68-18

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

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STRATIGRAPHY AND PALYNOLOGY OF A PERMIAN SECTION, TATONDUK RIVER, YUKON TERRITORY

(Report, 2 figures and 5 plates)

E. W. Bamber, M. S. Barss

Price, $1.50

1969

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E. W. Bamber, M. S. Barss

DEPARTMENT OF ENERGY, MINES AND RESOURCES

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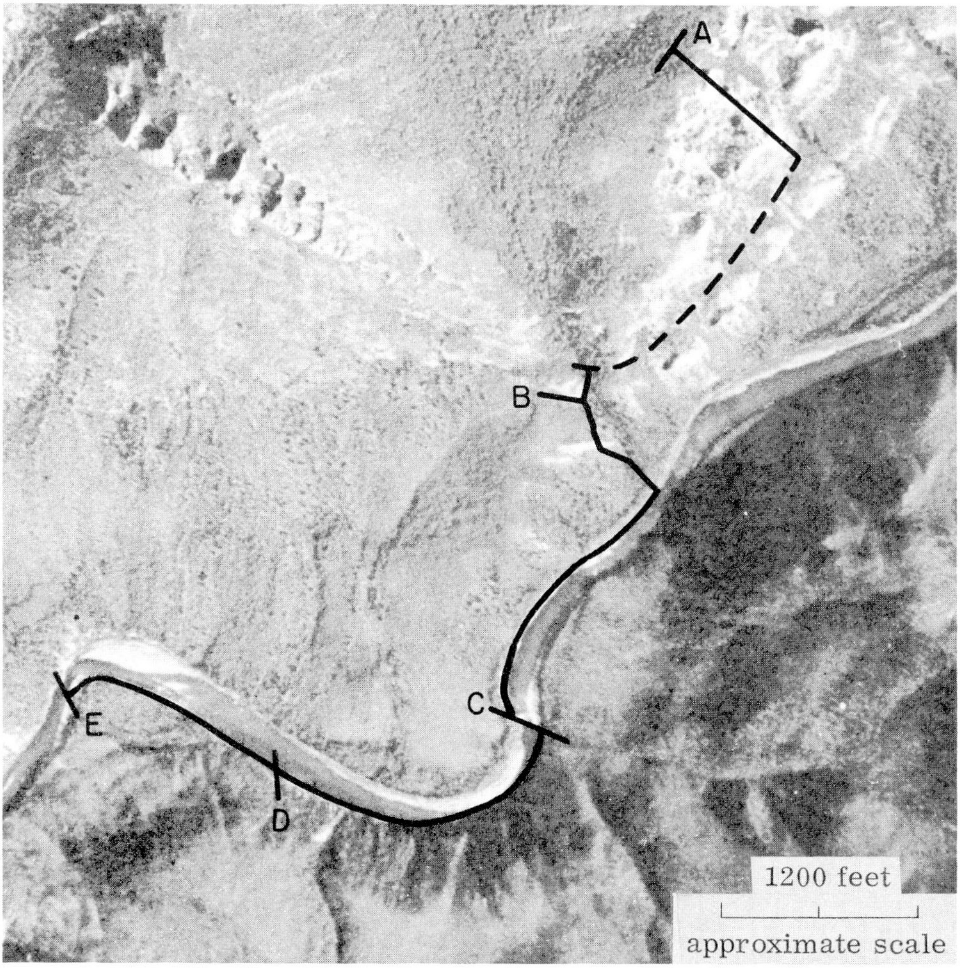

Plate 1. Aerial view of measured section (from air photo A13784-39):

A. top of Tahkandit Formation.
B. top of middle recessive unit.
C. top of rock unit B.
D. top of rock unit A.
E. base of rock unit A.

ABSTRACT

The following four stratigraphic units are described (base to top) from a well-exposed stratigraphic section of Permian rocks on Tatonduk River in northwestern Yukon Territory (64° 58' N, 140° 54' W). (1) rock unit A, 859 feet thick, consisting of pyritic shale and siltstone with thin-bedded chert at the base; (2) rock unit B, 1,279 feet thick, consisting of interbedded, argillaceous, spicular limestone and calcareous, pyritic shale; (3) middle recessive unit of Nelson (1961), 1,648 feet thick, composed mainly of interbedded siltstone, shale, and limestone with some sandstone and conglomerate; (4) Tahkandit Formation, 1,088 feet thick, comprising spicular chert with some limestone, dolomite, and siltstone. The lower three units contain a great variety of Lower Permian monosaccate, bisaccate, and striate sporomorphs. These are associated with a marine fauna, which includes Wolfcampian fusulinid Foraminifera in the upper part of the middle recessive unit. The occurrence of reworked ?Devonian and Lower Carboniferous sporomorphs with the Permian assemblage is a reflection of Early Permian erosion, which produced a widespread sub-Permian unconformity in the area.

PART I

STRATIGRAPHY OF TATONDUK RIVER SECTION

by

E.W. Bamber

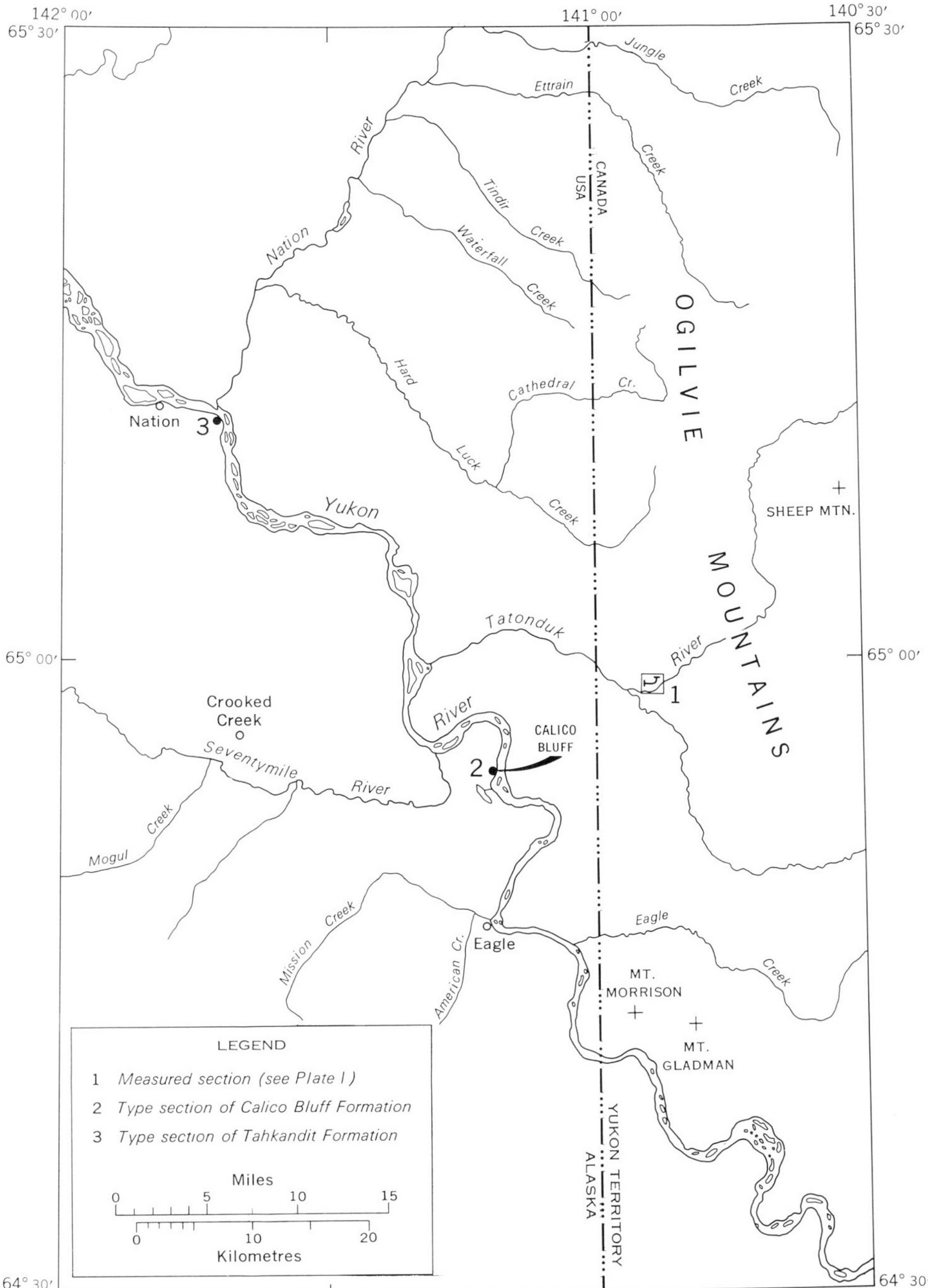

Figure 1. Index map showing locations of sections

INTRODUCTION

The stratigraphic section described in this paper is located on Tatonduk River, near the Yukon - Alaska border (Figs. 1 and 2). The section was measured and described by Bamber during the field seasons of 1962 and 1963. Subsequent palynological studies carried out by Barss, combined with macrofossil evidence, have established a Permian age for most of the stratigraphic interval.

