30, 31; Plate 7, figures 1–3

Holotype. C-134171, 3, 10.8 x 93.4, GSC 105552.

Figured specimens. C-161950, 3, 30.3 x 93.2, GSC 105553; C-134171, 4, 38.8 x 93.8, GSC 105554; C-161926, 3, 21.3 x 94.7, GSC 105555.

Occurrence. Sabine Bay, Assistance, and Trold Fiord formations.

Diagnosis. Taeniate disaccate pollen, haploxylonoid. Amb transversely elongate oval; corpus approximately circular to transversely oval. In some specimens (Pl. 7, fig. 1), the corpus has longitudinal intexinal folds parallel to the saccus roots. Cappa 1 µm thick, finely intrareticulate. Divided by transverse, occasionally bifurcating, clefts into approximately 7–10 taeniae. Taeniae up to 7 µm wide, but taper to wedge shape. Sacci distally inclined, almost semicircular in polar view; length less than corpus. Saccus exoexine 0.5 µm thick, intrareticulate. Sacci bases sometimes barely visible. Cappula longitudinally oval, exine thin; breadth approximately one fifth that of corpus.

Dimensions. (10 specimens), total breadth 51 to 57 µm, mean 57 µm; saccus breadth 20 to 25 µm, mean 20 µm; corpus breadth 36 to 50 µm, mean 50 µm; cappula breadth 2 to 18 µm, mean 18 µm; saccus offlap 5 to 6 µm, mean 5 µm; saccus length 40 to 44 µm, mean 40 µm; corpus length 42 to 45 µm, mean 45 µm.

Remarks. Protohaploxypinus panaki has a more robust corpus and cappa than *P. latissimus* (Luber) Samoilovich, 1953. *Protohaploxypinus suchonensis* (Sedova) Hart, 1965 has smaller sacci relative to the size of the corpus.

Derivation of name. Inuit, *panak*, snow knife.

Protohaploxypinus perfectus (Naumova) Samoilovich, 1953

Plate 7, figures 4–6

Synonymy. Protohaploxypinus perfectus (Naumova) Samoilovich, 1953, Pl. VI, fig. 1a–c; Pl. XII, fig. 1a, b; *Striatohaploxypinites perfectus* (Naumova) Zauer, 1965, Pl. XIII, fig. 4; *Striatopinites perfectus* (Naumova) Zauer, 1965, v. 1, Pl. 61, fig. 9.

Figured specimens. C-161960, 3, 28.6 x 102.0, GSC 105556; C-126275, 3, 13.6 x 95.5, GSC 105557; C-126275, 3, 14.0 x 94.1, GSC 105558.

Occurrence. Sabine Bay, Assistance, Trold Fiord, and van Hauen formations.

Description. Taeniate disaccate pollen, haploxylonoid, amb transversely oval. Corpus well defined, shape circular to suboval with transverse elongation. Cappa approximately 2 µm thick, finely intrareticulate in proximal view; divided by narrow (less than 0.5 µm) transverse clefts. Taeniae 6 to 13, each 2 to 7 µm wide, occasionally branched, with 1 to 3 taeniae extending part way. Poorly defined monolete mark (up to 20 µm) occasionally present. Sacci hemispherical, to greater than hemispherical in polar view, exoexine thin (less than 1 µm), intrareticulate. Cappula oval or approximately rectangular in shape; breadth generally approximately one quarter to one third of corpus. Cappula commonly bordered by narrow longitudinal intexinal folds.

Dimensions. (25 specimens), total breadth 54.0 to 98.0 µm, mean 70.5 µm; saccus breadth 21.5 to 37.0 µm, mean 29.5 µm; corpus breadth 29.5 to 64.0 µm, mean 41.0 µm; cappula breadth 7.0 to 5.0 µm, mean 6.5 µm; saccus offlap 10.0 to 21.5 µm, mean 15.0 µm; saccus length 31.0 to 69.0 µm, mean 43 µm; corpus length 35.0 to 69.0 µm, mean 44 µm.

Remarks. The specimens described here closely resemble those illustrated by Samoilovich (1953) from the Permian of the Cis-Urals, Russia, and those illustrated as *Striatohaploxypinites perfectus* (Naumova) Zauer, 1965 by Varyukhina (1971) and Molin and Koloda (1972) from the northeast European part of Russia.

Protohaploxypinus sp. A

Plate 7, figure 7

Figured specimen. C-126269, 3, 10.5 x 103.4, GSC 105559.

Occurrence. Sabine Bay, Assistance, and Trold Fiord formations.

Diagnosis. Taeniate disaccate pollen, haploxylonoid, amb transversely oval. Corpus fairly well defined, shape almost circular. Cappa approximately 1 µm thick, finely intrareticulate in proximal view, divided by narrow (approx. 0.25 µm) clefts. Approximately 5 taeniae, each 2 to 9 µm wide. Saccus greater than hemispherical in polar view, exoexine approximately 0.25 µm, intrareticulate; sacci bases poorly defined; length of sacci greater than corpus so that they are linked at the longitudinal margins by a narrow (3 to 4 µm) strip of exoexine. Cappula poorly defined, breadth approximately one half that of corpus.

Dimensions. (1 specimen), total breadth 53 µm; saccus breadth 20 µm; corpus breadth 30 µm; cappula breadth 15 µm; saccus offlap 11 µm; saccus length 29 µm; corpus length 36 µm.

Remarks. Protohaploxypinus sp. A differs from *P. perfectus* in that it has fewer and broader taeniae, and the corpus length is less than the saccus length.

Genus *Scutasporites* Klaus, 1963

Type species. Scutasporites unicus Klaus, 1963.

Scutasporites nanuki sp. nov.

Plate 7, figures 8–12

Synonymy. Scutasporites sp. cf. *S. unicus* Balme, 1980, p. 32, 33, Pl. 3, fig. 5.

Holotype. C-79889, 3, 40.4 x 112.7, GSC 105560.

Figured specimens. C-79890, 3, 41.0 x 97.6, GSC 105561; C-79890, 3, 33.0 x 98.8, GSC 105562; C-99228, 13, 30.6 x 108.2, GSC 105563; C-161962, 3, 9.4 x 94.1, GSC 105564.

Occurrence. Trold Fiord Formation and upper van Hauen Formation.

Diagnosis. Taeniate disaccate pollen, haploxylonoid. Corpus transversely elongate oval. Cappa 1 µm thick, exoexine thickened to form a single transverse polar taenia up to 10 µm wide, or between one quarter and one third of the diameter of the corpus, commonly becoming broader at its lateral extremities, intrapunctate. Monolete mark on taenia 7 to 13 µm long; does not extend to margin of corpus. Sacci hemispherical in polar view; narrow bands (3 to 5 µm wide) of sacci exine extend on to longitudinal margin of corpus. Proximal attachment at equator or with slight overlap on to corpus. Saccus exine thin (less than 0.25 µm), intrareticulate. Cappula with subparallel lateral margins.

Dimensions. (10 specimens), total breadth 44 to 70 µm, mean 56 µm; saccus breadth 15 to 37 µm, mean 21 µm; corpus breadth 22 to 50 µm, mean 36 µm; cappula breadth 10 to 30 µm, mean 21 µm; saccus offlap 9 to 15 µm, mean 12 µm; saccus length 25 to 47 µm, mean 32 µm; corpus length 28 to 40 µm, mean 33 µm.

Remarks. Scutasporites nanuki differs from *S. unicus* Klaus, 1963, which has a broader taenia (25 µm) and sickle-shaped, rather than semicircular, sacci. The specimens described from the *Vittatina* Association of Kap Stosch by Balme (1980a) as *Scutasporites* sp. cf. *S. unicus* are similar to *S. nanuki.*

Derivation of name. Inuit, *nanuk*, polar bear.

Genus *Striatoabieites* Zoricheva and Sedova ex Sedova emend. Hart, 1964

Type species. Striatoabieites brickii Sedova, 1956.

Striatoabieites borealis sp. nov.

Plate 7, figures 13–16

Holotype. C-79876, 3, 24.5 x 105.5, GSC 105565.

Figured specimens. C-79878, 3, 18.2 x 100.4, GSC 105566; C-170896, 3, 40.8 x 99.0, GSC 105567; C-99228, 17, 27.1 x 108.2, GSC 105568.

Occurrence. Trold Fiord Formation.

Diagnosis. Taeniate disaccate pollen, haploxylonoid. Corpus laterally elongate to circular. Some specimens have intexinal fold on distal surface of corpus running parallel to the transverse axis. Cappa approximately 0.5 to 1 µm thick, exine punctate; traversed by narrow clefts that in most specimens are barely visible. Approximately 12 to 15 taeniae, some of which are wedge-shaped and do not extend the full breadth of the corpus; width of taeniae generally less than 6 µm. Monolete mark on proximal surface sometimes visible; approximately 8 µm long. Sacci smaller than corpus, distally inclined; exoexine thin (less than 0.25 µm), finely intrareticulate; crescent-shaped, longitudinal intexinal folds commonly present on corpus above discernible distal sacci base of at least one of the sacci. Brochi faint with radial elongation. Cappula with rectangular to slightly fusiform sulcus extending full length of corpus.

Dimensions. (7 specimens), total breadth 71 to 90 μm, mean 78 μm; saccus breadth 23 to 30 μm, mean 26 μm; corpus breadth 41 to 70 μm, mean 46 μm; cappula breadth 20 to 35 μm, mean 25 μm; saccus offlap 10 to 20 μm, mean 14 μm; saccus length 42 to 55 μm, mean 45 μm; corpus length 39 to 60 μm, mean 48 μm.

Derivation of name. Latin, *boreus*, northern.

Remarks. Striatoabieites borealis is distinguished by its very thin, commonly folded sacci with poorly discernible distal attachment, and the faint taeniae. It is larger than *S. striatus* (Luber) Hart, 1964 and the corpus is less elongate laterally.

Striatoabieites striatus (Luber and Waltz) Hart, 1964

Plate 7, figures 17–20

Synonymy. Pemphygaletes striatus Luber and Waltz, 1941, p. 63, 64, Pl. 13, fig. 223; *Striatoabieites striatus* (Luber and Waltz) Hart, 1964, p. 42, 43, textfig. 94.

Figured specimens. C-126254, 3, 21.5 x 98.3 (lateral view), GSC 105569; C-126273, 3, 7.0 x 106.2, GSC 1055570; C-126269, 4, 38.2 x 97.2 (lateral view), GSC 105571; C-134167, 4, 12.6 x 97.6, GSC 105572.

Occurrence. Sabine Bay, Assistance, Trold Fiord, and van Hauen formations.

Description. Taeniate disaccate pollen, haploxylonoid. Amb transversely elongate-oval. Corpus well defined, transversely oval. Exoexine of cappa approximately 1.5 μm thick, finely intrareticulate, divided by barely visible narrow (less than 0.5 μm) branching clefts. Taeniae 2 to 5 μm wide, 5 to 7 in number. Sacci distally inclined, less than semicircular in polar view; base length less than that of corpus; saccus exoexine 1 μm thick, finely intrareticulate, brochi radially elongate. Cappula rounded rectangular, breadth approximately seven eighths of corpus, exine structureless.

Dimensions. (14 specimens), total breadth 51 to 88 μm, mean 64 μm; saccus breadth 12 to 29 μm, mean 20 μm; corpus breadth 36 to 58 μm, mean 43 μm; cappula breadth 18 to 34 μm, mean 25 μm; saccus offlap 9 to 19 μm, mean 12 μm; saccus length 17 to 36 μm, mean 26 μm; corpus length 27 to 46 μm, mean 33 μm.

Remarks. Luber and Waltz (1941) described specimens from the Permian of the Solikamsk region as containing comparatively small sacci, and having an oblong corpus that sometimes bears taeniae. Hart (1964) described the corpus as elongate with 7 or 8 taeniae. Some specimens described in the present paper have only 5 taeniae, but they have nevertheless been included in *S. striatus.*

Genus *Striatopodocarpites* Zoricheva and Sedova ex Sedova emend. Hart, 1964

Type species. Striatopodocarpites tojmensis Sedova, 1956.

Striatopodocarpites circulus sp. nov.

Plate 7, figure 21–23

Holotype. C-126269, 3, 22.2 x 101.8, GSC 105573.

Figured specimens. C-161930, 3, 17.2 x 95.3, GSC 105574; C-134170, 3, 11.2 x 109.0, GSC 105575.

Occurrence. Sabine Bay, Assistance, and Trold Fiord formations.

Diagnosis. Taeniate disaccate pollen, diploxylonoid. Corpus well defined, circular to transversely oval. Cappa traversed by faint, narrow, wavy transverse clefts (less than 0.25 μm) separating 6 to 12 taeniae approximately 2 to 7 μm wide. Some taeniae do not extend the full breadth of the cappa and are wedge-shaped. Exoexine of cappa approximately 3 μm thick, finely intrareticulate; at margins contact of exoexine layers produces a rim up to 3 μm wide. Intexine not visible. Sacci greater than semicircular in polar view. Exoexine of sacci 0.5 μm thick, intrareticulate; brochi 1 to 3 μm diameter, with radial elongation near sacci bases. Cappula approximately one quarter as broad as corpus, longitudinally elongate-oval, exine thin; bordered by crescentic intexinal thick folds, up to 6 μm wide, located below bases of sacci.

Dimensions. (10 specimens), total breadth 60 to 68 μm, mean 66 μm; saccus breadth 26 to 30 μm, mean 28 μm; corpus breadth 28 to 32 μm, mean 30 μm; cappula breadth 8 to 11 μm, mean 9 μm; saccus offlap 18 to 22 μm, mean 20 μm; saccus length 38 to 42 μm, mean 40 μm; corpus length 30 to 32 μm, mean 31 μm.

Remarks. Striatopodocarpites circulus differs from *S. tojmensis* (Sedova) Hart, 1965 in that the latter has differentially thickened central taeniae and generally

6 or, rarely, 7 taeniae. It is similar to *Striatopodocarpites* sp. 2 of Zauer (1965, Pl. XI, fig. 5) although the cappula of the latter is rectangular rather than oval. *Striatopodocarpites cancellatus* (Balme and Hennelly) Hart, 1963 has a more transversely elongate corpus and narrower cappula.

Derivation of name. Latin, *circulus*, circle.

Striatopodocarpites sp. A

Plate 7, figure 24; Plate 8, figure 1

Figured specimen. C-134171, 3, 10.4 x 94.0, GSC 105576; C-134171, 4, 4.9 x 103.6, GSC 105577.

Occurrence. Sabine Bay and Trold Fiord formations.

Diagnosis. Taeniate disaccate pollen, slightly diploxylonoid. Corpus well defined, almost circular to laterally elongate. Cappa traversed by narrow transverse clefts (less than 0.25 μm wide) separating 9 to 10 taeniae approximately 4 to 10 μm wide. Some taeniae do not extend the full breadth of the cappa and are wedge-shaped. Monolete mark 6 to 12 μm in length. Exoexine of cappa approximately 1.5 μm thick, finely intrareticulate. Intexine not visible. Sacci greater than semicircular in polar view. Exoexine of sacci 0.5 μm thick, intrareticulate, brochi 1 to 3 μm diameter, with radial elongation near proximal sacci bases. Cappula slightly less than one half as broad as corpus, longitudinally elongate rectangular, exine thin; bordered by crescentic intexinal thick folds up to 6 μm wide, located at sacci bases.

Dimensions. (3 specimens), total breadth 75 to 88 μm; saccus breadth 31 to 34 μm; corpus breadth 36 to 50 μm; cappula breadth 19 to 25 μm; saccus offlap 22 to 20 μm; saccus length 44 to 52 μm; corpus length 40 to 50 μm.

Remarks. Striatopodocarpites sp. A differs from *P. perfectus* by its slightly diploxylonoid outline and its broader cappula. It differs from *S. circulus*, in that the former has a narrower cappula, a circular corpus and is smaller. *Striatopodocarpites pantii* (Jansonius) Balme, 1970 has a similar overall shape, but is larger (92 to 124 μm; mean 108 μm) and has fewer taeniae. *Protohaploxypinus hartii* Foster, 1979 differs in that it has a less transversely elongate corpus and a narrower cappula.

Turma PLICATES Naumova emend.
Potonié, 1962

Subturma POLYPLICATES Erdtmann, 1952

Genus *Vittatina* (Luber) ex Wilson, 1962

Types species. Vittatina subsaccata Samoilovich ex Wilson, 1962.

Remarks. The genus *Ventralvittatina* Koloda, 1989 appears to be similar to the concept of *Vittatina* Luber, 1941. The main difference, according to the description of Koloda, 1989, is that *Ventralvittatina* has an equatorial thickening, whereas *Vittatina* does not. In some cases e.g., *Ventralvittatina rotunda* Koloda, 1989, this equatorial thickening would appear to be due to contact of the exoexine at the proximal-distal margin. In this present work, the author has found it difficult to differentiate the two genera and has maintained the use of *Vittatina.*

Vittatina connectivalis (Zauer) Varyukhina,
1971 ex. Utting

Plate 8, figures 2–5

Synonymy. Vittatina subsaccata Samoilovich forma *connectivalis* Zauer, 1965, *nom. nud.*, Pl. VII, fig. 2a (no description); *Vittatina subsaccata* forma *connectivalis* Varyukhina, 1971, *nom. nud.*, p. 90–91, Pl. VIII, 2a, b (no holotype designated)

Holotype. C-161961, 3, 29.7 x 101.0, GSC 105578.

Figured specimens. C-79890, 3, 25.8 x 104.0, GSC 105579; C-161950, 3, 20.8 x 95.0, GSC 105580; C-161956, 3a, 25.8 x 107.2, GSC 105581.

Occurrence. Sabine Bay, Assistance, van Hauen, and Trold Fiord formations.

Emended diagnosis. Monosulcate pollen grain. Amb transversely oval. Exine 1 μm thick. Thin, transparent intexine overlain by transversely taeniate exoexine. Individual taeniae 1 to 2 μm wide, separated by clefts 1 μm or less wide. Taeniae (approx. 16) terminate at proximo-distal margin, although in some cases a few may extend on to the distal surface and continue longitudinally; they may be interrupted along their length by secondary clefts at an oblique angle to primary clefts, producing rounded, irregular blocks of various shapes and sizes. Rudimentary coarsely granulate (grana up to 2 μm diameter) saccus attached proximally at proximo-distal margin. Slight offlap (up to 3 μm) of sacci at transverse poles. Distal saccus attachment at approximately one quarter to one third corpus breadth from the proximo-distal margin of the corpus. Single distal longitudinal band of granulate thickened exoexine (approximately 7 μm wide).

Dimensions. (5 specimens), breadth 34 to 50 μm, mean 44 μm; length 34 to 38 μm, mean 37 μm.

Remarks. Vittatina connectivalis resembles *Vittatina subsaccata* forma *connectivalis* described by Varyukhina, 1971 from the Kungurian, Ufimian to Kazanian stages of the Pechora Basin. It differs from *Vittatina costabilis* Wilson, 1962, by the presence of secondary clefts on the taeniae and the coarsely granular rudimentary saccus.

Vittatina heclae sp. nov.

Plate 8, figures 6–10

Holotype. C-126269, 3, 7.2 x 97.0, GSC 105582.

Figured specimens. C-126269, 3, 9.8 x 104.6, GSC 105583; C-161926, 3, 19.4 x 104.0, GSC 105584; C-126276, 3, 30.3 x 99.4, GSC 105585; C-126270, 3, 17.4 x 102.5, GSC 105586.

Occurrence. Sabine Bay, Assistance, van Hauen, and Trold Fiord formations.

Diagnosis. Monosulcate pollen grain with monolete laesura up to 7 μm long on proximal pole. Overall outline transversely oval to almost circular. Exine approximately 1 μm thick, consists of very thin intexine overlain proximally by taeniate, finely intrapunctate exoexine. Individual exoexinous taeniae, approximately 8 to 12, are 2 to 5 μm wide and less than 0.5 μm apart. In polar compressions, taeniae run transversely on the proximal face, and terminate approximately 3 to 6 μm before the proximo-distal margin; some are wedge-shaped and are thus shorter than others. Equatorial rim of similar dimension and structure, continuous along equatorial outline; proximal taeniae do not join equatorial rim, but near lateral margins, the rim expands onto distal surface. Secondary longitudinal fold commonly present near base of one of these thickenings. On distal surface, exoexine thins in the sulcal area.

Dimensions. (12 specimens), breadth 34 to 58 μm, mean 43 μm; length 29 to 50 μm, mean 38 μm.

Remarks. Vittatina heclae is less transversely oval than *V. simplex* Jansonius, 1962, which has fewer taeniae (7–8) and lacks a monolete mark; *V. subsaccata* Samoilovich, 1953 and the closely related *V. saccifer* Jansonius, 1962 are similar, but have expansion at ends of lateral axis into small sacci. *Vittatina minima* Jansonius, 1962 has fewer taeniae and strongly pendant rudimentary sacci. *Ventralvittatina vittifera* (Luber) forma *minor* (Samoilovich) Koloda, 1989, is smaller and has rudimentary sacci.

Derivation of name. After *Hecla*, one of the vessels used by Lieutenant E. Parry, R.M. on his exploration voyage of 1819–20 during which the Parry Channel was discovered.

Vittatina subsaccata Samoilovich, 1953

Plate 8, figures 11, 12

Figured specimens. C-161938, 3, 28.2 x 104.2, GSC 105591.

Occurrence. Sabine Bay, Assistance, van Hauen, and Trold Fiord formations.

Description. Monosulcate pollen grain. Overall shape transversely oval. Exine approximately 1.5 μm thick, consisting of very thin intexine overlain by taeniate, finely intrapunctate exoexine. Individual exoexinous taeniae 10 to 11 in number, up to 3 μm wide, clefts approximately 0.25 μm wide; a few clefts may bifurcate so that the taeniae are not continuous. In polar compressions, taeniae extend transversely on proximal face and terminate slightly before proximo-distal margin. Small, thin-walled intrareticulate bladders with proximal attachment at margin, distal attachment poorly discernible extending approximately one third onto distal surface. Crescentic folds above sacci bases. Monolete mark on proximal surface 3 μm long.

Dimensions. (1 specimen), breadth 47 μm; length 36 μm.

Remarks. Vittatina saccifer Jansonius, 1962, is similar, but differs in that it has thick walled bladders, and has laevigate rather than intrapunctate exoexine.

Vittatina vittifera (Luber) Samoilovich, 1953

Plate 8, figure 13

Synonymy. Zonaletes vittifera Luber, 1941, p. 61, Pl. XIII, fig. 217.

Figured specimens. C-126268, 3, 28.0 x 102.3, GSC 105592.

Occurrence. Sabine Bay, Assistance, van Hauen, Degerböls, and Trold Fiord formations.

Description. Monosulcate pollen grain. Overall outline transversely oval. Exine approximately 1 μm thick, consisting of very thin intexine overlain by taeniate, finely intrapunctate exoexine. Individual exoexinous taeniae are 11 to 17 in number, 2 to 4 μm wide, and less than 0.5 μm apart. A few clefts may bifurcate so that the taeniae are not continuous. In polar compressions, taeniae extend transversely on the proximal face, and terminate almost at the proximo-distal margin, although in some specimens, taeniae may overlap slightly onto distal surface.

Dimensions. (12 specimens), breadth 48 to 76 μm, mean 61 μm; length 36 to 59 μm, mean 46 μm.

Remarks. In some specimens of *V. vittifera*, one or two taeniae overlap slightly onto the distal surface. If the number of overlapping taeniae exceeds two, the specimens have been included in *W. striatus*.

Vittatina vittifera Luber forma *minor* Samoilovich, 1953

Plate 8, figure 14

Synonymy. Ventralvittatina vittifera Luber forma *minor* (Samoilovich), Koloda, 1989, p. 62, 63, Pl. I, figs. 5-8.

Figured specimen. C-170861, 3, 6.8 x 104.6, GSC 105593.

Occurrence. van Hauen and Trold Fiord formations.

Description. Monosulcate pollen grain. Overall shape longitudinally oval. Exine approximately 1 μm thick, consisting of very thin intexine, overlain by taeniate, finely intrapunctate exoexine. Individual exoexinous taeniae, extending parallel to transverse axis, approximately ten, each up to 3 μm wide; clefts approximately 0.25 μm wide. A few clefts may bifurcate, so taeniae are not continuous. Taeniae terminate before reaching lateral margin. Equatorial rim of similar structure to taeniae is 2.5 to 4 μm wide.

Dimensions. (1 specimen), breadth 27 μm; length 19 μm.

Remarks. The specimen differs from *Vittatina minima* Jansonius, in lacking rudimentary sacci.

Genus *Weylandites* Bharadwaj and Srivastava, 1969

Type species. Weylandites indicus Bharadwaj and Srivastava, 1969.

Discussion. In this paper, *Weylandites* is used for species that have taeniae on the proximal (transverse taeniae) and distal (longitudinal taeniae) surfaces, and that lack sacci (see Foster, 1979 for selected synonymy). Although *Vittatina* is used for those species where the taenia are transversely orientated and confined to the proximal face, some species may have rudimentary sacci.

