SOME CUTINIZED MICROFOSSILS

FROM

WESTERN CANADA

A. W. NORRIS

For Reference: not to be taken
from this room!

University of Alberta

Faculty of Arts and Science

Department of Geology

The undersigned hereby certify that they have read and recommend to the School of Graduate Studies for acceptance, a thesis entitled "Some Cutinized Microfossils from Western Canada", submitted by Arnold Willy Norris, B. Sc., in partial fulfilment of the requirements for the degree of Master of Science.

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SOME CUTINIZED MICROFOSSILS FROM WESTERN CANADA

A DISSERTATION

SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE.

FACULTY OF ARTS AND SCIENCE

DEPARTMENT OF GEOLOGY

by

ARNOLD WILLY NORRIS

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ERRATA

Throughout thesis change:

"Sporangitoides ellipsoprolata" to "Sporangitoides ellipsoprolatum",

"Sporitoides spinus" to "Sporitoides spinum",

"Sporitoides discus" to "Sporitoides discum".

ABSTRACT

These preliminary descriptive studies of unclassified cutinized microfossils, occurring in sedimentary rocks of Cretaceous age of Western Canada, deal particularly with forms occurring in samples from the middle (?) portion of the Loon River shale, on the Peace River, Alberta.

Two new form-genera are proposed; Sporangitoides for those forms which look like a spore-sac or spore-container, and Sporitoides, for those forms which look like a megaspore. On the basis of distinctive morphology and size two new species of Sporitoides are proposed.

Affinities of these cutinized microfossils are in doubt but they are probably organs of plants representing a part of their reproductive cycles. They are relatively constant in size and morphology within restricted stratigraphic horizons and geographic localities.

Cutinized microfossils have been observed, also in samples of the Grand Rapids sandstone, Joli Fou shale and Pelican sandstone, from surface outcrops along the Athabaska river, Alberta; in the basal Lloydminster shale and Viking sand, Edmonton area; from the St. John formation in type area, British Columbia; more rarely in samples from the Second White Specks zone, Spirit River area, Alberta.

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CHAPTER I

1. INTRODUCTION

This study deals particularly with a group of unclassified microfossils occurring in the Cretaceous Loon River shale of Northern Alberta. Because of the primary nature of this study the treatment is of necessity, mainly descriptive. Descriptive and taxonomic studies of these fossils alone will occupy the energies of this field prior to an evaluation of stratigraphic facies relationships. Cutinized microfossils should be a new tool which could be used by micropaleontologists of Western Canada in the correlation of rock units which lack other types of suitable fossils. Cuticular remains along with other fragmentary bits of carbonized and distorted organic material are frequently prominent as microfossils. Spores and pollen have received the most study. A major obstacle in these investigations has been the difficulty in classifying this material on a practical commercial level for oil companies. The writer has of necessity leaned heavily on the available micropaleobotanical literature, most of which is not directly pertinent but rather applies to spores and pollen. The study of these latter groups of microfossils is now a firmly established science with a long backlog of contributors. Most of this literature on spores pertains to Paleozoic, especially the Carboniferous.

Spores and pollen occurring in Recent and Pleistocene sediments, especially peats, are also intensively studied. Only a small amount of literature pertaining to Mesozoic forms was available to the writer. Information gathered from readily available references has undoubtedly prejudiced the treatment of morphological features of cutinized microfossils considered in this thesis.

Micropaleontologists in Western Canada have been aware of the presence of these cutinized microfossils which are known to occur in certain sediments of Lower Cretaceous and lower Upper Cretaceous ages, but for various reasons, been neglected. No previous study has been published pertaining directly to these cutinized microfossils of Western Canada. This seems a little surprising as they are comparatively abundant, especially in some zones. Observations to date indicate that they are most abundant in some zones where Foraminifera are very scarce or entirely absent, so-called, "barren zones".

These cutinized elements appear to have been ideally suited to preservation. In their present fossilized state, they seem to consist of an organic substance that is relatively inert to the action of acids and bases, and little affected by a wide range of heat treatment. This substance is presumably one

of the most stable in the organic world, in fact, so much so, that its chemical composition is still not completely known. (Ref. 16, p.16).

After a careful search of available literature, and from comparative morphology, the writer believes that these elements are the reproductive parts of plants. Throughout this thesis, for convenient reference and general discussion of the group as a whole, they are descriptively designated as "cutinized microfossils". These same elements have commonly been referred to as "spores". Spores and pollen proper, belong to a lesser degree of smallness. These cutinized microfossils appear more like spore-sacs or spore-containers. A discussion of their morphology,

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The production of spores by a special cell or organ - (sporangium). (Coulter, Ref. 9, pp. 12, 17, 54).

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size and comparison with spores and pollen proper is given later in the main body of this thesis.

Where possible the cutinized microfossil occurrences have been tied in with megafossil zone indices, other microfauna, including Foraminifera and Radiolaria, and previously established lithologic marker horizons.

The foraminiferal content of the samples from surface outcrops of the Loon River shale on the Peace River, between a sample collecting station located 8 miles upstream from Ft. Vermilion and as far upstream and south to a point located 10 miles north of the 25th base line, was the original objective of examining these shale samples. The samples were divided with Mr. F. H. Trollope handling those from the south, that is, those samples of numerical sequence below 518, and those to the north were done by the writer, that is those samples of numerical sequence of 518 up. The paucity of Foraminifera in most of the samples studied by the writer and the relative abundance of cutinized microfossils, prompted a change of the scope and treatment of the investigation, to a study of this previously neglected group of microfossils.

2. CUTINIZED MICROFOSSILS

Eight main types of cutinized microfossils, based on easily discernible morphology have been recognized and are known to occur in varying abundance in the Loon River shale. They have been noted in some abundance from other sources but the writer confined the greater portion of this preliminary study to those forms occurring in the Loon River shale.

The principal types are as follows:

1. Thin-lenticular form, (<u>Sporangitoides lenticulare</u> n.genus, n. sp.)

2. Large thin-lenticular form, approximately twice as large as the above, does not occur in the Loon River shale, (<u>Sporangitoides giganteum</u> n. sp.)

3. Broad-lenticular form, (<u>Sporangitoides ellipsoprolatum</u> n. sp.).

4. Large flat circular form, (<u>Sporangitoides circulare</u> n. sp.).

5. Smaller flat circular form, quite rare, (<u>Sporangitoides mesocirculare</u> n. sp.).

6. Small flattened disc-shaped form with from one to four minute spine-like appendages protruding from the peripheral margin, (<u>Sporitoides spinus</u> n. genus n. sp.).

7. Small flattened disc-shaped form, lacking spines, relatively rare, (<u>Sporangitoides discus</u> n. sp.)

8. Very small fragile, thin, disc-shaped form with 5 to 11 delicate appendages projecting radially outward from peripheral margin, (<u>Hystrichosphaera loonriverensis</u> n. sp.), referred to the Hystrichosphaerid group.

Several other beautifully preserved cutinized microfossils have been described and illustrated but not considered in this general discussion because of their scarcity.

A characteristic common to all of the cutinized micro-elements is their apparent consistent composition, which seems highly resistant to decay, rendering them favorable to preservation, although some horizons show more corrosion of specimens than others. The organic substance is presumably cutin-like in composition, having a waxy or somewhat resinous appearance. Its color varies from a light straw-yellow to a dark amber; thinner and more translucent portions always appear lighter in color than the thicker forms and portions of the same speciman.

All of the larger forms, that is all those forms which have been designated Sporangitoides, can easily be seen by the naked eye, and range in size from 0.2 to 1.5 mm. The smaller forms are down near the lower limits of unaided vision. This applies particularly to the Sporitoides and Hystrichosphaerid groups, which range in size from 0.09 to 0.19 mm. The size measurements within a group are relatively constant for forms occurring within a restricted geographic location and stratigraphic horizon. Magnification of moderate power is indeed helpful in studying detailed morphology of the larger forms and is a necessity for the smaller forms.

These cutinized microfossils under a microscope of moderate power and reflected lighting, reveal

little of their structure. The walls can in some cases be distinguished from the internal portion which may be seen to enclose patches of floculent or granular matter. The specimen, against a light background with transmitted light, reveals certain structural features not seen otherwise. Spheroidal globules, of irregular distribution and sizes are in most forms contained inside the wall. Some forms also appear to have a cell-like wall structure. All forms have been flattened which in some forms has produced fortuitous folding of the outer coat. As all these are translucent to light, these features stand out as light and dark areas with two or more features superimposed on one another. As well as being folded, the outer surface of the coat is generally faintly and irregularly papillated, which is in some cases, a surface expression of the contained spheroidal masses within. The coat itself appears to be composed of a very fine granular cutinized substance.

3. OCCURRENCES OF CUTINIZED MICROFOSSILS WITHIN THE LOON RIVER SHALE.

A key to "Geographic Locations of Stations and Faunal Suites" and a "Statistical Record of Micro-organisms and other Elements from each Sample" are

included in the appendix for convenient reference.

This discussion applies only to that limited portion of the Loon River shale from which samples were studied. These samples are from 24 collecting localities from the banks of the Peace River, Alberta. The most northerly position is located 8 miles upstream, west south-west of Ft. Vermilion and the most southerly collecting locality is located 18 miles north of where the 25th. base line crosses the Peace River. The winding river distance separating the north from the south sample collecting localities is 130 miles. The straight line distance between these two points is approximately 65 miles.

Sporangitoides lenticulare n. sp. is the most abundant and was noted in most samples from 16 of the 24 sections considered. In all samples containing an abundance of Foraminifera and Radiolaria, cutinized microfossils, including *S. lenticulare* are sparse or not represented. Within the area considered by this study, cutinized microfossils are spread over a winding river distance of approximately 100 miles and a straight line distance of approximately 50 miles. They seem to be conspicuously absent from several consecutive sampled localities in the south and are sparsely distributed in samples from the most north located sampled locality.

The broad-lenticular type, designated *Sporangitoides ellipsoprolatum* n. sp. is never as abundant as *S. lenticulare* and its distribution within a section is quite sporadic. A high frequency count of *S. ellipsoprolatum* usually coincides with a high count for the *S. lenticulare*. Zones containing a high frequency count of this type can in some places be traced through several consecutive section localities and for this reason proved of more value than *S. lenticulare* in tentative correlation from section to section.

The circular type of cutinized microfossil, designated *Sporangitoides circulare* n. sp. is less abundantly represented in the samples and for this reason zones containing a high frequency count are usually more conspicuous than either of the two previously mentioned form species.

The disc-like types, including the two form species *Sporitoides spinus* n. sp. and *S.* discus n. sp. appear to have a more restricted and local distribution. The greatest numbers occur in samples from section localities 187:518-532, that is 7 miles north of Tompkins Landing, and 194:538-559, that is 11 miles north north-east of Tompkins Landing. Frequency counts indicate that they are relatively abundant throughout these two sections. In the remaining

sections in which these types occur, their distribution is sporadic and zones showing a high frequency count profile can in some cases be traced through several sections over a lateral distance of approximately 6 miles. Because of its apparent local geographic distribution its value as a correlative indicator was found to be not as useful as the three previously mentioned form species.

<u>Sporitoides spinus</u> and <u>S. discus</u> have been seen only in samples from the Loon River shale. It is a very small cutinized microfossil, ranging in size from 160 to 190 mu and therefore could quite easily be missed on picking when using the lower powers of magnification.

Another unusual form seen only in samples from the Loon River shale and designated as <u>Hystrichosphaera loonriverensis</u> is very small, fragile, and looks somewhat like a spoked-wheel lacking an outer rim. This form species has been seen in relatively few samples and appears to have erratic and local distribution. It occurs in most of the samples from section locality 202:565-576, situated 40 miles north north-east of Tompkins Landing. This form species was noted in a few samples from only two other section localities situated some distance upstream and to the south.

4. OBSERVED OCCURRENCES OF CUTINIZED MICROFOSSILS FROM OTHER FORMATIONS AND GEOGRAPHIC LOCALITIES.

Additional information regarding the occurrences of cutinized microfossils from other sources was obtained from a cursory study of suites in collections of the Geology Department, University of Alberta. These included suites picked in 1949-50 by A. R. Nielson, D. B. Bullock and W. Bahan, and those of R. Wetter, F. H. Trollope of 1950-51, also suites from the basal Moosebar formation picked by Imperial Oil Ltd.

Basal portion of Moosebar Formation.

Numerous bits of fragmentary matter of probable organic origin had been picked and mounted indicating that if the cutinized microfossils had been present they would have received the same consideration as other micro-organic elements present in some samples.

Grand Rapids sandstone, Joli Fou shale, and the Pelican Sandstone.

Cutinized microfossils occur in samples from the Grand Rapids sandstone, Joli Fou shale and Pelican sandstone from surface outcrops along the Athabasca River, Alberta, between Sec. 19, Tp. 80, Rge. 17, W. 4th. meridian to Sec. 19, Tp. 86, Rge. 17, W. 4th meridian, (Supp. Ref. 1). Three main types were recognized which are as follows: Sporangitoides giganteum n. sp. S. ellipsoprolatum n. sp. var. B.

and S. circulare n. sp. The three main types appear in maximum abundance in samples B-71-0 and B-71-10, from the top and 10 feet from the top, respectively of the Joli Fou shale, Cutinized microfossils including the three form species were noted in fewer numbers in one sample. (B-Z-1-7), in the Joli Fou shale, 7 feet from the base. Beautifully preserved specimens of Sporangitoides circulare n. sp. occur in samples from here along with specimens of S. giganteum n. sp. and S. ellipsoprolatum n. sp. var. B. A sparse distribution of S. giganteum n. sp. and S. ellipsoprolatum n. sp. var. B. was noted in two samples, B-70-6 and B-70-19, from the Pelican sand, 15 and 7 feet respectively from the base. Very few cutinized microfossils occur in samples B-76-7, B-76-15, B-76-2 and B76-23, spaced within 7 and 23 feet from the top of the Grand Rapids sandstone.

The cutinized microfossils noted from these formations are larger than similar form species occurring in the Loon River shale and closely compare with those from the Basal Lloydminster shale, (Viking sands) from the Eldorena Imperial #1 well, Edmonton area, Alberta.

Lower Lloydminster shale (Viking sand).

Cutinized microfossils, (referred to as "spores"

by Mr. D. B. Bullock), also occur in samples from the Lower Cretaceous, Viking sands within the Lower Lloydminster shale from the Imperial Eldorena #1 well, of the Edmonton area, Alberta, LSD 4, Sec. 27, Tp. 57, Rge. 20, W. 4th meridian. (Bullock, Supp. Ref. 2). The main types occurring here are: Sporangitoides gigantuem n. sp., S. ellipsoprolatum n. sp. S. circulare n. sp., and several other cutinized microfossils not seen elsewhere.

A study of a graph presented by Bullock (Supp. Ref. 2. fig. V), showing the percentage breakdown of fossil population reveals some interesting data. In this graph, Bullock uses the total of cutinized microfossils or "spore" content of the samples which he analyzed statistically from 1934 feet to 2128 feet in the Eldorena #1 well. "Spores" first appear at 2060 feet, just a little below the base of the second Viking sand and extend up to 1974 feet or to a few feet above the top of the Viking sand. The maximum occurrence of "spores" is at 2020 feet, which is just above the top of a thin shale zone separating the first and second Viking sands. A minor maximum occurs at the top of the second Viking sand and extends a short distance upward into the shale zone. Cutinized microfossils, "spores", outnumber all other forms of organic

life in the upper Viking sand.

A distinctive difference between comparable morphologic types occurring in the Loon River shale and the Viking sands is size. In general, cutinized microfossils from the Viking sands are about twice the size as those from the Loon River shale. Many of the specimens are beautifully preserved and being comparatively large renders them excellent material to study. For this reason several specimens from this source have been described and illustrated.

Shaftesbury formation.

A sparse number of cutinized microfossils of two types Sporangitoides circulare n. sp. and S. lenticulare n. sp. var. D occur above the middle gypsiferous sandstone horizon (fish-scale horizon), in the Shaftesbury formation. (Nielsen, Supp. Ref. 3). At a locality (16-47-30) on the east bank of the Smoky river, about 1/2 mile west of Judah railway station, Alberta, samples containing cutinized microfossils (M3904, M3906, and M3911) occur respectively 45, 36, and 10 feet above the fish-scale sand. (Location map, Nielsen. Supp. Ref. 3). One speciman only of a cutinized microfossil, S. circulare n. sp. was seen in a sample (M3958) from locality 16-47-31, on the east bank of the Smoky River 1¼ miles north north-east of Judah railway station, Alberta. This occurs at 148 feet above the fish-scale sand in the Shaftesbury formation.

These specimens occur in silty shales and are on the average very well preserved and of slightly larger dimensions than comparative forms occurring in the Loon River shale. The writer suspects that they occur in relatively larger numbers than is indicated by the mounted microsuites, because Mr. Nielsen's study was primarily concerned with the Foraminiferal content.

St. John formation.