This is one of the thickest and most completely exposed Permian sections in the northwest Yukon Territory, and is significant because of its proximity to the type sections of the Calico Bluff (Late Mississippian to Pennsylvanian?) and Tahkandit (Permian) Formations in Alaska (Fig. 1). The occurrence of Permian sporomorphs in association with a marine fauna in this section provides an opportunity for more accurately defining the age of the sporomorph assemblage in terms of the standard North American marine Permian succession.

The most comprehensive early works on the late Paleozoic succession of the area are those of Cairnes (1914) and Mertie (1930, 1932, 1937), which contain detailed descriptions of the Carboniferous and Permian rocks near the Yukon - Alaska border and along Yukon River immediately to the west. Several more recent publications deal directly with the Tatonduk River section. Nelson (1961), in a general account of the stratigraphy and paleontology of the Carboniferous and Permian of northern Yukon, was the first to report fusulinid Foraminifera from the upper part of the section. A generalized description of the upper part of this succession was given by Green and Roddick (1962, p. 11; map-units 15a, 16), and a more detailed description of approximately the same stratigraphic interval was given by Laudon et al., (1966, pp. 1877-1844, Fig. 6). Fusulinid Foraminifera from outcrops at this locality have been described by Ross (1967). Skinner and Wilde (1966) described fusulinids from a boulder collected in the Tatonduk River bed, apparently from below the section described by Laudon et al. (ibid.) ; the locality information given by Skinner and Wilde (ibid., p. 58) is indefinte. A preliminary account of the Permian sporomorphs from the section described here was given by Barss (1967, pp. 10, 88, 90, 92; Pl. XXXVI - XXXVIII). Nelson and Johnson (1968) have described brachythyrid and horridonid brachiopods from Tatonduk River and other localities in northern Yukon.

FIELD WORK AND ACKNOWLEDGEMENTS

Field work on Tatonduk River in 1963, and visits to the type sections of the Calico Bluff and Tahkandit Formations in Alaska during 1963 and 1967, were made possible by the United States Geological Survey,which provided boat and helicopter transportation, and general field support. Correlation of the Tatonduk River sequence with sections in Alaska was greatly facilitated by discussions in the field with United States Geological Survey geologists, including E.E. Brabb and M. Churkin, Jr., who are investigating the regional geology of east-central Alaska; and A.K. Armstrong and R.E. Grant, who are studying several of the late Paleozoic faunal groups of the area.

STRATIGRAPHY

STRATIGRAPHIC SETTING

The Tatonduk River sequence is part of a 5,000 - to 7,000-foot thick succession of Upper Paleozoic rocks that forms many of the prominent topographic features in the Ogilvie Mountains near the Yukon - Alaska border, along Tatonduk River, and at the headwaters of Ettrain and Jungle Creeks. Nelson (1961) divided this succession into four units which are, in ascending order: (1) the Calico Bluff Formation, consisting mainly of calcareous shale and argillaceous limestone; (2) a lower limestone unit (cherty limestone); (3) a middle recessive unit comprising calcareous shale, argillaceous limestone, siltstone, sandstone, and conglomerate; (4) the Tahkandit Formation, composed of limestone and chert with subordinate amounts of conglomerate, sandstone and shale (see Fig. 2). The middle recessive unit and the Tahkandit Formation are Permian in age (Nelson, 1961, pp. 3, 4; Ross, 1967, p. 713). Middle Pennsylvanian fusulinid Foraminifera have been reported by Ross (ibid.) from the lower part of the lower limestone unit at the headwaters of Ettrain Creek (Fig. 1), but the exact age of the upper part of this unit is unknown. Nelson (1961, p. 4) tentatively assigned a Late Pennsylvanian age to the unit and later (1962, p. 962; 1965, p. 28) suggested a Middle Pennsylvanian age, based on the presence of the tabulate coral ?*Multithecopora penchiensis* Yoh.

The Upper Paleozoic sequence immediately to the west in Alaska (Mertie, 1932, pp. 416-423; Brabb and Churkin, 1964, 1965) consists of a Upper Devonian to Lower Mississippian shale and chert unit (unnamed), the Calico Bluff Formation of Late Mississippian to Pennsylvanian? age (Nelson, 1961, p. 4; Laudon, et al., 1966, p. 1873), and the Permian Tahkandit Formation.

Permian rocks in both Alaska and Yukon rest unconformably on strata ranging in age from Devonian to Pennsylvanian, and the sequence above this unconformity varies considerably in character and thickness. The Tahkandit Formation, at its type section in Alaska (Fig. 1), rests unconformably on the Nation River Formation which is Devonian in age (Brabb and Churkin, 1967, p. D12; Scott and Doher, 1967). Norford (1964, pp. 119-121) and Norris (1967, pp. 102, 103) reported an angular unconformity between Permian and Devonian rocks on Porcupine River near the mouth of Driftwood River, Yukon (see also Martin, 1959, pp. 2445-2449; and Knipping, 1960, pp. 3-5). Middle Pennsylvanian fossils have been found in rocks beneath the Permian at the headwaters of Ettrain Creek (Ross, 1967, p. 713), but the age of the youngest pre-Permian rocks is unknown at this locality, and the position and nature of the base of the Permian succession has not been established.

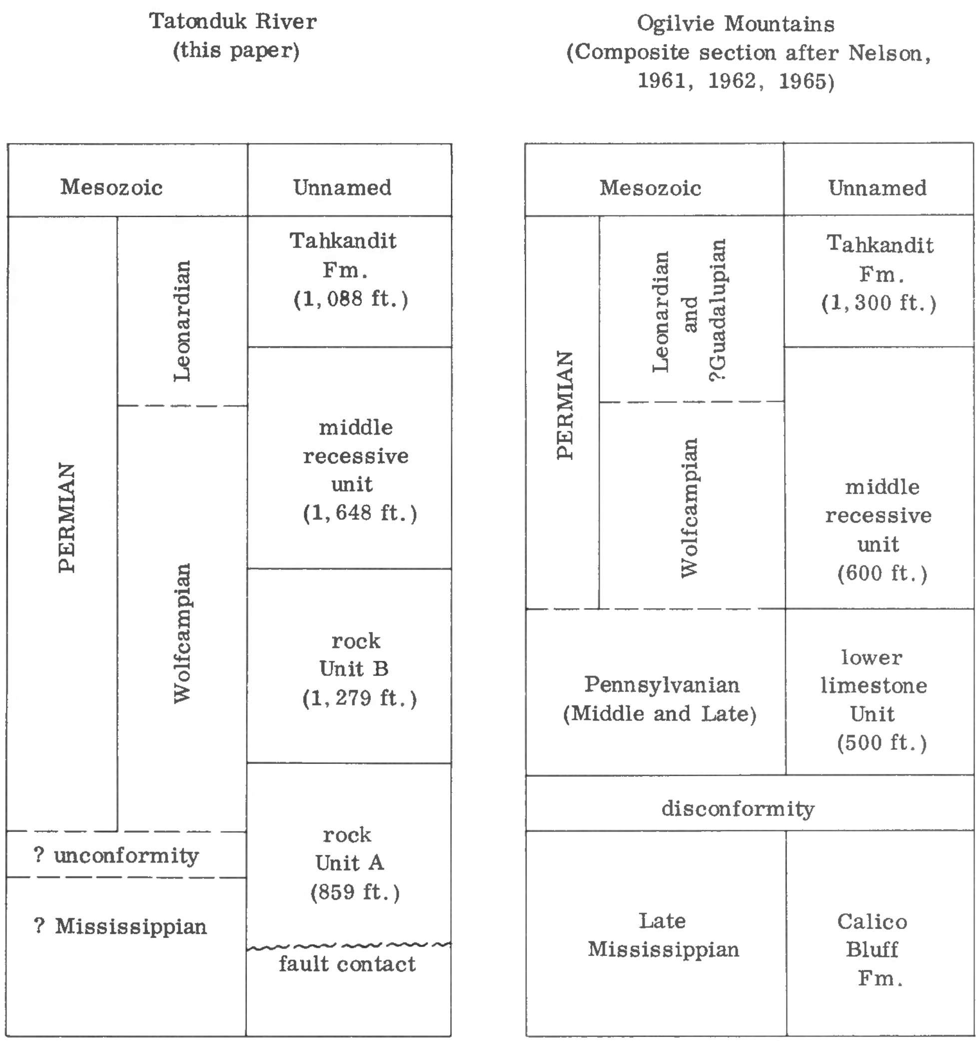

Figure 2. Carboniferous and Permian stratigraphic nomenclature, Ogilvie Mountains.