Weylandites cincinnatus (Luber ex. Varyukhina, 1971) comb. nov.

Plate 8, figures 15, 16

Synonymy. Vittatina cincinnata Luber ex. Varyukhina, 1971, *pars.* p. 87, 88, Pl. VII, fig. 3a.

Figured specimens. C-126269, 4, 19.2 x 109.0, GSC 105594, C-99245, 3, 37.2 x 105.2, GSC 105595.

Occurrence. Sabine Bay, Assistance, van Hauen, and Trold Fiord formations.

Description. Monosulcate pollen grain. Amb circular. Transversely arranged, closely spaced taeniae on proximal surface total approximately 14, and are in the order of 2 to 5 μm wide; narrow (less than 0.25 μm) clefts bifurcate in some specimens so that some taeniae may be discontinuous. Three to four outer taeniae extend on to the extremity of the distal surface longitudinally, extending parallel to subparallel; distal overlap 18 μm. Exine laevigate and approximately 0.25 μm thick. Exoexine thin to absent in sulcal area.

Dimensions. (6 specimens), breadth 40 to 46 μm, mean 43 μm; length 41 to 45 μm, mean 43 μm.

Remarks. In some specimens, the distal taeniae are curved so that the sulcal area is narrower in the centre than at the lateral margins. Foster (1979) explained how Varyukhina (1971) validated *V. cincinnata*, although the former considered *Vittatina cincinnata* Luber ex. Varyukhina, 1971 to be a junior synonym of *Weylandites lucifer* (Bharadwaj and Salujha) Foster, 1975. However, *W. cincinnata* differs from *W. lucifer* by its broader taeniae and circular outline, and has here been maintained as a separate species. *Vittatina* *magna* (Bose and Kar) Anderson, 1977 has broader taeniae.

Weylandites segmentatus sp. nov.

Plate 8, figures 17–20

Holotype. C-161930, 3, 15.6 x 98.5, GSC 105596.

Figured specimens. C-161938, 3, 33.7 x 107.8, GSC 105597; C-161948, 3, 57.2 x 100.0, GSC 105598; C-161948, 3, 45.1 x 93.5, GSC 105599.

Occurrence. Assistance and Trold Fiord formations.

Diagnosis. Monosulcate pollen grain. Amb subcircular. Transversely arranged, closely spaced taeniae on proximal surface total approximately 15 to 25, and are in the order of 1 to 4 μm wide. Narrow (less than 0.25 μm) clefts occasionally bifurcate so that some taeniae may be discontinuous. Three to four outer taeniae extend onto the extremity of the distal surface longitudinally, running parallel to subparallel. Taeniae segmented by secondary clefts 0.25 to 1 μm wide, running normal to the main one. Segments vary in length from 0.25 to 2 μm. Smaller segments resemble large grana or verrucae with subrectangular outlines. Geniculate haptotypic mark on proximal surface approximately 10 μm long. Arcuate secondary folds generally present on distal surface. Exine laevigate and approximately 0.25 μm thick.

Dimensions. (6 specimens), breadth 53 to 70 μm, mean 62 μm; length 51 to 75 μm, mean 60 μm.

Remarks. Weylandites segmentatus differs from *Weylandites striatus* (Luber) comb. nov. by its subcircular to circular outline and finely segmented taeniae. *Vittatina persecta* Zauer, 1965 (illustrated, but not described) differs from *W. segmentatus* in that the taeniae are less segmented and cover the entire distal surface, and there is no geniculate mark. *Marsupipollenites striatus* (Balme and Hennelly) Foster, 1975 is superficially similar in appearance, but has a fusiform sulcus and lacks true taeniae.

Derivation of name. Latin, *segmentatus*, segmented.

Weylandites striatus (Luber) comb. nov.

Plate 8, figures 21–24

Synonymy. Azonaletes striatus Luber, 1941, p. 62, Pl. XIII, fig. 218; *Vittatina striata* Luber forma *angusticostata* (Zauer) ex. Varyukhina, 1971, p. 89, Pl. VIII, figs. 7a, b; *Vittatina persecta* forma *angusticostata* Zauer, 1960, *nom. nud.*, fig. 3 (no description); *Vittatina persecta* forma *angusticostata* Zauer, 1965, *nom. nud.*, Pl. VI, fig. 1, 1a (no description); *Vittatina persecta* forma *angusticostata* (Zauer) ex. Varyukhina, 1971, *nom. nud.*, p. 88, Pl. VII, figs. 4a, b (no holotype designated).

Figured specimens. C-126269, 3, 13.3 x 109.4, GSC 105600; C-126269, 3, 9.0 x 97.2, GSC 105601; C-126271, 4, 31.5 x 105.0, GSC 105602; C-170909, 3, 16.4 x 107.6, GSC 105603.

Occurrence. Sabine Bay, Assistance, Degerböls, van Hauen, and Trold Fiord formations.

Description. Monosulcate pollen grain. Overall outline slightly transversely oval. Exine approximately 1 μm thick, consists of very thin intexine overlain by ribbed, finely intrapunctate exoexine. The ribs are separated by narrow clefts, less than 0.5 μm wide, which occasionally bifurcate. There are approximately 16 to 25 individual exoexinous ribs, approximately 2 to 4 μm wide; sometimes segmented by secondary clefts less than 0.25 μm wide, that extend normal to the main one. Segments vary in length, but may be as little as 2 μm. Individual ribs are generally continuous, and looped so that they pass from the proximal (laterally arranged) to the distal (longitudinally arranged) surface. Exoexine very thin to absent in the sulcal area. Monolete mark on proximal surface 8 to 12 μm long.

Dimensions. (26 specimens), breadth 48 to 80 μm, mean 64 μm; length 40 to 65 μm, mean 53 μm. Overlap of taeniae onto distal surface approximately 10 to 23 μm.

Remarks. Weylandites striatus shows considerable variation in shape, size, and distribution of taeniae. Zauer (1965) subdivided *V. striatus* into a number of varieties, but did not describe them; some of these were subsequently validated by Varyukhina (1971). The present writer found these varieties to be subjective and not easy to differentiate; there also appears to be continuous variation between specimens.

Subturma PRAECOLPATES Potonié and Kremp, 1954

Genus *Pakhapites*

Type species. Pakhapites fasciolatus (Balme and Hennelly) Hart, 1965.

Pakhapites rotundus (Koloda) comb. nov.

Plate 9 figures 1–3

Synonymy. Vittatina striata Luber forma *minor* Zauer, 1965 (no description), Pl. III, fig. 8; *Ventralvittatina rotunda* Koloda, 1989, p. 66, 67, Pl. III, figs. 1–3; Pl. II, fig. 8.

Figured specimens. C-126270, 3, 40.0 x 100.8, GSC 105588; C-126270, 3, 22.1 x 101.4, GSC 105587; C-161934, 3, 19.2 x 99.4, GSC 105589.

Occurrence. Sabine Bay, Assistance, and Trold Fiord formations.

Description. Monosulcate pollen grain. Overall shape longitudinally oval. Exine approximately 1 μm thick, consisting of very thin intexine overlain by taeniate, intrapunctate exoexine. 9 to 11 individual exoexinous taeniae, up to 4 μm wide, clefts approximately 0.25 μm wide; a few clefts may bifurcate so that taeniae are not continuous. In polar compression, taeniae extend transversely on proximal face and terminate at proximo-distal margin; contact of exoexine at margin may produce a rim approximately 1 μm wide. Sulcus bordered by crescentic folds extending full length of grain.

Dimensions. (3 specimens), breadth 22 to 30 μm; length 31 to 36 μm.

Remarks. This species has been combined with *Pakhapites* Hart, 1965, as it is monosulcate, lacks an aperture, and contains proximal striations. Specimens of *Ventralvittatina rotunda* described by Koloda (1989) are smaller (10–18 μm), but otherwise appear to be identical. The cingulum mentioned by Koloda (1989) is not present on every specimen, and appears to be produced by the contact of the exoexinal layers at the margin.

Genus *Sverdrupollenites* Utting gen. nov.

Type species. Sverdrupollenites agluatus sp. nov.

Diagnosis. Amb subcircular to longitudinally oval. Monosulcate with a distal sulcus that is elongate. Proximal surface alete or with a monolete to geniculate mark elongated parallel to the transverse axis. Exine thick columellate, surface lacks ornament.

Remarks. Marsupipollenites Balme and Hennelly emend. Balme, 1970 differs in that it has a trilete mark on the proximal surface and the exine has an ornament of small, closely spaced rounded elements. It also has intraexinal elements that are randomly disposed or arranged in roughly parallel, transverse rows simulating taeniae. *Entylissa* Naumova, 1939 ex Ischenko, 1952, *Gynkgaletes* Luber, 1955 ex Potonié, 1958 and *Cycadopites* Wodehouse, 1933 have a thin exine, which lacks columellate structure. *Subsacculifer* Luber, 1939 ex Dyupina, 1982 is illegitimate because it is based on a specimen that already is the type of *Gynkgaletes* Luber, 1955 ex Potonié, 1958.

Derivation of name. After the Sverdrup Basin of the Canadian Arctic Archipelago.

Sverdrupollenites agluatus sp. nov.

Plate 9, figures 4–7, 11

Holotype. C-126257, 3, 33.3 x 102.7, GSC 105610.

Figured specimens. C-126257, 3, 21.2 x 100.5, GSC 105611; C-161946, 3, 45.6 x 98.3, GSC 105612; C-126270, 3, 40.6 x 95.1, GSC 103896.

Occurrence. Sabine Bay, Assistance, and lower van Hauen formations.

Diagnosis. Monosulcate, amb longitudinally oval. Exoexine approximately 1.5 to 2 μm thick; finely columellate structure clearly visible at equatorial margin, produces finely reticulate appearance in plan with intra-exinal structural elements rounded or oval and approximately 0.5 μm in diameter. Intexine approximately 1 μm thick. Sulcus on distal surface extending almost to poles; slightly contracted at the pole resulting in oval shape; thinning of exoexine in sulcal area so that the sulcus essentially comprises intexine; sulcus bordered by secondary folds up to 7 μm wide. Monolete to geniculate mark on proximal surface; approximately 10 to 12 μm.

Dimensions. (26 specimens), length 41 to 68 μm, mean 50 μm; breadth 29 to 58 μm, mean 40 μm.

Remarks. Marsupipollenites retroflexus (Luber) Varyukhina, 1971, p. 103, Pl. XI, fig. 8 is similar in shape, but differs in that it lacks a haptotypic mark, as do the specimens of *Azonaletes retroflexus, A. retroflexus* forma *cinctus* and *A. retroflexus* forma *minor*, illustrated, but not described, by Luber, 1941.

Derivation of name. Inuit, *aglu*, seal's breathing hole in ice.

Sverdrupollenites connudatus sp. nov.

Plate 9, figures 12–14

Synonymy. *Marsupipollenites retroflexus* forma *cinctus* (Luber) Varyukhina, 1971, *nom. nud.*, p. 103, 104, Pl. XI, fig. 9 (no holotype designated).

Holotype. C-126270, 3, 18.6 x 102.6, GSC 105607.

Figured specimens. C-126258, 3, 14.0 x 100.5, GSC 105608; C-126277, 3, 17.2 x 101.6, GSC 105609.

Occurrence. Sabine Bay, Assistance, and lower van Hauen formations.

Diagnosis. Monosulcate, amb longitudinally oval. Exoexine approximately 1.5 to 2 μm thick; finely columellate structure clearly visible at equatorial margin, produces finely reticulate appearance in plan, with intra-exinal structural elements rounded or oval and approximately 0.5 μm in diameter. Intexine approximately 1 μm thick. Sulcus on distal surface extending almost to poles; slightly expanded at the pole so that sides are concave; thinning of exoexine in sulcal area, essentially comprising intexine; sulcus bordered by secondary folds up to 8 μm wide. No haptotypic mark on proximal surface.

Dimensions. (6 specimens), length 54 to 70 μm, mean 61 μm; width 26 to 31 μm, mean 29 μm.

Remarks. *Entylissa caperata* has a thin exine with a reticular-shagreenate surface and lacks the columellate exinal structure of *S. connudatus*. In the original description by Luber, 1941, the exine of *E. caperata* is described as thin, whereas that of *S. connudatus* is thick and columellate. *Gynkgaletes retroflexus* (Luber) ex Potonié, 1958 lacks a haptotypic mark, but has a thin exine.

Derivation of name. Latin, *connudatus* bare.

Subturma MONOCOLPATES Iversen and Troels-Smith, 1950

Genus *Cycadopites*

Type species. *Cycadopites follicularis* Wilson and Webster, 1946.

Cycadopites follicularis Wilson and Webster, 1946

Plate 9, figures 8–10

Synonymy. *Cycadopites follicularis* Wilson and Webster, 1946, p. 274, 275, fig. 7.

Figured specimens. C-161961, 3, 21.2 x 109.2, GSC 105606; C-161961, 3, 6.2 x 98.7, GSC 105604; C-148184, 2, 34.6 x 94.1, GSC 105605.

Occurrence. Sabine Bay, Assistance, and Trold Fiord formations.

Description. Monosulcate pollen grain. Amb ellipsoidal, with rounded ends. Sulcus extends full length of grain, generally narrower near distal pole. Exine approximately 1 μm thick, laevigate to finely intragranulate.

Dimensions. (5 specimens), length 27 to 43 μm, mean 38 μm; breadth 15 to 25 μm, mean 20 μm.

Turma ALETES Ibrahim, 1933

Genus *Cladaitina* Maheshwari and Meyen, 1975

Type species. *Cladaitina dibnerae* Maheshwari and Meyen, 1975.

Cladaitina kolodae sp. nov.

Plate 9, figures 15–17

Synonymy. *Reticulatina heterobrochata* Molin et al., 1983, *nom. nud.*, p. 11, Pl. 7, fig. 1–6 (no description).

Holotype. C-126269, 3, 7.1 x 107.0, GSC 105613.

Figured specimens. C-126268, 3, 25.7 x 105.6, GSC 105614; C-170909, 3, 12.5 x 105.5, GSC 105615.

Occurrence. Sabine Bay and Assistance formations.

Diagnosis. Alete grain. Amb circular to oval, margin irregular. On one surface of 'polar' compressions, ornament of network of muri 1 to 1.5 μm wide, 1 μm high, foveolae oval or polygonal, 1 to 2 μm diameter. Opposite surface is punctate, with punctae less than 0.25 μm diameter and less than 0.5 μm apart. Exoexine thin (0.5 μm), arcuate folds sometimes present; intexine thick (1 μm) generally separated from exoexine, producing an inner body. Lateral compressions common.

Dimensions. (15 specimens), 42 to 68 µm, mean 53.5 µm.

Remarks. The species has been assigned to *Cladaitina* although according to the original description of Maheshwari and Meyen (1975) the saccus exoexine has and ornament of closely spaced small verrucae rather than muri described here. *Reticulatina heterobrochata* Molin et al., 1983 may be similar, but as stated by Jansonius and Hills (1990), this is a *nomen nudum*, as no diagnosis or description was given and no holotype designated.

Derivation of name. Named for N.A. Koloda for her contribution to the Permian palynology of Russia.

Genus *Inaperturopollenites* Thomson and Pflug, 1953

Inaperturopollenites nebulosus Balme, 1970

Plate 9, figure 18

Figured specimens. C-170905, 3, 28.2 x 105.5, GSC 105616.

Occurrence. Trold Fiord Formation.

Description. Alete grain. Outline subcircular, distorted by secondary folding. Exine approximately 0.5 µm thick, with ornament of closely spaced grana approximately 0.25 to 0.5 µm diameter and less than 0.5 µm high.

Dimensions. (1 specimen), 74 µm.

Remarks. Inaperturopollenites nebulosus was recorded by Balme (1970) from the Chhidru Formation of Late Permian age, Pakistan, and from the *Vittatina* association of Greenland of Dzhulfian? age (Balme, 1980a).

Genus *Crinalites* gen. nov.

Type species. Crinalites sabinensis sp. nov.

Diagnosis. Algal spore or cyst, amb subcircular to oval; traversed by smoothly curved suture that passes from one surface to another and back again; curve interrupted periodically by a few acutely sigmoidal or "hairpin" bends. Exine single layered, surface laevigate.

Remarks. Sigmopollis Hedlund, 1965, which has been described from the Maastrichtian, has a single sigmoidal aperture and each half of the aperture has an operculum (Srivastava, 1984). Srivastava (1984), proposed that *Sigmopollis* was a freshwater algal cyst or zygote.

Derivation of name. Latin, *crinale*, hairpin.

Crinalites sabinensis sp. nov.

Plate 9, figures 19–23

Holotype. C-170909, 3, 9.1 x 96.1, GSC 105617.

Figured specimens. C-170909, 4, 35.2 x 100.5, GSC 105618; C-170909, 4, 26.4 x 108.5, GSC 105619; C-170909, 3, 14.7 x 104.7, GSC 105620; C-170909, 3, 17.2 x 104.6, GSC 105621.

Occurrence. Sabine Bay Formation.

Diagnosis. Shape subcircular to oval laevigate. Exine single layered, smooth, 1.25 to 1.5 µm thick. Narrow (less than 0.25 µm), smoothly curved suture passes from one side to the other of the grain; smooth curve interrupted periodically by acutely sigmoidal or "hairpin" bends.

Dimensions. (10 specimens), length 45 to 72 µm, mean 57 µm; breadth 37 to 68 µm, mean 48 µm.

Remarks. The species has been found only in shallow marine to nonmarine delta front sediments of the Sabine Bay Formation, and their presence may be of paleoecological significance. Srivastava (1984) suggested that the morphologically related *Sigmopollis*, which has a single sigmoidal aperture, may occur in eutrophic to mesotrophic freshwater environments similar to those proposed for sigmoid spinulose spores from the Holocene.

Derivation of name. Sabine Peninsula, Melville Island.

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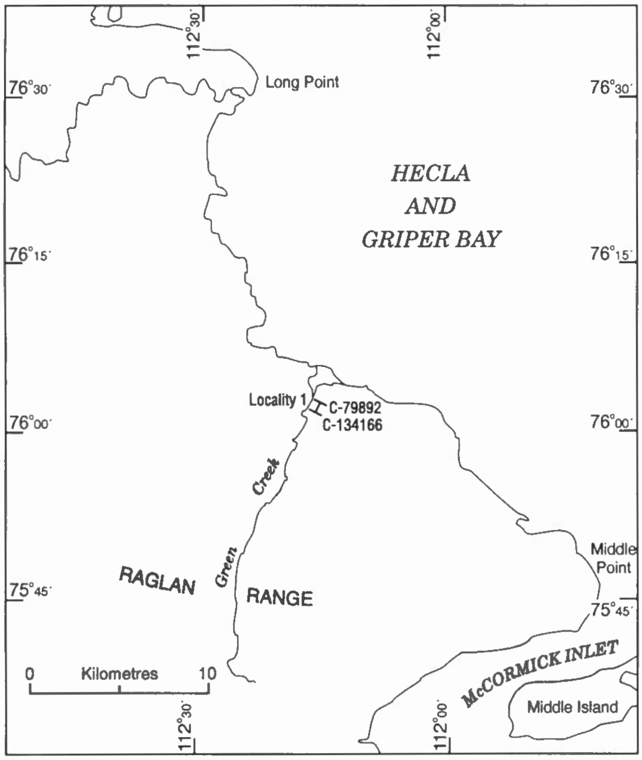
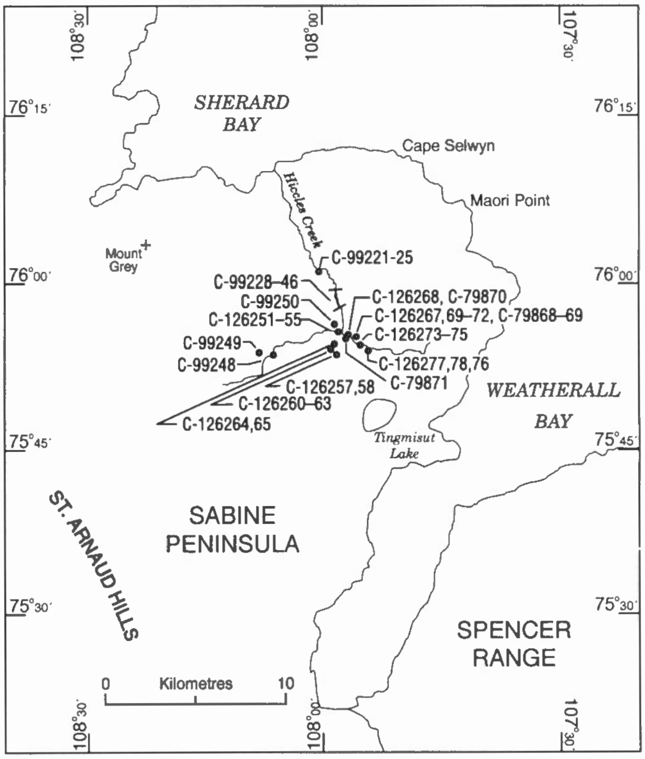
APPENDIX

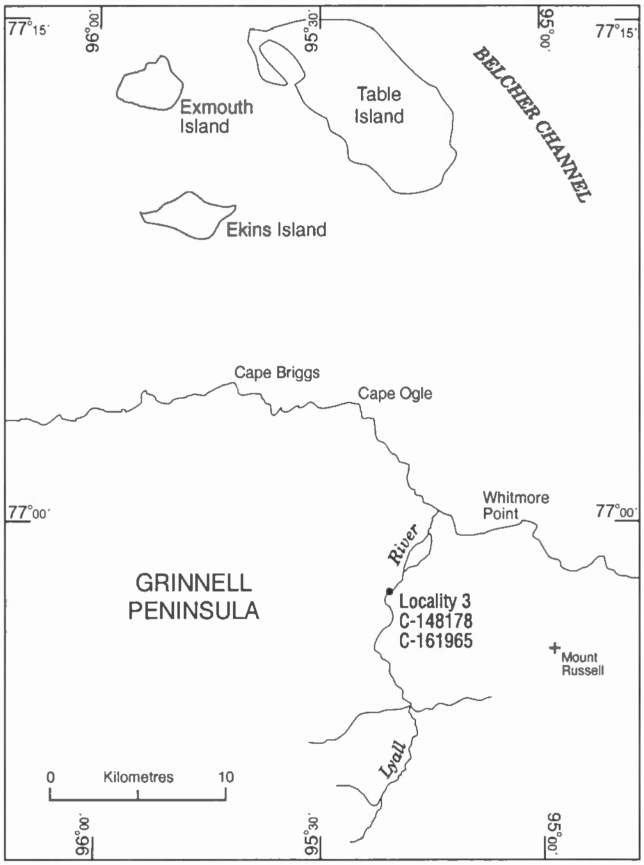
Figures 1–16



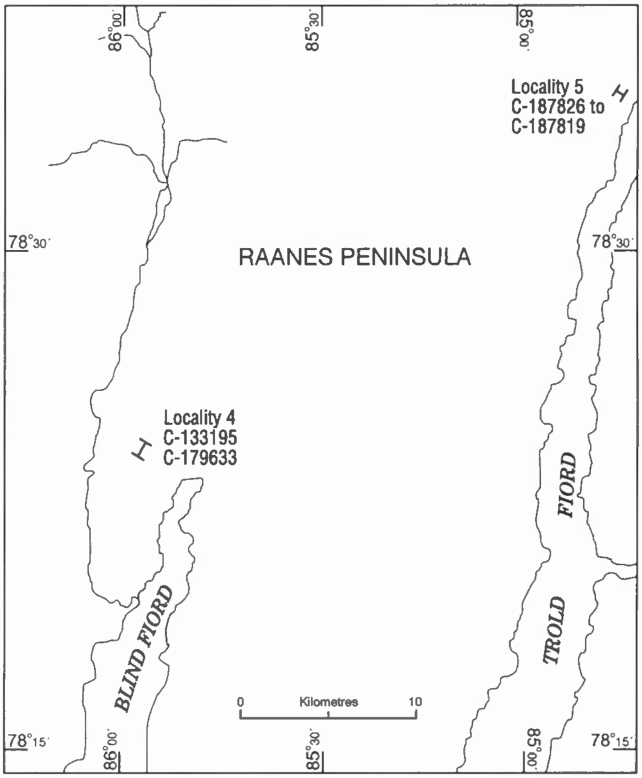
Appendix Figure 1. *Geographic distribution of sample localities at locality 1, Green Creek, Melville Island (see Fig. 4, locality 1).*