A cursory study of R. Wetter's microsuites (Supp. Ref. 6), indicates that three main types of cutinized microfossils occur in the St. John formation (Cenomanian age). They are *Sporangitoides circulare* n. sp., *S. lenticulare* n. sp. var. D. and *S. ellipsoprolatum* n. sp. A major maximum is indicated by a sample (4912) from 65 feet above the base of the fish scale sand zone at locality A, on Septimus Creek, British Columbia, in Sec. 20, Tp. 28, Rge. 18, W. 8th meridian. A minor maximum occurs at 49 feet above the second tuff horizon, (sample 4610). This latter sample is from a locality at the mouth of St. John Creek, on Beatton River, British Columbia. *S. ellipsoprolatum* n. sp. in the major maximum occurrence zone makes up 87% of the cutinized microfossil count. Within the minor maximum cutinized microfossil occurrence zone, *S. circulare* n. sp. is the predominant form species with S. lenticulare n. sp. and S. ellipsoprolata n. sp. sparsely represented.

Upper Cretaceous, Second White Specks (Turonian Age).

Varieties of cutinized microfossils of two form species, S. circulare n. sp. and S. ellipsoprolatum n. sp. are known to occur in samples from the second white specks zone (Turonian age) from a well in the Spirit River area. (Mr. J. Wall, personal communication, 1951). S. circulare n. sp. is the predominant type. Considered as a group, they are considerably larger than similar forms occurring in the Loon River shale. To the writer's knowledge to date, this sediment (Second white specks) is the youngest to reveal evidence of cutinized microfossils.

5. HOW OBTAINED AND METHODS OF STUDY.

The procedure of treatment of samples was essentially the same as described in the thesis of Mr. A. R. Nielsen (Supp. Ref. 3 pp. 3-8), except a 120 mesh screen size was used in place of the 150 screen for part of the work. A record was kept of those samples which were washed using the latter screen in case of a noticeable difference of results which could be attributable to that cause.

Details of the morphology of the cutinized microfossils stand out much clearer when placed against a light background. In contrast, external features of Foraminifera are seen to best advantage

when studied against a black background. For higher magnification, the cutinized microfossils were placed on thin glass slides and a Bausch and Lomb petrographic microscope used. The combination of XIO ocular with a 0.25 mm objective was found to be the most suitable.

Camera lucida drawings were made of selected well preserved representative specimens as a means of portraying morphologic features. The writer believes that in the early formative stages of a study such as this, making numerous drawings is indeed an aid in the interpretation of structure and morphology. It is also a valuable record for later comparisons. With regard to this same idea, the writer quotes the following from Wodehouse (Ref. 49, p. 56).

"In making microscopical drawings the eye is compelled to dwell upon the contours and minute detail of the object. At first these appear to be without arrangement, but after the eye has studied them and put them accurately together on paper an underlying plan is revealed, and from the apparent chaos gradually emerges the plan of the whole which may be resolved into its structural elements. These may be captured and retained only as dictated to the mind by the trained eye and skillful hand. As more forms are examined the same structural elements are found to occur again and again in different combinations, and different but related plans are revealed. In this way the morphological science is built up as a visual structure."

A comparison of earlier and later drawings by the writer reveals that there is considerable truth in the above statements of Wodehouse. The eye does require training to be able to discern some of the finer details of structure. Structural features are frequently seen to advantage by using a combination of reflected and transmitted lighting and by altering the intensity of the light source. This is somewhat analogous to the frequent practice of micropaleontologists, of moistening the test of a Foraminifera with a fine brush and then watching the changing light as it dries from cell to cell. Indistinct cell and obscure suture lines are frequently detected in this manner.

Most of the camera lucida drawings were done at a scale of X110. Where necessary for very small forms the magnification was increased to approximately X155 and likewise for very large forms the magnification was reduced. Where possible a constant scale was used so as to portray relative size differences within a type and between markedly different types.

Best results are obtained using microscopes having vertically orientated oculars, that is, perpendicular to the page of the drawing book placed on an horizontal surface, as constant checking of position of the drawing book is required when a camera lucida is attached to an ocular or body tube which is not orientated vertically. In this case, in order

to maintain the page of the drawing book perpendicular to the ocular, it has to be placed on an inclined surface where there is greater tendency for it to slip out of position.

The writer suggests to anyone continuing the study of cutinized microfossils that the black mat background of the mounting cells be surfaced with a white material as specimens of the cutinized type show up to best advantage against a light colored, preferably white background.

There are several excellent references which explain in detail methods of maceration, microscopic mounts, staining procedures, etc. Among these is an excellent treatise by G. Erdtman, 1943 (Ref. 15, pp. 26-42).

The methods of maceration, mounting, etc., applied to the samples investigated by the writer are those which are best suited to the study of Foraminifera as no special techniques had as yet been developed for cutinized remains alone.

CHAPTER II

1. ALLIED FORMS AND BRIEF HISTORY OF SOME OF THE STUDIES.

The early history of the observed occurrences of plant microfossils is quite probably associated with the development of the microscope. Waltham, 1833, (Wilson, Ref. 47. p. 112) was apparently one of the first to describe the occurrence of fossil spores in the bituminous coals of England. Almost all of the plant microfossil literature pertains to spores and pollen occurring in peat and coal where they are found most abundantly in the fossil state. In this country, Dawson in 1863, (Ref. 11), described the occurrence of disc-like spore bodies, (Sporangites, now Tasmanites,) from the shales of eastern Canada. White and Stadnichenko in 1923, (Ref. 47) record the presence of small roundish spore sacs, now flattened and appearing as somewhat wrinkled or creased, irregularly rounded bodies, 3 to 5 mm. in diameter, in black shales, regarded as of Genesee age, in northeastern Kentucky. Another plant part described is the forking divisions or thalli of presumably a small seaweed, named Foerstia. I mention these types because of the similarity in description of their composition to the cutinous microfossils studied

from the Loon River shale, although size and morphology indicate that they are obviously different. Parts of the above plants are referred to as waxy resinous in composition which seem especially designed to resist decay. A paper by Bradley (1931, Ref.7), illustrates and describes numerous microfossils found in the Green River formation of Colorado and Utah. The Green River formation is of fresh water origin and has yielded an abundance of fossilized plant material including spores and pollen.

The writer has examined and for comparison illustrates with camera lucida drawings a piece of Exshaw shale. (Upper Devonian), containing a specimen of "Sporangites". This name was first proposed by Dawson in 1863;; and the name and form is discussed quite thoroughly by Schopf, Wilsoh and Bentall. (Ref. 31. p. 11). They give reasons why the term should not have generic significance. Dawson applied the name to spore or "spore cases" which he thought were referable to Lepidodendron, Calamites and other similar plants. The present common use of the term "Sporangites" by geologists, refers to the presence of more or less disc-shaped, resinous-appearing bodies that are commonly found in Devonian-Mississippian black shale.

Schopf, Wilson and Bentall, 1944(Ref. 31) of the Illinois State Geological Survey published a report in the form of an annotated synopsis of the literature which describes most of the Paleozoic fossil spores known to that date. A fairly complete review of recent "spore" literature since that date has been done by Schopf 1949 (Ref. 33). One of the outstanding omissions from the earlier report was material from Russian literature. Much of this Russian literature is still not available but what has been obtained so far is of extreme interest. The writer quotes the following from Schopf, (Ref. 33, p. 499).

"Naumova lists species characteristic of Devonian, Lower Carboniferous, (European province, Karaganda province), Middle and Upper Carboniferous(of Donetz and the Ruhr), Permian (Donetz province and Siberian province), Upper Triassic (Uralian province), Jurassic and Lower Cretaceous (East Asiatic province), and the Upper Cretaceous and Tertiary. The differentiation of the floristic provinces is of considerable interest and when fully reported will probably hold much significance. Angiosperm pollen is said to appear first in Jurassic coals of the Caucasus; in the far east it does not appear earlier than the Upper Cretaceous. No illustrations of this interesting

material are given, nor is the fossil specifically identified."

The study of modern spore and pollen morphology and analysis now is a well established science. Three comprehensive treatises have been written on this subject within the past sixteen years. "POLLEN GRAINS, Their structure, identification and significance in science and medicine" by R. P. Wodehouse appeared in 1935. This treatment is the most complete and summarizes most of the American knowledge and much of the European contributions to this new science. This text discusses fossilized remains and is for this reason a valuable reference for anyone engaged in a study such as this.

The European slant and background is comprehensively represented by the two following texts. In 1943 appeared "An Introduction to POLLEN ANALYSIS" by G. Erdtman. This book was first written in Swedish and later translated to English. In the editor's preface, it is stated that the book is meant primarily as a short introduction to the principles of pollen analysis and an atlas of the principal types of pollen grains met by the beginning pollen analyst.

The most recent text off the press (1950) is by two Danish workers, Knut Faegri and Johs. Iversen, entitled, "Text-Book of Modern Pollen Analysis".

This book summarizes those methods and principles which have guided Danish workers on pollen-analytical work.

These texts are of obvious value to any investigator dealing with Recent spores and pollen types but are of little direct help in clarifying the problem of affinity of the cutinized microfossils.

The forms investigated by the writer appear to be some part or parts of the reproductive organs of plants. Micropaleontologists of Western Canada have tentatively designated them as "spores" and it is for this reason that the writer devotes a great deal of space to the discussion of spores.

If the cutinized microfossils investigated by the writer do happen to be spores or pollen, they are of giant proportions. Most pollen grains are small, in fact so small that they cannot be seen by the naked eye. One of the largest modern pollen grains is that of the pumpkin, which has a diameter of about 200 mu and from this size pollen grains range downward to about 4 ½ mu in diameter (Ref. 49. p.80.)

In the hope of clarifying the relationship and meaning of spores and pollen the writer is including the following summary.

"Pollen Grains are Spores" (Wodehouse, Ref. 49, page 1).

"They correspond to the small or male spores of

the ferns. It is even a little difficult to draw a hard-and-fast line between pollen grains and other kinds of spores. Perhaps the best distinction is this: "When a spore, like the fern spore, germinates, it ruptures its wall, and the developing prothallus emerges; when a pollen grain germinates, the young prothallus, which is only rudimentary does not rupture the spore wall but is entirely contained within it."

Other micro-organisms which compare in size and have superficial resemblance to cutinized microfossils are the Radiolaria and Heliozoa. The shells of these aquatic animals generally consists of some siliceous or calcareous material, which is chemically entirely unrelated to the substance of the cutinized microfossils. Nevertheless the simple families of the order Foraminifera was searched in the hope of finding comparable forms. The family Allogromiidae is described as: "Test either wanting or of chitin, not porous; aperture either single or at each end of the test, the surface of test sometimes with attached foreign materials; fresh and brakish water, sometimes marine, not known as fossils." (Cushman, Ref. 10, p. 65).

For the same reason the Calcareous Algae may be dismissed as a possibility of affinity. With regard to the Charophyta, the writer quotes the following brief description, (LeRoy, Ref. 23, p. 99).

"The Charophyta are a distinctive, isolated group of algae, usually classed with the green algae (Charophyta). Calcium carbonate is usually precipitated around the tips of the branches and spore cases. These structures are the only portions of many of the plants that are calcified. The spore cases (oogonia) form a distinctive fossil".

The _diatoms_ compare in size and shape with the microfossil elements studied by the writer, but they possess mineral skeletal parts which eleminates this group from serious consideration. A brief description of this group is given by LeRoy, (Ref. 23, p. 101).

"Diatoms are microscopic unicellular plants belonging to the phylum Thallophyta. The skeleton or frustule, composed of _opaline silica_, commonly consists of two shallow, disc-shaped halves (example: _Crapedodiscus_), one of which fits into the other similar to a flat pillbox. Other forms are elongate and bilaterally symmetrical with respect to an axial strip. Individual specimens may range in diameter from 0.1 to 0.15 mm."

The unicellular plants _Desmids_, although similar in outline to _Sporangitoides lenticulare_ n. sp. and _S. giganteum_ n. sp., are characterized by distinctly

different and definite structure. Desmids for the most part grow solitary, but frequently remain attached and form filamentous colonies. Some are common as freshwater plankton. Most desmids consist of two similar halves, semi-cells, and frequently a constriction called an isthmus separates the two semi-cells. (Holman and Robbins, Ref. 19, p. 361).

The fossil form of Peridinium, a Dinoflagellate, (Protozoa), has been found in the firestone of Delitzet, of Cretaceous age. The modern Peridinium is common both in fresh and salt water. (Harmer and Shipley, Ref. 18, fig. 46, pp. 131-133). In general outline only does this form resemble the cutinized microfossil S. lenticulare n. sp. Another form noted in the same reference and under the same group which compares favorably in size and shape to S. lenticulare n. sp. is Pyrocysitis fusiformus. A constriction (isthmus) at the center separates two semi-cells.

A careful check was made of a study by Elias of prairie-grass seeds of the Late Tertiary deposits of the Prairie States. (Elias, 1942, Ref. 14). The illustrated fossil grass vegetative and reproductive parts are much too large as well as being obviously morphologically different from any of the cutinized microfossils studied by the writer. Grass pollen is

not considered in the above statement.

Modern grass pollen is remarkably uniform throughout the family. (Wodehouse, Ref. 49. pp. 303-304). Their shape when fully expanded are generally spheroidal or, some species, tend to be ovoidal or ellipsoidal. Their size ranges from about 22 mu to a little over 100 mu in diameter. The writer mentions the pollen of grasses because of two morphologic features which have striking resemblance to a form designated by the writer as Sporitoides spinus n. sp. A small spine-like projection is frequently seen on some of these forms which can be compared to the single germ pore, the base of which is surrounded by a thickened rim of exine. (Wodehouse, Ref. 49, pp. 304-305). Its general shape outline is also somewhat similar. A noticeable difference however is size; as mentioned previously, the maximum diameter of grass pollen is a little over 100 mu. The mean diameter of S. discus varies between 160 to 190 mu. Wodehouse states (Ref. 49, p. 306) that the single minute germ pore is unique having been recorded in the grains of no other plants.

A brief discussion of the pollen of FOSSIL GYMNOSPERMS, Cycadofilicales, (Pteridosperms), is taken from a section of the text of Wodehouse (Ref. 49,

pp. 211 - 232) where quite a number of forms are fully described.

As mentioned earlier in this thesis, modern pollen grains are quite small, in fact so small that they were not at first considered very seriously as a possible source of close comparison to the cutinized microfossils occurring in the Loon River shale and other sedimentary rocks. Wodehouse cites evidence (Ref. 49, p. 211) of fossil pollen of comparatively large dimensions. He states: "The most outstanding characters of the pollen grains of the Cycadofilicales are their large size and pluricellular structure". Different described species range in size from 70 to 500 mu in diameter. In some, the cell cavity contains only two cells while in others there is as many as 30. The cell cavity is almost invariably filled with cellular tissue having well-developed walls. Saporta and Marion (1885), from Wodehouse, (Ref. 49, p. 211), describes pluri-cellular pollen grains which are 500 mu long which were taken from the pollen chamber of Pachytesta. Similar grains about 400 mu long and without exines were described by Rennault presumably about the same time. An important point discussed by Wodehouse,(Ref. 49, p. 213), is the lack of the broad germinal furrow which were so

prevalent in the later gymnosperms. This is significant because none of the cutinized microfossils studied by the writer show a germinal furrow of this description, and if they are spores or pollen they are presumably acolpate.

The Cycadofilicales are the most primitive gymnosperms, with the habit and certain of the anatomical features of ferns. It is now thought (Wodehouse, Ref. 49) that the Cycadofilicales were not derived from ferns but existed with them in Devonian times. In their early history they probably gave rise to the Cordaitales, and this group extended a little way into the Mesozoic. From them developed the group Bennettitales or Hemicycadales which became the dominant vegetation of the Mesozoic.

Some of the larger forms of this latter group also seem to possess marked similarities to the cutinized microfossils described in this thesis. One of these is Stephanospermum akenoides Brongn. Most of the description is from Oliver (1904), after Wodehouse (Ref. 49, p. 218). It is ellipsoidal, 160 by 100 mu or occasionally 200 mu long. "Texture of the outer coat finely granulated or sculptured, the interior of the grain divided into about 20 wedge-shaped cells disposed in five rows around the major

axis of the grain." The whole interior of the grain is marked out by internal tissue, consisting of numerous cells which line the exospore everywhere. The above grains were taken from pollen chambers. The writer has frequently observed a pluricellular structure in some of the cutinized microfossils considered in this thesis and is apparently a common feature. The writer has not seen however, the wedge-shaped cells as depicted in the drawings by Wodehouse, (Ref. 49, p. 219, fig. 62).

Another large species is Pachytesta gigantes Grand'Eury, (Wodehouse, Ref. 49, p. 221, fig. 65, B. and C.)

"Grains ellipsoidal, about 500 mu long, pluricellular. Found in the pollen chamber of Pachytesta (Saporta and Marion, 1885, p. 64), a Permocarboniferous genus of seeds from the coal measures of France and elsewhere, distinguished by their large size, which is about equal to that of a hen's egg. The plants which bore these seeds are certainly not known but probably belonged to the Medullosae (Seward, 1917)."