TATONDUK RIVER SECTION

Location

The section is located in the Ogilvie Mountains, on Tatonduk River (64° 58' N, 140° 54' W), approximately 3 miles east of the Yukon - Alaska border, where the river cuts through a north-south trending syncline in which Permian and Mesozoic rocks are exposed (Fig. 1). The upper 1,000 feet of the Permian sequence was measured on the east limb of the syncline on the high bluffs just north of Tatonduk River; the remainder was measured on the west limb, mainly along the banks of the river (Plate I). The upper part of this section appears to be that described by Laudon et al., (1966, pp. 1877-1884, Figs. 1 and 6). The section location given by these authors, "approximately 0.5 miles east of the Yukon - Alaska border" (ibid., p. 1878), appears to be in error because no Permian rocks were shown at this location by Green and Roddick (1962).

Stratigraphic Sequence

The sequence on Tatonduk River (Fig. 3) is divisible into the following four units, in descending order (see pp. 20-21 for detailed description).

Tahkandit Formation (1,088 feet) Mainly light grey, cliff-forming, spicular chert with some skeletal limestone, dolomite, and siltstone; lower 280 feet is glauconitic, fossiliferous limestone containg chert pebbles.

Middle recessive unit (Nelson, 1961) (1,648 feet) Interbedded calcareous siltstone, calcareous shale, argillaceous, sandy limestone, and calcareous sandstone with some conglomeratic limestone near the top; several prominent ribs of chert-pebble conglomerate in lower 200 feet of unit.

Rock unit B (1,279 feet) Interbedded, argillaceous, spicular limestone and calcareous, pyritic shale; unit fairly resistant.

Rock unit A (859 feet) Pyritic shale with some pyritic siltstone beds; unit recessive, largely covered, thin-bedded chert at base.

The chert beds at the base of rock unit A are in fault contact with lower Paleozoic rocks to the west (see point E on Plate I for basal contact). The base of rock unit B is the base of the lowest resistant limestone along the south bank of the river (unit 6 in section, p. 28; see point D on Plate I for approximate position). The contact between rock units A and B is covered. The upper contact of rock unit B is sharp and corresponds with the base of the lowest bed in a series of chert-pebble conglomerate beds (unit 11 in section, p. 26) which forms a resistant rib and causes a sharp deflection in the river (see point C on Plate I). The lower part of the Tahkandit Formation contains shale similar to that in the middle recessive unit, and the gradational contact between these two units is arbitrarily placed at the base of the lowest, main, cliff-forming limestone (unit 27 in section; see point B on Plate I). The Tahkandit Formation is overlain unconformably by Mesozoic clastic rocks (Nelson, 1961, Fig. 1; Laudon et al., 1966, Fig. 6c; see point A on Plate I).

Age and Correlation

A large marine fauna is present in the upper three units of the Tatonduk section. Ross (1967) described early Leonardian fusulinid Foraminifera, including Schwagerina jenkinsi Thorsteinsson, S. hyperborea (Salter), S. sp. B. of Ross, and Boultonia yukonensis Ross from a number of collections from the cherty and conglomeratic limestone of the upper part of the middle recessive unit and the lower Tahkandit Formation [1]. He also reported Eoparafusulina yukonensis (Skinner and Wilde), of middle Wolfcampian age, from 200 feet lower in the middle recessive unit. The middle recessive unit and the Tahkandit Formation contain a Permian macrofauna consisting mainly of brachiopods, but including some corals, bryozoans and pelecypods (Nelson, 1961, Pl. XXVIII, XXIX; Nelson and Johnson, 1968; Laudon et al., 1966, pp. 1879-1884). Brachiopods and corals are also present in rock unit B, but have not yet been studied.

Permian sporomorphs (see pp. 11-15; Pl. II-V) are present in 7 samples collected from rock units A and B, and from the middle recessive unit. The positions of these samples are given in the section description (pp. 20-29).

The age of the chert at the base of unit A and of the overlying covered interval (unit 2) is not definitely known. Brachiopods found in shale across the Tatonduk River, on strike with this covered interval, are similar to those found in the lower part of the type Calico Bluff Formation and in Lower Carboniferous beds on Peel River to the east. The Tatonduk River brachiopods, however, are too poorly preserved to provide a reliable age determination and no sporomorphs were obtained from the matrix surrounding them.

The Tahkandit Formation and the middle recessive unit correspond to the units of the same name reported by Nelson (1961) in the western Ogilvie Mountains. The Middle Pennsylvanian rocks (Ross, 1967, p. 713) in the lower part of Nelson's lower limestone unit apparently have no equivalents in the Tatonduk River section. The upper part of this unit, which has not been definitely dated, may be equivalent to some part of rock unit A or B.

---

[1] The conglomeratic limestone bed from which Schwagerina sp. B of Ross was collected is here included in the upper part of the middle recessive unit, rather than in the Tahkandit Formation (see Ross, 1967, p. 713). The detailed section description (pp.20-29) gives the positions of other Geological Survey of Canada collections studied by Ross (ibid., p. 712).

The Permian section is considerably thicker (approximately 4,570 feet) on Tatonduk River than in the adjacent part of Alaska (approximately 520 feet - Mertie, 1930, p. 122). The Tahkandit Formation is conglomeratic at its base, as it is at the type section, but the upper part of the formation is mainly chert on Tatonduk River, whereas in Alaska it is mainly bioclastic limestone. The chert may be a local development, however, since elsewhere in the western Ogilvies the Tahkandit Formation has a lithology similar to that of the type section, and is directly underlain by the middle recessive unit, as it is on Tatonduk River. The Permian rocks on Tatonduk River below the Tahkandit Formation may be equivalent to approximately 1,000 feet of unnamed shale and chert - pebble conglomerate stratigraphically above the Calico Bluff Formation, about three miles northwest of Calico Bluff in Alaska (E.E. Brabb, written communication, 1968). The middle recessive unit is not correlative with the Nation River Formation, as has previously been suggested (Nelson, 1961, p. 4; Laudon et al., 1966, p. 1870; see p. 3). The lithology of the shale and chert at the base of rock unit A is similar to that of the shale and chert beneath the type Calico Bluff Formation (E.E. Brabb, written communication, 1968). This similarity, combined with the meagre faunal evidence from the overlying shale (see p.8), suggests that equivalents of the Lower Carboniferous part of the Calico Bluff Formation are present on Tatonduk River and are directly overlain by Permian rocks.

All of the shale samples from Tatonduk River (Table 1) contain reworked ?Devonian and Lower Carboniferous sporomorphs (p. 15, Pl. V, Figs. 11-20). The presence of these forms in association with those of Early Permian age is a reflection of erosion and re-deposition of ?Devonian and Lower Carboniferous rocks during Early Permian time. The reworked sediments containing the older sporomorphs may have been derived from the north or northwest along Dave Lord Ridge and from the Nation River area of Alaska, where the most severe erosion took place, exposing the oldest rocks found beneath the sub-Permian unconformity (p. 5).

PART II

PALYNOLOGY OF TATONDUK RIVER SECTION

by

M.S. Barss

PALYNOLOGY

INTRODUCTION

This section of the paper presents the results of a palynological study of seven samples collected from the lower three units of the Tatonduk River section. Sporomorphs from these samples are identified and illustrated, and their stratigraphic significance is discussed. This is not intended as a taxonomic contribution but, rather, as a report on the occurrence of sporomorphs in the Tatonduk River section. No systematic description of the material is given because of a scarcity of well-preserved specimens. The sporomorphs indicate a Permian age for the lower three rock units in the section. The association of a Permian sporomorph assemblage with Wolfcampian fusulinid Foraminifera is recorded from the upper part of the section, thereby allowing more precise dating of the sporomorphs in terms of the standard North American Permian succession.

The samples were treated with 10 per cent hydrochloric acid, followed by concentrated hydrofluoric acid. At this stage a few striate bisaccate grains were seen. Subsequent oxidation of the organic residue with Schulze reagent liberated addtional palynomorphs, including reworked Lower Carboniferous and ?Devonian spores. Further chemical treatment of the striate, saccate forms was not necessary. Additional oxidation was carried out on part of the residue to further clear the reworked sporomorphs, but this treatment destroyed most of the striate, bisaccate, and monosaccate spores and pollen.