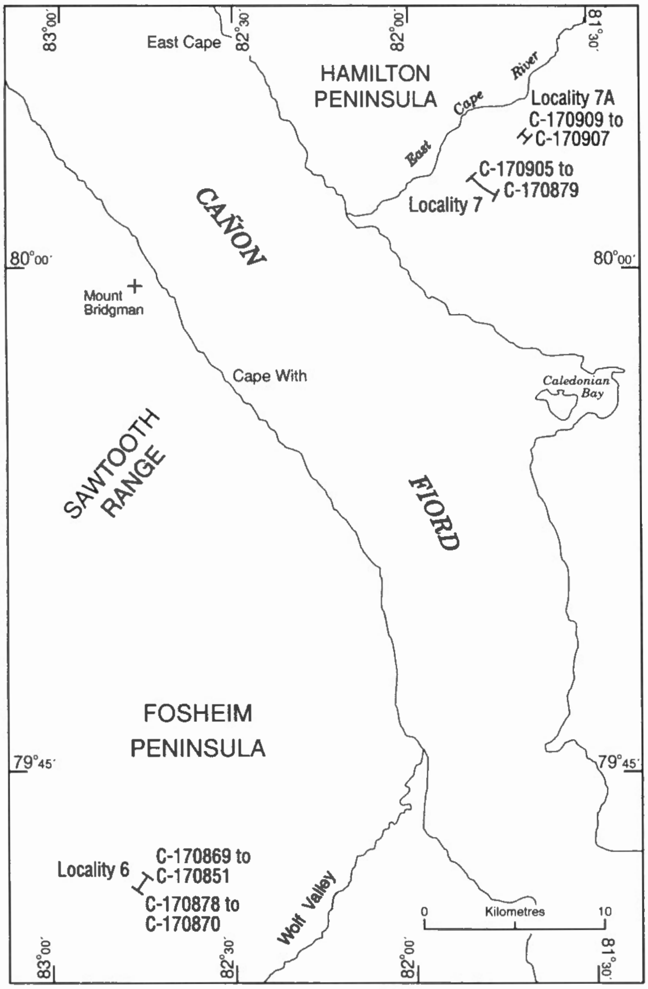
Appendix Figure 2. *Geographic distribution of sample localities at locality 2, Sabine Peninsula, Melville Island (see Fig. 4, locality 2).*



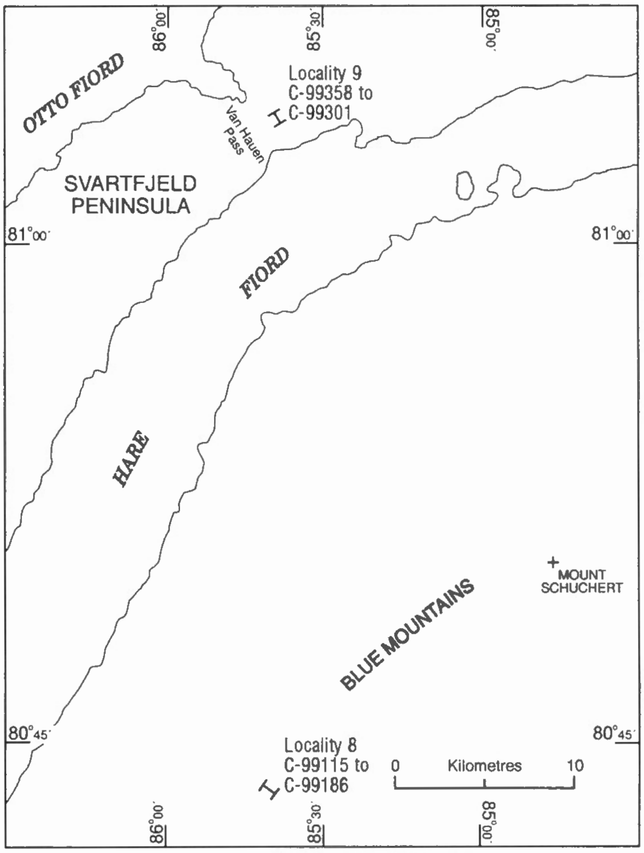
Appendix Figure 3. *Geographic distribution of sample localities at locality 3, Grinnell Peninsula, Devon Island (see Fig. 4, locality 3).*



Appendix Figure 4. *Geographic distribution of sample localities at localities 4 and 5, Blind Fiord and Trold Fiord, Ellesmere Island (see Fig. 4, localitites 4, 5).*



Appendix Figure 5. *Geographic distribution of sample localities at localities 6 and 7 (supplemented by locality 7a), Fosheim and Hamilton peninsulas, Ellesmere Island (see Fig. 4, localities 6, 7, 7a).*



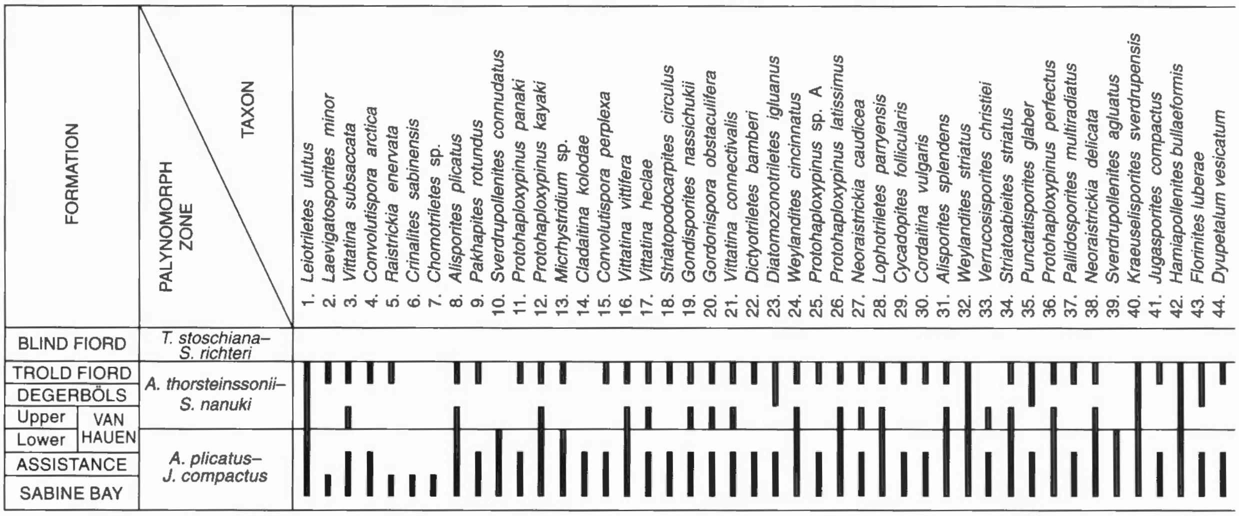
Appendix Figure 6. *Geographic distribution of sample localities at localities 8 and 9, Blue Mountains and van Hauen Pass, Ellesmere Island (see Fig. 4, localities 8, 9).*

ALPHABETICAL INDEX OF TAXA

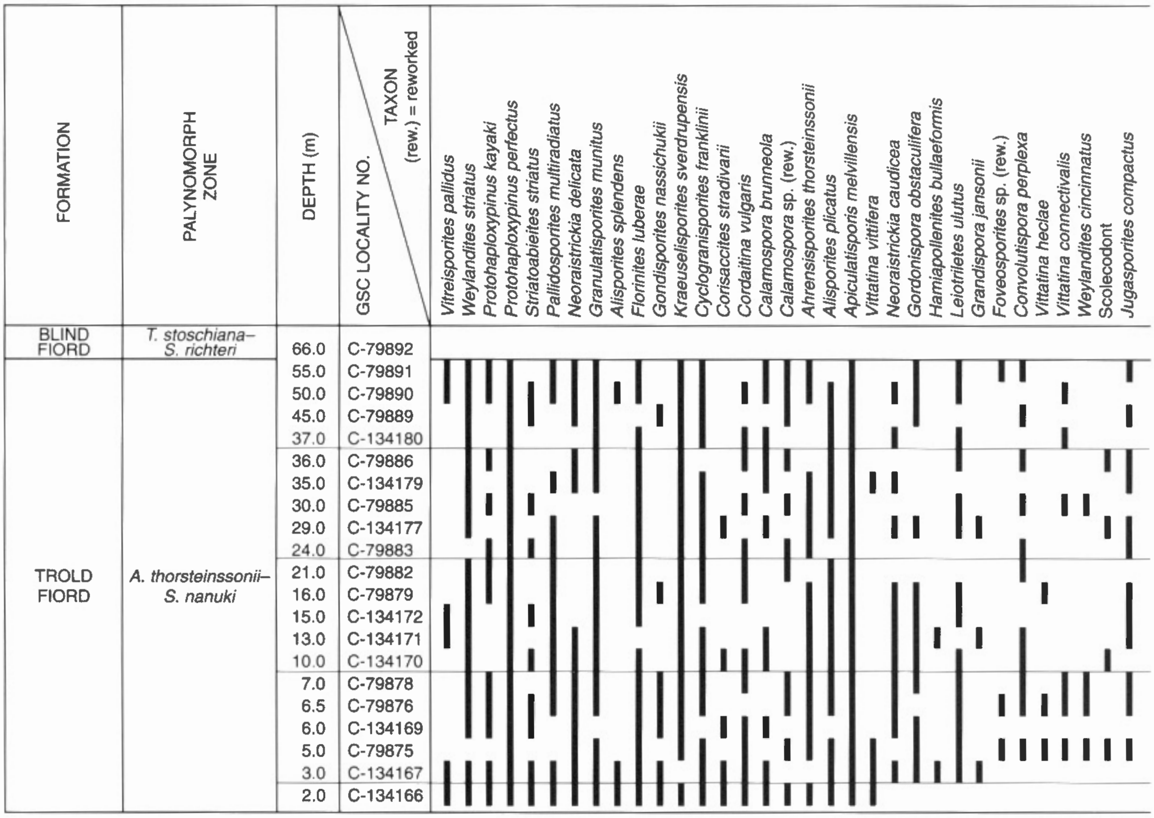
Index numbers correspond to the columns in which a taxon appears

Index number	Name of taxon	Index number	Name of taxon
55	*Abiespollenites* sp. A	65	*Lunatisporites beauchampii* sp. nov.
75	*Ahrensisporites microfloridus* sp. nov.	89	*Lunatisporites noviaulensis* (Leschik) Foster, 1979
64	*Ahrensisporites thorsteinssonii* sp. nov.	92	*Maculatasporites* sp.
8	*Alisporites plicatus* Jizba, 1962	13	*Micrhystridium* sp.
31	*Alisporites splendens* (Leschik) Foster, 1979	27	*Neoraistrickia caudicea* sp. nov.
50	*Apiculatisporis melvillensis* sp. nov.	38	*Neoraistrickia delicata* sp. nov.
49	*Botryococcus* sp.	9	*Pakhapites rotundus* (Koloda) comb. nov.
48	*Calamospora brunneola* Virbitskas, 1983	37	*Pallidosporites multiradiatus* sp. nov.
7	*Chomotriletes* sp.	78	*Piceapollenites nookapii* sp. nov.
102	*Chordasporites* sp.	63	*Pinuspollenites* sp. A
14	*Cladaitina kolodae* sp. nov.	62	*Potonieisporites* sp. A
4	*Convolutispora arctica* sp. nov.	96	*Proprisporites pocockii* Jansonius, 1962
15	*Convolutispora perplexa* sp. nov.	12	*Protohaploxypinus kayaki* sp. nov.
30	*Cordaitina vulgaris* (Zauer) Varyukhina, 1971 ex. Utting comb. nov.	26	*Protohaploxypinus latissimus* (Luber) Samoilovich, 1953
56	*Corisaccites stradivarii* sp. nov.	11	*Protohaploxypinus panaki* sp. nov.
6	*Crinalites sabinensis* sp. nov.	36	*Protohaploxypinus perfectus* (Naumova) Samoilovich, 1953
70	*Crustaesporites* sp. A	85	*Protohaploxypinus samoilovichii* (Jansonius) Hart, 1965
29	*Cycadopites follicularis* Wilson and Webster, 1946	25	*Protohaploxypinus* sp. A
101	*Cycadopites* sp.	35	*Punctatisporites glaber* (Naumova) Playford, 1962
47	*Cyclogranisporites franklinii* sp. nov.	5	*Raistrickia enervata* sp. nov.
54	*Cymatiosphaera* sp.	60	*Raistrickia* sp. A
68	*Diatomozonotriletes hypenetes* sp. nov.	46	Scolecodont
23	*Diatomozonotriletes igluanus* sp. nov.	66	*Scutasporites nanuki* sp. nov.
79	*Diatomozonotriletes* sp. A	74	Scytinasciae
22	*Dictyotriletes bamberi* sp. nov.	99	*Simeonospora minuta* (Jansonius) comb. nov.
44	*Dyupetalum vesicatum* sp. nov.	72	*Striatoabieites borealis* sp. nov.
87	*Ephedripites steevesii* (Jansonius) de Jersey and Hamilton, 1967	88	*Striatoabieites richteri* (Klaus) Hart, 1964
98	*Falcisporites zapfei* Potonié and Klaus, 1954	34	*Striatoabieites striatus* (Luber and Waltz) Hart, 1964
94	*Filisphaeridium setasessitante* (Jansonius) Fensome et al., 1990	18	*Striatopodocarpites circulus* sp. nov.
43	*Florinites luberae* Samoilovich, 1953	45	*Striatopodocarpites* sp. A
71	*Florinites* sp. A	52	*Striomonosaccites* sp. A
19	*Gondisporites nassichukii* sp. nov.	39	*Sverdrupollenites agluatus* sp. nov.
20	*Gordonispora obstaculifera* sp. nov.	10	*Sverdrupollenites connudatus* sp. nov.
97	*Gordonispora* sp.	61	*Tripartites* sp. A
69	*Grandispora jansonii* sp. nov.	80	*Triquitrites* sp. A
51	*Granulatisporites munitus* sp. nov.	91	*Tympanicysta stoschiana* Balme, 1980
83	*Granulatisporites* sp. A	59	*Unellium* sp.
42	*Hamiapollenites bullaeformis* (Samoilovich) Jansonius, 1962	90	*Uvaeporites imperialis* (Jansonius) comb. nov. emend.
84	*Hamiapollenites erebi* sp. nov.	33	*Verrucosisporites christiei* sp. nov.
73	*Inaperturopollenites nebulosus* Balme, 1970	53	*Veryhachium* sp.
41	*Jugasporites compactus* sp. nov.	57	*Vitreisporites pallidus* (Reissinger) Nilsson, 1958
86	*Klausipollenites staplinii* Jansonius, 1962	21	*Vittatina connectivalis* (Zauer) Varyukhina, 1971 ex. Utting
95	*Kraeuselisporites spinosus* Jansonius, 1962	17	*Vittatina heclae* sp. nov.
40	*Kraeuselisporites sverdrupensis* sp. nov.	3	*Vittatina subsaccata* Samoilovich, 1953
2	*Laevigatosporites minor* Loose, 1934	16	*Vittatina vittifera* (Luber) Samoilovich, 1953
76	*Leiosphaeridia* sp.	67	*Vittatina vittifera* var. *minor* Samoilovich, 1953
1	*Leiotriletes ulutus* sp. nov.	81	*Waltzispora* sp. A
77	*Limitisporites* sp. A	24	*Weylandites cincinnatus* (Luber ex. Varyukhina, 1971) comb. nov.
28	*Lophotriletes parryensis* sp. nov.	58	*Weylandites segmentatus* sp. nov.
100	*Lunatisporites albertae* (Jansonius) comb. nov.	32	*Weylandites striatus* (Luber) comb. nov.
82	*Lunatisporites arluki* sp. nov.	93	*Wilsonastrum colonicum* Jansonius, 1962

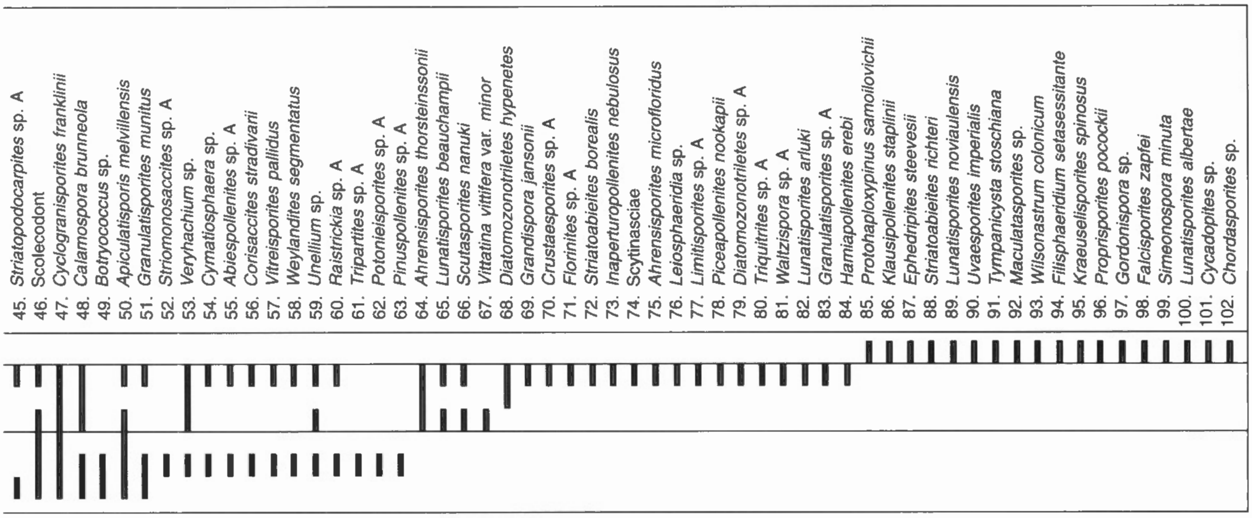
Appendix Figure 7. *Summary of vertical distribution of all in situ taxa recorded in Sabine Bay, Assistance, van Hauen, Degerböls, Trold Fiord, and Blind Fiord formations, accompanied by list of all taxa recorded. Reworked taxa shown in Appendix Figures 8–16.*



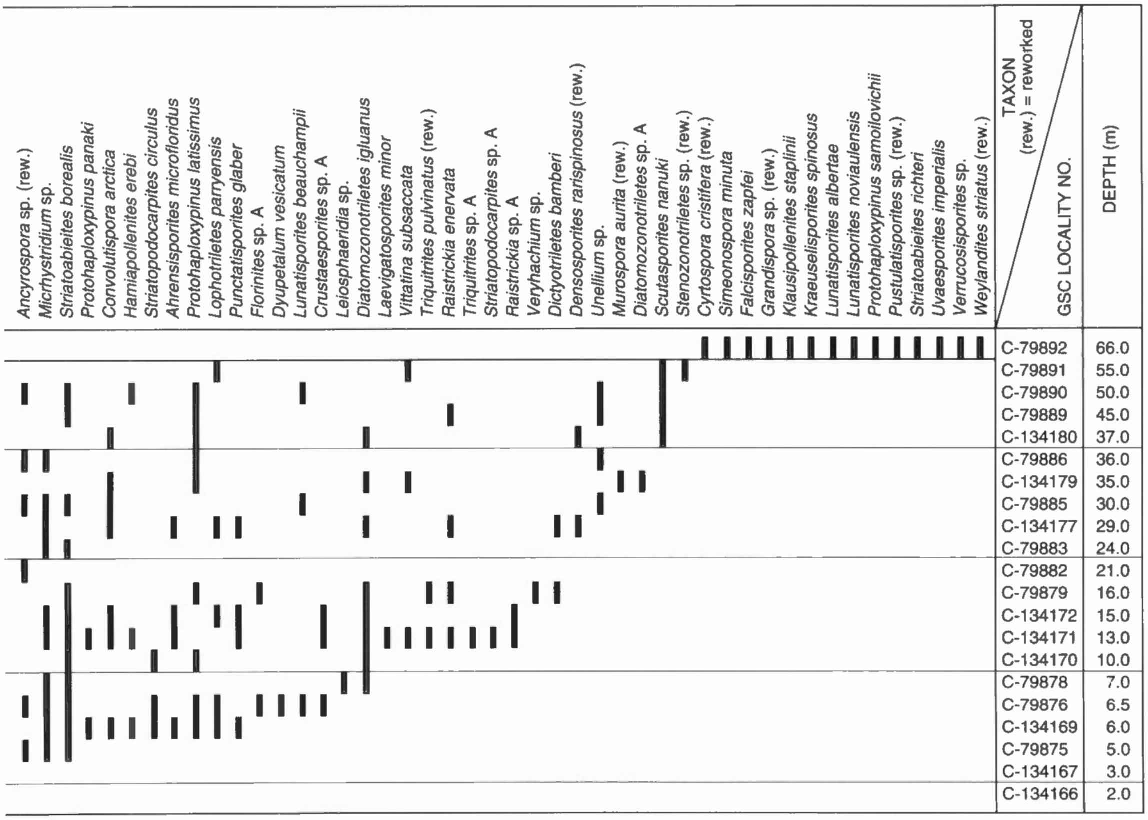
Appendix Figure 7. *(cont'd.)*



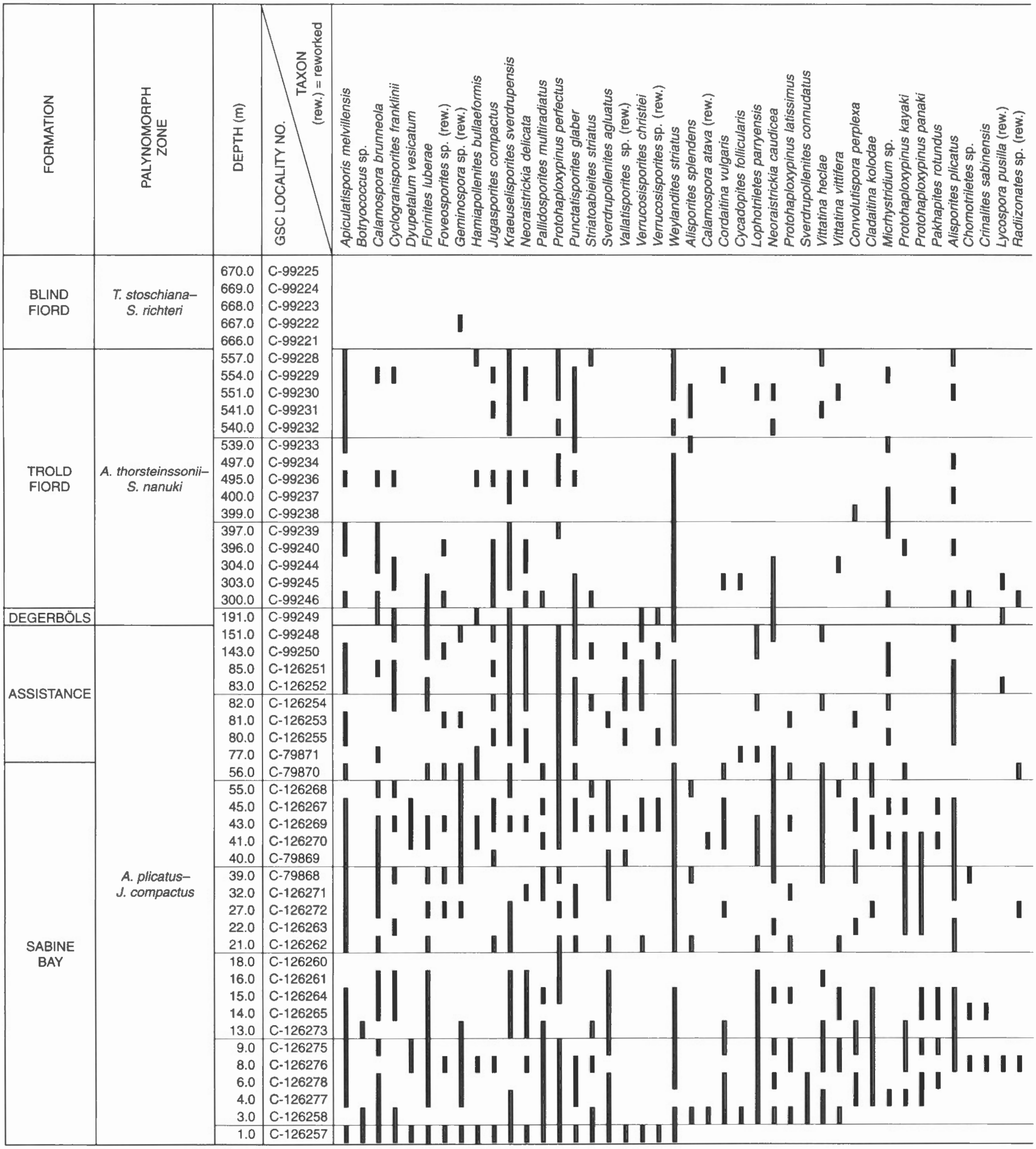
Appendix Figure 8. *Locality 1. Vertical distribution of palynomorph taxa at Green Creek, Melville Island.*