Atheotesta elliptica, (Wodehouse, Ref. 49, p. 221, fig. 65, A). Described as, ellipsoidal form, with dimensions of 320 to 400 mu long and 270 to 310 mu broad. The interior cavity is divided into a number of walls forming numerous cells. The name

was given by Renault to seeds found in rocks of Permian age but unknown affinities. He thought they might belong to Dolerophyllum.

The fossil pollen of Cordaitales can be dismissed from consideration because of their small size, (maximum diameter 100 mu) and these grains posses a single longitudinal furrow.

2. METHODS OF DESIGNATING PLANT MICROFOSSILS, (TERMINOLOGY)

Several methods have been devised by micro-paleontologists to designate the specific identity of spores and pollen. Different uses for which the studies were undertaken and personal preferences are main reasons for these various methods. Designations also vary with the geologic age of the material and the state of morphologic knowledge of the plants to which they are related. Some Cenozoic plant material can be assigned with some degree of certainty to existing groups of plants. A great many are tentatively placed in artificial morphologic groups because botanical relationships are in many cases merely conjectural. These "species" nevertheless are frequently valuable from a geologic point of view. This tendency is of necessity more prevalent as one goes back in geologic time. However desirable it is to know the affinities of spores, and other microcutinized

elements, it is not necessary to wait until such knowledge is attained. This is supported by the fact that several systems for designating spores and pollen have been used with some success in geologic, especially, stratigraphic work.

British workers, including (Raistrick, Ref. 28) and (Paget, Ref. 27) and others, have designated the identity of a number of Carboniferous spores with a letter to represent general groups and a subnumber to represent specific forms. Six spore groups, referred to by letters from A to F, were established, (Wilson, Ref. 48 p. 116) and specific forms within a group were designated as A_1, A_2, A_3, etc.

German workers started other systems. Potonie (1934), after (Erdtman, 1943, Ref. 15, pp. 215-216), used a number of symbols to convey some ideas of shape, numbers of furrows or pores and type of ornamentation, etc. Erdtman suggests that a standard system of this type would be useful in routine work of a specialized institution, but would not be of much use in common practice.

General terms were also introduced, for example the generic name Sporonites, (R. Pontonie, 1931) after (Erdtman, Ref. 15 p. 217), when dealing with fossil fungus spores. Fossil bryophyte and pteridophyte spores, whose determinations are not certain,

are called Sporites. This name is also used when there is doubt as to whether the material is pollen or spores. Sporites has been divided into three major groups: (1) those spores without a germinating aperture (Aletes), (2) spores with one germinating aperture (Monoletes), (3) spores with a trilete aperture (Triletes). Genera were established under these three groups, according to the character of the spore coat ornamentation, such as degree of smoothness, reticulation, punctation, etc. Megaspores and microspores were not separated in the above classification. An example of subdivisions of the Alete group of Sporites is as follows. (Ibrahim, 1933 after Erdtman, Ref. 15, p. 217).

1. Punctata - sporites
2. Apiculata - sporites
3. Zonala - sporites
4. Reticulara - sporites.

German workers also found it expedient to designate fossil pollen as pollenites. Modified generic names, as prefixes, were hyphenated with the term pollenites, for example Tilia - pollenites. Ertdman, (Ref. 15, p. 218), objects to the word pollenites because it merely indicates the fact that the object so designated is a fossil pollen grain; also, it becomes so universal in application that it means almost nothing. Wodehouse surmounted this

shortcoming by proposing (1933), (Wilson, Ref. 48. pp. 116-117 and Erdtman, Ref. 15, pp. 218-219) a modified system of nomenclature. Fossil pollen whose identification was relatively certain with respect to the family but remain unknown as to genus would carry the root name of the family plus the suffix " - pites." In cases where the fossil material is identified with some assurance to an existing genus, then, the root of the genus is used with the suffix " -pites." If a positive generic relationship is determined, the valid generic name is used. In cases where fossil pollen resembles an established species of a modern plant but some doubt exists as to its certainty, the suffix "-pites" is added to the root of that species. The chief advantages of this system are, the freedom of the use of descriptive adjectives as specific names without the introduction of trinomials; also, some idea of the exactness or reliability is conveyed. The fact that the determination was based on fossil pollen grains is indicated by the suffix.

In America, Schopf, Wilson and Bentall, (1944, Ref. 31), reviewed most of the literature pertaining to the classification of Paleozoic spores. They attempted to place the descriptions of these fossils on the basis of the International Rules of Nomenclature and to assemble them into more natural

groupings. This taxonomic revision was presented in the form of an annotated synopsis of several hundred Paleozoic fossil spores in which generic groups were defined. For a complete discussion of the guiding principles which relates to their treatment, the writer refers the reader to their work.

A very brief summary of the guiding principles established and applied by Schopf, Wilson and Bentall, is as follows:

"1. Only adherence to the systematic principles embodied in the International Rules will give satisfactory results in the study of microfossils".

"2. Species classified within the same genus or under the same generic name must possess significant characteristics in common."

"3. There is considerable divergence amongst paleobotanists in their treatment and interpretation of unusually complete specimens. In most cases parts are found separated and generally classified separately." In subtype, they state the following: "No plant, and certainly no single specimen can have more than one valid name. However, instances arise in which it is difficult to determine which of two or more names should actually be applied. In spite of this, systematic procedure demands that an author follow some consistent usage".

4. The practice adopted by the authors with regard to the determination of synonymy is conservative to the extent that unless conspecific relationship is proved for two nomenclatural types, both names are valid. The word synonym is used as an absolute term, i. e. partial synonyms are not synonyms.

5. In making specific identifications, emphasis is placed on positive evidence of similarity rather than on negative evidence of lack, real or fancied, of features which cannot be examined critically.

6. This synopsis considers a species of plant, as a group of organisms. It is fairly certain that spores are just as definitive of a species as any other organ belonging in a coordinated manner to the life cycle of a particular plant individual.

7. The primary purpose of giving a name is simply a convenience in reference. All previously given names that are taxonomically valid should be continued.

3. TERMINOLOGY USED IN THIS THESIS, (CLASSIFICATION)

With regard to terminology and nomenclature, the writer is faced with the problem of not knowing with certainty the plant or animal affinities of the micro-elements studied. Certain morphologic structures, composition, and other features, strongly suggest that most of these micro-elements are the parts of the

reproductive organs of plants. In view of the foregoing discussion on methods of classification and terminology, which apply directly to spores and pollen proper, the writer feels that a somewhat tentative, artificial system, based on morphologic characteristics of the microfossils, would at the present time, be of the most use. As mentioned before the main purpose of giving a name to a taxonomic group is not to indicate the characters or history of the group, but is merely a convenience in reference. A name focuses attention on, and it is hoped, will stimulate further study of this previously-neglected group of microfossils. Until more is learned about the finer details of their structure, terminology should be restricted to the more salient features of morphology. Descriptive terms have been suggested by the writer which it is hoped would not cause later confusion when this gap in the knowledge of these microfossils has been studied and more fully understood.

The writer introduces two "form-genus" group names. These are "Sporangitoides" and "Sporitoides." Sporangitoides refers to all forms whose size and morphology resemble spore-sacs or spore-containers. Sporitoides is used to designate those form types

which look like megaspores. The term megaspore is here used in reference to size only. According to botanical usage, the distinction between microspores and megaspores is based on functional differences. R. B. Thomson (Ref. 45) has shown anomalous cases where the microspore is sometimes larger than the megaspore. The form-genus group *Sporangitoides* is subdivided into five finer divisions, that is, form-species, on the basis of distinctive morphologic and size differences. These have been designated as follows, by giving descriptive trivial names.

1. *Sporangitoides lenticulare*
2. *Sporangitoides giganteum*
3. *Sporangitoides ellipsoprolatum*
4. *Sporangitoides circulare*
5. *Sporangitoides mesocirculare*

The form-genus group *Sporitoides* is subdivided on the same basis as above, into two sub-groups, or form-species. They are as follows:

1. *Sporitoides spinus*
2. *Sporitoides discus*

Generally, common and well preserved specimen types were isolated and studied structurally. These are permanently located in the University of Alberta

Type Micropaleontological Collections. Complete descriptions have been prepared which are contained in Chapter III of this thesis along with camera lucida drawings of each of the selected proposed holotype and paratype specimens. All of the commoner forms have been illustrated by drawings of several selected paratypes. This has been done to indicate the variance of morphology within the arbitrary form-genera and form-species. In addition, Chapter I, includes statements concerning the abundance and stratigraphic distribution of these types as revealed to date, by this preliminary study.

Another form type is tentatively assigned to the Hystrichosphaerid group.

A glossary of morphologic terms is included in the appendix of this thesis.

CHAPTER III

DESCRIPTIONS OF MORPHOLOGIC TYPES

Kingdom: Incertae sedis

Genus: Hystricosphaera Wetzel 1933.

Hystrichosphaera loonriverensis, n. sp.

Plate 1, figures 25, 29, 30, 31, 32, and 33.

Symmetry. Central body is circular, flattened and disc-like with radial symmetry in one plane. Spoke-like projections vary in number and position of attachment to the disc-like body.

Shape. Body proper is a flattened circular, or nearly circular disc with 6 to 11 spoke-like projections extending radially outward from the periphery of the disc. Some are bent into various shapes. In some specimens these projections extend inward a short distance into the disc and appear slightly thickened at the proximal end. The thickness of the arm-like projections is not constant, some appearing filamentous and some considerably thicker, even within the same specimen. On some specimens, (476-150), a loose irregular, thin menbranous folded exine extends outward from near the center of the flattened disc.

The outer extremities of the spoke-like appendages are enlarged, in some they appear like small barbs, in others the enlargement is irregular. There is a faint indication that the appendages consist of elongated cylinder shaped segments, joined end to end. The body of a paratype (specimen 498-150-3 pl. 1, fig. 32), is very compressed and has little content and appears like a thin menbranous sac. Paratype 498-150-4 (pl. 1, fig. 29) is impregnated with, or contains within the sac a black granular substance.

Size

Specimen number	1	2	3	4	5
Diam. flattened disc.	66	72-75	78-94	71-80	62-75
Overall max. diam.	134	158	130	136	136
Mean length of arm-like proj.	39	20-40	26-32	32	26-45
Thickness of center disc.	13				24

(All measurements in microns)

Specimen number	Specimen
1	476-150-1
2	476-150-2
3	498-150-3
4	498-150-4
5	565-100-5

Ornamentation. All forms are minutely granulose and slightly rugose. Specimen 476-150-1, pl. 1, fig. 33, has a comparatively large depression in the center of the disc which seems to have been caused by collapse of the outer wall. Specimen 476-150-2, pl. 1, fig. 25, has very faint markings on the flat side of the disc as indicated by accentuated shading in camera lucida drawing. None of the other specimens show distinct ornamentation.

Color. Varies from a light straw to a light resinous yellow. Arm-like projections appear lighter in color as they are more translucent to light than the thicker flattened disc-like center. Specimen 498-150-4, pl. 1, fig. 29, is the only one which contains a fine granular substance, black, and opaque to light.

Coat. Cutinous, generally quite thin and seems uniform in thickness. Under high magnification appears finely

granular and less translucent to light than substance of spoke-like projections.

Diagnostic features. Size and shape are relatively constant. Disc is always compressed and flat, with spokes always joined to the disc at or near peripheral margin of disc. Number of spoke-like projections cannot be considered diagnostic as they vary from 6, most common, to as high as 11.

Affinity. This form compares most closely to *Hystrichosphaera tubifera*, Ehrenburg, Upper Cretaceous, France, (Glaessner, Ref. 17, pl. 3, fig., p. 49) and is assigned to the Hystrichosphaerid group.

The typical representative of this group is the genus *Hystrichosphaera* O. Wetzel, 1933, described as a hollow sphere of microscopic size, consisting of a chemically highly resistant membrane bearing numerous acicular, tubular or branching spines. The diameter of the sphere varies from 0.01 to 0.07 mm. They were originally referred to *Zanthidium*, a genus of a living freshwater algae, by Ehrenburg in 1836. Subsequent investigators have noted similar elements from the Ordovician, Silurian, Devonian, Jurassic, Cretaceous, Eocene and Miocene rocks. Merrill (1895), after Glaessner, considered similar forms found in Cretaceous flints from Texas as sponge spicules (*Geodia*).

Other authors have suggested that they may be the spiny eggs of a marine crustacea (ova hispida). O. Wetzel thinks they might be the unknown remains of organisms related to the dinoflagellates. Eisenack (1938), after Glaessner, referred to the Hystrichosphaerids as "cysts".

Remarks. The form illustrated in Glaessner, (Ref. 17, pl. 3, fig. 6, p. 49). Shows twenty spine-like projections on the species H. tubifera. It is also noted that their point of attachment to the main body is not confined to the outer peripheral margin. Measurement made of the drawing indicate that it has an overall diameter of 93 mu and the diameter of the irregular sphere-like center is 40 mu, and has projections 25-28 mu long. This indicates that this genus is somewhat smaller than the form from the Loon River formation.

In general outline, Hystrichosphaera loonriverensis compares with the Foraminifera genus Vahhoeffenella Rhumbler 1905, family Astrorhizidae. (Cushman, Ref. 10, key plate 1, fig. 14). Its description is as follows: (Cushman, Ref. 10 p. 72) "Test free, consisting of a compressed central chamber with thin chitinous wall, the exterior a polygonal, peripheral, tubular chamber of sand grains with apertural tubes at the angles; apertures at ends of tubes. -- Recent, particularly

the Antarctic. This genus is somewhat similar to an *Astrorhiza* with the outer material removed from the central disc, leaving the chitinous lining."
Of the numerous specimens of *H. loonriverensis* examined, no sand grains were evident, all were naked of foreign material. The size of *Vanhoeffenella* is also much larger than *H. loonriverensis*.

Comments on Zygospore of a Desmid.

A form illustrated by Bradley (Ref. 7, pl. 23, fig. 4) from the Green River formation, has close similarity in size and shape to *Hystrichosphaera loonriverensis* n. sp. Bradley has tentatively designated it as a Zygospore of a Desmid (?). It consists of a central prolate spheroidal body from which six appendages project outward, the arrangement of which is not symmetrical. Measurements made of the illustration indicate that the diameter of the central body varies between 55 and 70 mu. Overall diameter of the speciman is 90 mu., mean length of arm - like projections vary between 12 - 55 mu.

Occurrences and Stratigraphic Range.

This genus has been seen in microsuites of seven samples from the Loon River formation only.

Holotype localities.

Specimen 476-150-1, Peace River, Alberta, Sec. 2, Tp. 101, Range 20, W. 5th meridian, section station 175, 55 feet above the water level of the

Peace River, Loon River shale, just below the *Ammodiscus* 411A subzone.

Specimen 476-150-2, sample 476, section station 175, 55 feet above the water level of the Peace River, Alberta, Sec. 2, Tp. 101, Rge. 20, W. 5th meridian, Loon River shale, just below the *Ammodiscus* 411A subzone.

Specimen 498-150-3, sample 498, section station 180, 7 3/4 feet above the water level of the Peace River, Alberta, Sec. 29, Tp. 102, Rge. 21, W. 5th meridian, Loon River shale.

Specimen 498-150-4, sample 498, section station 180, 7 3/4 feet above the water level of the Peace River, Alberta, Sec. 29, Tp. 102, Rge. 21, W. 5th meridian, Loon River shale, Lower Cretaceous, just below the *Ammodiscus* 411A subzone.

Holotypes. University of Alberta, Paleontological Type Collection.

Phylum PTERIDOPHYTA

Family *Polypodiaceae* - Ferns

Genus *Woodsia*

Woodsia cf. *scopulina* D. C. Eaton, Canad. Nat. II. 2: 91, 1865. (Abrams, Ref. 1, fig. 10, p. 6).

Fossil Indusium of a Fern cf. Woodsia.

Hypotype specimen 628-48, Plate 2, figures 2 and 3.

Symmetry. Only portions of stellate pattern of indusium remain and therefore elements of symmetry are uncertain.

Shape. Roughly elliptical in outline. Edge of margin is quite jagged, with suggestion that indusium was originally deeply cleft. Form is now shaped somewhat like a saucer. On concave side, near the center is a small circular ridge with a circular depression in its center. On the opposite, convex side, a thickening occurs at the center which appears to have been the point of attachment of the indusium to the leaf. Before flattening by compression form may have been more bowl shaped.

Size. Diameter 320 to 560 mu.

Color. Streaked bronze resinous color in reflected light.

Ornamentation. Very finely venated, radiating outward from the point of attachment of the indusium, veins get finer towards the margin. The vein-like tracings are of two distinct sizes, 3 to 5 fine veins are interspaced between the coarser veins. Transmitted light reveals a faint and very fine reticulated surface with the lines radiating outward standing out in sharp contrast to the circular lines crossing them.

These circular lines are more like shadows and appear like faint growth rings, assumed to be the cell wall limits.

Diagnostic features.

Closely spaced radiating venate markings which extend to the outer margin and inward to the thickened center portion of the indusium. Distinct saucer shape, convex as seen from the proximal side, and concave on distal side.

Coat. Very thin and composed of very fine granular, cutin-like substance.