Many of the saccate forms are folded, broken, differentially corroded, pitted by mineral grains, and exhibit loss of bladders and distortion of sculptured features. Single-grain mounts were made from the better preserved specimens.

The samples were collected from the GSC localities listed in Table I. Samples from localities 56961 and 57036 provided the greatest number of well-preserved sporomorphs; 57032 contained the greatest number of reworked forms; 57029 and 57035 contained few forms, but these were generally well preserved; and 56950 yielded an assemblage composed almost entirely of Potonieisporites. Slides bearing the figured specimens are deposited in the type collection of the Geological Survey of Canada, Ottawa, Canada.

Table I lists the identifiable forms and shows their distribution. The apparent distribution of the taxa is probably biased by the poor preservation of some of the specimens. For this reason Table I should not be regarded as a stratigraphic range chart in the usual sense. It does, however, show the minimum ranges for the taxa within the interval studied.

Table I. Occurrence of Permian sporomorphs in Tatonduk River section.

Sporomorphs		Stratigraphic Unit						
		Middle recessive Unit		Rock Unit B		Rock Unit A		
	GSC loc. Nos.	57035	56956	57032	57036	57029	56961	56950
	Footage above base of Section	3548	2755	2073	1623	824	514	306
Cycadopites vetus					x			
Cycadopites glaber					x	x		
Cycadopites cf. C. caperatus		x						
Cycadopites sp. 1							x	
Leiotriletes sp. 1					x			
Lophotriletes sp. 1					x		x	
Latosporites sp. 1							x	
Endosporites sp. 1			x					
Cordaitina cf. C. crenulata			x				x	
Cordaitina balmei								x
?Cordaitina sp. 1		x			x			
Potonieisporites cf. P. novicus							x	
Potonieisporites cf. P. simplex					x		x	
Potonieisporites sp. 1		x	x		x		x	x
Florinites eremus		x		x	x		x	
?Vesicaspora sp. 1					x			
Protohaploxypinus cf. P. samoilovichii							x	
Protohaploxypinus globus		x	x	x			x	
Protohaploxypinus sp. 1					x			
?Protohaploxypinus sp. 2							x	
Protohaploxypinus sp. 3						x		
Striomonosaccites sp. 1							x	

Sporomorphs		Stratigraphic Unit						
		Middle recessive Unit		Rock Unit B		Rock Unit A		
	GSC loc. Nos.	57035	56956	57032	57036	57029	56961	56950
	Footage above base of Section	3548	2755	2073	1623	824	514	306
Lueckisporites virkkiae					x		x	
Piceapollenites sp. 1					x			
Limitisporites monstruosus			x		x	x	x	
Limitisporites sp. 1					x			
Limitisporites sp. 2					x			
Limitisporites sp. 3				x	x			
Vestigisporites cf. V. methoris					x			
Vestigisporites sp. 1				x		x		
? Vestigisporites sp. 2					x			
cf. Gardenasporites leonardi		x			x			
Striatoabietites cf. S. striatus					x			
Striatoabietites multistriatus ?					x			
Striatoabietites sp. 1							x	
Striatoabietites sp. 2							x	
Striatopodocarpites cf. S. divaricata					x			
Striatopodocarpites cf. S. cancellatus					x			
Striatopodocarpites sp. 1					x			
Striatopodocarpites sp. 2					x			
Tumoripollenites sp. 1							x	
Hamiapollenites sp. 1					x		x	
cf. Pityosporites papilionis					x			
Vittatina subsaccata							x	
cf. Vittatina wodehousei							x	
Vittatina vittifer			x		x	x		

Sporomorphs		Stratigraphic Unit						
		Middle recessive Unit		Rock Unit B		Rock Unit A		
	GSC loc. Nos.	57035	56956	57032	57036	57029	56961	56950
	Footage above base of Section	3548	2755	2073	1623	824	514	306
Vittatina simplex					x			
Vittatina vittifer forma cinctutus			x		x			
Vittatina cf. V. saccifer							x	
? Vittatina costabilis					x			
Vittatina sp. 1					x		x	
Vittatina sp. 2		x	x	x	x			
Vittatina sp. 3			x				x	
Vittatina sp. 4				x	x			
cf. Vittatina sp. L.			x					
Costapollenites sp. 1							x	

AGE AND COMPARISON WITH OTHER ASSEMBLAGES

According to Tschudy and Kosanke (1966), a great diversity of monosaccate, bisaccate, and striate spores and pollen characterizes the Early Permian assemblages of Texas, effectively distinguishing them from those of Late Pennsylvanian age. An abundance of two-winged grains with striate bodies has been considered as a guide for identifying Permian rocks of Oklahoma, Kansas, and Texas (Jizba, 1962). The great variety of monosaccate, bisaccate and striate palynomorphs recorded in Table I, with only a few specimens of uppermost Carboniferous aspect, such as Vestigisporites, Potonieisporites, and Protohaploxypinus globus (Hart) Hart (see Barss, 1967, Pl. XXXIII), indicates that the assemblage is not older than Permian. Of the 55 forms recorded, 31 are striate, 13 are monosaccate, and 24 are bisaccate. This diversity of saccate forms together with the relative scarcity of forms with Mesozoic affinities such as Cycadopites, suggests that this assemblage is older than the Artinskian and younger assemblages from Arctic Canada (McGregor, 1965; Barss, 1967). There have been many emendations and new combinations of names in the available literature on Permian sporomorphs because of the great variation within the numerous taxa concerned. This fact, combined with the scarcity of well preserved material, has hampered comparison of the Tatonduk River material with published taxa. Although many comprehensive reports of Permian spores and pollen from Australia, South Africa, Europe, U.S.S.R., India, and several other countries are available, relatively few papers have been published on North American assemblages. These include Wilson (1962), Jizba (1962), and Tschudy and Kosanke (1966), from the United States; and Jansonius (1962), Barss, Haquebard, and Howie (1963), and Barss (1967), from Canada. Because of this scarcity of North American publications, comparisons have, in general, been made with European and southern hemisphere assemblages.

Of the 26 sporomorphs listed in Table I that have been identified to species, 18 were originally described from Europe, U.S.S.R., and the southern hemisphere, and 8 from North America. According to the range charts of Hart (1965), and other available data, thirteen of these 26 taxa are common to the Upper and Lower Permian, 12 are restricted to the Lower Permian, and 1 has been found only in the Upper Permian. These data, combined with the presence of Wolfcampian fusulinid Foraminifera in the upper part of the section (p. 8), strongly indicate an Early Permian age of the units below the Tahkandit Formation on Tatonduk River.

RE-DEPOSITED SPOROMORPHS

All seven samples contained reworked Lower Carboniferous sporomorphs and some contained forms that are probably of Devonian age. The reworked material is not included in Table I, but some of the more diagnostic reworked forms are illustrated on Plate V. The samples provided several dozen species of typical Lower Carboniferous sporomorphs, which are almost identical to those reported by Hacquebard and Barss (1957), Staplin (1960), Playford and Barss (1963), and Playford (1962, 1963), and are also similar to many Lower Carboniferous spores from the U.S.S.R. The stratigraphic significance of the reworked material is discussed on p. 9.

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APPENDIX

Measured Section

Section. Tatonduk River, about 3 miles east of the Yukon-Alaska border (64° 58' N, 140° 54' W).