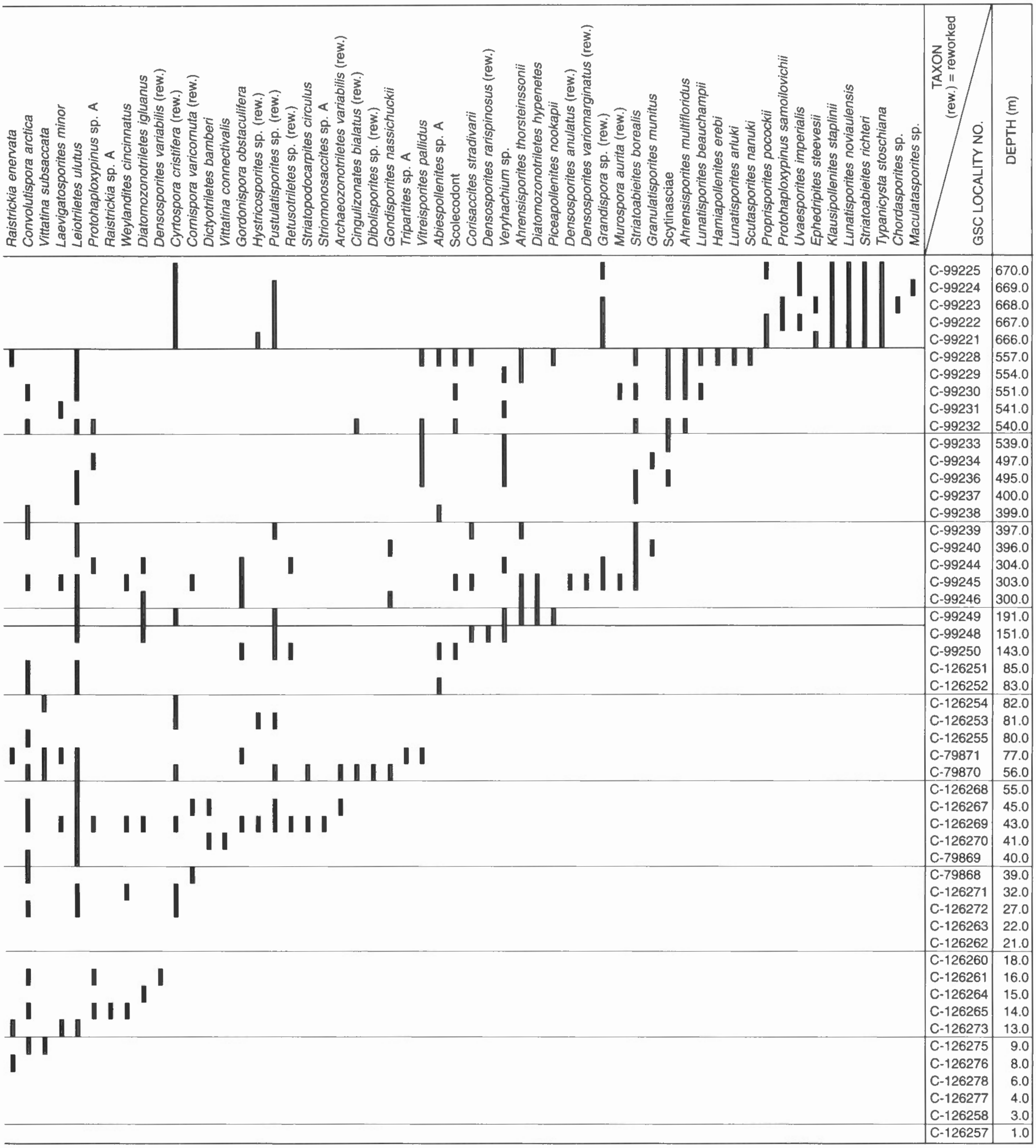
Appendix Figure 7. *(cont'd.)*



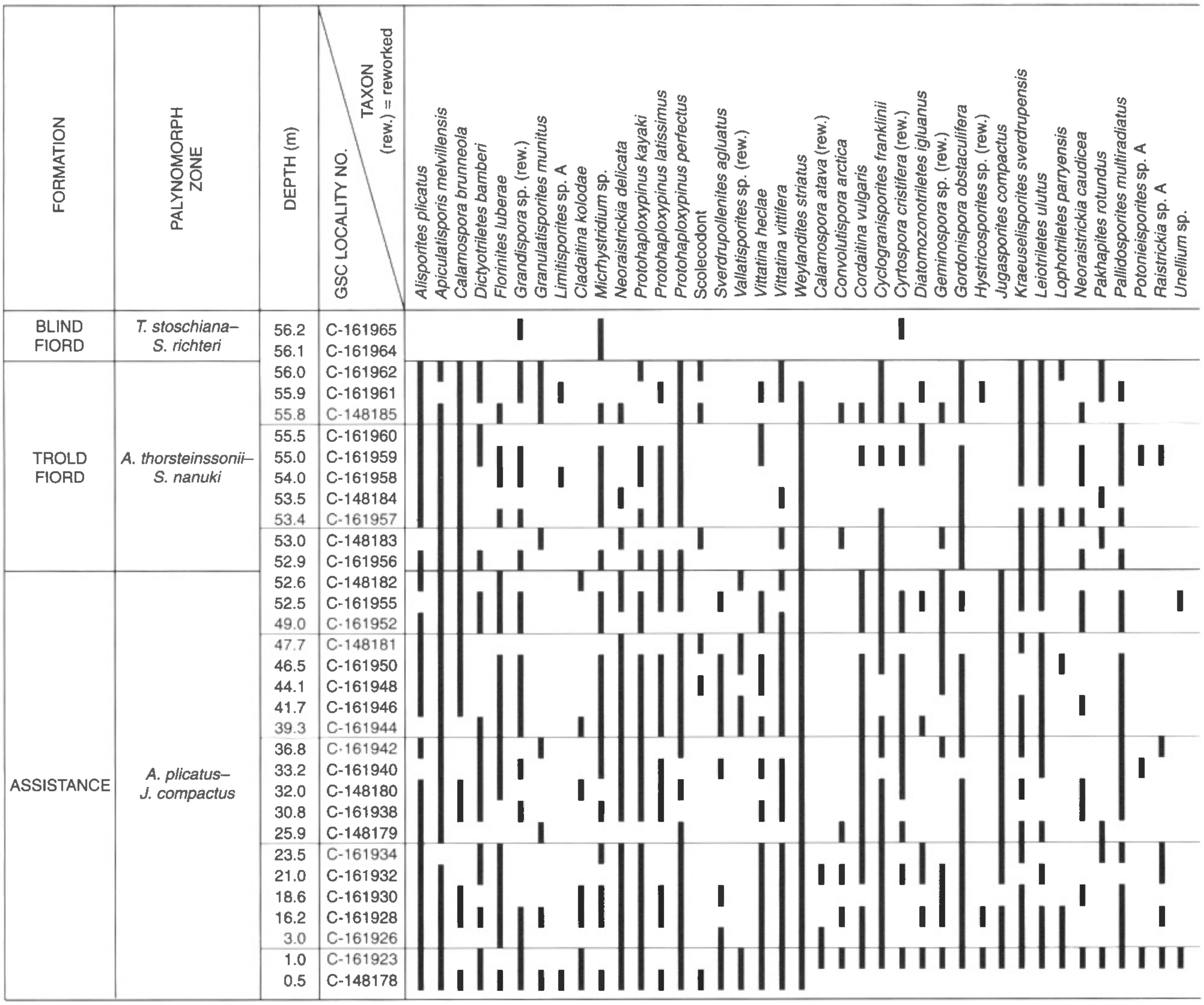
Appendix Figure 8. *(cont'd.)*



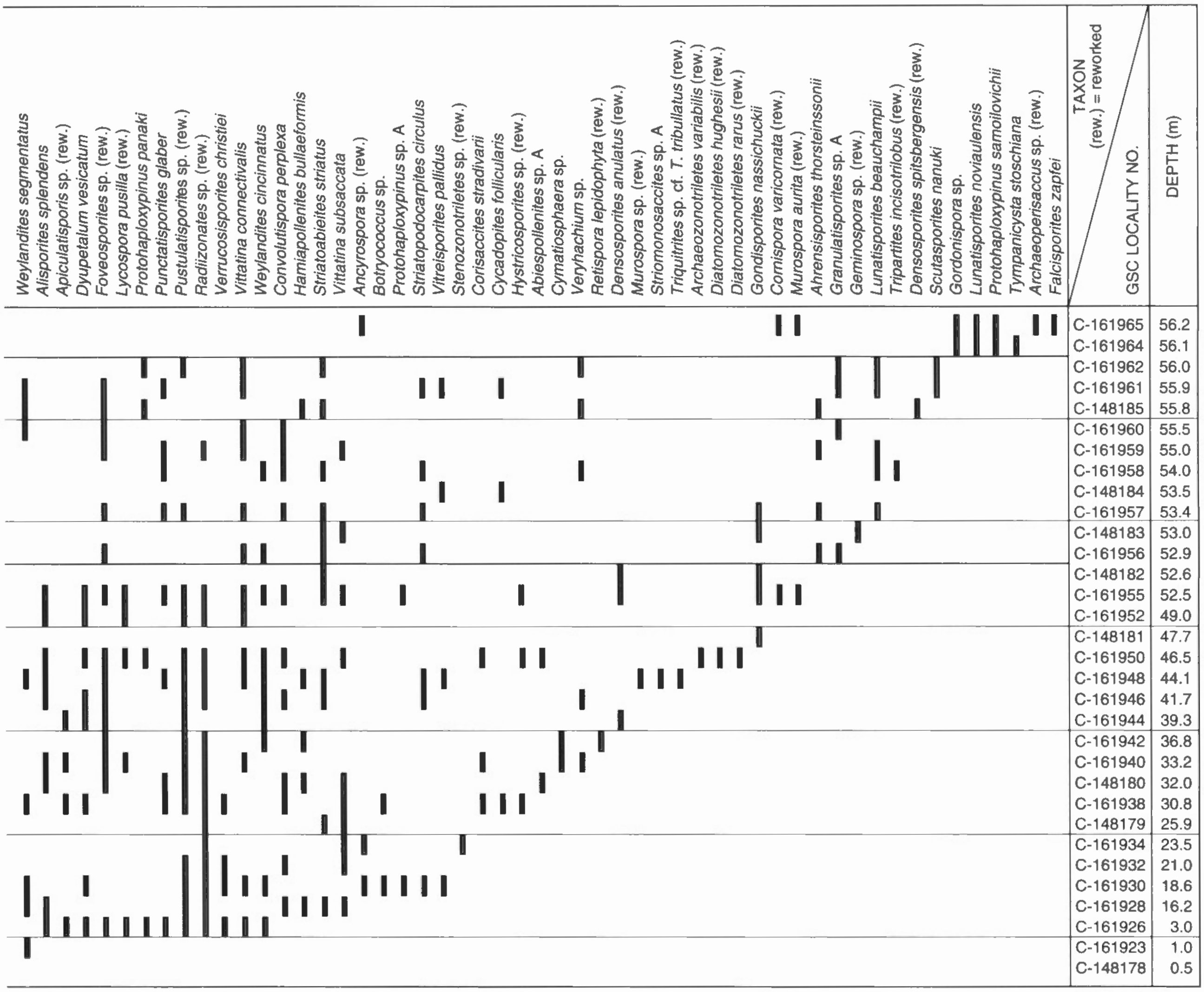
Appendix Figure 9. *Locality 2. Vertical distribution of palynomorph taxa at Sabine Peninsula, Melville Island.*



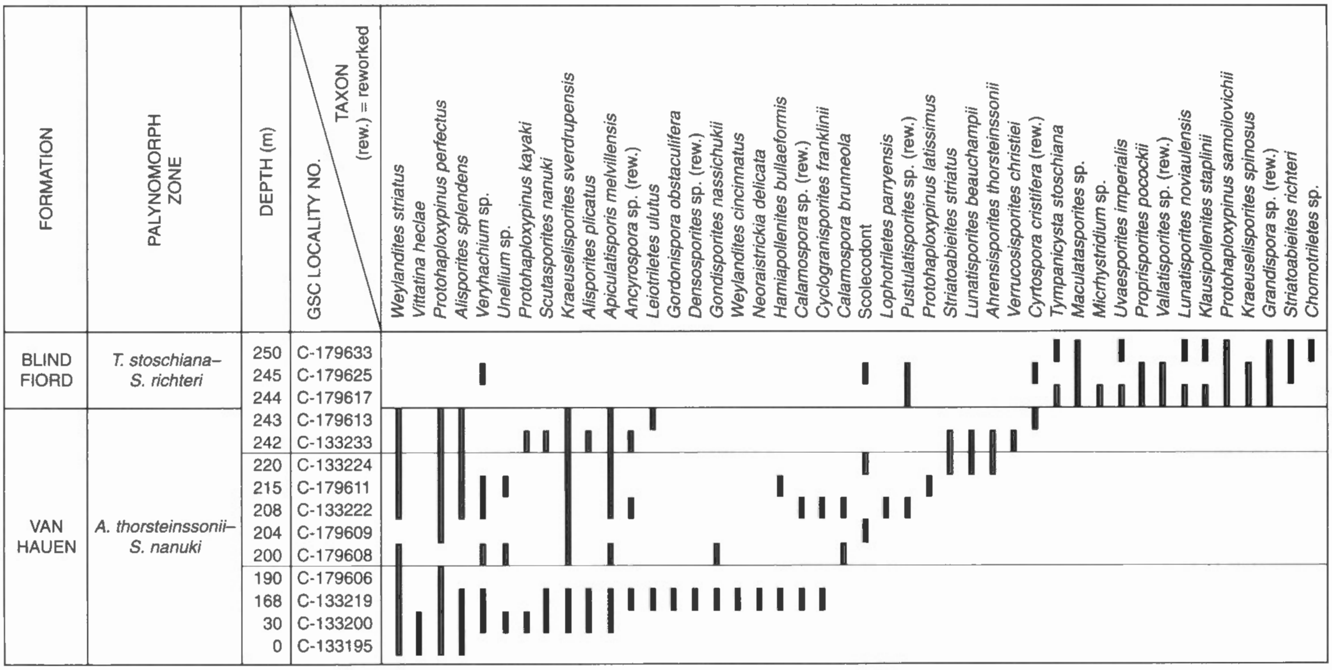
Appendix Figure 9. *(cont'd.)*



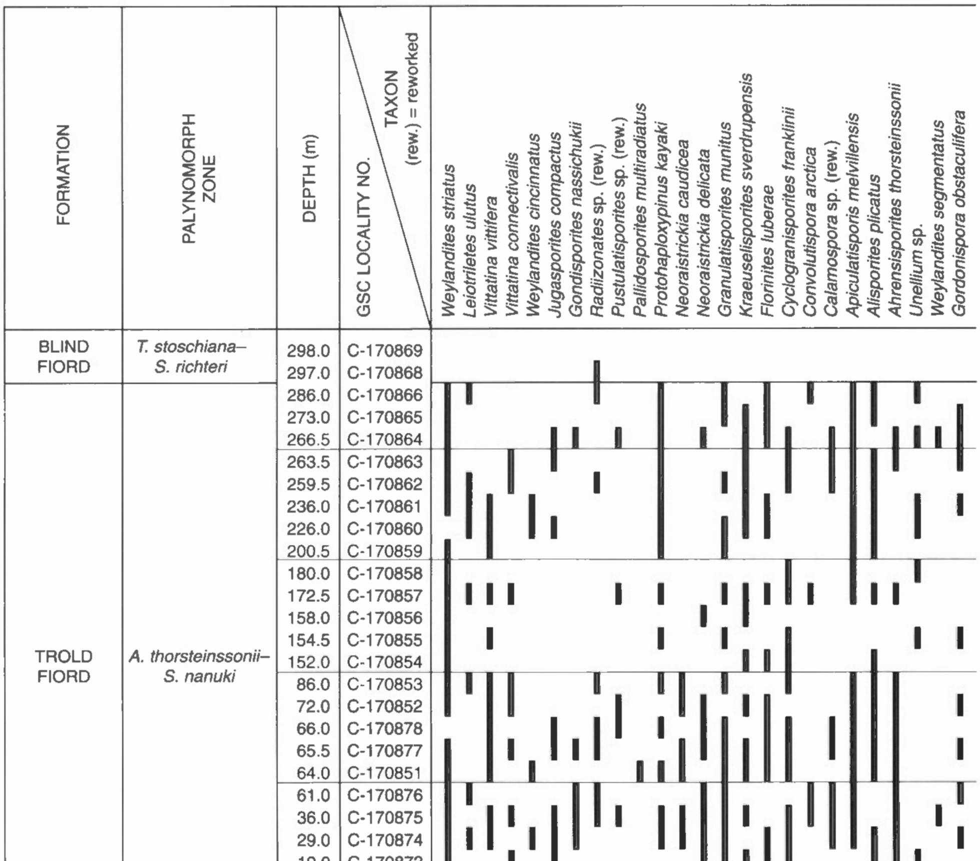
Appendix Figure 10. *Locality 3. Vertical distribution of palynomorph taxa at Grinnell Peninsula, Devon Island.*



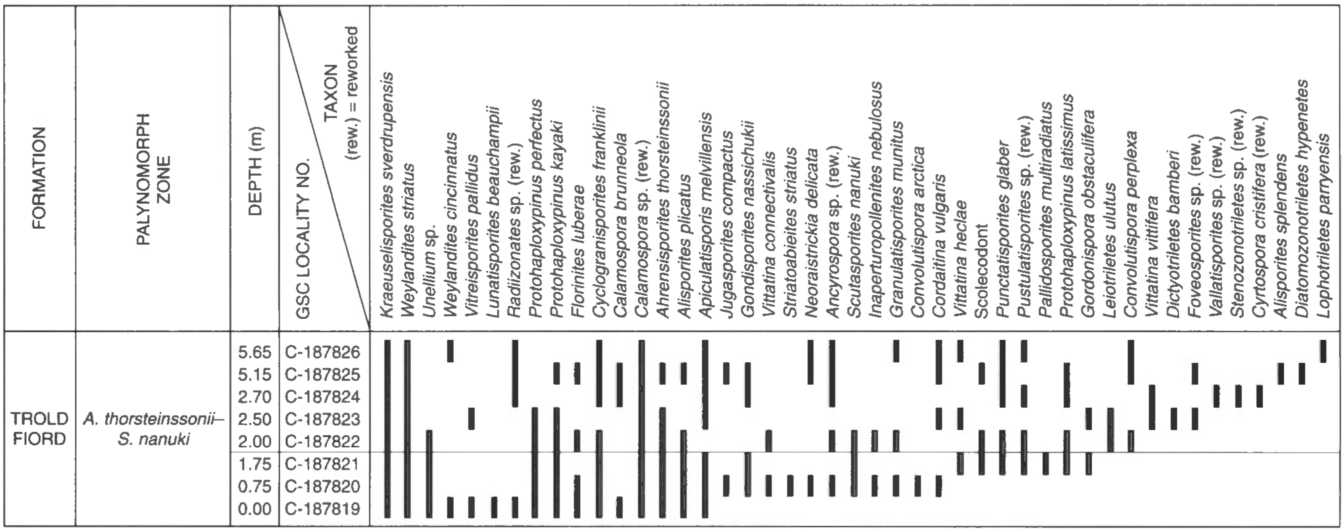
Appendix Figure 10. *(cont'd.)*



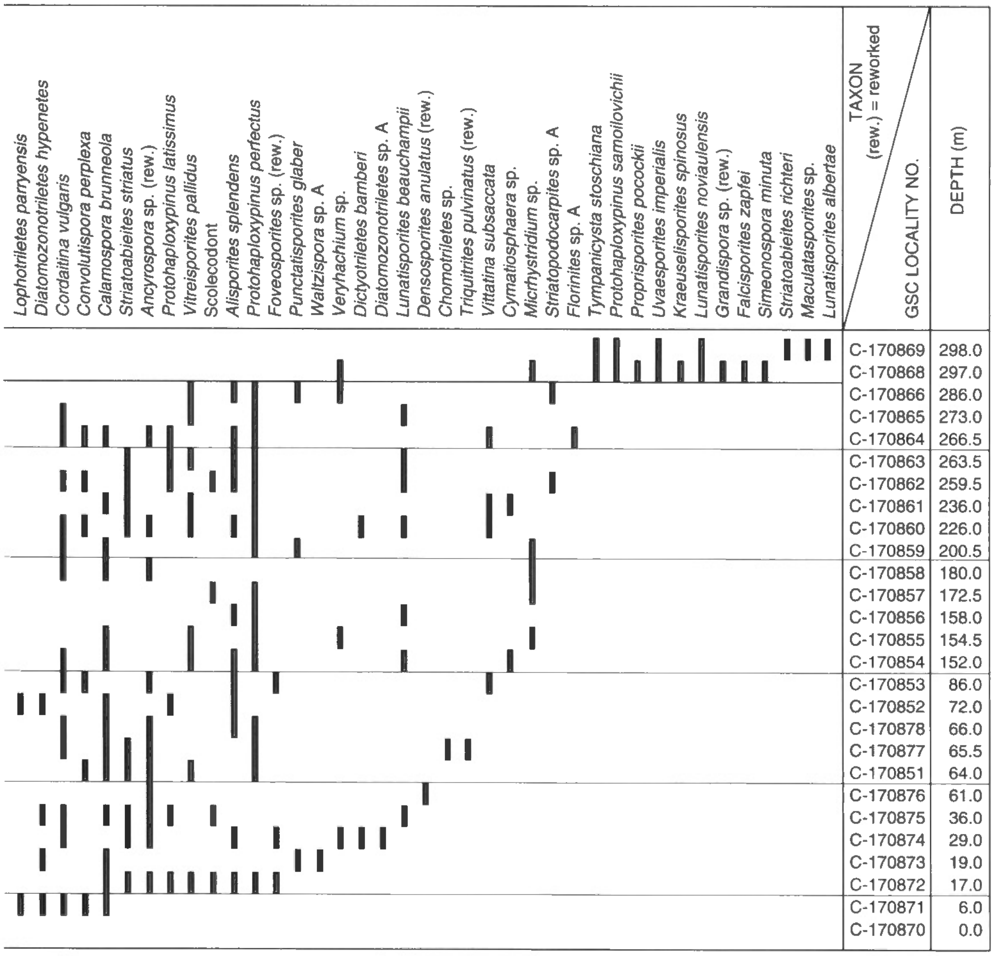
Appendix Figure 11. *Locality 4. Vertical distribution of palynomorph taxa at Blind Fiord, Ellesmere Island.*



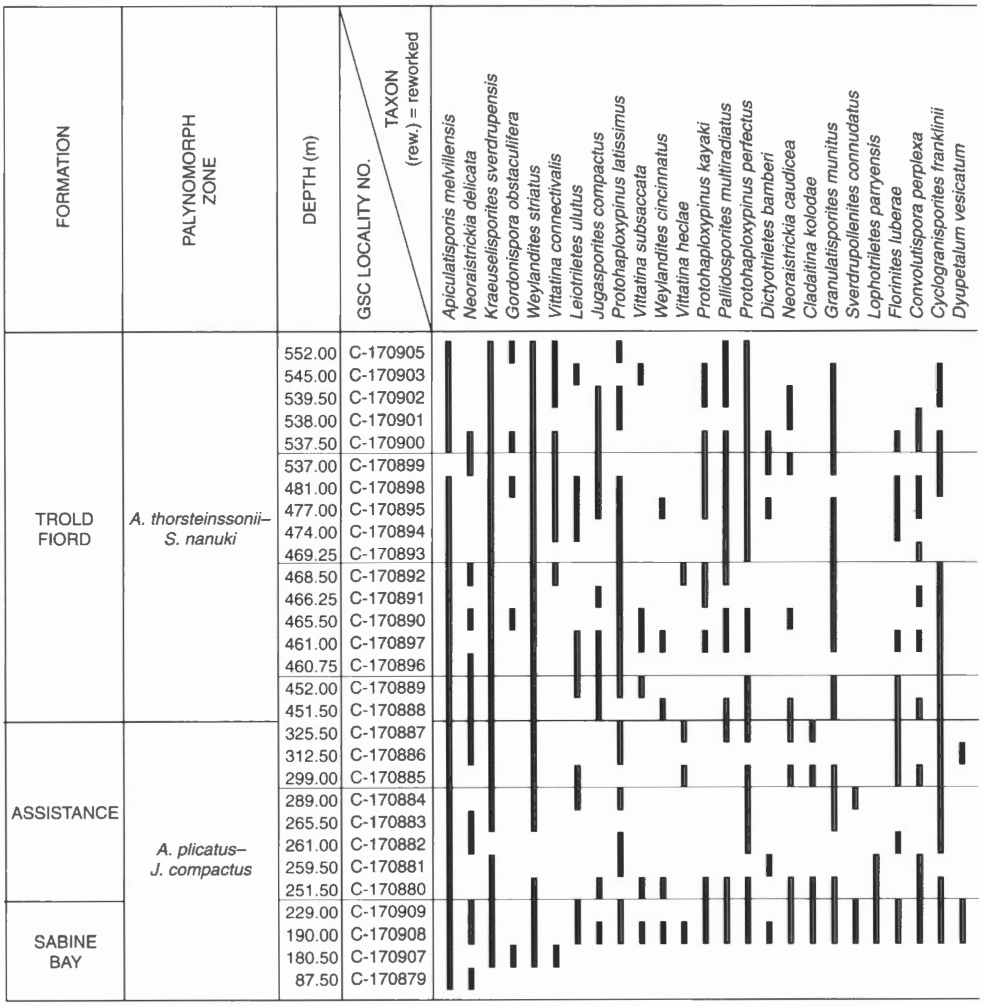
Appendix Figure 13. *Locality 6. Vertical distribution of palynomorph taxa at Fosheim Peninsula, Ellesmere Island.*