Affinity. This form is strikingly similar to the indusium, i. e., the thin membranous protective covering over the sori of some of the recent ferns, illustrated in Abrams, (Ref. 1, fig.10, p. 6). In this species (*Woodsia* cf. *scopulina*), the indusium is wholly inferior and has divisions which are stellate or spreading. The sori are dorsal, upon the veins, separate, not marginal.

Remarks. Paratype specimens include fragments, one of which looks like portion of the base of indusium, another, consists of outer flange-like portion of an indusium.

Occurrence. Holotype occurs in sample 628, from section station 220, from the Loon River shale,

Lower Cretaceous, approximately the same horizon as the Radiolarian (<u>Conostrobus</u>, <u>Artocapsa</u>, <u>Cyrtocapsa</u>) zone. Occurs 61 feet above the water level of the Peace River, Alberta, Sec. 17, Tp. 106, Rge. 16, W. 5th meridian.

Paratypes from sample 609, from section station 211, from the Loon River shale, Lower Cretaceous, 61 1/2 feet above the water level of the Peace River, Alberta, Sec. 4, Tp. 105, Rge. 16, W. 5th meridian .

Genus: undetermined.

Fern Sporangium (?)

Specimen 2026-Bullock, Plate 5, Figure 5, 6, 7.

<u>Symmetry</u>. A plane of symmetry parallel to length and coinciding with line of dehiscence.

<u>Shape</u>. Side view outline is roughly an ellipse and equatorial plan view appears to have been circular or nearly so before compression on fossilization. In present fossilized state, it is considerably flattened in a plane containing the long axis. A circular indentation at one end appears to have been a point of attachment (proximal end), other end (distal), is more pointed, lacks the indentation, and is quite distinct from proximal end. Specimen is split longitudinally down one side, from end to end, which is probably the line of dehiscence forming the opening through which spore content was dispersed.

Size.

Maximum or longitudinal diameter = 757 mu.
Equatorial diameter = 543 mu.
Thickness of wall = 100 mu.

Color. In thicker regions color is a medium amber yellow, areas where wall is thinner color is a light amber yellow.

Ornamentation. Somewhat coarsely granular, rugose, in reflected and transmitted light, surface of sporangium has a coarse reticular structure which is the surface expression of large, closely spaced cells, making up sporangium wall.

Sporangium wall. Wall is made up of large cells, spheroidal in shape, with their long axis perpendicular to the outer surface. Nine or ten of these cells can be seen arranged side by side along the line of dehiscence for almost the whole length of the specimen. Outer surface of sporangium wall appears to be covered by a very thin granular exine. Composition of entire speciman appears cutinous.. The surface expression of the large closely spaced cells of the wall is a reticulate pattern.

Diagnostic features. Large size makes it easily visible to the unaided eye. Thick wall of the sporangium made up of large thick closely spaced cells.

Remarks and Affinity. This speciman has a remarkable

similarity to sporangia of modern ferns. A point of difference is the lack of a row of enlarged cells along one side which opens the sporangium when ripe, then snaps it shut and the ripened spores are cast out. Illustrations of Recent fern sporangia show the remainder of the wall as being comparatively thin. This fossil specimen has a wall that is uniformly thick throughout.

Occurrences and Stratigraphic Range.

Seen only from one sample (2026-Bullock), from the base of the top Viking sand, basal Lloydminster shale, from the Imperial Eldorena #1 well, LSD 4, Sec. 27, Tp. 57, Rge. 20, W. 4th meridian.

Holotype. University of Alberta, Micropaleontological Type Collection.

Class: Incertae sedis

Sporangitoides n. genus

In this thesis the form-genus *Sporangitoides* is erected to include a group of cutinized microfossils which look like a sporangium, that is, a spore sac or spore cohtainer. Five distinct form species have been tentatively assigned to this form-genus and they are as follows:

1. *Sporangitoides lenticulare* n. sp.
2. *S. giganteum* n. sp.
3. *S. circulare* n. sp.
4. *S. ellipsoprolatum* n. sp.
5. *S. mesocirculare* n. sp.

Sporangitoides giganteum is hereby designated as the genotype. Specimens of this genus all appear to be composed of the same substance which has a somewhat waxy or resinous lustre and is translucent to light. The color varies from a light straw yellow to an amber yellow as seen in reflected and transmitted light. Thinner specimens and thinner portions of the same specimen appear lighter in color than the thicker portions.

Size. Size range for this form generic group varies from 1.5 mm. for the genotype down to 0.2 mm. Form species within this group from restricted geographic localities and stratigraphic horizons appear to be relatively constant in size.

Symmetry. Disregarding irregularities, the form species tentatively assigned to this form genus can be referred to two types of symmetry. Those forms of disc-like, flattened circular outline show approxmate radial symmetry in one plane and those of thin and broad lenticular shape-outlines show a bilateral symmetry as seen in plan view of broad side and edge view.

Shape Outline. The shape outline of some form species varies considerably from the genotype but is relatively constant for form species. Basically, two shape pattern

are represented, a lenticular outline and a circular outline. *S. giganteum* (genotype), *S. lenticulare*, and *S. ellipsoprolatum* are form species representative of the lenticular shape outline and *S. circulare* and *S. mesocirculare* are form species representative of the circular plan outline. A very narrow, elongate, thin-lenticular form, resembling somewhat a flattened spindle is represented by *S. lenticulare* and *S. giganteum*. They are morphologically similar but differ markedly in size, as *S. giganteum* is approximately twice that of *S. lenticulare*. These thin-lenticular form species have a length to width ratio which varies between 3.2 and 5.8 to 1.

A form of much broader lenticular outline has been tentatively designated as S. ellipsoprolatum. The length to width ratio of this form species varies between 2.1 and 2.24 to 1.

All forms assigned to this generic group are quite thin compared to length and width measurements which could be attributed to compression since burial.

Coat and ornamentation. Two form species within this form genus, *S. ellipsoprolatum* and *S. circulare*, are forms which are essentially thin membranous coats that appear like flattened sacs. Very few of these two forms have been split which may be interpretated as caused by compression or it may be a dehiscent feature. Original form was probably spheroidal for *S. circulare* and of prolate spheroidal design for *S.*

ellipsoprolata. Evidence for such an assumption is based on the frequent observation of folds and wrinkles and as they are not constant in design they are not a part of the ornamentation of the sac-like membrane.

Another rare form consisting of a coat only and assigned to this generic group has been tentatively named S. mesocirculare. It is somewhat disc-shaped, subcircular in plan view, with one side concave and the opposite convex. Faint circular spherical impressions are frequently seen on the concave side, which appear to have been formed by spheroidal masses or spores before dehiscence and dispersal. The line of dihiscence coincides with the outer peripheral margin or circumference of form.

In contrast to the above forms which appear thin, membranous and sac-like, are two form species which have a more solid, filled-out appearance. These have been tentatively designated S. lenticulare and S. giganteum (genotype). Most specimens of these latter two above form species have a contained thickened rib of sporogenous tissue extending longitudinally down the medial portion from end to end of specimens. The exterior coat appears thin and of very fine granular texture.

Globular, spheroidal masses, slightly flattened, are seen contained inside the coat of all form species of this form generic group except S. mesocirculare. They vary in size within the same specimen and from specimen to specimen, and have a slight preferential arrangement parallel to length and/or very roughly parallel to circumference of circular forms. In some cases they are doubtfully interpretated as cells, but in the main the writer thinks that they are fossilized globules of some oily or fatty substance, The surface expression of the contained globules, is a warty or pimple-like appearance.

As all the forms are translucent, internal and external features are seen superimposed on one another which show up as light and dark areas as seen with transmitted light.

Small, dark colored, opaque spheres were seen in one specimen only of S. giganteum. The specimen when teased apart with a sharpened needle revealed spheres seen embedded in the medial mass of sporegenous tissue.

Many specimens of S. giganteum and S. lenticulare show a partial splitting apart along the outer edge, into two halves, which frequently is seen to be sheared laterally like the open blades of a pair of scissors so that the specimen roughly resembles a letter "Y".

Size Statistics for *Sporangitoides lenticulare* n. sp.

Graphs in histogram form reveals that 18 out of the 26 specimens considered from this Loon River shale range in length between 540 and 720 mu. Within this "greatest frequency" concentration, 3 out of the 18 range in size between 700 and 720 mu.

Considering width, 16 out of the 26 specimens are between 125 and 170 mu. Three out of 16 are between 150 and 155 mu.

Taking 680 as the weighted mean length and 152 mu as the weighted mean width results in a length to width proportion of 4.5 to 1.

Size Measurements of Sporangitoides lenticulare n. sp.

Specimen	Length (mu)	Width (mu)	Thickness (mu)
683-100	640	145	36
666-80	815	247	18.5
482-100	682	206	16.6
531-150	609	157	
615-120	647	152	10.5
614-150	628	108	Length of stem 246
617-100A	713	150	10
617-100B	700	191	
627-100	819	181	10
639-80	667	162	
654-100	678	134	
476-150	860	121	
665-100	815	149	
665-80	720	261	
610-100A	472	185	
610-100B	590	232	
548-150A	548	137	
548-150B	458	158	
548-150C	484	126	
611-120-8	573	167	
611-120-9	660	153	
611-120-10	675	150	
607-150-1	568	116	
607-150-2	550	100	
607-150-3	457	135	
607-150-4	610	126	

<u>Sporangitoides</u> <u>circulare</u> n. sp.

Plate 2, Figure 9, 10.

Plate 5, Figure 1, 2, 3, 8, 9, 10,12, 13, 15.

<u>Symmetry</u>. Approximate radial symmetry in one plane.

<u>Shape.</u> Comparatively large, roughly circular very flattened disc which was probably nearly spherical in shape before compression. In present state shows no proximo-distal orientation preference. Some specimens show a slight thickening around the periphery.

<u>Size.</u>

Speciman	Max. Diam.	Min. Diam.	Thickness	2
480-80	480	416	19.5	Holotype, pl. 5, fig. 9, 10.
481-80	Mean diam. = 470		7	Hypotype, pl. 2, fig. 9, 10, pl. 5, fig. 8.
475-80	500	384		Hypotype, pl. 5, fig. 1, 2, 3.
628-48-1	538	523		Hypotype
2036 (Bullock)	837	623		Hypotype pl. 5, fig. 12.
Spirit R. specimens	710	655		Not illus.
	615	575		Not illus.

(All measurements in microns).

Specimens of Sporangitoides circulare from the Loon River shale vary in size between a maximum diameter measurement of 507 mu and a minimum of 384 mu. Thickness not diagnostic as dependent upon extent of compression.

Color. Thin areas a light amber yellow and in thickened folded areas color darkens to an amber yellow.

Ornamentation. Distinct surface ornamentation is lacking. Thickened ridges are not a part of the outer surface ornamentation but appears to have been formed by fortuitous folding of coat.

Coat. Thin, cutinous, pluricellular (?), membranous, in the form of a flattened disc. Cellular structure of the coat is sometimes revealed by transmitted light. Thickened portions seem to cone the light forming a rough reticulated surface pattern of light and dark. Few specimens show a longitudinal line of dehiscence, coat then appear as two halves, joined at one end which presumably is the proximal end or point of attachment.

Diagnostic features. Size seems relatively constant for those forms occurring in the Loon River formation, Peace River area, Alberta. They always appear saclike, cutinous, membranous, with the coat made up of numerous closely spaced circular cells. There is no distinctive geometric pattern to the arrangement of cells.

Affinity. These forms have not been found attached and although they appear sac-like, that is, like a sporangium, no spore content was ever definitely seen.

Holotype locality. Specimen 480-80, sample 480, section station 175, 25 feet above the water level of the Peace River, Alberta, Sec. 2, Tp. 102, Rge. 19, W. 5th meridian, Loon River shale, approximately equivalent to the Ammodiscus 411A subzone.

Hypotype localities. Specimen 481-80, section 175, sample 481, 22 feet above the water level of the Peace River, Alberta, Sec. 2, Tp. 102, Rge. 19, W. 5th meridian, Loon River shale.

Specimen 475-80, sample 475, section station 175, 48 feet above the water level of the Peace River, Alberta, Sec. 2, Tp. 102, Rge. 19, W. 5th meridian, Loon River shale.

Specimen 628-48, section station 220, sample 628, 61 feet above the water level of the Peace River, Alberta, Sec. 17, Tp. 106, Rge. 16, W. 5th meridian, Loon River shale, approximately equivalent to the Radiolarian (Cyrtocapsa, Artocapsa, Conostrobus) zone.

Specimen 2036-48 (Bullock), from Imperial Eldorena #1 well, Edmonton area, Alberta, LSD 4, Sec. 27, Tp. 57, Rge. 20, W. 4th meridian, from the bottom part of the shale zone separating the upper and lower Viking sands in the lower Lloydminster shale.

Specimens from Spirit River area, Second White Specks, Turonian age.

Holotype and Hypotypes. University of Alberta, Micro-paleontological Type Collection.

Sporangitoides lenticulare n. sp.

Plate 3, fig. 1, 2, 3, 5, 6, 7, 9, 10,11.

Plate 2, fig. 1, 4, 5.

Plate 4, fig. 3, 4, 6.

Proposed Holotype, specimen 683-100.

Plate 3, Figure 5, 6, 7.

Symmetry. Disregarding irregularities, specimen may be referred to a longitudinal axis of four-fold symmetry, and two longitudinal planes of symmetry.

Shape. In transverse plan view, thin elongate, or thin lenticular. Length : width : thickness ≑ 19 : 4.2 : 1, length : width ≑ 4.4 : 1. In shape outline it may be compared to a narrow leaf, pointed at both ends. One end is terminated by two sides, convex outward, meeting at a point, the other end is terminated by sides concave outward meeting at a point. The latter end is arbitrarily considered by the writer to be the point of attachment or proximal end, assuming of course, that the form was attached.

Size.

Length = 640 mu

Width = 145 mu

Thickness = 34 mu (33.6 mu)

Color. Straw yellow in thinner portions, darkening to an amber yellow in thicker portions.

Ornamentation. Distinct external surface ornamentation of outer coat is absent. In plan view a thickened irregular rib extends down the center from end to end. Transmitted and reflected light reveals closely spaced, flattened, sphere-like cells or fossilized globules of fats or oils. The latter suggestion is probably the more correct because they seem to portray no consistent geometric arrangement which they probably would have if they were cells. There is however a slightly preferred orientation of these globular masses parallel to length. The surface expression of these contained globules is a warty appearance. These thickened areas cones transmitted light and stand out quite clearly as seen against a white background. The thickened longitudinal center is interpretated as a concentration of sporogenous tissue. The globules in this speciman vary in diameter from 18 to 45 mu.

Coat. Is comparatively thin, fine granular, cutinous-like substance.

Diagnostic features. Shape : length : width ratio is relatively uniform from specimen to specimen. Thickness is the most variable of the measurements. Thickened longitudinal rib is present in most specimens although it is not always confined to the center. Central rib is located off to one side in a few specimens.

Holotype locality. Specimen 683-100, sample 683, section station 251, 39 feet above the water level of the Peace River, Alberta, Sec. 23, Tp. 107, Rge. 15, W. 5th meridian, Loon River shale, about 12 feet above the Radiolarian (_Cyrtocapsa_, _Artocapsa_, _Conostrobus_) zone.

Holotype. University of Alberta, Micropaleontological Type Collection.

Sporangitoides lenticulare n. sp. var. A.
Hypotype Specimen 666-80,
Plate 4, Figure 3, 4, 6.

This specimen shows a line of dehiscence along the outer edge. It is partially open and spread apart slightly like the blades of a pair of scissors. This is a common feature seen in specimens of _Sporangitoides lenticulare_ and _S. giganteum_.

Size.

Length = 815 mu

Width = 247 mu

Thickness = 18.5 mu

Shape

Length : width : thickness = 22.7 : 7.5 : 1, length : width = 3.3 : 1. A thickened longitudinal rib of sporogenous tissue on the inside extends from end to end. Two distinct sizes of cells or spherical globules are seen. Mean diameter of larger globules 60 mu and mean diameter of the smaller globules or cells = 29 mu.

Color. Light yellow, darker in the thicker areas.

Remarks. Softens slightly in water and acids.

Coat. Appears to be thinner near the outer flange-like edge.

Hypotype locality. From sample 666, section station 241, 76 feet above the water level of the Peace River, Alberta, Sec. 20, Tp. 107, Rge. 15, W. 5th meridian, Loon River shale.

Hypotype. University of Alberta, Micropaleontological Type Collection.

Sporangitoides lenticulare n. sp. Var. B.
Hypotype Specimen 614 - 150.
Plate 5. Figure 14.

This specimen is unique in having an extra appendage attached to one end, which is tapered and made up of 8 or 9 segments or divisions. The camera

lucida drawing illustrating this speciman is an interpretive, diagrammatic in part, reconstruction.

Size.

Overall length = 866 mu

Length of appendage = 248 mu

Length of body proper = 628 mu

Width of sporangium = 108 mu

Length : width = 5.8 : 1

Hypotype locality. From sample 614, from section station 211, 39 1/2 feet above the water level of the Peace River, Alberta, Sec. 1, Tp. 105, Rge. 16, W. 5th meridian, Loon River shale.