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Tahkandit Fm. (1,088 feet measured)		
28	Chert and limestone, minor dolomite and siltstone. Chert; spicular; light grey to light yellowish grey, some dark grey beds especially in lower half of unit; 4-inch to 2-foot thick irregular, lensing beds; some intervals of light to medium greyish brown chert with sugary texture containing scattered fragments of brachiopods and echinoderms, in lenses up to 30 feet thick scattered throughout unit and associated with limestone. Limestone, skeletal, light brown, very fine- to fine-grained; 3-inch to 6-foot lenses; contains spicules, forams, and fragments of brachiopods, echinoderms, and other fossils; some thicker limestone beds with rare glauconite and chert grains. Lower half of unit contains some dolomite. Dolomite, medium brownish grey; microcrystalline to very finely crystalline, 2-inch to 2-foot lensing beds; contains scattered grains of glauconite and iron oxide; weathers orange-brown. Siltstone, argillaceous; calcareous (in part), dark grey; several beds up to 35 feet thick in lower part of unit. Unit weathers light to medium greyish brown with some dark grey beds; forms cliffs. Lower 1/3 of unit partly covered. Chert amounts to 65 per cent of unit; limestone and dolomite 30 per cent; and siltstone 5 per cent	808	4,874
27	Limestone, skeletal, glauconitic in part; dark grey with some light brownish grey intervals, strong green and red tinge in lower 63 feet; coarse- to very coarse-grained with some fine-grained intervals; 6-inch to 3-foot beds composed of fossil fragments including brachiopods, bryozoans, echinoderms, corals, and fusulinid foraminifers; clear calcite cement; rare partings of argillaceous limestone; rare, light grey and dark grey-brown chert pebbles in some beds, numerous in lower 63 feet where		

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	some beds grade to chert-pebble conglomerate; much glauconite in some beds as pore fillings and grains, weathers dark reddish brown in part; much silicified fossil debris; unit weathers light to medium brownish grey with orange and light grey patches; cliff former; some covered intervals (10 to 15 per cent of unit); abundant fusulinid foraminifers between 3,815 and 3,877 feet (GSC locs. 53933-53937, 53939, 53941-53943, 57265, 57145, 57051); Schwagerina jenkinsi Thorsteinsson, S. hyperborea (Salter), Boultonia yukonensis Ross	280	4,066
	Middle Recessive Unit (of Nelson 1961) (1,648 feet measured)		
26	Covered	131	3,786
25	Limestone, skeletal, conglomeratic; medium brownish grey with green and red tinge in part; coarse- to very coarse-grained, 6-inch to 3-foot beds; composed of fossil fragments (echinoderms, brachiopods, fusulinids, bryozoans) with clear calcite cement; some glauconite pore fillings; contains numerous chert grains and pebbles up to 1 inch maximum diameter, medium- to well-rounded, light and dark grey, brown and rarely green; grades to conglomerate in many beds; unit weathers dark reddish brown with some dark greyish brown beds; resistant; fusulinid foraminifers at 3,610 feet (GSC loc. 57259) and 3,653 feet (GSC loc. 57260) - Schwagerina sp. B? of Ross (1967)	46	3,655
24	Limestone, skeletal, contains quartz grains; medium to dark grey, with reddish hue in upper 27 feet; coarse- to very coarse-grained with some fine-grained intervals; fine-grained in lower 17 feet; 6-inch to 3-foot beds; composed of fossil fragments (fusulinid foraminiers, bryozoans and brachiopods); scattered, rounded chert grains (dark grey) and glauconite grains abundant in some beds; numerous angular to subrounded quartz grains in lower 17 feet; matrix of clear calcite cement; some irregular		

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	beds and laminae of shale and argillaceous material; shale in 2-inch to 1-foot beds, makes up 30 per cent of outcrop in lower 17 feet; unit weathers medium greyish brown with orange patches; resistant. 3,550 to 3,582 feet covered; fusulinid foraminifers between 3,587.5 and 3,609 feet (GSC locs. 56926, 57002, 57007, 57050, 57120, 57150, 57268) - Schwagerina sp. B? of Ross (1967). Spores from 3,548 feet (GSC loc. 57035)	76	3,609
23	Covered	130	3,533
22	Sandstone, quartzose, cherty, calcareous; light to dark grey; very fine- to fine-grained; 4-inch to 1-foot beds, laminated in part; composed of angular to subrounded quartz grains, with numerous medium brown to dark grey chert grains and scattered glauconite grains; calcite cement; $\frac{1}{4}$- to $\frac{1}{2}$-inch layers, from 3,379 to 3,385 feet, bear numerous fusulinid foraminifers; some fossil fragments and irregular, argillaceous laminae in lower 22 feet; unit weathers medium to dark brownish grey; resistant; lower 22 feet is 70 per cent covered; abundant fusulinid foraminifers between 3,379 and 3,384.5 feet (GSC locs. 56932, 56937, 57005, 57066) - Eoparafusulina yukonensis (Skinner and Wilde), Schwagerina sp. A of Ross (1967)	46	3,403
21	Covered	246	3,357
20	Siltstone, calcareous, argillaceous; medium brownish grey to dark grey; grades to very fine-grained sandstone in part; 4-inch to 2-foot beds, poorly defined and up to 10 feet thick in some intervals; contains scattered spicules and fragments of bryozoans and brachiopods in some beds; argillaceous material abundant, associated with worm burrows in some beds; rare glauconite grains and fillings; clear quartz cement in part, but mainly calcite cement; grades to silty limestone in part and contains beds up to 10 feet thick of skeletal limestone mainly in lower 53 feet of unit; weathers light grey to dark brownish grey; resistant, cliff former in part	234	3,111

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
19	Interbedded siltstone and limestone. Siltstone, calcareous, argillaceous in part; slightly glauconitic; medium to dark grey; beds up to 10 feet thick, laminated in part; composed of quartz grains with scattered glauconite grains and some argillaceous material concentrated in worm burrows; some disseminated, dark grey organic material; scattered small fossil fragments in some beds; grades to very fine-grained sandstone with calcareous matrix; weathers medium to dark brownish grey with yellow and orange patches; resistant in part; occurs in units 6 to 40 feet (commonly 15 to 20 feet) thick. Limestone, skeletal, spicular, argillaceous; dark grey; very fine-grained with some large fossil fragments; 2- to 5-foot beds composed mainly of siliceous and calcareous spicules with some coral and brachiopod fragments, scattered glauconite grains; matrix calcareous in upper part of unit, argillaceous from base of unit to 2,786 feet; scattered dark grey organic material; worm burrows filled with argillaceous material; some beds, up to 2 feet thick, of coarse-grained, fragmental limestone composed of fossil fragments with glauconite grains; limestone weathers dark brownish grey with yellowish brown patches; resistant; Shale, calcareous, silty; medium brownish grey with some dark grey beds; contains dark grey flecks of organic material; brachiopods present in some beds; weathers medium grey with light grey patches; recessive; occurs in intervals 8 to 12 feet thick. Spores from 2,755 feet (GSC loc. 56956) Siltstone amounts to 50 per cent of unit, limestone 30 per cent, and shale 20 per cent	289	2,877

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
18	Sandstone and shale. Sandstone, quartzose, cherty, calcareous, glauconitic in part; medium to dark grey; very fine- to fine-grained, rarely medium-grained; 1- to 3-foot beds, cross-bedded in part; composed of subangular to angular quartz with some light brown and dark grey chert grains, some foraminifers and other fossil fragments; matrix is mosaic of calcite crystals; conglomeratic in part, with chert pebbles and fossil fragments; 6-inch bed of chert-pebble conglomerate with calcareous sandstone matrix at 2,439 feet; sandstone weathers light grey to orange-brown, resistant, Shale, calcareous, very silty; medium brownish grey; occurs in several intervals up to 30 feet thick; contains black flecks of organic material, weathers medium grey, recessive; some beds with numerous fossil fragments, (bryozoans, brachiopods, spicules or spines, ostracods, foraminifers). Several covered, recessive intervals, 18 to 25 feet thick. Sandstone amounts to 40 per cent of unit, shale 35 per cent, and covered intervals 25 per cent	153	2,588
17	Covered, with 3 feet of rubbly outcrop of silty shale, calcareous, dark brownish grey, recessive, from 2,357 to 2,360 feet	97	2,435
16	Limestone, fragmental, conglomeratic, contains quartz sand, slightly glauconitic in part; medium to dark grey; fine- to coarse-grained, poorly sorted; 1- to 2-foot beds; composed of fossil fragments (mainly brachiopods, with some bryozoans, foraminifers, ostracods and calcispheres) with clear calcite cement; contains numerous very fine to fine grains of quartz and chert; grades to sandstone in part; also, there are numerous pebbles of dark grey, pale green, and brown chert; weathers orange-brown, resistant	7	2,338

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
15	Conglomerate, chert-pebble, slightly calcareous; mottled light and dark grey; pebbles of chert up to 1 inch maximum diameter, rounded to subrounded, poorly sorted, light grey, dark grey, brown, and pale green; matrix of fine, medium and coarse grains of chert, subangular, with some calcite cement; upper 2 feet is very coarse-grained sandstone with siliceous cement; weathers dark grey with light grey patches, resistant	8	2,331
14	Covered, with some poor outcrop at 2,289 feet of slightly silty, calcareous; dark brownish grey shale	51	2,323
13	Sandstone, quartzose, cherty; dark grey; composed of equal amounts of quartz and chert grains; calcite cement; some lensing beds (up to 4 inches thick) with numerous chert pebbles; sandstone beds 1 to 2 feet thick; unit weathers dark grey to medium brownish grey with orange-brown stain; resistant	5	2,272
12	Alternating limestone and shale. Limestone, argillaceous; light to medium brownish grey; contains much argillaceous material in irregular laminae; weathers medium grey to orange-brown; relatively resistant. Shale silty, slightly calcareous; dark brownish grey; 1-inch to 3-foot beds; weathers dark brownish grey; recessive. Shale amounts to 70 per cent of unit, limestone 30 per cent	71	2,267
11	Alternating conglomerate and sandstone. Conglomerate, chert-pebble, medium grey, mottled with light and dark grey; pebbles of chert, poorly sorted, up to 2 inches maximum diameter; chert mainly dark grey with some light grey, brown, and green; some sand-sized quartz and chert; sand grains subangular, pebbles rounded; matrix is microcrystalline quartz mosaic; several lenses, up to 6 inches thick, of sandstone, medium- to coarse-grained, same composition as conglomerate, amounts to 30 per cent of upper 12 feet of unit; conglomerate weathers deep reddish brown to dark grey, resistant. Sandstone, as in lenses within conglomerate, but matrix		