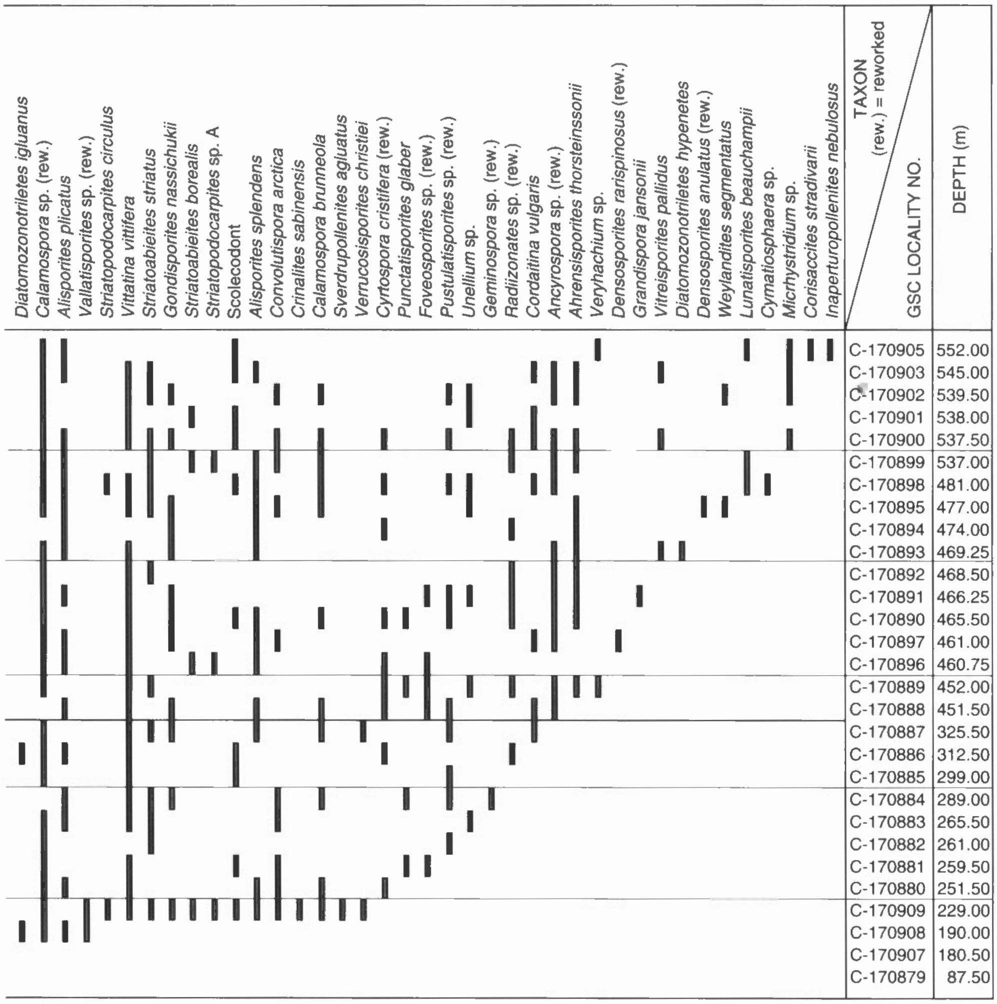
Appendix Figure 12. *Locality 5. Vertical distribution of palynomorph taxa at Trold Fiord, Ellesmere Island.*



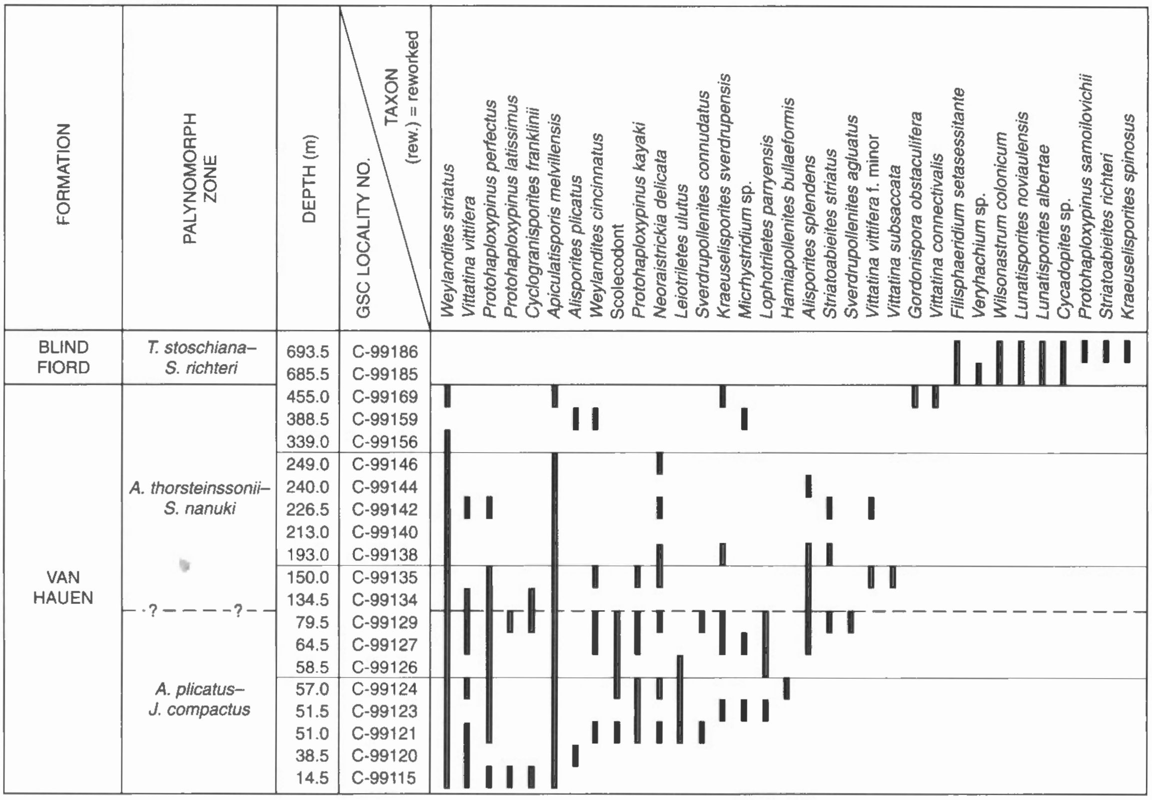
Appendix Figure 13. *(cont'd.)*



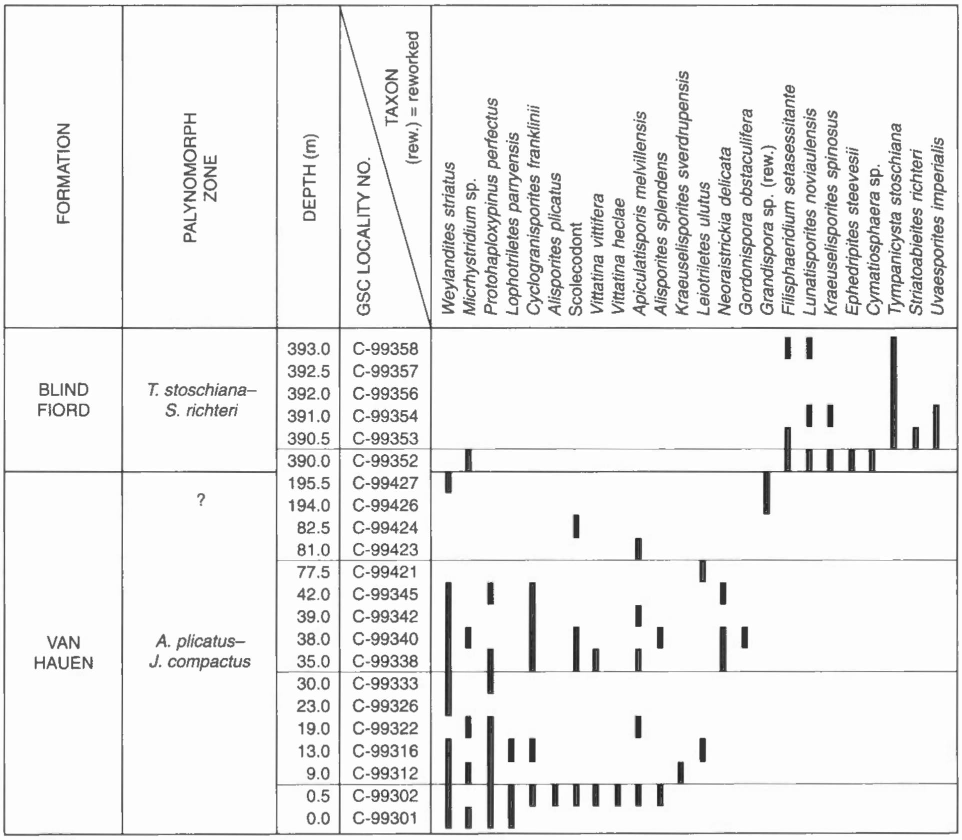
Appendix Figure 14. *Locality 7. Vertical distribution of palynomorph taxa at Hamilton Peninsula, Ellesmere Island.*



Appendix Figure 14. *(cont'd.)*



Appendix Figure 15. *Locality 8. Vertical distribution of palynomorph taxa at Blue Mountains, Ellesmere Island.*



Appendix Figure 16. *Locality 9. Vertical distribution of palynomorph taxa at van Hauen Pass, Ellesmere Island.*

PLATES 1–10

All figures are from unretouched negatives and prints. Transmitted light photomicrographs were taken under bright field illumination.

In the explanation of figures, the species name is followed by the GSC locality number, the slide number, stage co-ordinates and the GSC type number. All specimens are in the collections of the Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada.

Stage co-ordinates given in the explanation of plates and in the systematic palynology section are those of Leitz Orthoplan microscope no. 9856599 of the Institute of Sedimentary and Petroleum Geology, Calgary, Alberta, Canada.

The magnification of all illustrated specimens is x 500 unless otherwise stated.

PLATE 1

Figures 1–3. *Calamospora brunneola* Virbitskas, 1983
1. C-126264, 3, 19.2 x 95.7, GSC 105392.
2. C-126264, 3, 26.8 x 106.0, GSC 105393.
3. C-126264, 3, 43.3 x 110.0, GSC 105394.

Figures 4–8. *Leiotriletes ulutus* sp. nov.
4. Holotype, C-126269, 4, 39.7 x 103.0, GSC 105395.
5. C-126269, 3, 33.0 x 100.5, GSC 105396.
6. C-79879, 3a, 9.0 x 98.0, GSC 105397.
7. C-134172, 3, 30.2 x 101.7, GSC 105398.
8. C-161948, 3, 55.5 x 94.4, GSC 105399.

Figures 9, 10. *Punctatisporites glaber* (Naumova) Playford, 1962
9. C-99250, 3, 15.5 x 108.8, GSC 105400.
10. C-161961, 3, 10.1 x 94.5, GSC 105401.

Figures 11–13. *Cyclogranisporites franklinii* sp. nov.
11. Holotype, C-126264, 3, 26.5 x 99.1, GSC 105402.
12. C-126264, 3, 21.0 x 101.6, GSC 105403.
13. C-126261, 3, 43.4 x 95.1, GSC 105404.

Figures 14–16. *Granulatisporites munitus* sp. nov.
14. Holotype, C-134170, 3, 19.6 x 99.6, GSC 105405.
15. C-134171, 3, 7.8 x 93.7, GSC 105406.
16. C-134171, 3, 20.0 x 95.9, GSC 105407.

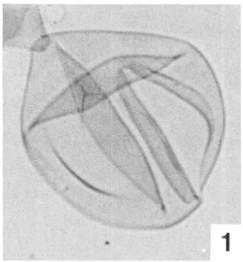
Figures 17, 18. *Granulatisporites* sp. A
17. C-161956, 3b, 37.7 x 109.4, GSC 105408.
18. C-161956, 3b, 34.7 x 111.0, GSC 105409.

Figure 19. *Waltzispora* sp. A
19. C-170874, 3, 33.6 x 103.4, GSC 105417.

Figures 20, 21, 25. *Verrucosisporites christiei* sp. nov.
20. Holotype, C-99249, 3, 8.2 x 99.4, GSC 105410.
21. C-126267, 4, 25.0 x 101.3, GSC 105411.
25. C-170909, 3, 37.5 x 98.4, GSC 105412.

Figures 22–24, 26–29. *Apiculatisporis melvillensis* sp. nov.
22. Holotype, C-170963, 3, 27.7 x 93.6, GSC 105418.
23. C-79869, 3, 44.3 x 104.2, GSC 105590.
24. C-161956, 3a, 40.6 x 109.0, GSC 105420.
26. C-79890, 3, 28.0 x 108.5, GSC 105421.
27. C-170871, 3, 10.9 x 99.8, GSC 105422.
28. C-161952, 3, 15.2 x 99.7, GSC 105423.
29. C-126269, 3, 9.2 x 97.6, GSC 105419.

PLATE 1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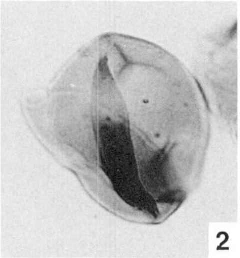
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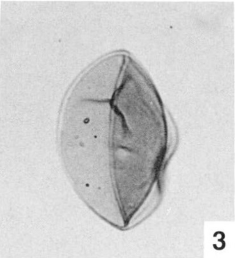
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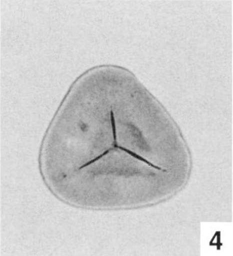
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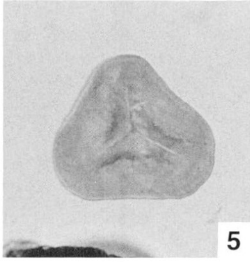
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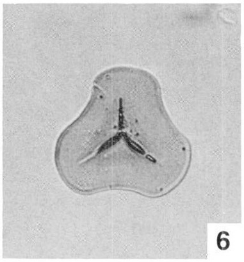
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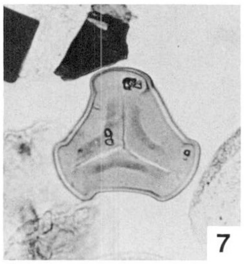
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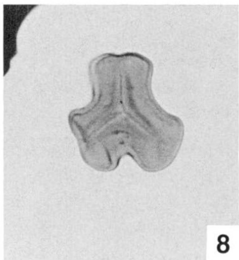
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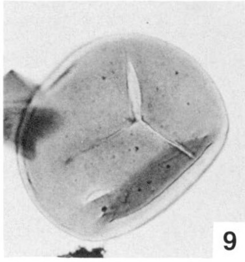
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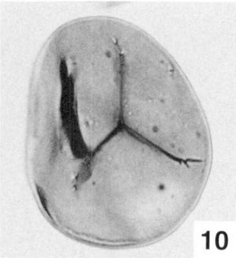
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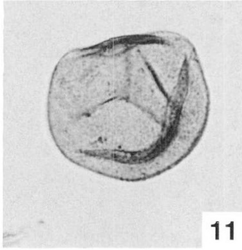
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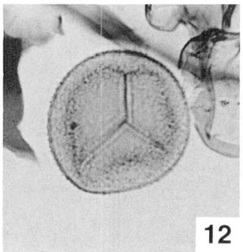
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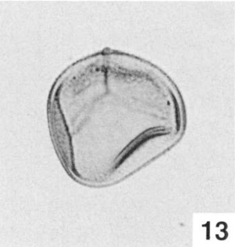
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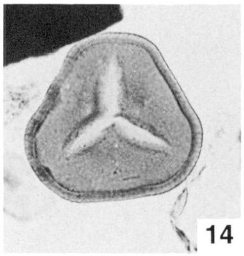
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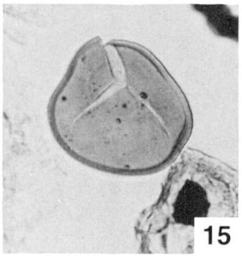
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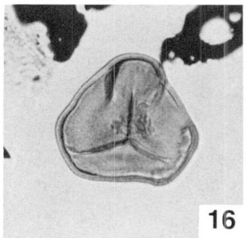
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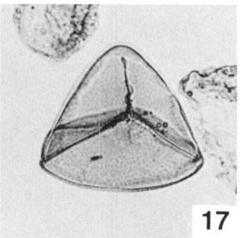
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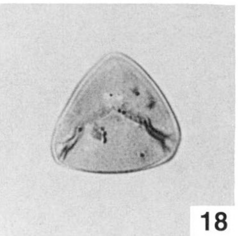
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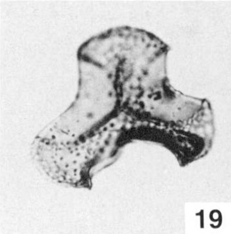
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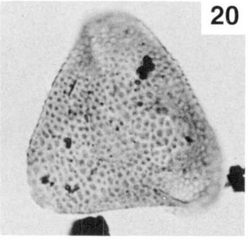
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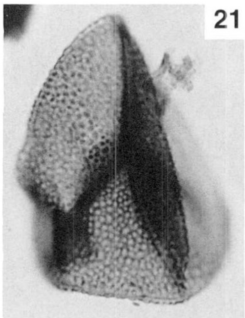
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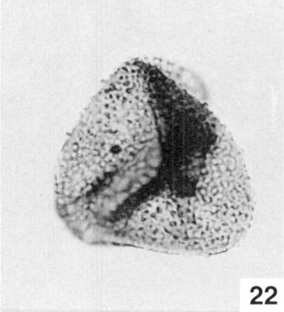
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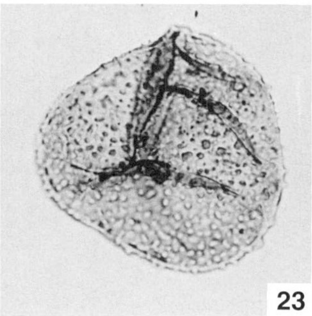
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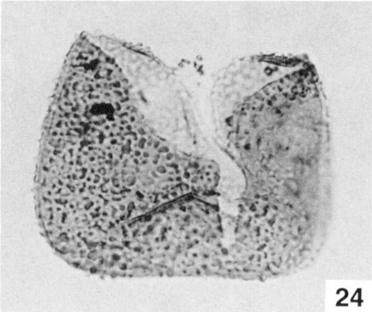
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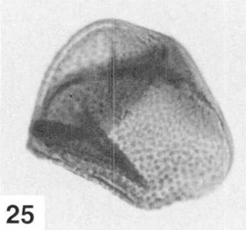
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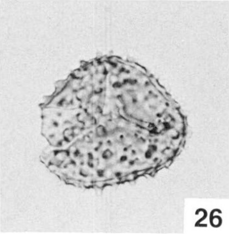
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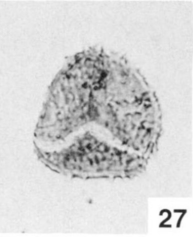
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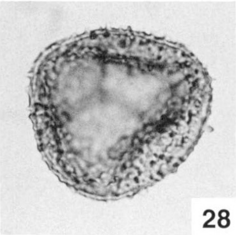
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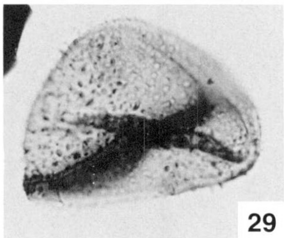
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PLATE 2

Figures 1–3. *Lophotriletes parryensis* sp. nov.
1. Holotype, C-126261, 3, 7.7 x 96.8, GSC 105424.
2. C-126261, 3, 33.5 x 95.4, GSC 105425.
3. C-126261, 3, 26.4 x 95.8, GSC 105426.

Figures 4–12. *Neoraistrickia caudicea* sp. nov.
4. Holotype, C-79890, 3, 21.0 x 93.0, GSC 105427.
5. C-134177, 3, 6.4 x 99.3, GSC 105428.
6. C-79879, 3, 33.4 x 95.9, GSC 105429.
7. C-170909, 3, 42.2 x 96.0, GSC 105434.
8. C-126269, 3, 35.0 x 97.0, GSC 105435.
9. C-79890, 3, 25.0 x 104.8, GSC 105436.
10. C-99248, 3, 10.7 x 102.3, GSC 105440.
11. C-161944, 3, 15.0 x 97.2, GSC 105441.
12. C-79878, 3, 22.3 x 105.4, GSC 105442.

Figures 13–16. *Neoraistrickia delicata* sp. nov.
13. Holotype, C-126269, 3, 21.1 x 103.0, GSC 105430.
14. C-170909, 3, 23.2 x 92.4, GSC 105431.
15. C-170909, 3, 23.3 x 95.1, GSC 105432.
16. C-126261, 3, 18.2 x 96.4, GSC 105433.

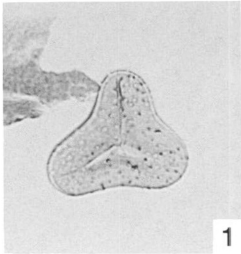
Figures 17–19. *Raistrickia enervata* sp. nov.
17. Holotype, C-99228, 10, 38.2 x 106.5, GSC 105437.
18. C-79879, 3, 43.2 x 100.1, GSC 105438.
19. C-134171, 3, 6.4 x 93.8, GSC 105439.

Figures 20–22. *Raistrickia* sp. A
20. C-134171, 3, 20.6 x 96.0, GSC 105443.
21. C-126265, 3, 38.8 x 95.8, GSC 105444.
22. C-134172, 3, 22.6 x 95.0, GSC 105445.

Figures 23–25. *Convolutispora arctica* sp. nov.
23. Holotype, C-126269, 3, 19.5 x 103.0, GSC 105446.
24. C-134169, 3, 37.1 x 100.8, GSC 105447.
25. C-134169, 3, 32.4 x 103.1, GSC 105448.

Figures 26–29. *Convolutispora perplexa* sp. nov.
26. Holotype, C-134171, 4, 14.1 x 100.1, GSC 105449.
27. C-126253, 3, 38.7 x 95.7, GSC 105450.
28. C-126269, 3, 8.6 x 97.0, GSC 105451.
29. C-170909, 3, 22.5 x 112.7, GSC 105452.