Hypotype . University of Alberta, Micropaleontological Type Collection.

Sporangitoides lenticulare n. sp. var. C.

Hypotype Speciman 627-100

Plate 3, Figure 9, 10, 11.

The camera lucida drawings illustrating this form were done during the early stages of this work when the writer first began to examine them critically. Two of the drawings, pl. 3, fig. 9, 10, illustrate the surface features as seen in reflected light. In transmitted light and against a white background, internal structure is seen, interpretated and a

tentative reconstruction given. Solid lines indicate structure that is distinct and easily seen. In the thicker center portions where structure is less distinct internal structural interpretation is given by dotted lines, pl. 3, fig. 11.

The central thickened sporogenous tissue stands out as a dark shadow extending from end to end of the speciman. This central mass consists of flattened spherical masses arranged in line and joined end for end. Each side of the central mass is bordered by the outer coat which forms a thin flange-like projection tapering to a point at each end. In transmitted light very small sphere-like masses can be seen superimposed on the much larger spheroidal structures.

Size.

Length = 819 mu

Width = 180 mu

Thickness = 10 mu

Length : width : thickness = 81.9 : 18 : 1.

Length : width = 4.5 : 1

Hypotype locality . From sample 627, section station 220, 67 feet above the water level of the Peace River, Alberta, Sec. 17, Tp. 106, Rge. 16, W. 5th meridian, Loon River shale.

Hypotype. University of Alberta, Micropaleontological Type Collections.

Sporangitoides lenticulare n. sp. var. D.

Hypotype Specimen 4912-100A (Wetter).

Plate 3, Figure 1, 2. 3.

Symmetry. Form can be referred to an approximate longitudinal axis of four-fold symmetry and two planes of symmetry passing through the longitudinal axis.

Size.

Length = 613 mu

Maximum width = 191 mu

Maximum thickness = 61 mu.

Color. Medium to dark amber or resinous yellow.

Shape. Thin elongate or thin-lenticular in plan view.

Length : width : thickness = 10 : 3.1 : 1.

Length : width = 3.2 : 1.

One end is distinctly more pointed than the other. Form is quite robust, filled-out. A distinct thickened ridge extends from end to end parallel to the length, maximum width of this thickened ridge is 121 mu. In transmitted light it is seen to consist of closely spaced comparatively large fossilized sporogenous tissue and what looks like globules of oil or fat. Some of these could be spores (?). Assuming more blunt

end to be proximal and opposite end as distal.

Ornamentation of outer coat. Slightly wrinkled (rugose). Surface expression of contained spherical globules is slightly raised bumps which have a general linear arrangement parallel to length.

Remarks. This is the thickest specimen of Sporangitoides lenticulare studied.

Hypotype locality. About 65 feet above the base of the fish scale sand zone (Cenomanian), St. John formation, at locality A, on Septimus Creek, British Columbia, in Sec. 20, Tp. 28, Rge. 18, W. 8th meridian. (Ref. 6, Wetter).

Hypotype. University of Alberta, Micropaleontological Type Collection.

Sporangitoides lenticulare n. sp., var. D.

Hypotype specimen 4912-100-B (Wetter)

Plate 2, Figure 1, 4, 5.

Size.

Length = 667 mu

Maximum width = 152 mu

Maximum thickness = 43 mu

Cell or globular mass measurements:

Maximum diameter = 52 mu

Minimum diameter = 19 mu

Length : width : thickness = 15.5 : 3.5 : 1.

Length : width = 4.4 : 1.

Shape. Narrow, elongate, both ends gently tapered, terminated by rounded ends, one end more blunt than the other. For proximo-distal orientation assuming blunt end to be proximal, or point of attachment and opposite end as proximal. Side peripheral edges quite sharp which coincides with line of dehiscence. In many of the Loon River specimens, edge is frequently flange-like, in contrast to those from the St. John formation which are in most specimens comparatively much thicker.

This specimen also exhibits a central thickened rib extending from end to end longitudinally.

Coat. Slightly rugose, made up of very fine granular cutinous-like material as seen in reflected light.

Hypotype locality. About 65 feet above the base of the fish scale sand zone, Cenomanian, St. John formation, at locality A, on Septimus Creek, British Columbia, in Sec. 20, Tp. 28, Rge. 18, W. 8th meridian.

Hypotype. University of Alberta, Paleontological Type Collection.

Sporangitoides giganteum n. sp.

Plate 3, Figure 4, 8, 12.

Sporangitoides giganteum n. sp.

Proposed Holotype Specimen B-70-6 (Bahan)

Plate 3, Figure 8, 12.

Symmetry. Before dehiscence form can be referred to two approximate planes of symmetry and a longitudinal axis of four-fold symmetry.

Shape. Unusually large when compared to S. lenticulare. In plan view it is thin elongate or thin lenticular, may be compared to a flattened spindle. Tapers to a rounded termination at both ends. This specimen has dehisced, that is, split apart along the outer edges for about 4/5 of its total length, the two halves are still attached together at one end. At the opposite end the two halves have been sheared laterally, like the blades of a pair of scissors. Its present shape outline may be compared to a rough letter Y.

Size.

Length = 1580 mu

Width of specimen before dehiscence = 324 mu

Diameter of globules = 85.6 mu

Diameter of smaller globules or cells of outer wall = 21 mu

Thickness = 113 mu

Length : width : thickness = 14 : 2.9 : 1.

Length : width = 4.9 : 1.

Ornamentation and structure.

Where corrosion has not obliterated structure, on both the inner and outer sides of the sporangium can be seen spherical globular masses of two general sizes. The smaller flattened spheres appear to be a part of the sporangium wall which are very closely spaced and have a general arrangement parallel to length. The larger flattened sphere-like masses have less regular distribution and are confined more to the medial area. The larger spherical indentations and raised flattened spheres appear like fossilized oil globules or part of the contained sporogenous mass.

Color. Straw to amber yellow.

Coat. Is distinctly seen when specimen is placed on edge. At a magnification of X105, it appears to be quite thin and membranous.

Diagnostic features. It compares closely in general morphology to *S. lenticulare*, occurring in the Loon River shale, but is considerably larger. *S. giganteum* is twice the average length of *S. lenticulare*.

Holotype locality. From the Pelican sand, 15 feet from the base, Athabaska River, Alberta, 1 mile below Wheel Rapids, on the east bank at the apex of sharp "V" band in the river, Sec. 16, Tp. 81, Rge. 17 W. 4th. meridian.

Holotype. University of Alberta, Micropaleobotanical Type Collection.

Sporangitoides giganteum n. sp. var. A.

Hypotype Specimen 2026 (Bullock)

Plate 3, Figure 4.

This specimen has been teased apart, split in half along the two lines of dehiscence. Inside, embedded in the medial mass of sporogenous tissue are small black colored spheres, which appear pyritized. Semispherical cavities can be seen where spheres have been dislodged from position by teasing with a sharpened needle. A thickened sporogenous tissue is confined to the medial inside half of the sporangium. In complete specimens it is this same mass which forms the thickened rib extending from end to end and parallel to length. The spheres when examined under higher magnification (X380) appear to have a very faint spiral line extending around the sphere from pole to pole. The writer makes this latter statement with reservation because it was seen so indistinctly. These spheres are presumably spores.

Size.

Width of sporangium = 307 mu

Diameter of sphere = 38 mu

Comparison.

These spheres (spores ?) are larger than the smaller flattened spheres and slightly less than one half as large as the larger spheres in the holotype specimen.

Color. Thin areas of sporangium is a dirty yellow, in thicker areas it is a dirty amber yellow.

Hypotype locality. From the top of the shale zone separating the upper and lower Viking sands, Lloydminster shale, Imperial Eldorena #1 well, Alberta, LSD 4, Sec. 27, Tp. Rge. 20, W. 4th meridian.

Sporangitoides ellipsoprolatum n. sp.

Plate 2, Figure 6, 7, 5.

Plate 4, Figure 1, 2, 4, 7, 8.

Plate 5, Figure 4, 11.

Proposed Holotype Specimen 475-100

Plate 4, Figure 1, 5.

Symmetry. Bilateral symmetry.

Size.

Longitudinal diameter = 607 mu

Equatorial diameter = 304 mu

Thickness = 44 mu.

Shape. Is similar to a flattened lemon. Plan view of broad side is broad lenticular or ellipse-like. The elliptical outline has a length to width ratio of approximately 2 to 1. Before flattening by compression

shape was probably very similar to that of a filled out lemon. Edge view shows that specimen has been compressed to a thickness of about one cell.

Coat and ornamentation. Using transmitted light, internal structure is seen to consist of numerous closely spaced fossilized oil or fat globules or cells. This structural feature is seen with difficulty using a binocular microscope with reflected lighting. There is no regular geometric distribution or arrangement to the cell-like or globular masses. Irregular ridges and troughs of the outer coat is interpreted as compression folds, it appears to consist of a fine granular cutinous substance which is thin and membranous. When teased with a needle, coat is tough and somewhat springy. It is softened very slightly by the application of water, acids, and bases.

Color. A light amber or straw yellow.

Remarks. This form resembles an elongated, flattened spindle, sac-like container and for this reason the writer assumes it to be a sporangium. Only one specimen was seen to have a line of dehiscence along one side which could also be interpreted as a split caused by compression. The writer has never been able to obtain distinct tangible evidence of a spore content as was obtained for S. giganteum.

Hypotype locality. From sample 475, section station 175, 47 feet above the water level of the Peace River, Alberta, Sec. 11, Tp. 102, Rge. 19, W. 5th meridian, Loon River shale, approximately equivalent to the bottom part of the Haplophragmoides 424 zone.

Sporangitoides ellipsoprolatum n. sp. Var. A.
Hypotype Specimen 665-80
Plate 2, Figure 6, 7, 8.

Symmetry. Bilateral, if specimen was not damaged at one end.

Size.

Longitudinal diameter = 713 mu
Equatorial diameter = 318 mu
Maximum thickness of sporangium = 76 mu
Diameter of top, largest sori impression = 76 mu
Diameter of the smallest and center sori = 109 mu
Diameter of the bottom sori = 117 mu

Color. Light to dirty yellow.

Shape. Plan view outline of flat side is broad lenticular somewhat like a very flattened ellipse with a length to width proportion of 2.24 to 1. Edge view of sporangium is very thin elongate. Original shape was probably spindle-like and similar to a sac-like container, gently tapered at both ends.

Ornamentation and other markings on coat.

Camera lucida drawing pl. 2, fig. 6, shows a carbonaceous fragment of a parallel venated leaf impressed on the outer surface of the sporangium wall. Near the upper right hand side of the leaf fragment is a distinct circular depression, the one beneath is a slightly raised impression and the one above is seen as a very faint shadow outline. These comparatively large circular markings are interpretated as being the sori of a fern leaf. The fern leaf and sporangium were superimposed on one another and pressed together during fossilization.

The small cells of the sporangium, if they are cells, stand out like small warts or pimples. They have a general distribution parallel to the length of the sporangium. The outer surface coat is minutely granulose showing little folding and appears cutinous in substance. At some places along the outer periphery sporangium wall is more translucent than medial areas.

Hypotype locality.

From sample 665, section station 241, 83 ½ feet above the water level of the Peace River, Alberta, Sec. 20, Tp. 107, Range 15, W.5th meridian, Loon River shale.

Hypotype. University of Alberta, Micropaleontological Type Collection.

Sporangitoides ellipsoprolatum n. sp.

Hypotype Specimen 480-100

Plate 5, Figure 4, 11.

Size.

Longitudinal diameter = 666 mu

Equatorial diameter = 326 mu

Thickness = 84 mu

Length : width = 2.04 : 1.

Remarks. This specimen is illustrated by two camera lucida drawings of the same side. Pl. 5, fig. 4, shows the external surface coat features indicating the prominent folds formed by compression. By lowering the plane of focus and using transmitted light, internal structural features are noted and an attempt made to illustrate them, pl. 5, fig. 11. Internally it is seen to be made up of numerous closely spaced flattened globules.

Hypotype locality. From sample 480, section station 175, 23 ½ feet above the water level of the Peace River, Alberta, Sec. 11, Tp. 102, range, 19, W. 5th. meridian, Loon River shale.

Hypotype. University of Alberta. Micropaleontological Type Collection.

Sporangitoides ellipsoprolatum n. sp. Var. B.

Hypotype Specimen B-71-10 (Bahan)

Plate 4, Figure 2, 7, 8.

Symmetry - Approximately bilateral.

Size.

Longitudinal diameter = 980 mu

Equatorial diameter = 457 mu

Maximum thickness = 88 mu

Mean diameter of the larger spherical globules = 47 mu

Mean diameter of the smaller spherical globules, cells (?) = 24 mu.

Length : width = 2.14:1.

Shape. Plan view of flattened side is broad lenticular. Rounded tapered ends with one end sharper than the other. Blunter end is considered as proximal or point of attachment and sharper end is considered distal. Edge view shows that specimen has been considerably compressed.

Structure, ornamentation and other markings.

Both flattened sides exhibit pronounced folding of the thin, fine granular, cutinous coat. Outer surface is covered with closely spaced irregularly distributed raised spherical protuberances, like numerous pimples. This seems to be the surface expression of the outer coat containing the spherical masses within. Their substance does not seem to differ

from the outer coat. The larger spherical masses contain smaller spheres within them. As the light source is moved it is noted that the sphere outlines change position slightly, indicating that thickened areas has a coning effect upon the light rays.

Line of dihescence probably coincides with sharp line of folding along circumference of specimen.

Color. Thinner portions more translucent and a light straw yellow, tending to a darker almost amber color in the thicker less translucent portions.

Comparison. Shape is similar to, but is considerably larger than similar forms occurring in the Loon River shale.

Remarks. Horn seen at one end of edge view of this specimen, pl. 4, fig. 7, is not a diagnostic feature, but is merely a fortuitous twist of the distal end of specimen.

Hypotype locality. Ten feet from the top of the Joli Fou shale, Sec. 16, Tp. 81, Rge. 17, W. 4th meridian, on the east bank of the Athabaska River, about one mile north-east of Wheel rapids, Alberta.

Hypotype. University of Alberta, Micropaleontological Type Collection.

Sporangitoides mesocirculare n. sp.

Plate 1, Figure 22, 23, 24, 26, 27, 28.

Proposed Holotype Specimen 665-80

Plate 1, 26, 27, 28.

Symmetry - Approximately bilateral.

Size.

Longitudinal diameter = 196 mu

Equatorial diameter = 241 mu

Color. Light amber yellow.

Composition . Fine granular cutinous substance.

Shape and ornamentation. One half of this sporangium is missing. Line of dehiscence coincides with the circumference of specimen. In plan view outline shape is subcircular, with the outer side convex as shown by camera lucida drawing pl. 1, fig. 26. Drawing, pl. 1, fig. 28, is the concave or inner side of sporangium wall. Drawing, pl. 1, fig. 27, shows in oblique view the indented or concave side of sporangium.

On the inner concave side distinct spherical indentations can be seen, which on the opposite side show up as shadows. The writer is interpreting these indentations as formed by spherical masses or spores before dehiscence and dispersal. It is difficult to

determine whether the wall structure of this sporangium is pluricellular, as some of the spherical indentations can be seen and it may be the shadows of this feature which look like cells. The diameter of the cells (?) or spherical indentations vary between 18 and 30 mu.

Remarks. S. mesocirculare is a very rare form.

Holotype locality. Sample 665, section station 241, 83 feet above the water level of the Peace River, Alberta, Sec. 20, Tp. 107, Rge. 15, W. 5th meridian, Loon River shale, about 20 feet above the Radiolarian (Cyrtocapsa, Artocapsa, Conostrobus) zone.

Holotype. University of Alberta, Micropaleontological Type Collection.

Sporangitoides mesocirculare n. sp. Var. A.
Paratype Specimen 4610-100-2 (Wetter).
Plate 1, Figure 22, 23, 24.

Symmetry . Approximately bilateral.

Color. Light amber yellow.

Size.

Longitudinal diameter = 238 mu

Equatorial diameter = 224 mu

Thickness = 33 mu

Comparative size measurements of other specimens.

Specimen	Long. diam. (mu)	Equat. diam. (mu)	
4610-100-1	248	238	Not illus.
4610-100-3	276	247	Not illus.
4610-100-4	234	219	Not illus.

Shape. In disc-like, subcircular in plan view outline, comparatively thin as seen in edge view. One side is slightly convex outward and the other is concave. A suggestion that specimen has split in two halves by dehiscence along the outer circumference. An examination of comparative specimens indicates that although they all tend to be circular and are approximately the same size, the irregularities in shape outline are not constant from specimen to specimen.

Ornamentation. Surface is slightly rugose. Coat appears to be finely granular, cutinous in composition, thin. Seen in reflected and transmitted light the thin membranous wall appears to be made up of cells. Seen on the concave side these structures appear more like faint impressed indentations formed by spore-like masses, spores (?), which were dispersed on dihiscence.