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	is mosaic of coarsely crystalline calcite; rare, dark grey chert pebbles in some beds; conglomerate comprises 33 per cent of unit in 7- to 12-foot beds, sandstone 32 per cent in 7- to 9-foot beds, covered intervals 35 per cent (21-foot interval from 2,154 to 2,175 feet); upper 12 feet of unit forms resistant rib causing abrupt bend in Tatonduk River (see point C, Figure 2)	58	2,196
	Rock Unit B (1,279 feet measured)		
10	Covered	64	2,138
9	Shale with minor limestone. Shale, very calcareous, silty in part; dark brownish grey; 4-inch to 1-foot beds; between 2,026 feet and 2,070 feet it contains numerous very fine fossil fragments and rare glauconite grains, some large brachiopod fragments; in this interval there are several 1- to 2-foot beds of limestone. Limestone, fragmental, argillaceous, dark brownish grey with light grey mottling, medium- to coarse-grained, composed mainly of fossil fragments (echinoderms, brachiopods, bryozoans, rare foraminifers) with matrix of very finely crystalline calcite and argillaceous material, some worm burrows, rare glauconite blebs filling pores in fossils. Shale weathers dark brownish grey with orange stain in part; limestone weathers medium brownish grey with orange brown stain. Limestone amounts to 70 per cent of outcrop between 2,026 and 2,049 feet. Spores from 2,073 feet (GSC loc. 57032)	65	2,074
8	Alternating limestone and shale. Limestone, spicular, argillaceous; medium to dark grey; 1- to 3-foot beds; composed mainly of spicules (silicified in part), finely crystalline calcite cement and disseminated argillaceous material; numerous worm burrows and dark grey flecks of organic material; weathers medium greyish brown with yellow and orange stain; resistant; occurs in 1- to 10-foot intervals. Shale, very calcareous; dark brownish grey; 4-inch to 1-foot beds; contains very fine fossil fragments, some pyrite blebs; weathers dark brownish grey, moderately resistant: limestone amounts to 50 per cent of unit, shale 50 per cent	135	2,009

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
7	Interbedded limestone and shale. Limestone, as in unit 8 mainly, but fewer spicules, more argillaceous and silty in part, and contains numerous fragments of brachiopods, bryozoans, and echinoderms in some beds; rare beds of coarse fragmental, glauconitic, sandy limestone; limestone rarely grades to calcareous siltstone; limestone occurs in 5- to 40-foot intervals. Shale, very calcareous, silty; dark brownish grey, contains numerous silt-sized calcite and quartz grains, some pyrite blebs, numerous worm burrows; irregular laminae present; weathers dark brownish grey, slightly recessive; some of the shale is non-silty, as in unit 8, and some grades to argillaceous limestone with scattered fossils; shale occurs in 2- to 20-foot intervals. Spores from 1,623 feet (GSC loc. 57036). Shale amounts to 45 per cent of outcrop, limestone 55 per cent; covered intervals from 1,838 to 1,870 feet and from 1,283 to 1,318 feet	634	1,874
6	Alternating limestone and shale. Limestone, spicular, argillaceous, as in unit 8; in intervals of 1 to 30 feet, rarely up to 45 feet. Shale, silty, calcareous, pyritic (blebs and stringers); dark grey; weathers medium to dark grey; recessive; occurs in intervals of 2 to 20 feet. Rare, thin beds of limestone, fragmental, glauconitic, spicular, medium to dark grey, coarse-grained, scattered throughout unit: limestone amounts to 55 per cent of unit, shale 45 per cent	381	1,240
	Rock Unit A (859 feet measured)		
5	Covered, spores collected from samples at 824 feet from shale outcrop across Tatonduk River, along strike (GSC loc. 57029)	237	859

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
4	Mainly covered, with several outcrops, 3 to 13 feet thick, of calcareous, slightly silty, pyritic shale; dark grey with slight brown tinge; weathers dark brownish grey, recessive: spores from 514 feet (GSC loc. 56961)	171	622
3	Shale and siltstone. Shale, slightly silty, pyritic, dark grey with slight brown tinge; weathers dark brownish grey, recessive; contains 4-inch to 1-foot beds of siltstone. Siltstone, pyritic, slightly calcareous, medium greenish grey, contains numerous small blebs and crystals of pyrite, weathers medium orange-brown, resistant, in beds at 2- to 20-foot intervals in shale, with some lenses between; siltstone amounts to less than 5 per cent of unit: spores from 306 feet (GSC loc. 56950)	147	451
2	Covered, some outcrops of shale along strike across Tatonduk River	284	304
1	Chert, dark grey; conchoidal fracture; regular beds, 1 to 2 inches thick; weathers dark grey with dark reddish brown stain; resistant; folded and faulted, thickness estimated	20	20

PLATES II - V

Figures are magnified X500

Numbers following fossil names in figure description are Geological Survey of Canada fossil plant type numbers

PLATE II

Figure 1.	Cycadopites vetus (Balme and Hennelly) Hart, 1965. 16553. Loc. 57036.
Figures 2, 3.	Cycadopites glaber (Luber and Waltz) Hart, 1965. 16554. Loc. 57036, 57029.
Figure 4.	Cycadopites sp. 1. 16555. Loc. 56961.
Figure 5.	Cycadopites cf. C. caperatus (Luber and Waltz) Hart, 1965. 16659. Loc. 57035.
Figure 6.	Leiotriletes sp. 1, 16556. Loc. 57036.
Figures 7, 8.	Lophotriletes sp. 1, 16559, 16660. Loc. 56961, 57036.
Figure 9.	Latosporites sp. 1, 16560. Loc. 56961.
Figure 10.	Endosporites sp. 1, 16557. Loc. 56956.
Figure 11.	Cordaitina cf. C. crenulata (Wilson) Hart, 1965. 16558. Loc. 56961.
Figure 12.	? Cordaitina sp. 1. 16661. Loc. 57036. The body is missing but there appears to be an impression of a trilete scar remaining.
Figure 13.	Potonieisporites cf. P. novicus Bhardwaj, 1954. 16565. Loc. 56961
Figure 14.	Florinites eremus Balme and Hennelly, 1955. 16662. Loc. 56961.
Figure 15.	Cordaitina balmei (Balme and Hennelly) Hart, 1965. 16663. Loc. 56950.
Figure 16.	Potonieisporites sp. 1. 16664. Loc. 57036. Possibly related to Potonieisporites ? Tschudy and Kosanke, 1966, pl. 2, Fig. 49.