Figure 30. *Dictyotriletes bamberi* sp. nov.
30. Holotype, C-161952, 3, 32.3 x 101.7, GSC 105453.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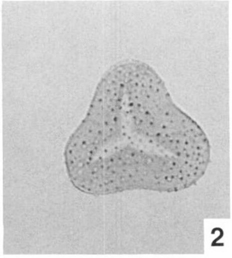
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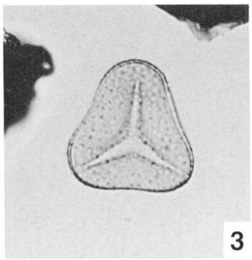
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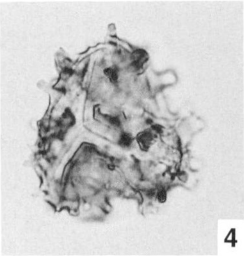
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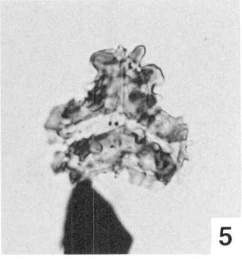
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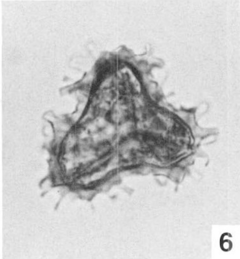
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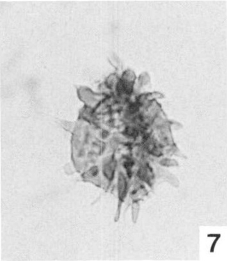
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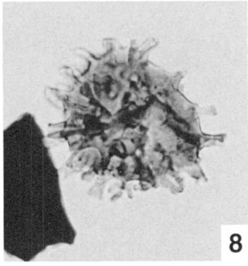
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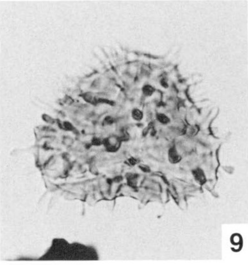
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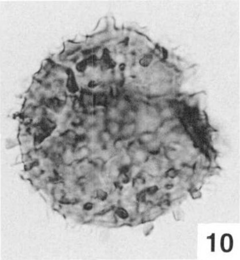
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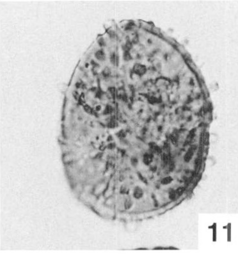
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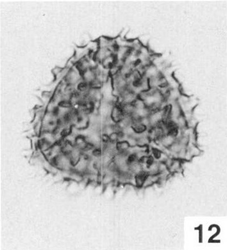
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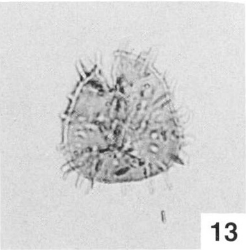
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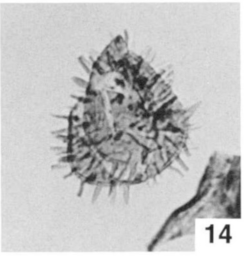
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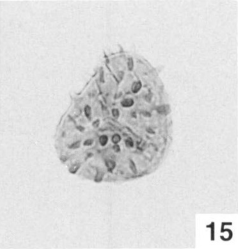
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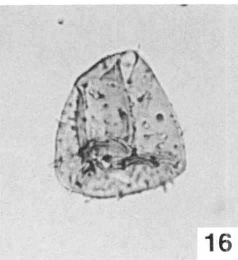
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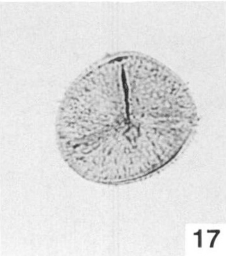
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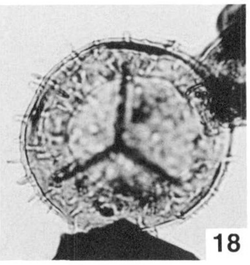
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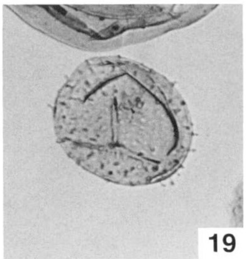
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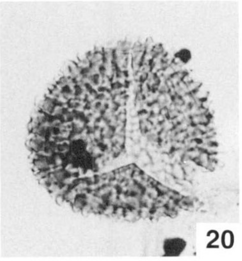
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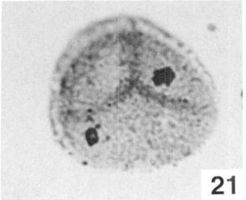
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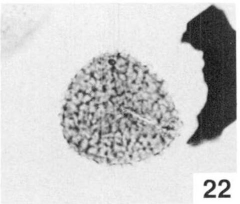
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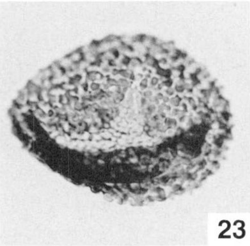
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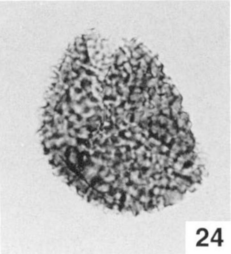
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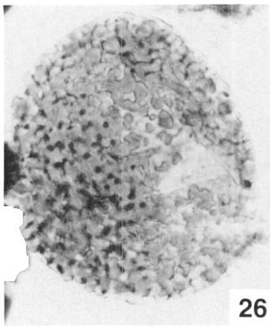
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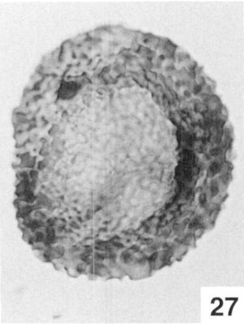
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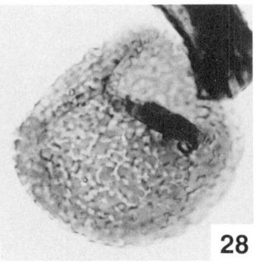
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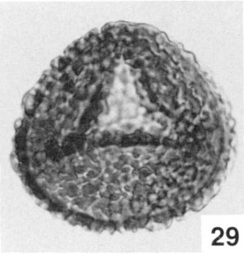
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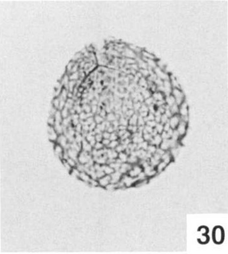
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PLATE 3

Figures 1, 2. *Dictyotriletes bamberi* sp. nov.
1. C-148178, 3, 16.7 x 95.0, GSC 105454.
2. C-134177, 3, 10.6 x 93.7, GSC 105455.

Figures 3–7. *Ahrensisporites multifloridus* sp. nov.
3. Holotype, C-134172, 4, 19.4 x 95.1, GSC 105456.
4, 5. C-134171, 4, 10.4 x 105.5, GSC 105457; distal surface and proximal surface.
6. C-134171, 4, 11.2 x 109.3, GSC 105458.
7. C-134177, 5, 16.1 x 98.1, GSC 105459.

Figures 8–11. *Ahrensisporites thorsteinssonii* sp. nov.
8. Holotype, C-134170, 3, 39.0 x 97.3, GSC 105460.
9. C-134172, 3, 41.3 x 107.6, GSC 105461.
10. C-134177, 3, 28.1 x 96.4, GSC 105462.
11. C-79890, 3, 12.4 x 106.9, GSC 103894.

Figure 12. *Tripartites* sp. A
12. C-79871, 2, 29.4 x 98.3, GSC 105463.

Figure 13. *Triquitrites* sp. A
13. C-134171, 3, 23.5 x 96.0, GSC 105464.

Figures 14–17. *Diatomozonotriletes hypenetes* sp. nov.
14. Holotype, C-99245, 3, 41.2 x 101.4, GSC 105465.
15. C-99245, 3, 30.3 x 98.4, GSC 105466.
16. C-99246, 3, 37.2 x 95.0, GSC 105467.
17. C-170852, 3, 34.5 x 99.3, GSC 105468.

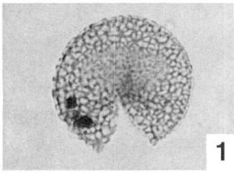
Figures 18–21. *Diatomozonotriletes igluanus* sp. nov.
18. Holotype, C-170908, 3, 38.2 x 107.7, GSC 105415.
19. C-161946, 3, 44.2 x 98.3, GSC 105414.
20. C-99248, 3, 17.8 x 102.2, GSC 105413.
21. C-126264, 3, 39.9 x 108.2, GSC 105416.

Figure 22. *Diatomozonotriletes* sp. A
22. C-134179, 3, 30.5 x 99.0, GSC 105469.

Figures 23–25. *Gordonispora obstaculifera* sp. nov.
23. Holotype, C-134171, 3, 20.0 x 107.0, GSC 105470.
24. C-134171, 3, 24.6 x 99.4, GSC 105471.
25. C-79890, 3, 28.2 x 102.6, GSC 105472.

Figures 26–28. *Kraeuselisporites sverdrupensis* sp. nov.
26. Holotype, C-79879, 3, 21.6 x 96.0, GSC 105473.
27. C-79879, 3, 19.2 x 97.6, GSC 105474.
28. C-79876, 3, 16.1 x 104.8, GSC 105475.

Figure 29. *Gondisporites nassichukii* sp. nov.
29. Holotype, C-79879 3, 10.2 x 96.6, GSC 105476.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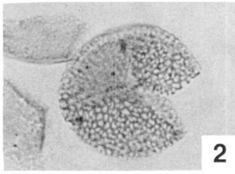
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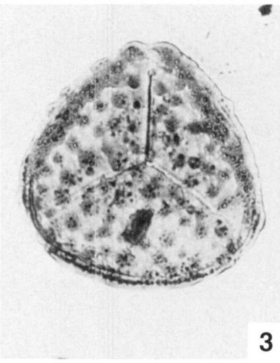
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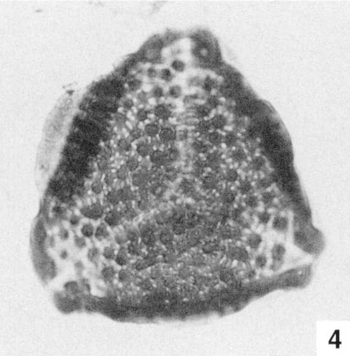
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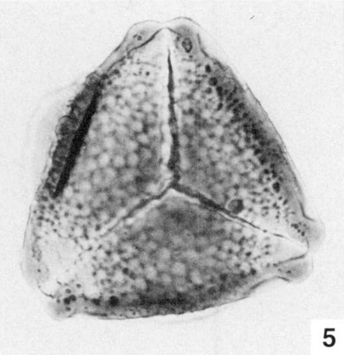
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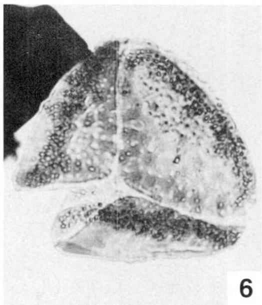
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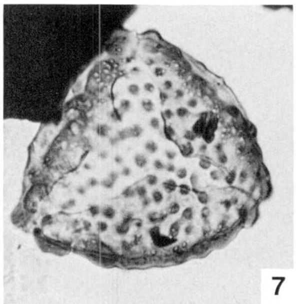
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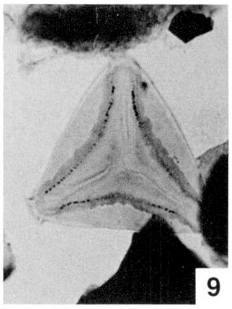
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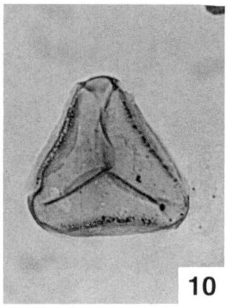
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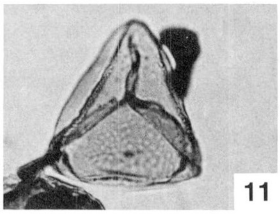
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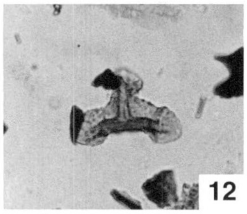
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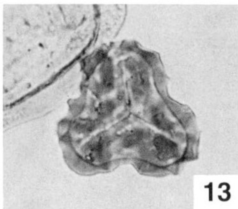
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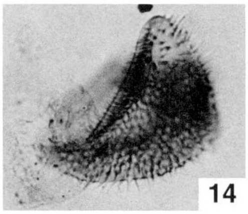
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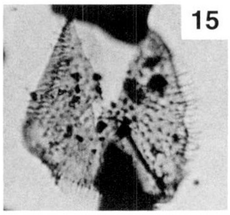
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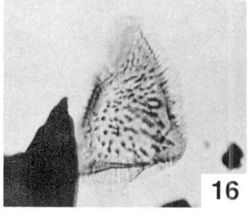
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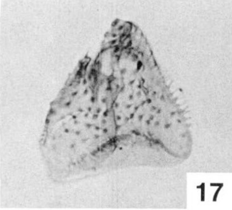
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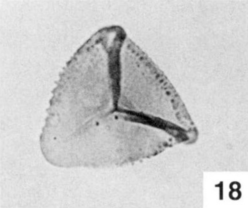
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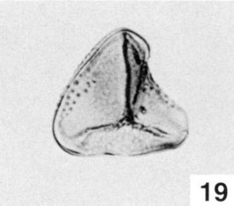
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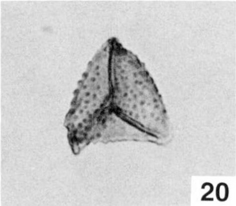
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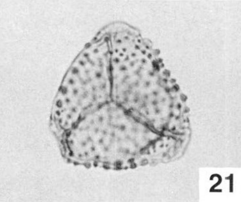
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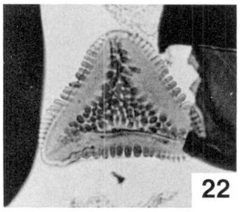
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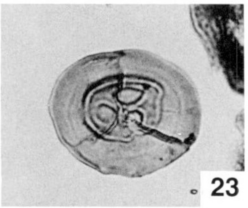
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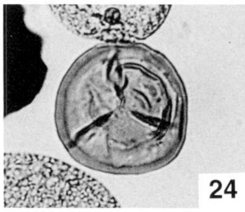
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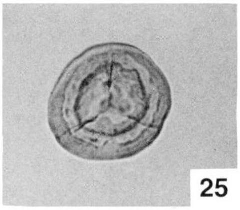
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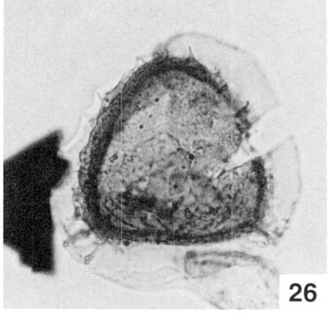
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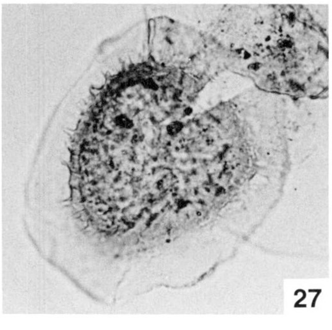
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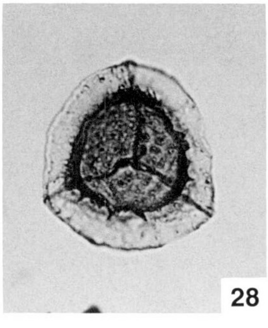
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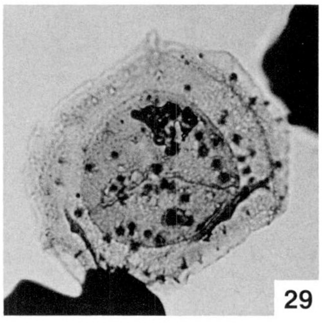
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PLATE 4

Figures 1–3. *Gondisporites nassichukii* sp. nov.
1. C-79879, 3, 33.3 x 110.0, GSC 105477.
2. C-79889, 3, 9.9 x 98.0, GSC 105478.
3. C-79879, 3, 28.7 x 102.0, GSC 105479.

Figures 4–8. *Grandispora jansonii* sp. nov.
4. Holotype, C-134171, 4, 28.0 x 105.3, GSC 105480.
5. C-134167, 5, 29.9 x 97.0, GSC 105481.
6. C-170891, 3, 10.2 x 95.8, GSC 105482.
7. C-134171, 4, 24.1 x 101.3, GSC 105483.
8. C-134177, 4, 42.6 x 97.1, GSC 105484.

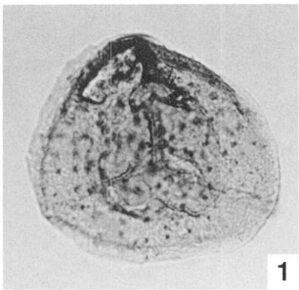
Figure 9. *Laevigatosporites minor* Loose, 1934
9. C-134170, 3, 36.2 x 100.8, GSC 105485.

Figures 10–13, 16, 20. *Cordaitina vulgaris* (Zauer) Varyukhina, 1971 ex. Utting comb. nov.
10. Holotype, C-99245, 3, 32.0 x 108.1, GSC 105486.
11. C-126269, 3, 22.4 x 95.1, GSC 105487.
12. C-79883, 3, 23.2 x 104.8, GSC 105488.
13. C-134171, 4, 34.5 x 112.3, GSC 105489.
16. C-99229, 5, 6.7 x 98.2, GSC 105490.
20. C-99229, 5, 18.1 x 105.6, GSC 105491.

Figures 14, 15, 18, 19, 21. *Dyupetalum vesicatum* sp. nov.
14, 15, 18. Holotype, C-126275, 3, 5.1 x 98.9, GSC 105492; 14, vesicles; 15, proximal surface; 18, distal surface.
19. C-126275, 3, 22.4 x 103.2, GSC 105493.
21. C-126275, 3, 22.4 x 93.7, GSC 105494.

Figures 17, 24. *Striomonosaccites* sp. A
17. C-126269, 4, 38.0 x 104.5, GSC 105495.
24. C-161948, 3, 37.2 x 94.1, GSC 105496.

Figures 22, 23. *Florinites luberae* Samoilovich, 1953
22. C-134170, 3, 9.4 x 100.6, GSC 105497.
23. C-126269, 6, 4.7 x 93.4, GSC 105498.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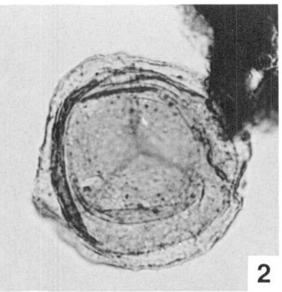
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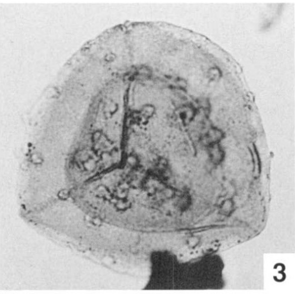
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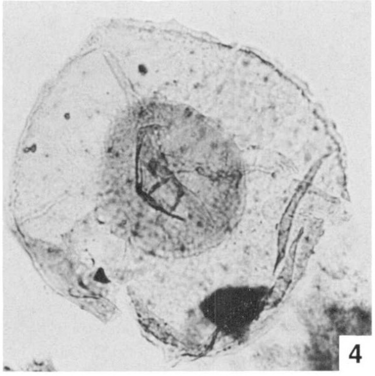
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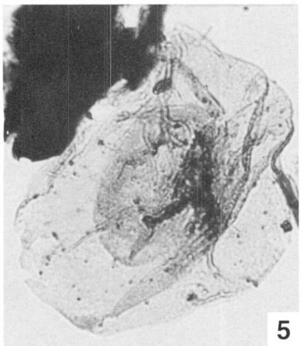
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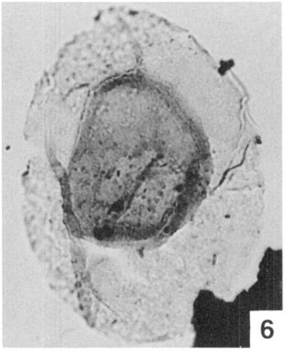
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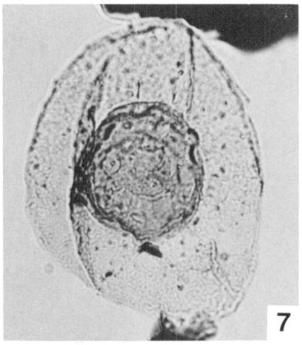
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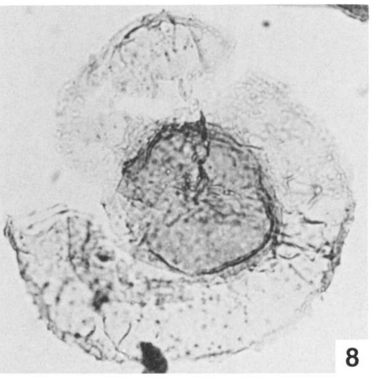
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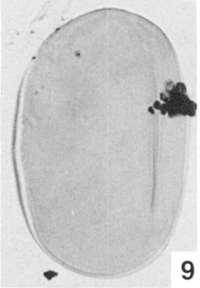
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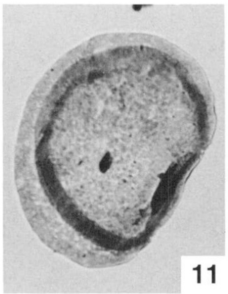
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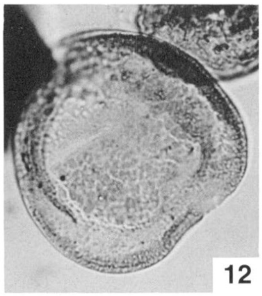
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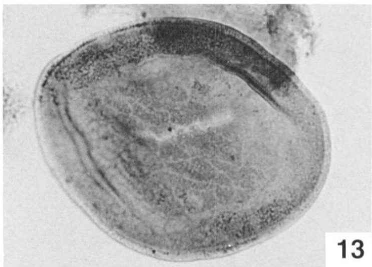
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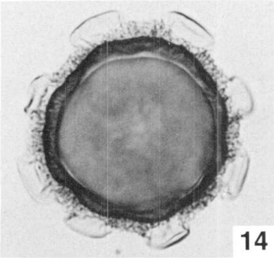
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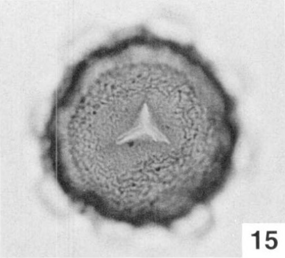
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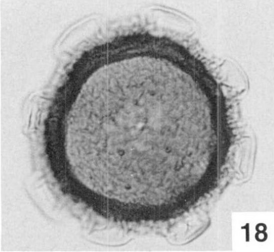
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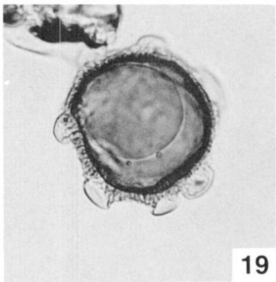
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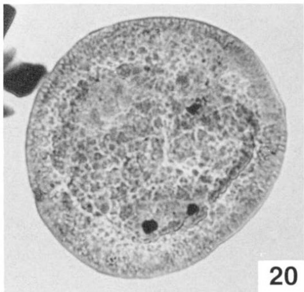
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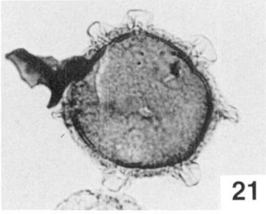
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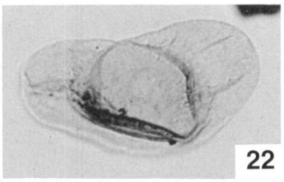
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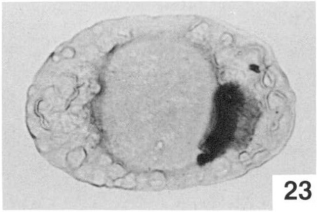
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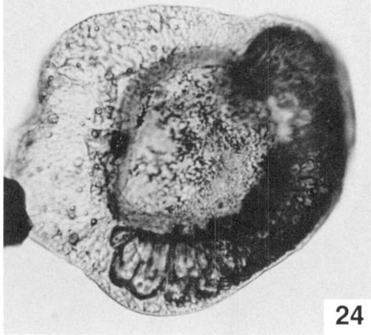
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PLATE 5

Figure 1. *Florinites luberae* Samoilovich, 1953
1. C-79879, 3a, 20.4 x 110.1, GSC 105499.

Figures 2, 3. *Florinites* sp. A
2. C-79876, 3, 23.3 x 104.8, GSC 105500.
3. C-79876, 3, 18.4 x 99.2, GSC 105501.

Figure 4. *Potonieisporites* sp. A
4. C-161940, 3, 26.9 x 104.1, GSC 105502.

Figures 5, 6. *Crustaesporites* sp. A
5. C-79876, 3, 34.4 x 101.1, GSC 105503.
6. C-134171, 4, 25.6 x 98.7, GSC 105504.

Figures 7, 8. *Abiespollenites* sp. A
7. C-126252, 3, 34.7 x 107.2, GSC 105505.
8. C-99250, 3, 26.5 x 93.8, GSC 105519.

Figures 9–11. *Alisporites splendens* (Leschik) Foster, 1979
9. C-79868, 3, 13.6 x 104.2, GSC 105506.
10. C-161952, 3, 29.2 x 94.8, GSC 105507.
11. C-161946, 3, 59.6 x 97.0, GSC 105508.

Figures 12–14. *Alisporites plicatus* Jizba, 1962
12. C-126253, 3, 30.8 x 109.1, GSC 105509.
13. C-126269, 4, 19.6 x 102.7, GSC 105510.
14. C-126254, 3, 22.7 x 104.7, GSC 105511.

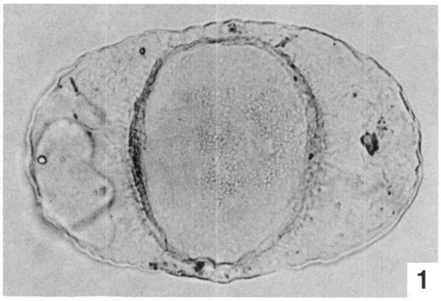
Figures 15–17. *Jugasporites compactus* sp. nov.
15. Holotype, C-126269, 4, 22.5 x 102.3, GSC 105512.
16. C-126269, 3, 31.8 x 96.8, GSC 105513.
17. C-126269, 4, 8.4 x 97.6, GSC 105514.