Remarks.

S. mesocirculare is considerably more abundant here, see below, than in theLoon River Shale.

Hypotype locality. Occurs 49 feet above the Second Tuff zone, St. John formation, from an exposure, at the mouth of St. John Creek, on Beatton River, Sec. 14, Tp. 84, Rge. 18, W. 6th meridian, locality B, British Columbia. (Personal communication, R. Wetter, 1951).

Class: Incertae sedis

Sporitoides n. genus

In this thesis the form genus Sporitoides is erected to include all those forms of cutinized microfossils which look like a megaspore. The term megaspore is used in reference to size only. Two distinct form species have been tentatively assigned to this form genus and they are as follows:

1. Sporitoides spinus n. sp.
2. S. discus n. sp.

Sporitoides spinus is hereby designated as the genotype. All specimens appear to be composed of the same composition which has a somewhat waxy resinous lustre and is translucent to light. Color is usually various shades of amber yellow with thin specimens tending to have a light straw yellow color.

Size range of specimens of the genotype S. spinus vary between 134 and 180 mu for longitudinal diameter, and 133 to 174 mu for equatorial diameter measurements.

For *S. discus*, longitudinal diameter varies between 134 and 171 and equatorial diameter measurements are between 98 and 166 mu.

Symmetry. Most specimens of this generic group are roughly bilaterally symmetrical as seen in plan view of broad side and edge view.

Shape outline. Most specimens assigned by the writer to this form genus group are characterized by a circular or nearly circular outline, very flattened in one direction so that the form resembles a small disc.

Some specimens have one to three, and in rare specimens, four spine-like protuberances projecting outward from the peripheral margin. Where there are more than one protuberance, one is usually larger and more spine-like than the rest. Some specimens show a small notch or depression on each side of the spine. Those specimens with spines have been assigned by the writer to the genotype form species *S. spinus*.

For orientation purposes the writer assumes the most prominent spine or protuberance as the proximal end or point of attachment (proximal pole). Relative to this orientation the other protuberances are situated on the equator and at ppposite sides, the fourth protuberance when present is located at the distal pole.

Those forms of approximately the same size and shape as the genotype S. spinus, but lack the spine or protuberances have been tentatively assigned to the form species S. discus.

Coat. Appears cutinous, membranous, fine granular, rugose in some specimens, with no definite pattern to folding. Some specimens, of the S. discus form species group reveal in transmitted light a mosaic of what looks like closely spaced cells, resembling in plan view a cobble stone pattern. This cell-like pattern is not seen in some specimens, example S. discus n. sp. var. A, pl. 1, fig. 34, 35 and 36.

Remarks. Because of the very small size of this form genus, high magnification is necessary to study them and the forms differing from the genotype are observed with difficulty using moderate power of magnification.

Record of size measurements for the genotype Sporitoides spinus n. sp.

(All measurements in mu)

No.	specimen	Long. diam.	Equat. diam.	Thick-ness	Hypotype (x)
1.	669-150	156	139	51	x
2.	534-150-3	134	146	52	x
3.	533-150	181	173		x
4.	530-150	177	174	23.8	Holotype
5.	529-150	190	171	52	x
6.	527-150	158	155		Not illus.
7.	614-150	177	174	9.7	x
8.	665-150-1	160	133		Not. illus.
9.	665-150-2	138	133		Not illus.
10.	459-150-6	180	160		Not illus.
11.	459-150-7	180	153		Not illus.
Arithmetic mean		166.3	159.1		

NOTE

Throughout thesis change:

"Sporitoides spinus" to "Sporitoides spinum",

"Sporitoides discus" to "Sporitoides discum".

Sporitoides spinus n. sp.
Plate 1, Figure 1, 2, 3, 4, 5, 6, 7, 8, 9,10, 11, 12, 15, 20, 21.

Sporitoides spinus n. sp.
Proposed Holotype Specimen 530-150
Plate 1, Figure 1, 2, 3.

Symmetry. Specimen can in a general way be referred to two longitudinal planes of symmetry and a longitudinal axis of four-fold symmetry.

Shape. Plan view outline of broad side is nearly circular, very flattened in one direction so that form is much like a small disc. At one pole is a spine-like projection. A small notch can be seen beside the base of the spine which in this particular specimen occurs only on one side. On some specimens this feature occurs on both sides and is more like a rounded depression rather than a sharp notch. Using the same orientation in space, two rounded protuberances are on the equator on each side opposite one another.

Size.

Equatorial diameter = 177 mu

Longitudinal diameter = 174 mu

Maximum thickness = 34 mu

Ornamentation

Spine and two protuberances referred to above.

Diagnostic features.

The disc-shape and relatively constant size are the two most diagnostic features. The spine is broken on many forms and the two side protuberances are lacking in many specimens, and are seen only under high magnification.

Coat.

Appears thin, cutinous, membranous, fine granular, quite rugose, no definite pattern to folding.

Color.

Dirty resinous to orange yellow.

Affinity. In general shape it is closest to the pollen of the grass family, but it does not compare in size, as the maximum diameter of grass pollen is a little over 100 mu. This is discussed in more detail, in Section 1 of Chapter II of this thesis.

Holotype locality. From sample 530, section station 187, 27 ½ feet above the water level of the Peace River, Alberta, Sec. 7, Tp. 104, Rge. 19, W. 5th. meridian, from the Loon River shale, approximately equivalent to the upper part of the *Ammodiscus* 411A subzone, of the *Haplophragmoides* 424 zone.

<u>Sporotoides</u> <u>spinus</u> n. sp.
Hypotype Specimen 529-150
Plate 1, Figure 4, 5, 6.

<u>Comparison.</u> At each side of the spine are smaller protuberances separated from the central spine by small depressions. Dark shaded areas are thickened ridges caused by folding of outer coat on compression and fossilization. This specimen is somewhat thicker than the proposed holotype specimen.

<u>Size</u>.

Equatorial diameter = 171 mu
Longitudinal diameter = 190 mu
Thickness = 52.

<u>Hypotype</u> <u>locality</u>. From sample 529, section station 187, 33 feet above the water level of the Peace River, Alberta, Sec. 7, Tp. 104, Rge. 19, W. 5th meridian, from the Loon River shale.

<u>Hypotype</u>. University of Alberta, Microbotanical Type Collection.

<u>Sporotoides</u> <u>spinus</u> n. sp. Var. A.
Hypotype Specimen 614-150.
Plate 1, Figure 10, 11, 12.

<u>Symmetry</u>. Specimen can be referred to two longitudinal planes and a longitudinal axis of four-fold symmetry.
<u>Shape.</u> Circular to rounded square outline with small pointed projections at each of the rounded corners. These projections are quite distinct at three corners and less so at the fourth.
<u>Coat ornamentation</u>. Surface has a medium granular texture. A slightly raised circular rim can be seen on both sides extending around, a short distance in, and roughly parallel to the peripheral margin or circumference. On one side, pl. 1, fig. 10, are three faint radial markings extending from near the center to the circumference. On both sides of the disc a slightly raised arcuate thickening joins a small spine-like protuberance projection at one pole to a similar small spine at the opposite pole. These markings do not appear to be consistent from specimen to specimen, and are probably the result of fortuitous folding, on compression, of the outer wall.
<u>Size.</u> Longitudinal diameter = 177 mu
Equatorial diameter = 174
Maximum thickness = 10 mu
<u>Hypotype</u> <u>locality</u>. From sample 614, section station 211, $38\frac{1}{2}$ feet above the water level of the Peace

River, Alberta, Sec. 4, Tp. 105, Rge. 16, W. 5th meridian, Loon River shale.

Hypotype. University of Alberta, Micropaleontological Type Collection.

Sporitoides spinus n. sp. Var. B.
Hypotype specimen 669-150
Plate 1, Figure 7, 8, 9.

Symmetry. Disregarding irregularities, specimen can be referred to two longitudinal planes of symmetry and an axis of four-fold symmetry.

Size. Longitudinal diameter = 156 mu
Equatorial diameter = 139 mu
Maximum thickness = 51 mu

Shape. Somewhat like a disc, plan view of flat side is subcircular, edge view is a medium lenticular outline with a sharper taper at one end than the other. A pronounced spine-like projection is at one end. For orientation purposes, this is referred to as the proximal pole.

Ornamentation of coat. Coat has fine granular surface and appears to consist of a tough membranous cutinous substance. This specimen is unique in showing raised impressions of small prolate spheroidal bodies contained within the coat. These may be stored fossil fats, oils or starch. They lack regular distribution and are seen on both sides.

Comparison. This specimen is smaller in diameter but is thicker than the specimen selected as holotype.

Hypotype locality. Sample 669, section station 241, 51 feet above the water level of the Peace River, Alberta, Sec. 20, Tp. 107, Rge. 15, W. 5th meridian, Loon River shale.

Hypotype. University of Alberta, Micropaleontological Type Collection.

Sporitoides spinus n. sp. Var. C.
Hypotype Specimen 534-150-3
Plate 1, Figure 20, 21.

Symmetry. Disregarding irregularities speciman can be referred to two planes of longitudinal symmetry and an axis of four-fold symmetry.

Size.	Longitudinal diameter	= 134 mu
	Equatorial diameter	= 146 mu
	Maximum thickness	= 52 mu

Shape In plan view, shape outline is somewhat like a toy top, with distal portion subcircular and proximal portion rectangular and terminated by a spine-like protuberance. At each side on the equator is a comparatively large outward bulge. They are irregular in shape and approximately opposite one another. In this respect this specimen is somewhat similar to the proposed holotype specimen 530-150. Edge view is lenticular, with one end rounded and the other quite sharply tapered.

Ornamentation Irregular ridges of local thickening which appear to have been produced by compression and fortuitous folding of outer wall. Coat is thin, membranous, fine granular and cutinous.

Color. Amber yellow as seen with a petrographic microscope, using transmitted light.

Hypotype locality. Sample 534, section station 192, 40 feet above the water level of the Peace River, Alberta, Sec. 32, Tp. 104, Rge. 19, W. 5th meridian, Loon River shale.

Hypotype . University of Alberta, Micropaleontological Type Collection.

Sporitoides spinus n. sp. Var. C.
Hypotype Specimen 533-150
Plate 1, Figure 15,

This specimen has been illustrated because it shows a part of the coat broken away exposing the hollow interior, left side, a part of the coat remaining in place. As seen here coat appears like a thin cutinous, fine granular membrane.

Size. Longitudinal diameter = 181 mu
Equatorial diameter = 173 mu

Hypotype locality.

Sample 533, section station 192, $32\frac{1}{2}$ feet above the water level of the Peace River, Alberta, Sec. 32, Tp. 104, Rge. 19, W. 5th meridian, Loon River shale.

Sporitoides discus n. sp.

Plate 1, Figure 13, 14, 16, 17, 34, 35, 36.

Sporitoides discus n. sp.

Proposed Holotype Specimen 534-150-4

Plate, 1, Figure 13, 14.

Symmetry. One longitudinal plane and an axis of two-fold symmetry.

Shape. Irregular disc shaped. Plan view of broad side is rounded and subcircular, as if a circle had been compressed from two opposite sides, approaching shape of an ellipse. Edge view is roughly lenticular with one side smoothly convex and the opposite, quite irregular and less convex in outline.

Size. Longitudinal diameter = 140 mu

Equatorial diameter = 98 mu

Maximum thickness = 42.5 mu

Coat ornamentation. Transmitted light reveals a mosaic of closely spaced cells which in plan view resemble cobble stones. Approximately 14 cells can be seen around the outer circumference of the specimen. Coat comparatively smooth, fine granular, cutinous, no distinct folded areas.

Color. Using petrographic microscope color appears amber yellow.

Comparison. Although size and general shape of S. spinus and S. discus are very similar, in fact so much so

that they cannot be told apart using a microscope of moderate to low magnification. _S. spinus_ lacks a cellular structure and _S. discus_ lacks spine-like protuberances.

Hypotype locality. From sample 534, section station 192, 37 feet above the water level of the Peace River, Alberta, Sec. 32, Tp. 104, Rge. 19, W. 5th. meridian, Loon River shale, approximately equivalent to the _Ammodiscus_ 411A subzone of the zone _Haplophragmoides_ 424.

Holotype. University of Alberta, Micropaleontological Type Collection.

Sporitoides discus n. sp.
Hypotype Specimen 553-150
Plate 1, Figure 16 , 17 .

Size. Longitudinal diameter = 134 mu
Equatorial diameter = 115 mu

Shape. General shape is somewhat like a small disc. Plan view outline of broad side is rounded and sub-circular similar to the outline of an egg, with one end more round and broader than the other end. Edge view is not illustrated but is very similar to that of the holotype.

Coat ornamentation. Placing specimen on a glass slide and using transmitted light, a closely spaced mosaic

of cells can be seen. Cell-like structure is not evident using reflected lighting. The writer is not certain if this cell-like structure is a part of the coat or inner contents of the specimen. Coat appears fine granular, cutinous, and using petrographic microscope color appears amber yellow.

Hypotype locality. From sample 553, section station 194, 21 feet above the water level of the Peace River, Alberta, Sec. 25, Tp. 104, Rge. 18, W. 5th meridian, Loon River shale.

Hypotype. University of Alberta, Micropaleontological Type Collection.

Sporitoides discus n. sp. var. A.

Hypotype Specimen 618-100

Plate 1, Figure 34, 35, 36.

Symmetry. Approximate radial symmetry in one plane.

Size. Longitudinal diameter = 171 mu

Equatorial diameter = 166 mu

Maximum thickness = 21 mu

Color. Light resinous yellow.

Shape. Shaped much like a disc. Plan view of broad side is almost circular. Edge view is narrow lenticular with one side slightly more convex outward than the opposite side. Original shape may have been nearly spherical.

Ornamentation. On both sides of the specimen there are several ridges and troughs which seem to have been formed by folding on compression of the outer coat. No indication of trilete scars indicative of haptotypic tetrad arrangement.

Coat. Very thin and translucent.

Comparison. This specimen differs from the other illustrated specimens of *S. discus* in that it lacks a pluricellular mosaic structure. It is also obviously different from *S. spinus* because of the absence of spine-like protuberances, but its size measurements compare most closely to the average of this form species.

Hypotype locality. Sample 618-100, section station 211, 20 feet above the water level of the Peace River, Sec. 4, Tp. 105, Rge. 16, W. 5th meridian, Loon River shale.

Hypotype. University of Alberta, Micropaleontological Type Collection.

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This is offered because many geologists are familiar with this form.

Genus TASMANITES Newton, 1875

Sporangites Dawson, 1863 (pars.), Canadian Naturalist, new ser., vol. 8, no. 6, pp. 431-457.

(Illustrated and fully described by Schopf, Wilson and Bentall, Ref. 31).

Plate 1, Figure 18, 19.

Symmetry. Radial symmetry in one plane.

Size. Diameter = 271 mu

Maximum thickness = 61 mu

Color. Dark resinous amber, tending to have a reddish hue in reflected light. Very slightly translucent.

Shape. A flattened disc, view of broad side almost circular, edge view, narrow lenticular. Original shape was spherical.

Ornamentation. There is a narrow ridge a short distance in from and parallel to the circumference. Rather than being a distinct feature of ornamentation, it is probably result of folding on compression. Surface of the disc is covered by numerous very small pits and protuberances.

Remarks. Two specimens of Tasmanites embedded in black shale were examined by the writer. No evidence of trilete or monolete markings were seen.

Specimen from Exshaw shale, Mississippian-Devonian boundary, Imperial Sterling #1 well.

EXPLANATION OF PLATE 1

Figure 1, 2, 3 : Sporitoides spinus n. sp., X106, proposed holotype specimen 530-150, from the Loon River shale, at locality 187-530, 27.5 feet above the water level of the Peace River, Alberta, approximately equivalent to upper part of Ammodiscus 411A subzone, of the Haplophragmoides 424 zone, 1, plan view of one side, 2, edge view, 3, plan view of opposite side.

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Figure 4, 5, 6: Sporitoides spinus n. sp., X105, hypotype, specimen 529-150, from the Loon River shale at locality 187-529, 33 feet above the water level of the Peace River, Alberta, 4, plan view of one side, 5, edge view, 6, plan view of the opposite side.

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Figure 7, 8, 9: Sporitoides spinus n. sp., Var. B. X108, hypotype, specimen 669-150, from the Loon River shale at locality 241-669, 51 feet above the water level of the Peace River, Alberta, 7, plan view of one side, 8, plan view of opposite side, 9, edge view.

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Figure 10, 11, 12: Sporitoides spinus n. sp., Var. A. X104, hypotype, specimen 614-150, from the Loon River shale, at locality 211-614, 38.5 feet above the water level of the Peace River, Alberta, 10, plan view of one side, 11, edge view, 12, plan view of opposite side.

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Figure 13, 14: Sporitoides discus n. sp., X164, proposed holotype, specimen 534-150, from the Loon River shale at locality 192-534, 37 feet above the water level of the Peace River, Alberta, approximately equivalent to upper part of the Haplophragmoides 424 zone, 13, plan view of one side, 14 edge view.