PLATE II

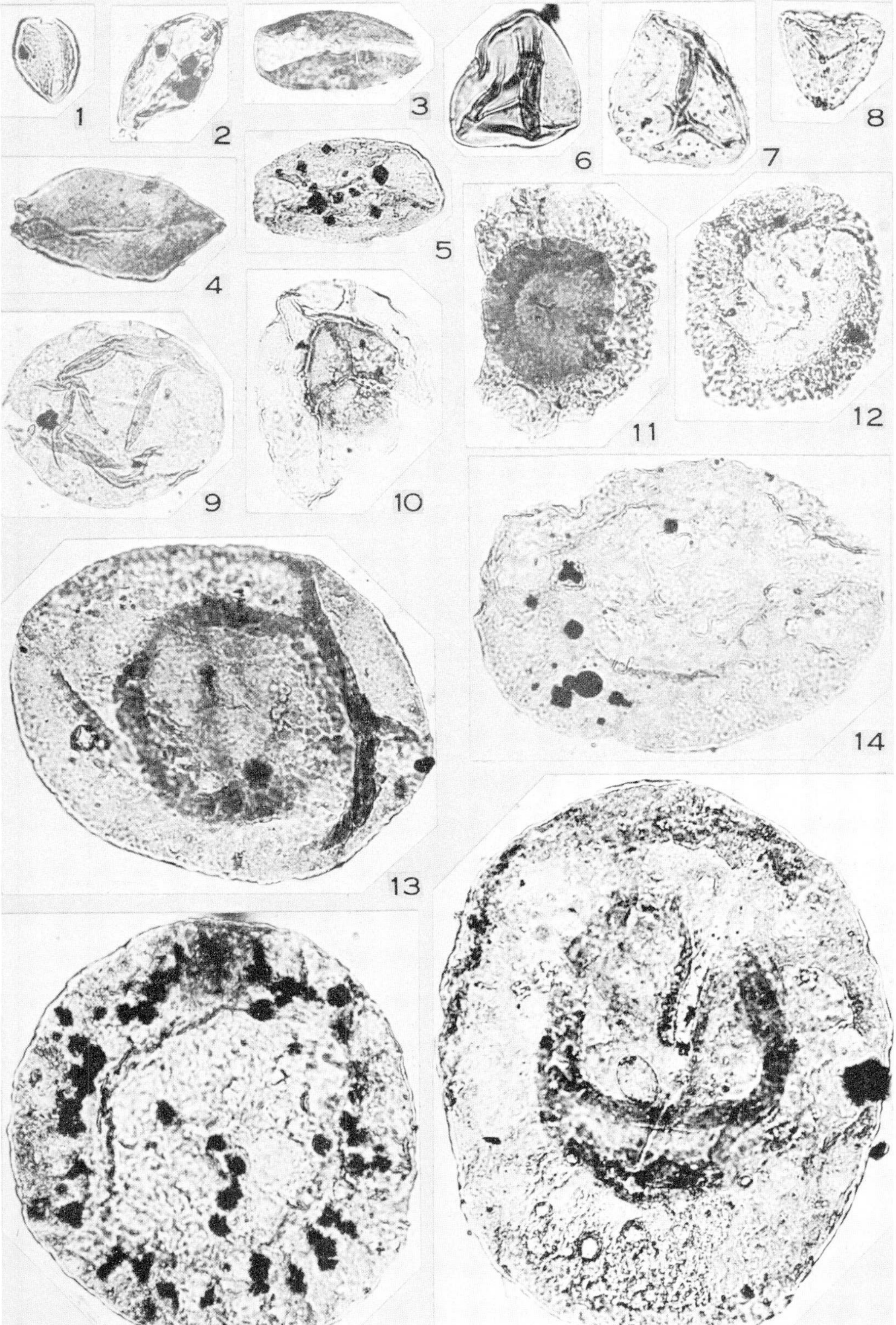

PLATE III

Figure 1. ? Vesicaspora sp. 1. 16561. Loc. 57036.
Figure 2. Protohaploxypinus sp. 1. 16584. Loc. 57036. Ten ribs on body.
Figure 3. Potonieisporites cf. P. simplex Wilson, 1962. 16564. Loc. 56961.
Figure 4. Vestigisporites cf. V. methoris Hart, 1960. 16563. Loc. 57036.
Figure 5. Protohaploxypinus cf. P. samoilovichii (Jansonius) Hart, 1964. 16562. Loc. 56961.
Figure 6. Striomonosaccites sp. 1. 16577. Loc. 56961. The body ribs are somewhat obscured but 14 can be counted.
Figures 7, 10. Lueckisporites virkkiae Potonié and Klaus, 1954. 16569. 16665. Loc. 57036. 56961.
Figure 8. Piceapollenites sp. 1. 16578. Loc. 57036.
Figure 9. Limitisporites sp. 1. 16666. Loc. 57036.
Figures 11, 13, 14. Limitisporites monstruosus (Luber and Waltz) Hart, 1965. 16576, 16570, 16568. Loc. 57036.
Figure 12. ? Protohaploxypinus sp. 2. 16572. Loc. 56961.
Figure 15. Limitisporites sp. 2. 16667. Loc. 57036. Monolete scar longer than in L. monstruosus.
Figure 16. cf. Gardenasporites leonardi Klaus, 1963, 16574. Loc. 57036.
Figure 17. Limitisporites sp. 3. 16668. Loc. 57036. Larger body-to-bladder ratio than in L. monstruosus.
Figure 18. ? Cordaitina sp. 1. 16669. Loc. 57036. Trilete mark is very small.
Figure 19. Vestigisporites sp. 1. 16670. Loc. 57029. The monolete scar is short, compared to that in other species of Vestigisporites.
Figure 20. ? Vestigisporites sp. 2. 16671. Loc. 57036. Monolete scar accompanied by heavy labra.

PLATE III

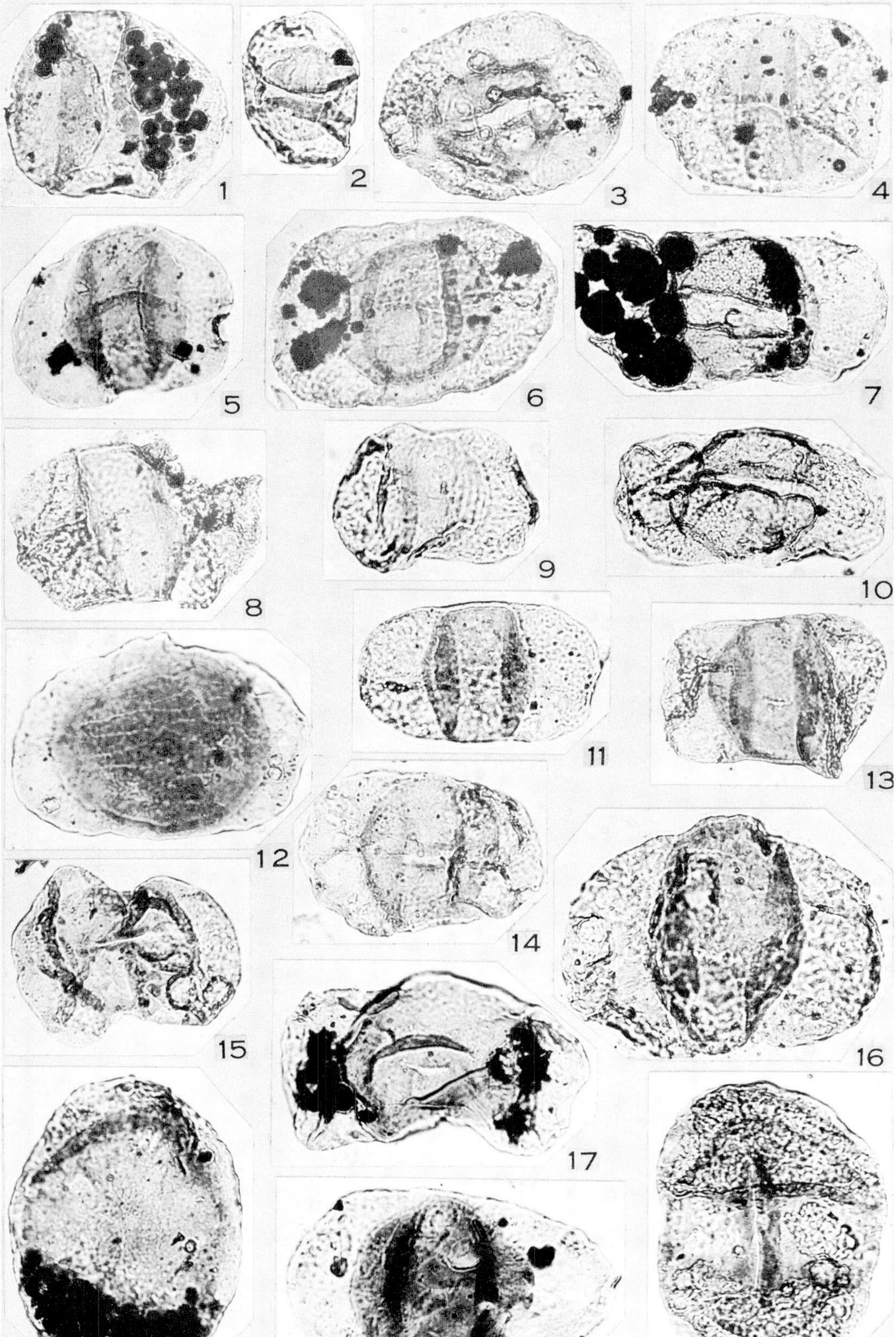

PLATE IV

Figure 1. Striatoabietites sp. 1. 16583. Loc. 56961. Central body has 8 ribs.

Figure 2. Striatoabietites cf. S. striatus (Luber and Waltz) Hart, 1964. 16672. Loc. 57036.

Figure 3. cf. Gardenasporites leonardi Klaus, 1963. 16673. Loc. 57035.