Figure 18. *Limitisporites* sp. A
18. C-161958, 3, 36.5 x 105.0, GSC 105515.

Figures 19–21. *Piceapollenites nookapii* sp. nov.
19. Holotype, C-99228, 10, 19.5 x 105.3, GSC 105516.
20. C-99228, 15, 5.4 x 98.6, GSC 105517.
21. C-99228, 12, 14.9 x 105.9, GSC 105518.

Figures 22–24. *Vitreisporites pallidus* (Reissinger) Nilsson, 1958
22. C-134172, 3, 19.8 x 94.8, GSC 105520.
23. C-79890, 3, 36.0 x 95.5, GSC 105521.
24. C-161961, 3, 4.7 x 101.0, GSC 105522.

Figures 25–28. *Corisaccites stradivarii* sp. nov.
25. Holotype, C-134167, 3, 40.5 x 103.0, GSC 105523.
26. C-134177, 3, 38.2 x 94.4, GSC 105524.
27. C-134171, 4, 15.5 x 96.1, GSC 105525.
28. C-161940, 3, 22.0 x 97.6, GSC 105526.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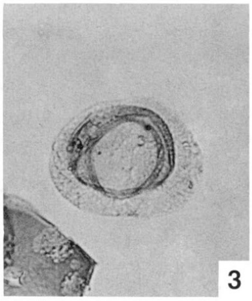
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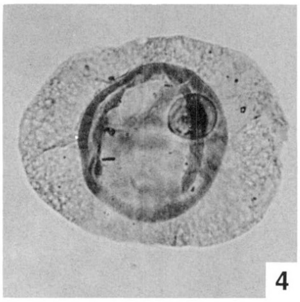
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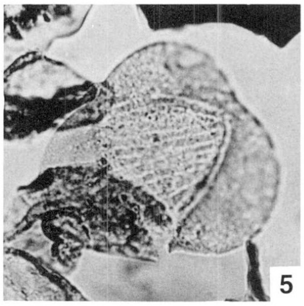
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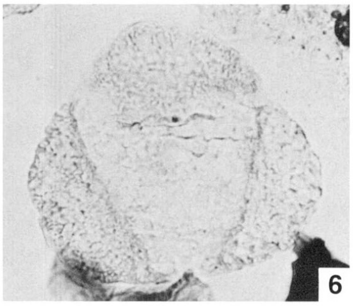
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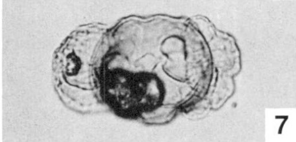
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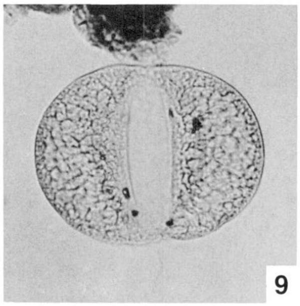
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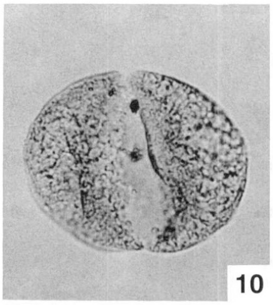
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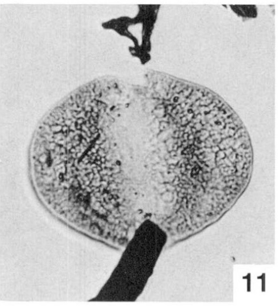
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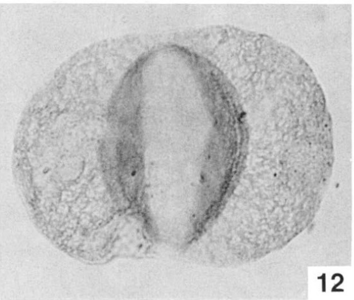
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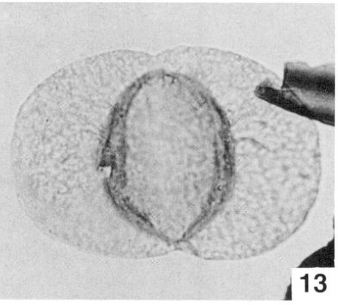
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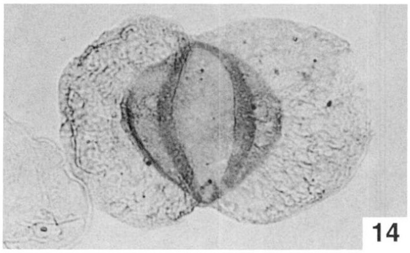
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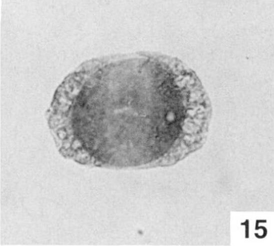
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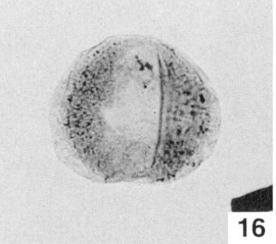
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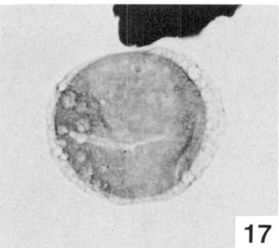
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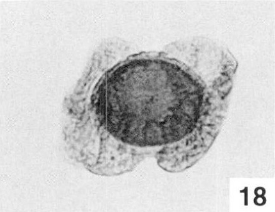
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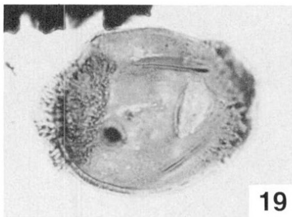
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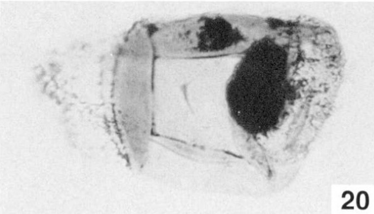
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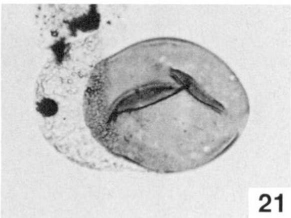
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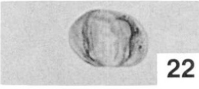
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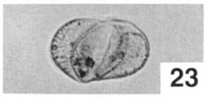
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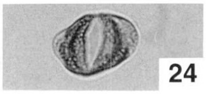
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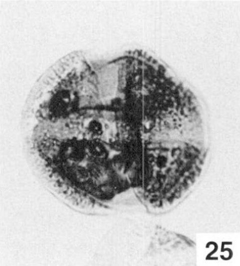
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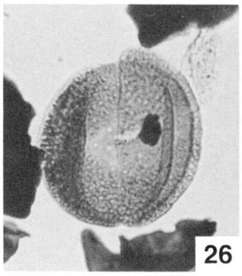
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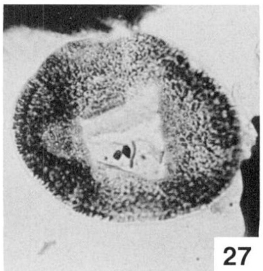
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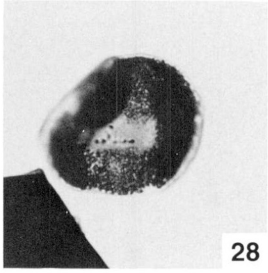
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PLATE 6

Figures 1, 2. *Corisaccites stradivarii* sp. nov.
1. C-161950, 3, 23.7 x 99.8, GSC 105527.
2. C-161938, 3, 22.0 x 95.0, GSC 103895.

Figures 3–5. *Hamiapollenites bullaeformis* (Samoilovich) Jansonius, 1962
3. C-126269, 3, 22.0 x 106.8, GSC 105528.
4. C-79870, 1a, 35.3 x 98.8, GSC 105529.
5. C-126270, 3, 36.4 x 93.6, GSC 105530.

Figures 6–9. *Hamiapollenites erebi* sp. nov.
6. Holotype, C-99228, 4, 30.3 x 108.7, GSC 105531.
7. C-99228, 4, 27.3 x 107.1, GSC 105532.
8. C-134169, 3, 14.9 x 97.8, GSC 105533.
9. C-134171, 5 18.6 x 102.5, GSC 105534.

Figures 10–13. *Lunatisporites beauchampii* sp. nov.
10. Holotype, C-170905, 3, 10.0 x 106.7, GSC 105535.
11. C-161961, 3, 4.4 x 100.8, GSC 105536.
12. C-161957, 3, 39.0 x 103.2, GSC 105537.
13. C-161959, 3, 41.1 x 108.7, GSC 105538.

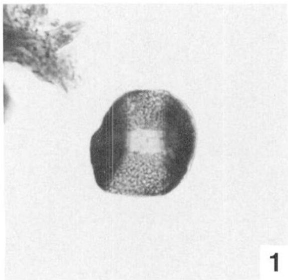
Figures 14–16. *Lunatisporites arluki* sp. nov.
14. Holotype, C-99228, 17, 35.0 x 107.0, GSC 105539.
15. C-99228, 14, 14.5 x 100.4, GSC 105540.
16. C-99228, 7, 25.4 x 100.0, GSC 105541.

Figures 17, 18, 22, 23. *Pallidosporites multiradiatus* sp. nov.
17. Holotype, C-126275, 3, 39.0 x 107.1, GSC 105542.
18. C-126257, 3, 39.7 x 101.1, GSC 105543.
22. C-126275, 3, 28.6 x 108.0, GSC 105544.
23. C-126275, 3, 41.2 x 101.4, GSC 105545.

Figures 19–21, 24–26. *Protohaploxypinus kayaki* sp. nov.
19, 24. Holotype, C-126275, 3, 20.3 x 99.8, GSC 105546; 19, distal surface; 24, proximal surface with haptotypic mark.
20, 25. C-126275, 3, 28.0 x 98.7, GSC 105547; 20, distal surface; 25, proximal surface with haptotypic mark.
21, 26. C-126275, 3, 7.0 x 99.7, GSC 105548; 21, distal surface; 26, proximal surface with haptotypic mark.

Figures 27–29. *Protohaploxypinus latissimus* (Luber) Samoilovich, 1953
27. C-126276, 3, 14.1 x 93.6, GSC 105549.
28. C-126262, 3, 38.0 x 95.0, GSC 105550.
29. C-79879, 3a, 9.5 x 96.4, GSC 105551.

Figures 30, 31. *Protohaploxypinus panaki* sp. nov.
30. Holotype, C-134171, 3, 10.8 x 93.4, GSC 105552.
31. C-161950, 3, 30.3 x 93.2, GSC 105553.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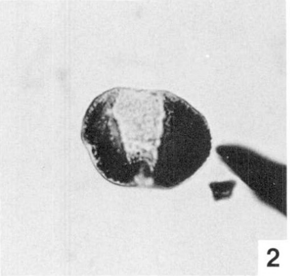
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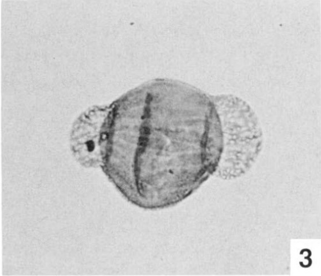
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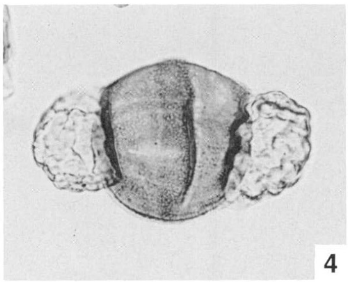
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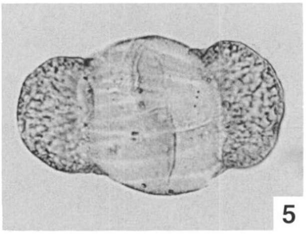
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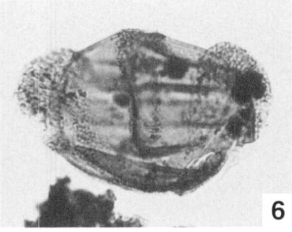
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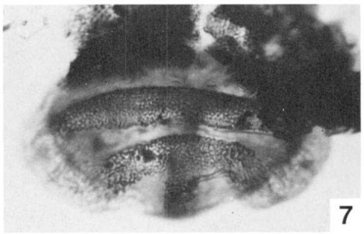
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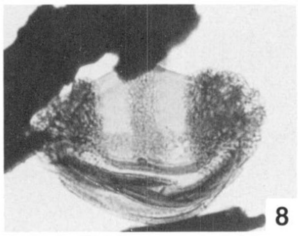
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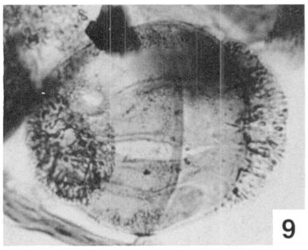
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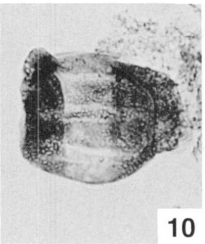
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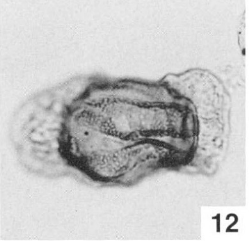
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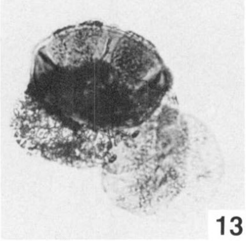
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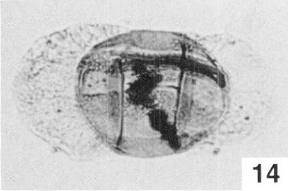
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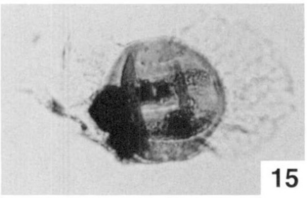
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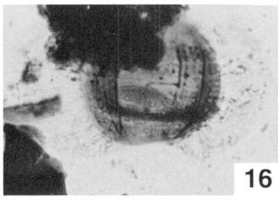
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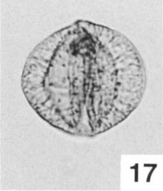
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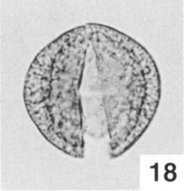
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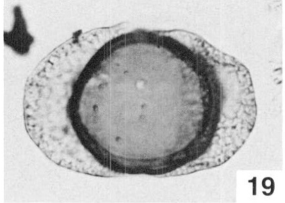
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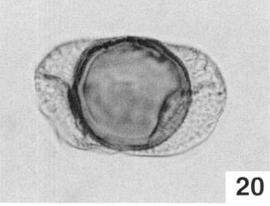
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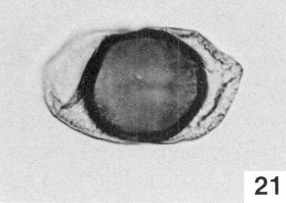
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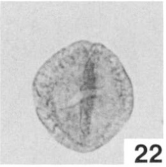
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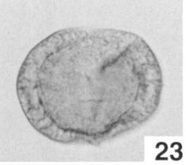
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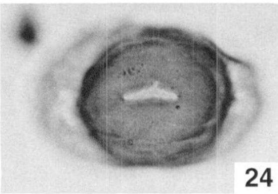
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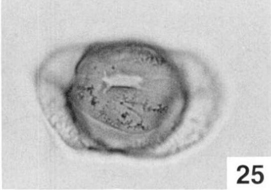
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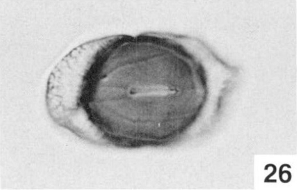
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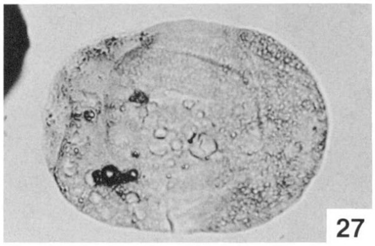
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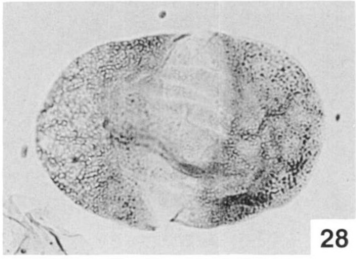
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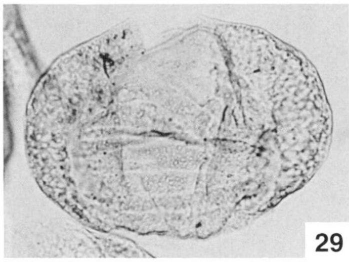
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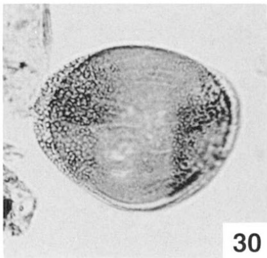
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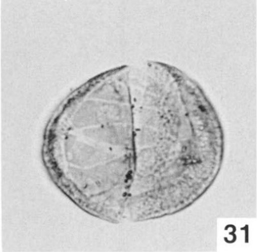
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PLATE 7

Figure 1–3. *Protohaploxypinus panaki* sp. nov.
1. C-134171, 4, 38.8 x 93.8, GSC 105554.
2, 3. C-161926, 3, 21.3 x 94.7, GSC 105555;
2, illustration of distal saccus attachment;
3, illustration of taeniae on proximal surface.

Figures 4–6. *Protohaploxypinus perfectus* (Naumova) Samoilovich, 1953
4. C-161960, 3, 28.6 x 102.0, GSC 105556.
5. C-126275, 3, 13.6 x 95.5, GSC 105557.
6. C-126275, 3, 14.0 x 94.1, GSC 105558.

Figure 7. *Protohaploxypinus* sp. A
7. C-126269, 3, 10.5 x 103.4, GSC 105559.

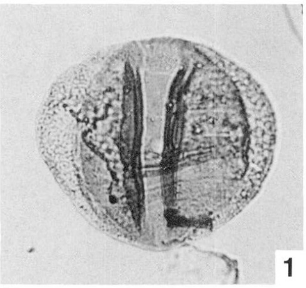
Figures 8–12. *Scutasporites nanuki* sp. nov.
8. Holotype, C-79889, 3, 40.4 x 112.7, GSC 105560.
9. C-79890, 3, 41.0 x 97.6, GSC 105561.
10. C-79890, 3, 33.0 x 98.8, GSC 105562.
11. C-99228, 13, 30.6 x 108.2, GSC 105563.
12. C-161962, 3, 9.4 x 94.1, GSC 105564.

Figures 13–16. *Striatoabieites borealis* sp. nov.
13. Holotype, C-79876, 3, 24.5 x 105.5, GSC 105565.
14. C-79878, 3, 18.2 x 100.4, GSC 105566.
15. C-170896, 3, 40.8 x 99.0, GSC 105567.
16. C-99228, 17, 27.1 x 108.2, GSC 105568.

Figures 17–20. *Striatoabieites striatus* (Luber and Waltz, 1941) Hart, 1964
17. C-126254, 3, 21.5 x 98.3 (lateral view), GSC 105569.
18. C-126273, 3, 7.0 x 106.2, GSC 105570.
19. C-126269, 4, 38.2 x 97.2 (lateral view), GSC 105571.
20. C-134167, 4, 12.6 x 97.6, GSC 105572.

Figures 21–23. *Striatopodocarpites circulus* sp. nov.
21. Holotype, C-126269, 3, 22.2 x 101.8, GSC 105573.
22. C-161930, 3, 17.2 x 95.3, GSC 105574.
23. C-134170, 3, 11.2 x 109.0, GSC 105575.

Figure 24. *Striatopodocarpites* sp. A
24. C-134171, 3, 10.4 x 94.0, GSC 105576.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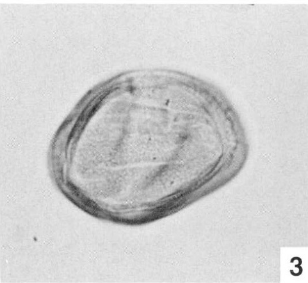
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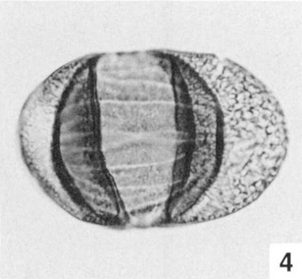
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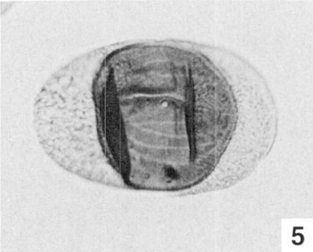
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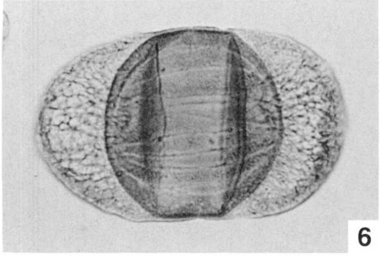
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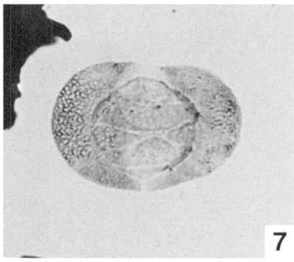
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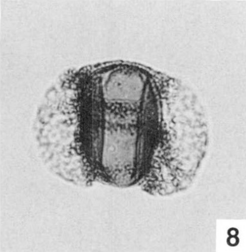
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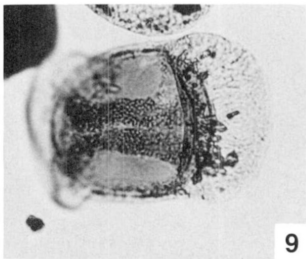
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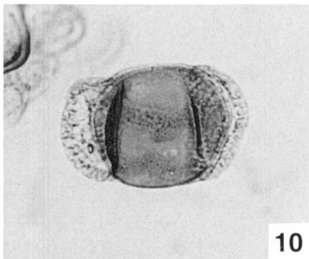
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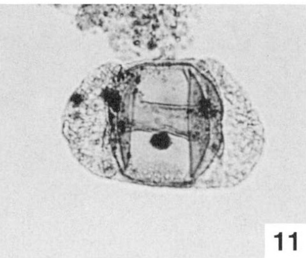
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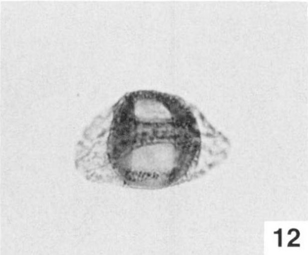
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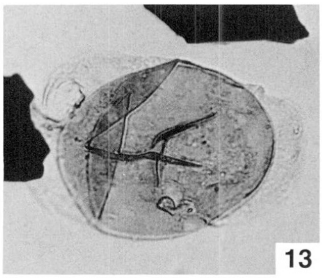
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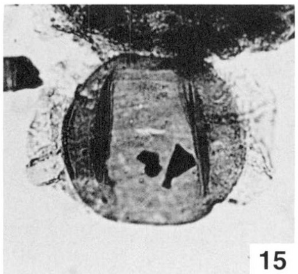
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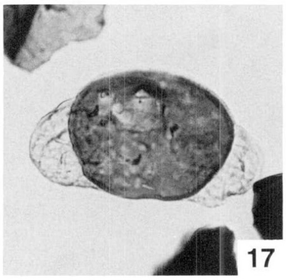
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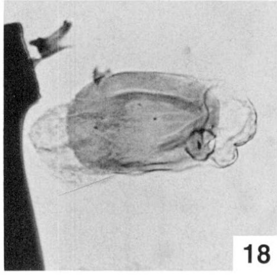
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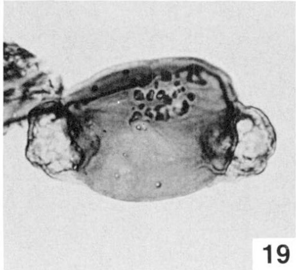
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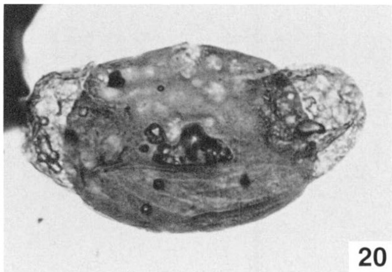
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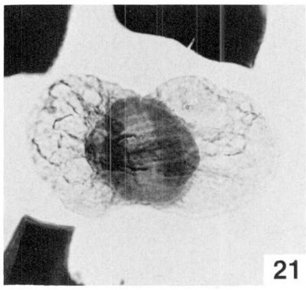
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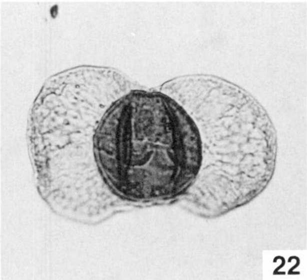
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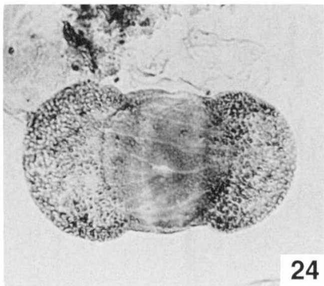
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PLATE 8

Figure 1. *Striatopodocarpites* sp. A

1. C-134171, 4, 4.9 x 103.6, GSC 105577.

Figures 2–5. *Vittatina connectivalis* (Zauer) Varyukhina, 1971 ex. Utting

2. Holotype, C-161961, 3, 29.7 x 101.0, GSC 105578.
3. C-79890, 3, 25.8 x 104.0, GSC 105579.
4. C-161950, 3, 20.8 x 95.0, GSC 105580.
5. C-161956, 3a, 25.8 x 107.2, GSC 105581.