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Figure 15: Sporitoides spinus n. sp., Var. C. X105, hypotype, specimen 533-150, from the Loon River shale at locality 192-533, 43.5 feet above the water level of the Peace River, Alberta, figure shows a part of coat torn away exposing hollow interior on right side, left side, a part of coat remaining in place.

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EXPLANATION OF PLATE 1, (continued)

Figure 16, 17: Sporitoides discus n. sp., X164, hypotype, specimen 553-150, from the Loon River shale at locality 194-153, 21 feet above the water level of the Peace River, Alberta, 16, plan view of one side, 17, plan view of the opposite side.

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Figure 18, 19: Genus TASMANITES Newton, 1875, Sporangites Dawson, 1863, (pars.), Canadian Naturalist, New Ser. vol. 8, no. 6, pp. 431-457. (After Schopf, Wilson, and Bentall, 1944, Ref. 31, p. 11)

A camera lucida drawing, X107, of a specimen of TASMANITES embedded in black Exshaw shale, from Imperial Sterling #1 well, Alberta, Mississippian-Devonian boundary, 18, plan view, 19, edge view.

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Figure 20, 21: Sporitoides spinus n. sp. var. C, X164, hypotype, specimen 534-150-3, from the Loon River shale, at locality 192-534, 40 feet above the water level of the Peace River, Alberta, 20, plan view of one side, 21, edge view.

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Figure 22, 23, 24: Sporangitoides mesocirculare n. sp. var. A, X105, hypotype, specimen 4610-100-2 (Wetter), from 49 feet above the second tuff zone, St. John formation, (Cenomanian), at the mouth of St. John Creek, on Beatton River, British Columbia, 22, plan view of one side, 23, edge view, 24, plan view of opposite side.

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Figure 25: Hystrichosphaera loonriverensis n. sp., cf. tubifera Ehrenberg after Deflandre, (illus. Glaessner, Ref. 16, pl. 3, fig. 6, p. 49), X152, hypotype, specimen 476-150-2, locality 175-476, 55 feet above the water level of the Peace River, Alberta, Loon River shale, 25, plan view of one side.

pp. 41-46

Figure 26, 27, 28: Sporangitoides mesocirculare n. sp., X112, proposed holotype, specimen 665-80, from the Loon River shale, at locality 241-665, 83 feet above the water level of the Peace River, Alberta, about 15 feet above the Radiolarian (Cyrtocapsa, Artocapsa, Conostrobus) zone, 26, plan view of one side, 27, oblique view, 28, plan view of opposite side.

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EXPLANATION OF PLATE 1, (continued)

Figure 29: Hystrichosphaera loonriverensis n. sp., cf. tubifera Ehrenberg after Deflandre, (Illus. Glaessner, Ref. 17, pl. 3, fig. 6, p. 49), hypotype, specimen 498-150-4, from the Loon River shale, locality 180-498, 7 3/4 feet above the water level of the Peace River, Alberta, 29, plan view, X154.
pp. 41-46

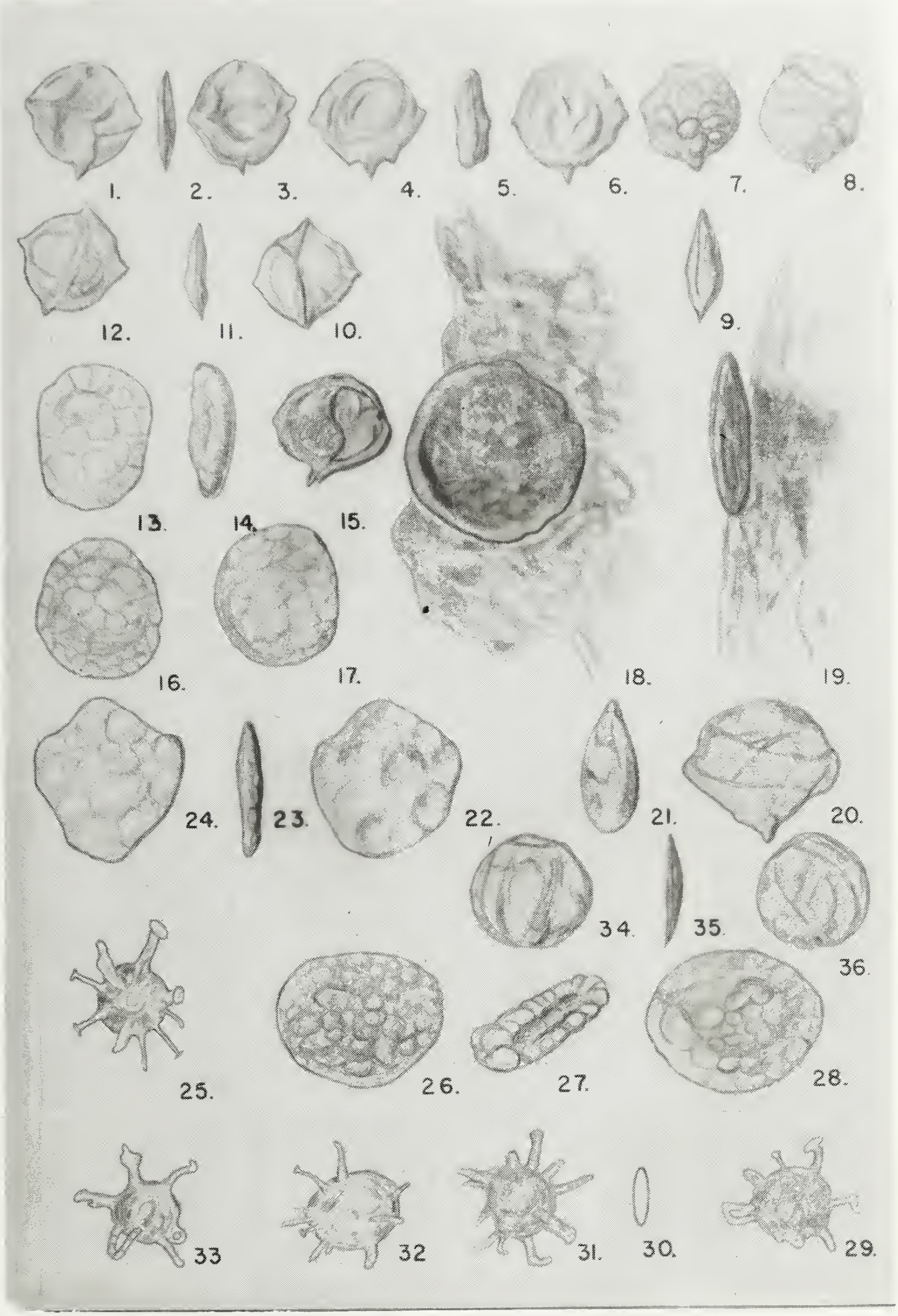
Figure 30: Diagrammatic edge view of Hystrichosphaera loonriverensis n. sp., cf. tubifera Ehrenberg after Deflandre, spoke-like projections not shown, X154.
pp. 41-46

Figure 31: Hystrichosphaera loonriverensis n. sp., cf. tubifera Ehrenberg after Deflandre, X154, hypotype, specimen 565-100-5, from the Loon River shale, locality 202-565, 62 feet above the water level of the Peace River, Alberta, 31, plan view.
pp. 41-46

Figure 32: Hystrichosphaera loonriverensis n. sp., cf. tubifera Ehrenberg after Deflandre, X154, hypotype, specimen 498-150-3, from the Loon River shale, locality 180-498, 7 3/4 feet above the water level of the Peace River, Alberta, 32, plan view.
pp. 41-46

Figure 33: Hystrichosphaera loonriverensis n. sp., cf. tubifera, Ehrenberg after Deflandre, (Illus. Glaessner, Ref. 17, pl. 3, fig. 6, p. 49), X154, proposed holotype, specimen, 476-150-1, from the Loon River shale, equivalent to the Ammodiscus 411A subzone which is the upper part of the Haplophragmoides 424 zone, locality 175-476, 55 feet above the water level of the Peace River, Alberta, 33, plan view.
pp. 41-46

Figure 34, 35, 36: Sporitoides discus n. sp. var. A, X105, hypotype, specimen 618-100, from the Loon River shale, locality 211-618, 20 feet above the water level of the Peace River, Alberta, 34, plan view of one side, 35, edge view, 36, plan view of the opposite side.
p. 98



CRETACEOUS CUTINIZED MICROFOSSILS

EXPLANATION OF PLATE 2

Figure 1, 4, 5: Sporangitoides lenticulare n. sp. var. D, X105, hypotype, specimen 4912-100B (Wetter), from 65 feet above the base of the fish scale zone, (Cenomanian), St. John formation, at locality A, on Septimus Creek, British Columbia, 1, plan view of one side, 4, edge view, 5, plan view of the opposite side.

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Figure 2, 3: Fossil indusium of fern cf. Woodsia scopulina, X105, proposed holotype, specimen 628-48, from the Loon River shale, about 20 feet above the Radiolarian (Cyrtocapsa, Artocapsa, Conostrobus) zone, locality 211-628, 61.5 feet above the water level of the Peace River, Alberta, 2, plan view of convex side, 3, view of opposide, concave side.

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Figure 6, 7, 8: Sporangitoides ellipsoprolatum n. sp. var. A, X105, hypotype, specimen, 665-80, from the Loon River shale, locality 241-665, 83.5 feet above the water level of the Peace River, Alberta, 6, plan view of one side, 7, edge view, 8, plan view of opposite side.

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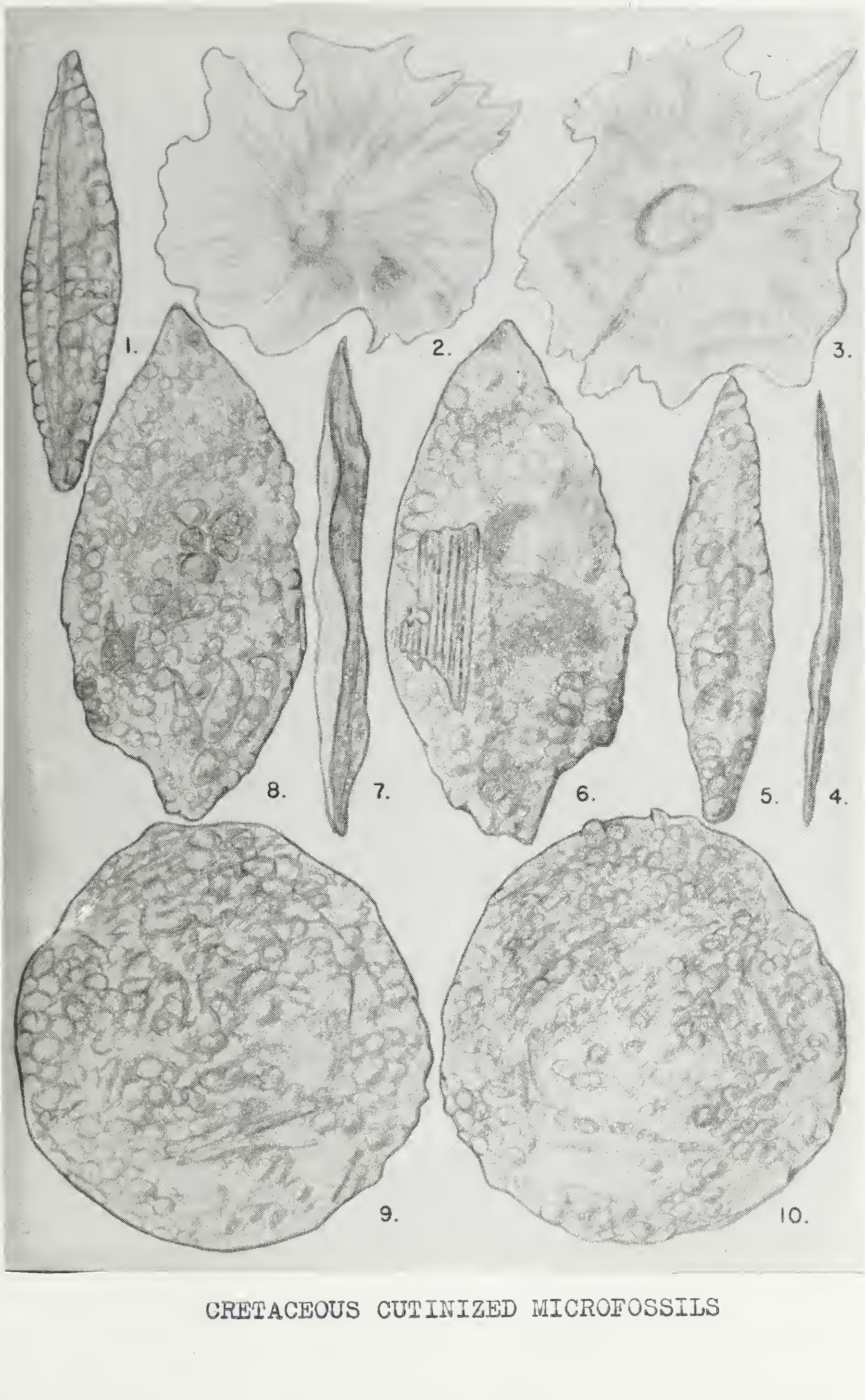
Figure 9, 10: Sporangitoides circulare n. sp. X149, hypotype, specimen 481-80, from the Loon River shale, locality 175-481, 22 feet above the water level of the Peace River, Alberta, 9, plan view, 10, plan view of the opposite side.

pp. 59-62



CRETACEOUS CUTINIZED MICROFOSSILS

EXPLANATION OF PLATE 3

Figure 1, 2, 3: Sporangitoides lenticulare n. sp., X107, hypotype, specimen 4912-100A (Wetter), about 65 feet above the base of the fish scale zone, (Cenomanian), St. John formation, at locality A, on Septimus Creek, British Columbia. p. 68

Figure 4: Sporangitoides giganteum n. sp. var. A, X104, hypotype, specimen 2026 (Bullock), from the top of the shale zone separating the first and second Viking sands, in the basal Lloydminster shale, Imperial Eldorena #1 well, Alberta, specimen has been split apart by teasing with sharpened needle, exposing small black, opaque spheres, embedded in sporogenous tissue, circular depressions can be seen where spheres have been dislodged. p. 74

Figure 5, 6, 7: Sporangitoides lenticulare n. sp., x110, proposed holotype, specimen 683-100, from the Loon River shale, occurs 34 feet above the Radiolarian (Cyrtocapsa, Artocapsa, Conostrobus) zone, locality 251-683, 39 feet above the water level of the Peace River, Alberta, 5, plan view, 6, edge view, 7, plan view of the opposite side. p. 62

Figure 8, 12: Sporangitoides giganteum n. sp., X105, proposed holotype, specimen B-70-6 (Bahan), from the Pelican sand, 15 feet above the base, Athabaska River, one mile below Wheel Rapids, Alberta, 8, plan view, 12, edge view. p. 71

Figure 9, 10, 11: Sporangitoides lenticulare n. sp. var. C, X105, hypotype, specimen 627-100, from the Loon River shale, locality 220-627, 67 feet above the water level of the Peace River, Alberta, 9, plan view showing outer surface configuration, 10, edge view, 11, plan view reconstruction of the interior of specimen. p. 65

CRETACEOUS CUTINIZED MICROFOSSILS

EXPLANATION OF PLATE 4

Figure 1, 5 : Sporangitoides ellipsoprolatum n. sp., X148, proposed holotype, specimen 475-100, from the Loon River shale, occurs in the bottom part of the Haplophragmoides 424 zone, locality 175-475. 47 feet above the water level of the Peace River, Alberta, 1, edge view, 5, plan view of one side.

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Figure 2, 7, 8: Sporangitoides ellipsoprolatum n. sp. Var. B. X108, hypotype, specimen B-71-10, ten feet from the top of the Joli Fou shale, on the east bank of the Athabaska River, Alberta, about one mile north-east of Wheel Rapids, 2, plan view, 7, edge view, 8, plan view of the opposite side.

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Figure 3, 4, 6; Sporangitoides lenticulare n. sp. Var. A. hypotype, specimen 666-80, from the Loon River shale, locality 241-666, 76 feet above the water of the Peace River, Alberta, 3, X153, plan view, 4, X110, plan view, 6, X108, plan view of the opposite side.

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CRETACEOUS CUTINIZED MICROFOSSILS

EXPLANATION OF PLATE 5

(These camera lucida drawings have been reduced 5/8 original size.)

Figure 1, 2, 3 : Sporangitoides circulare n. sp. X94, hypotype, specimen 475-80, from the Loon River shale, locality 175-475, 48 feet above the water level of the Peace River, Alberta, 1, plan view, 2, plan view of opposite side, 3, plan view using another microscope.

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Figure 4, 11: Sporangitoides ellipsoprolatum n. sp., X94, hypotype, specimen 480-100, from the Loon River shale, locality 175-480, 23.5 feet above the water level of the Peace River, Alberta, 4, plan view of outer coat, 11, plan view showing external features superimposed on internal structure.

p. 79

Figure 5, 6, 7: Fossil form which superficially resembles modern fern sporangia, X44, specimen 2026-C (Bullock), from the top of the shale zone separating the first and second Viking sands, in the basal Lloydminster shale, Imperial Eldorena #1 well, Alberta, 5, view of outer coat, 6, view of opposite side showing gap exposing inner cavity and cell structure of the sporangium wall, 7, view similar to 6 but at a slightly different angle.