Figure 4. Striatoabietites sp. 2. 16571. Loc. 56961. Six, possibly 8 ribs on central body.

Figure 5. Protohaploxypinus sp. 3. 16674. Loc. 57029. Body has 6 ribs.

Figures 6, 8 Protohaploxypinus globus (Hart) Hart, 1964. 16581. 16580. Loc. 56961.

Figure 7. Striatopodocarpites sp. 1. 16573. Loc. 57036.

Figure 9. Striatopodocarpites cf. S. divaricata (Wilson) Hart, 1964. 16582. Loc. 57036.

Figure 10. Striatopodocarpites sp. 2. 16475. Loc. 56961. There are 10, possibly 12 ribs on body.

Figure 11. Striatoabietites multistriatus ? (Balme and Hennelly) Hart, 1964. 16675. Loc. 57036.

Figure 12. Striatopodocarpites cf. S. cancellatus (Balme and Hennelly) Hart, 1963. 16586. Loc. 57036.

Figure 13. Tumoripollenites sp. 1. 16585. Loc. 56961.

Figures 14, 15. Hamiapollenites sp. 1. 16601. Loc. 56961. Distal and proximal views. Eight transverse ribs on distal side. Eight to ten discontinuous longitudinal ribs on proximal side. Bladders are pitted and broken by mineral grains.

Figure 16. Hamiapollenites sp. 1. 16600. Loc. 56961. Specimen with bladders intact.

Figure 17. cf. Pityosporites papilionis (Potonié and Klaus) Hart, 1965. 16676. Loc. 56961.

Figure 18. Vittatina subsaccata Samoilovich, 1953. 16579. Loc. 56961.

Figure 19. Vittatina sp. 1. 16677. Loc. 57036. Seven ribs on body, which has a very thick wall.

Figure 20. cf. Vittatina wodehousei (Jansonius) Hart, 1964. 16602. Loc. 56961.

Figure 21. Vittatina vittifer (Luber) Samoilovich, 1953. 16611. Loc. 57036.

Figure 22. Vittatina sp. 2. 16610. Loc. 57036. Body has 12 ribs.

Figure 23. Vittatina sp. 3. 16612. Loc. 56961. Body has 8 ribs, bladders small.

Figure 24. Vittatina sp. 4. 16690. Loc. 57036. Body has 8 ribs and prominent monolete slit.

Figure 25. Vittatina simplex Jansonius, 1962. 16613. Loc. 57036.

Figure 26. Vittatina vittifer (Luber) forma cinctutus Samoilovich, 1953. 16615. Loc. 57036.

PLATE IV

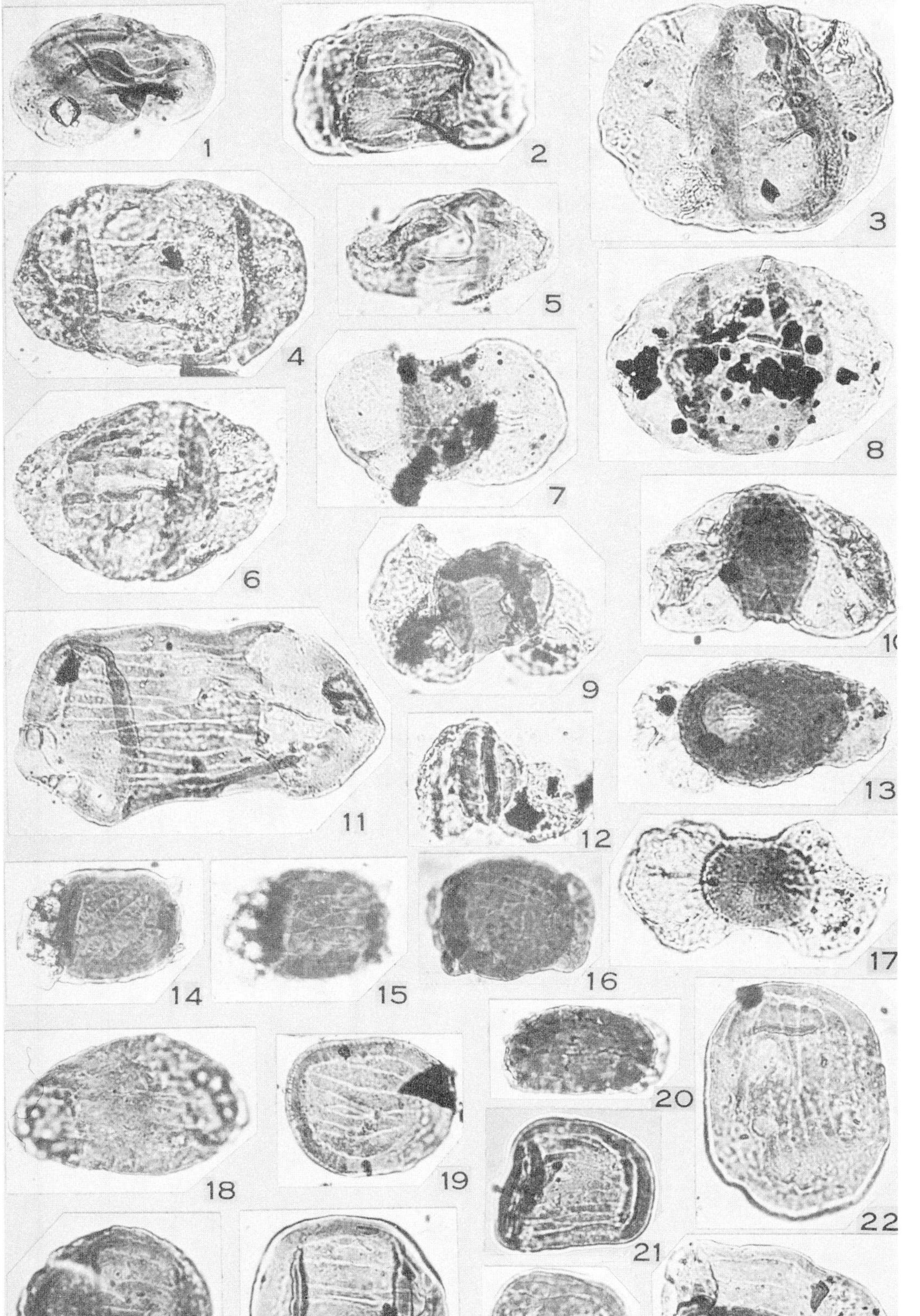

PLATE V

Figure 1. Vittatina subsaccata Samoilovich, 1953. 16603. Loc. 56961.

Figures 2,4. Vittatina vittifer (Luber) Samoilovich, 1953. 16604, 16614. Loc. 56956, 57036.

Figures 3,8. Vittatina sp. 2. 16605, 16608. Loc. 57036. Twelve ribs, some discontinuous.

Figure 5. Costapollenites sp. 1. 16678. Loc. 56961. Eight ribs on body, some discontinuous. Body wall very thick.

Figure 6. Vittatina cf. V. saccifer Jansonius, 1962. 16607. Loc. 56961.

Figure 7. Vittatina costabilis ? Wilson, 1962. 16609. Loc. 57036.

Figure 9. cf. Vittatina sp. L. in Jansonius, 1962. 16606. Loc. 56956.

Figure 10. Unidentified. 16679. Loc. 57036. This specimen is shown to illustrate the difficulty in identifying these striate saccate sporomorphs. In its entirety the specimen could probably be assigned to Protohaploxypinus. If both bladders were missing it would be assigned to Vittatina.

REWORKED SPORES

Figure 11. Murospora intorta (Waltz) Playford, 1962. 16680. Loc. 56956.

Figure 12. Densosporites bialatus (Waltz) Potonié and Kremp, 1956. 16681. Loc. 56956.

Figure 13. Labiadensites fimbriatus (Waltz) Hacquebard and Barss, 1957. 16682. Loc. 56956.

Figure 14. Knoxisporites literatus (Waltz) Playford, 1962. 16683. Loc. 56956.

Figure 15. Murospora aurita (Waltz) Playford, 1962. 16684. Loc. 56956.

Figure 16. Anulatisporites anulatus (Loose) Potonié and Kremp, 1954. 16685. Loc. 56956.

Figure 17. cf. Lophozonotriletes cristifer Kedo, 1957. 16686. Loc. 56956.

Figure 18. Murospora friendii Playford, 1962. 16687. Loc. 56956.

Figure 19. Tripartities incisotrilobus (Naumova) Potonié and Kremp, 1956. 16688. Loc. 56956.

Figure 20. Ancyrospora sp. 16689. Loc. 56956.

PLATE V