Figures 6–10. *Vittatina heclae* sp. nov.

6. Holotype, C-126269, 3, 7.2 x 97.0, GSC 105582.
7. C-126269, 3, 9.8 x 104.6, GSC 105583.
8. C-161926, 3, 19.4 x 104.0, GSC 105584.
9. C-126276, 3, 30.3 x 99.4, GSC 105585.
10. C-126270, 3, 17.4 x 102.5, GSC 105586.

Figures 11, 12. *Vittatina subsaccata* Samoilovich, 1953

11, 12. C-161938, 3, 28.2 x 104.2, GSC 105591;
11, distal surface showing sacci;
12, proximal surface showing taeniae.

Figure 13. *Vittatina vittifera* (Luber) Samoilovich, 1953

13. C-126268, 3, 28.0 x 102.3, GSC 105592.

Figure 14. *Vittatina vittifera* Luber forma *minor* Samoilovich, 1953

14. C-170861, 3, 6.8 x 104.6, GSC 105593.

Figures 15, 16. *Weylandites cincinnatus* (Luber ex. Varyukhina, 1971) comb. nov.

15. C-126269, 4, 19.2 x 109.0, GSC 105594.
16. C-99245, 3, 37.2 x 105.2, GSC 105595.

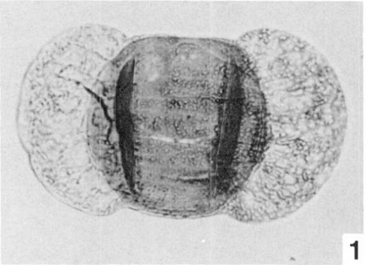
Figures 17–20. *Weylandites segmentatus* sp. nov.

17. Holotype, C-161930, 3, 15.6 x 98.5, GSC 105596.
18. C-161938, 3, 33.7 x 107.8, GSC 105597.
19. C-161948, 3, 57.2 x 100.0, GSC 105598.
20. C-161948, 3, 45.1 x 93.5, GSC 105599.

Figures 21–24. *Weylandites striatus* (Luber) comb. nov.

21. C-126269, 3, 13.3 x 109.4, GSC 105600.
22. C-126269, 3, 9.0 x 97.2, GSC 105601.
23. C-126271, 4, 31.5 x 105.0, GSC 105602.
24. C-170909, 3, 16.4 x 107.6, GSC 105603.

PLATE 8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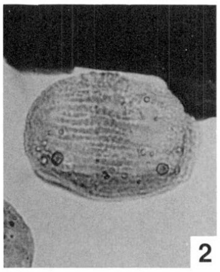
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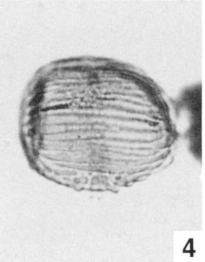
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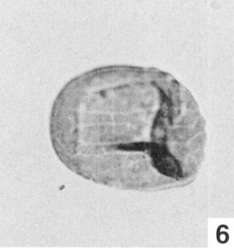
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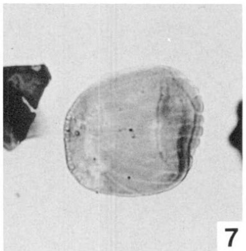
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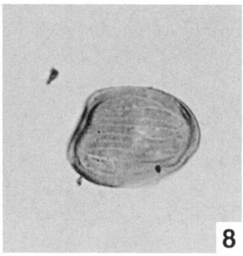
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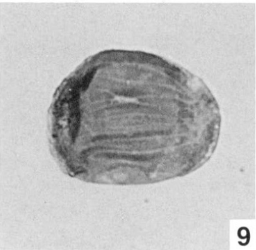
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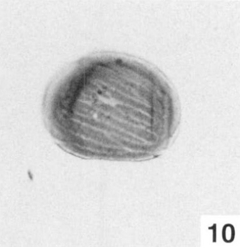
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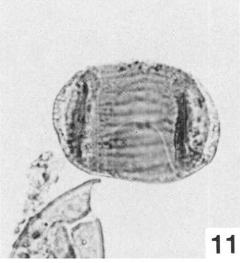
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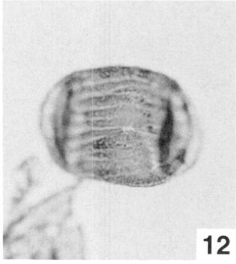
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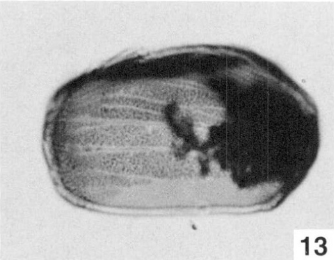
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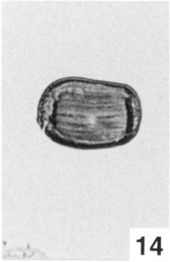
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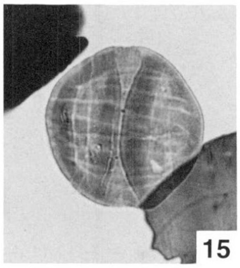
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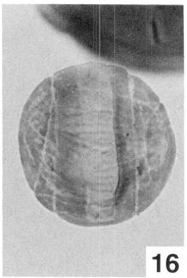
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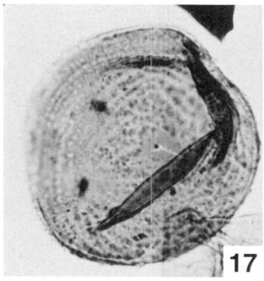
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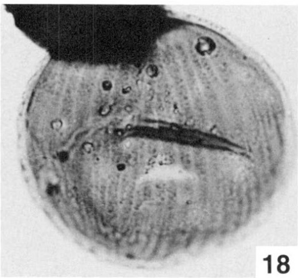
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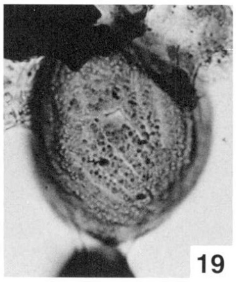
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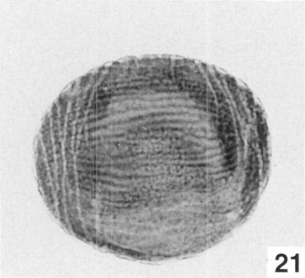
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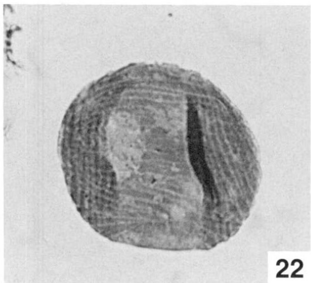
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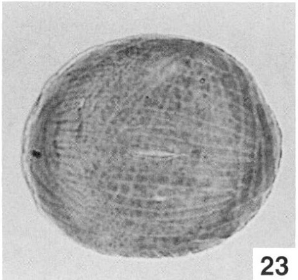
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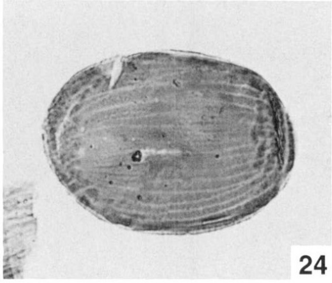
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PLATE 9

Figures 1–3. *Pakhapites rotundus* (Koloda) comb. nov.
1. C-126270, 3, 22.1 x 101.4, GSC 105587.
2. C-126270, 3, 40.0 x 100.8, GSC 105588.
3. C-161934, 3, 19.2 x 99.4, GSC 105589.

Figures 4–7, 11. *Sverdrupollenites agluatus* sp. nov.
4, 5. Holotype, C-126257, 3, 33.3 x 102.7, GSC 105610; 4, proximal surface showing haptotypic mark; 5, distal surface showing sulcus and collumellate exine.
6. C-126257, 3, 21.2 x 100.5, GSC 105611.
7. C-161946, 3, 45.6 x 98.3, GSC 105612.
11. C-126270, 3, 40.6 x 95.1, GSC 103896.

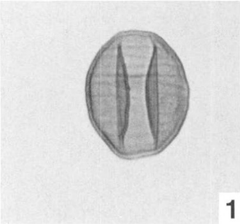
Figures 8–10. *Cycadopites follicularis* Wilson and Webster, 1946
8. C-161961, 3, 21.2 x 109.2, GSC 105606.
9. C-161961, 3, 6.2 x 98.7, GSC 105604.
10. C-148184, 2, 34.6 x 94.1, GSC 105605.

Figures 12–14. *Sverdrupollenites connudatus* sp. nov.
12. Holotype, C-126270, 3, 18.6 x 102.6, GSC 105607.
13. C-126258, 3, 14.0 x 100.5, GSC 105608.
14. C-126277, 3, 17.2 x 101.6, GSC 105609.

Figures 15–17. *Cladaitina kolodae* sp. nov.
15. Holotype, C-126269, 3, 7.1 x 107.0, GSC 105613.
16. C-126268, 3, 25.7 x 105.6, GSC 105614.
17. C-170909, 3, 12.5 x 105.5, GSC 105615.

Figure 18. *Inaperturopollenites nebulosus* Balme, 1970
18. C-170905, 3, 28.2 x 105.5, GSC 105616.

Figures 19–23. *Crinalites sabinensis* sp. nov.
19. Holotype, C-170909, 3, 9.1 x 96.1, GSC 105617.
20. C-170909, 4, 35.2 x 100.5, GSC 105618.
21. C-170909, 4, 26.4 x 108.5, GSC 105619.
22. C-170909, 3, 14.7 x 104.7, GSC 105620.
23. C-170909, 3, 17.2 x 104.6, GSC 105621.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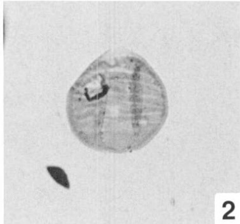
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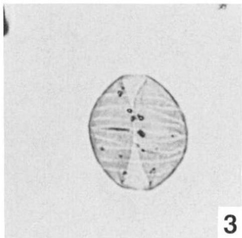
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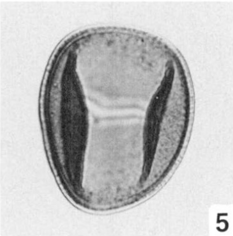
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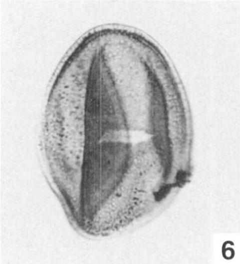
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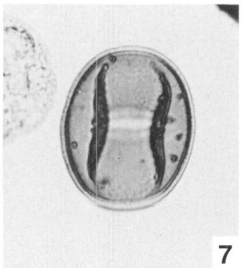
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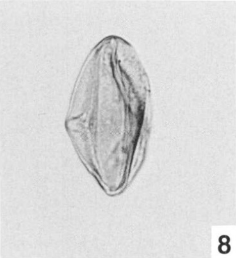
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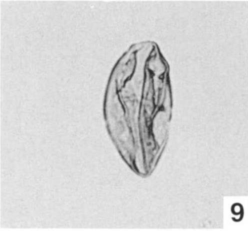
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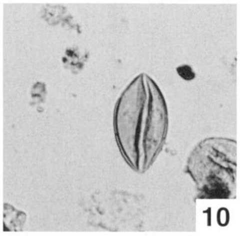
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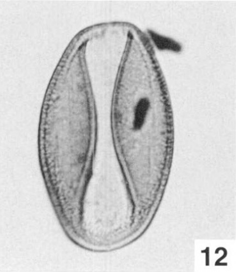
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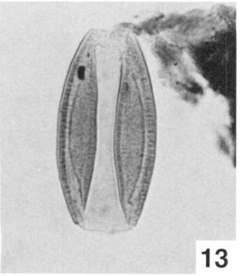
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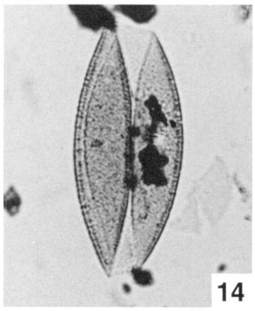
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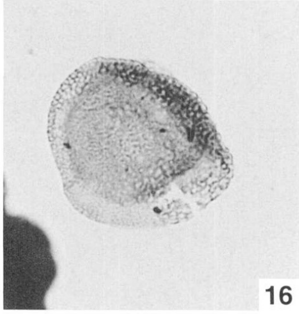
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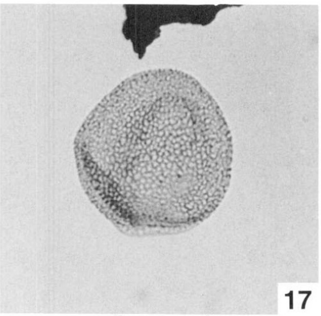
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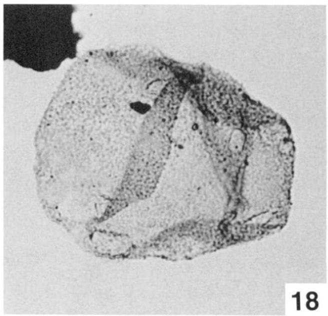
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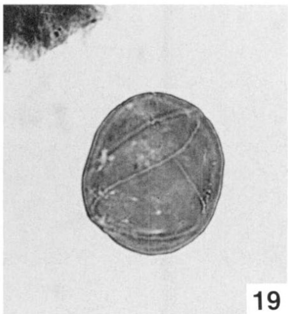
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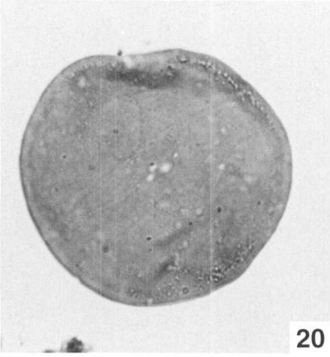
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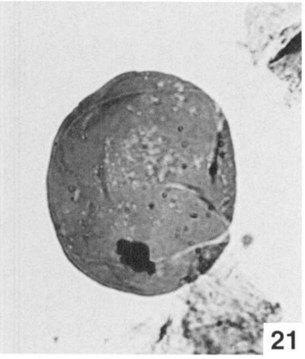
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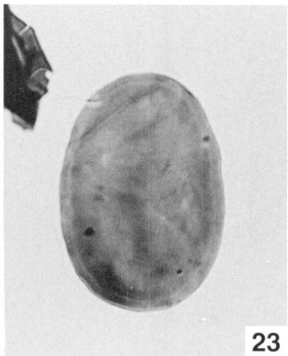
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PLATE 10

Triassic (Griesbachian) palynomorphs

Figures 1–3. *Uvaesporites imperialis* (Jansonius) comb. nov., emend.
1. C-170869, 3, 28.2 x 93.0, GSC 105622.
2. C-170869, 3, 32.1 x 96.8, GSC 105623.
3. C-170869, 3, 8.7 x 94.4, tetrad, GSC 105624.

Figure 4, 5. *Gordonispora* sp.
4. C-170868, 3, 11.6 x 95.9, GSC 105625.
5. C-79892, 3, 25.2 x 96.4, GSC 105626.

Figures 6, 7. *Simeonospora minuta* (Jansonius) comb. nov.
6. C-79892, 4, 25.1 x 108.2, GSC 105627.
7. C-79892, 3, 21.7 x 97.7, GSC 105628.

Figures 8, 9. *Proprisporites pocockii* Jansonius, 1962
8. C-99225, 3, 29.1 x 95.0, GSC 105629.
9. C-99221, 3, 32.0 x 97.1, GSC 105630.

Figure 10. *Kraeuselisporites spinosus* Jansonius, 1962
10. C-170868, 3, 11.4 x 102.2, GSC 105631.

Figure 11. *Klausipollenites staplinii* Jansonius, 1962
11. C-99223, 3, 29.4 x 106.3, GSC 105632.

Figure 12. *Chordasporites* sp.
12. C-99223, 3, 21.4 x 103.0, GSC 105633.

Figure 13. *Falcisporites zapfei* Potonié and Klaus, 1954
13. C-79892, 3, 20.8 x 100.1, GSC 105634.

Figures 14–16. *Lunatisporites noviaulensis* (Leschik) Foster, 1979
14. C-99223, 3, 21.5 x 99.3, GSC 105635.
15. C-99225, 3, 35.7 x 108.2, GSC 105636.
16. C-99223, 3, 23.5 x 108.0, GSC 105637.

Figures 17, 18. *Protophaploxypinus samoilovichii* (Jansonius) Hart, 1965
17. C-99223, 3, 40.8 x 94.1, GSC 105638.
18. C-99225, 3, 24.6 x 103.0, GSC 105639.

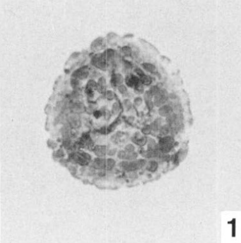
Figures 19, 20, 26. *Striatoabieites richteri* (Klaus) Hart, 1965
19. C-99221, 4, 34.2 x 94.5, GSC 105640.
20. C-99223, 3, 19.6 x 104.2, GSC 105641.
26. C-99223, 3, 23.0 x 104.0, GSC 105642.

Figures 21, 25. *Maculatasporites* sp.
21. C-170869, 3, 41.5 x 98.4, GSC 105643.
25. C-170869, 3, 22.5 x 95.5, GSC 105644.

Figures 22, 23. *Ephedripites steevesii* (Jansonius) de Jersey and Hamilton, 1967
22. C-99223, 3, 20.3 x 103.1, GSC 105645.
23. C-99223, 3, 37.6 x 104.3, GSC 105646.

Figure 24. *Cycadopites* sp.
24. C-99185, 3, 30.1 x 100.5, GSC 105647. This specimen is similar to specimens illustrated by Jansonius, 1962, Plate 16, figures 11–13, and identified as *Monosulcites* sp. cf. *M. minimus.*

Figures 27–29. *Tympanicysta stoschiana* Balme, 1980
27. C-99225, 3, 22.7 x 97.1, GSC 105648.
28. C-99222, 4, 14.9 x 100.7, GSC 105649.
29. C-99223, 3, 38.6 x 109.3, GSC 105650.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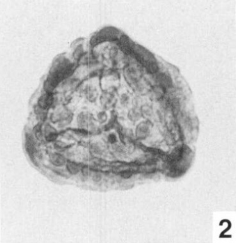
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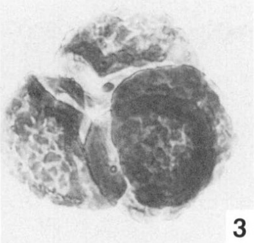
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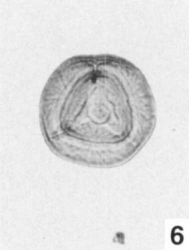
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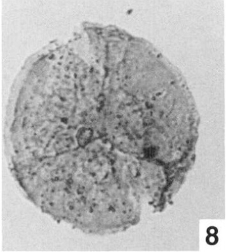
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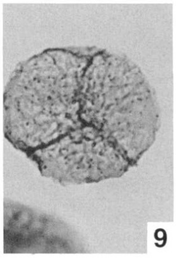
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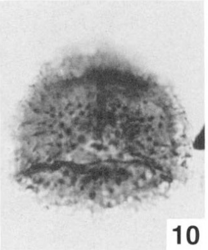
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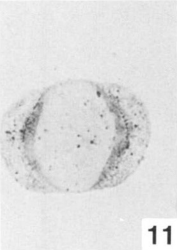
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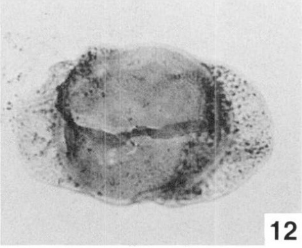
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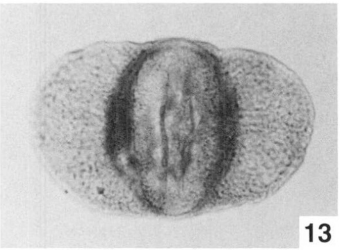
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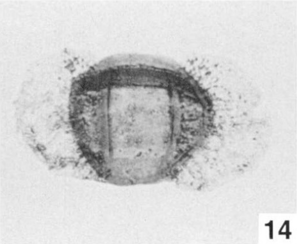
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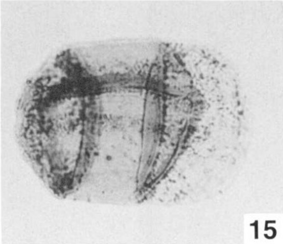
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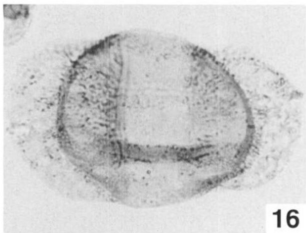
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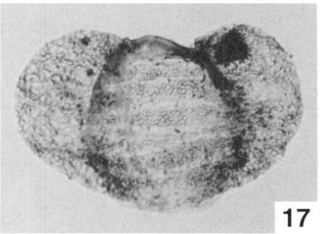
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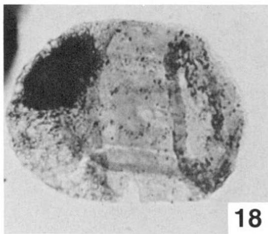
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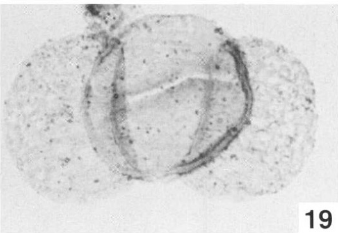
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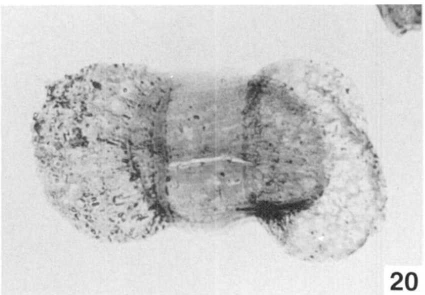
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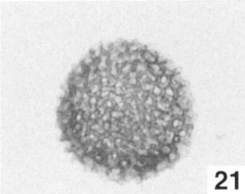
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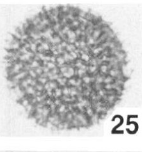
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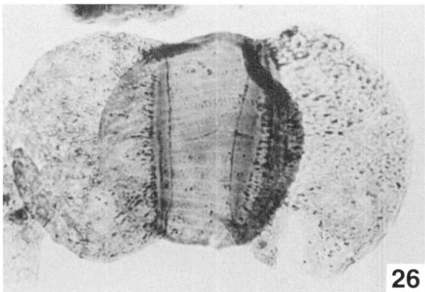
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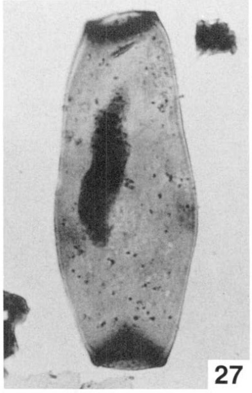
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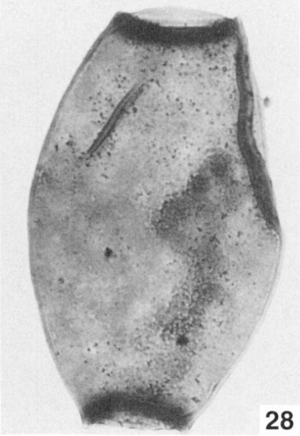
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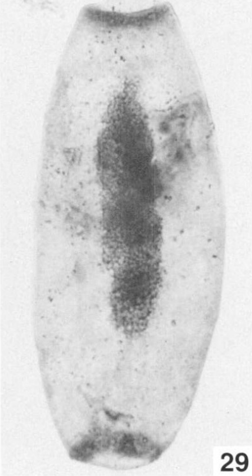
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