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Figure 8: Sporangitoides circulare n. sp. X93 hypotype, specimen 481-80, from the Loon River shale, locality 175-481, 22 feet above the water level of the Peace River, Alberta, edge oblique view.

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Figure 9, 10, 15: Sporangitoides circulare n. sp., X92.5, proposed holotype, specimen 480-80, from the Loon River shale, occurs in the bottom part of the Haplophragmoides 424 zone, locality 175-480, 25 feet above the water level of the Peace River, Alberta, 9, plan view, 10, edge view at a slight oblique angle, 15, plan view of the opposite side.

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EXPLANATION OF PLATE 5

(continued)

Figure 12 : Sporangitoides circulare n. sp. X73, hypotype, specimen 2036-48 (Bullock) 4 feet from the bottom of the shale zone separating the first and second Viking sands, basal Lloydminster shale, Imperial Eldorena #1 well, Alberta, plan view, specimen appears to be slightly pyritized.

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Figure 13: Sporangitoides circulare n. sp., X65.6, hypotype, specimen 628-48, from the Loon River shale, locality 220-628, 61 feet above the water level of the Peace River, Alberta, plan view.

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Figure 14: Sporangitoides lenticulare n. sp. Var. B. X65.6, hypotype, specimen 614-150, from the Loon River shale, locality 211-614, 39.5 feet above the water level of the Peace River, Alberta, plan view, diagrammatic in part, reconstruction, showing a segmented appendage at proximal end.

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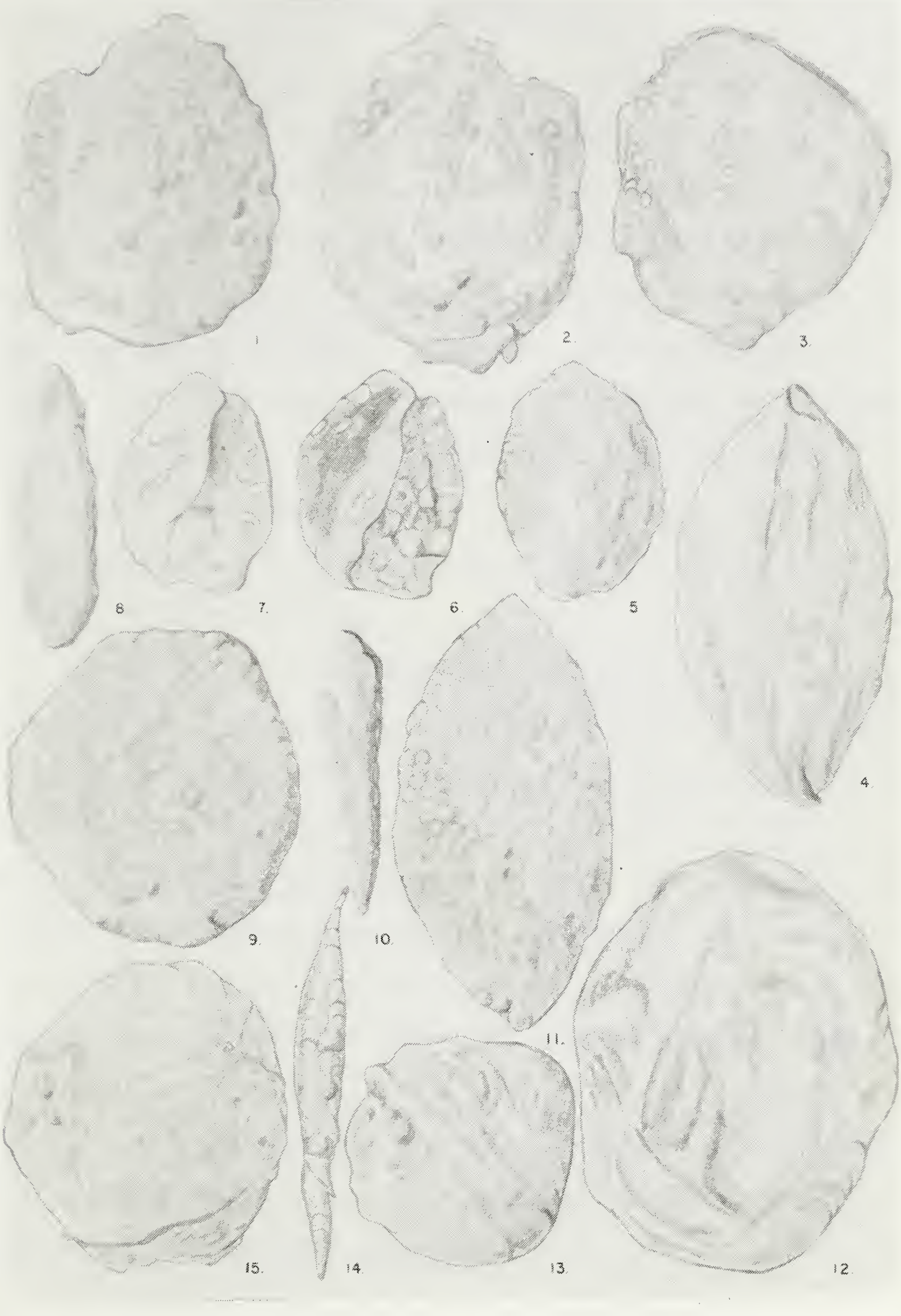


CRETACEOUS CUTINIZED MICROFOSSILS

CHAPTER 4

1. BIOLOGICAL CONCLUSIONS

Eight common and distinct types of cutinized microfossils based upon distinct morphologic and size differences have been recognized by the writer. The writer assumes, but is not certain, that they are the parts or organs of plants representing a part of their reproductive cycle. Evidence based on observation, and reference to available literature, pertaining to the composition of fossil and plant material seems to indicate that these parts or organs are in most cases composed of a very durable substance especially adapted to preservation.

The writer does not know the affinity of these microfossils as they were not found organically attached to the parent body. The larger types look like spore sacs or spore containers, (sporangia). One specimen only, of Sporangitoides giganteum n. sp. was seen to contain small sphere-like masses, presumably spores. All of these cutinized microfossils are considerably larger than most Recent spores and pollen proper. None of the material studied by the writer had monolete or trilete scars or germinal furrows indicating an haptotypic tetrad arrangement which is a common characteristic of most spores and pollen proper.

<u>Sporitoides</u> <u>spinus</u> n. sp. and <u>S</u>. <u>discus</u> n. sp. are amongst the smaller forms of cutinized microfossils studied by the writer and are assumed to be megaspores of unknown affinity.

A very small and fragile form, designated by the writer as <u>Hystrichosphaera</u> <u>loonriverensis</u> n. sp. has been tentatively assigned to the Hystrichosphaerid group whose affinity has been referred to quite a number of things by various authors. Ehrenberg, 1836, (Ref. 16, p. 20), determined them as <u>Zanthidium</u>, a genus of freshwater algae, Merrill, 1895, (Ref. 16), considered them as sponge spicules (Geodia). Lohmann, 1904, (Ref. 16) compared them to the spiny eggs of marine planktonic crustacea (ova hispida). O. Wetzel, 1933 (Ref. 16) stated that they were not "ova" but the remains of unknown organisms related to the dinoflagellates. He later revised his opinion and referred to the Hystrichosphaerids as "cysts."

Bradley, (Ref. 7, p. 45, pl. 23, fig. 4) illustrates a microfossil which has a remarkable similarity in size and shape to <u>Hystrichosphaera</u> <u>loonriverensis</u> n. sp. He refers to it as a Zygospore of a desmid (?).

2. STRATIGRAPHICAL CONCLUSIONS.

Stratigraphically, the samples from which the microfossils for the major part of this study were obtained are from the middle portion of the Loon River shale, that is about 200 feet from the top and about 400 feet from the base, representing a probably thickness of about 300 (?) feet. Geographically, they were obtained from 24 collecting stations spread out over a distance of approximately 64 miles. The most northerly collecting station is located 10 miles upstream from Ft. Vermilion and the most southerly station from which samples were collected and studied is situated 32 miles upstream from where Wolverine River empties into the Peace River.

Within the Loon River shale, the occurrences of cutinized microfossils is tied in with previously established megafossil, ammonoid and pelecypod zones, and new microfaunal zones as recognized and set up by Mr. F. H. Trollope (Supp. Ref. 5).

The age relationship existing between these various zones is shown by the following generalized table. Age sequence is from oldest at the bottom to youngest at the top.

LOWER CRETA-CEOUS	MIDDLE ALBIAN	Zones proposed by Trollope	LOON RIVER SHALE	Lemuroceras zone Beudanticeras zone Haplophragmoides 318B zone Gyroidina 355A (Bathysiphon) - Calcareous Foraminifera	
				Haplophragmoides 360 zone	- Inoceramus dowlingi- (NO CUTINIZED MICRO-FOSSILS) -CUTINIZED MICROFOSSILS
	LOWER ALBIAN			Conostrobus zone.	Cleoniceras
				Haplophragmoides. 424 zone	Ammodiscus 411A subzone -CUTINIZED MICROFOSSILS
				ZONE OF CUTINIZED MICROFOSSILS	
				Radiolarian zone - (Cyrtocapsa, Artocapsa, and Conostrobus)	
				Marine calcareous microfauna (Foraminifera) from a section below Ft. Vermilion, 150 feet approximately above the Devonian.	

It is to be noted that the table on the previous page merely attempts to portray the fossil zone sequences and does not indicate thickness of strata represented by each zone.

The zones contained within the two horizontal lines indicated on the left side of this generalized table are those which have been recognized by Mr. Trollope.

The shale samples containing the micro-organisms studied in this thesis are from strata of the Loon River shale below that in which Beudanticeras is known to occur, and younger than the strata containing the calcareous microfauna (Foraminifera) known to occur in samples from a section below Ft. Vermilion. The lower microfauna was not studied by the writer or by Mr. Trollope. This latter occurrence is estimated to be about 150 feet above the Devonian limestone at this locality.

The bottom-most Radiolarian zone consisting of the three main genera, Cyrtocapsa, Artocapsa and Conostrobus, was noted at the bottom of the most northerly section, (locality 257: 700-704) studied by the writer. It represents the lower limit of the Loon River shale strata in which cutinized microfossils have been observed in this study. The maximum occurrence of cutinized microfossils occurs above the aforementioned Radiolarian zone and below the Ammodiscus 411A subzone.

The Radiolarian, (Conostrobus) zone is immediately above the Ammodiscus 411A subzone and appears to be about 35 (?) feet thick. As the ammonite Cleoniceras is known to occur at the base of this zone it permits a reasonably accurate and long range correlation with the Folkstone Sands of England. (Spath, Ref. 37, vol. II, p. 699). Cleoniceras is said to be characteristic of the Leymereilla regularis subzone of the Leymereilla tardefurcata zone, which is uppermost Lower Albian in age.

Immediately above the Radiolarian (Conostrobus) zone cutinized microfossils come in again and occur in considerable abundance in 50 feet of strata. The cutinized microfossils extend into the bottom half of the Haplophragmoides 360 zone.

Regional section to section correlation based upon the spectra of cutinized microfossil occurrences was done with some success. It must be stated that correlation from section to section does not show exact counts or percentages of identical species, but successional and repetitional trends are indicated. Several obvious reasons why the successional trend is not exact in section to section are as follows: A strong factor would be the areal distribution of flora in this part of Loon River time in the area considered. Another, would be the corrosion of the cutinized microfossils, prior to and during fossilization. A non-uniform method of sampling and the later non-uniform treatment

of samples would produce erratic results.

A cursory examination of microsuites from other sources, from rocks stratigraphically younger than the Loon River shale conclusively indicates that cutinized microfossils are not localized stratigraphically or geographically. Further studies will no doubt reveal an even greater distribution.

Cutinized microfossils have been observed in samples from the Grand Rapids sandstone, Joli Fou shale and Pelican sandstone from sections on the Athabaska River, Alberta. (Bahan, Supp. Ref. 1). These microfossils are considerably larger than equivalent elements studied in the Loon River shale. Varieties of three form species are represented. Sporangitoides giganteum n. sp., S. ellipsoprolatum n. sp. and S. circulare which occur in maximum abundance at and near the top portion of the Joli Fou shale. The same assemblage of cutinized microfossils also occurs in the Viking sands of the Basal Lloydminster shale (Bullock, Supp. Ref. 2), from the Imperial Eldorena #1 well of the Edmonton area, Alberta. The maximum is at the base of the first or top Viking sand. Assuming the above correlation to be correct, this suggests that this zone may occur slightly higher stratigraphically than the similar maximum occurrence zone at the top of the Joli Fou shale.

A sparse number of cutinized microfossils, of two types, *Sporangitoides ellipsoprolatum* n. sp. and *S. circulare* n. sp. were seen in samples from the Shaftesbury Formation from a section on the Smoky River, near Judah railway station, Alberta. (Nielsen, Supp. Ref. 3). Stratigraphically, they were observed to range between 10 and 45 feet above the middle gypsiferous sandstone horizon in the Shaftesbury formation.

Three main types of cutinized microfossils occur in considerable abundance in the St. John formation (Cenomanian) as revealed by a cursory study of sample contents from sections on Septimus Creek, and from the mouth of St. John Creek, on Beatton River, British Columbia. (Wetter, Supp. Ref. 6), varieties of three form species are: *Sporangitoides ellipsoprolatum* n. sp., most abundant, *S. lenticulare* n. sp. var. D, *S. circulare* n. sp. These occur in maximum abundance at 65 feet above the base of the fish scale sand zone in the St. John formation.

The youngest strata in which cutinized microfossils have been observed to date occurs in the Second

White Specks (Turonian) from shale samples from a well in the Spirit River area, Alberta. (J. Wall, personal communication, 1951). A few specimens of varieties of two form species are noted; Sporangitoides circulare n. sp., most abundant, and S. ellipsoprolatum n. sp.

3. PALEO-ECOLOGICAL DISCUSSION OF CUTINIZED MICRO-FOSSILS.

Spores and pollen proper have been found in nearly all types of sedimentary rock although they are not known to have been extracted from conglomerates or Recent and Pleistocene gravel deposits. (Wilson, Ref. 48, p. 112) A few plant fossils have been found in sandstones but this type of sediment does not seem to be favorable to the preservation of spores and pollen; however, conifer pollen has been noted frequently in the sandy sediments underlying the peat of northern bogs. (Ref. 48) They occur rarely in marine limestones but occur abundantly in at least some of the fresh water limestones, especially marl, deposited by fresh water lakes. Calcareous concretions in coal seams has yielded some of the best morphologic material. Spore cases, spores and pollen are frequently so abundant in shales (Dawson, 1871, Ref. 11), (Bradley, Ref. 7) that they overlap one another as seen in thin sections.

The wide range of host rocks mentioned above illustrates the diversity of environmental conditions in which micro-plant material can be preserved.

Considering the Loon River shale, the environments of deposition can best be determined from a study of the sequence of micro-assemblages occurring in suites from the respective collecting stations. These interpretations are based upon the statistical analysis of the cutinized microfossils and their relation to other microfauna and megafossils. The lithology of the Loon River shale is also considered.

McConnell, (Ref. 25, p. 570) described the Loon River shale outcropping in this area as : "About 400 feet of dark greyish or nearly black, soft shales, holding calcareous and ironstone nodules, interstratified with occasional beds of sandstone, impure limestone and ironstone, Fossil wood was found in considerable quantities, scattered through this formation".

In the portion of the Loon River shale considered by this thesis, neither the lower contact with Devonian limestone nor the upper contact with the Peace River sandstone is seen.

The accuracy of the interpretation of the environmental significance of biotopes is limited because of the uncertainty in some cases of definite structural control between sampled localities. An initial study of this type should be done on a single section or samples from a single drilled hole where no doubt would exist about the sequences of micro-assemblages encountered.

With this in mind the writer offers the following generalized interpretation.

It is believed that the Loon River shales are of marine origin laid down by the fluctuating Clearwater sea which McLearn (Supp. Ref. 7) depicts as coming in from the north north-west and flooding to the south south-east. The known occurrence of marine calcareous Foraminifera in a section located below Ft. Vermilion on the Peace River indicates that at this time and place a marine neritic environment existed. This was followed by a considerable deepening of the sea and consequent flooding southwards. This is represented by shale which contains well developed genera of Radiolaria including Cyrtocapsa, Artocapsa and Conostrobus.

Within a short vertical interval and lateral distance to the south the micro-assemblages rapidly alters to that of cutinized microfossils consisting

mainly of Sporangitoides lenticulare n. sp. and lesser numbers of S. circulare n. sp. and S. ellipsoprolatum n. sp. The paucity and complete absence of Foraminifera and Radiolaria and the relative abundance of cutinized microfossils suggests a partial recession of the Clearwater sea resulting in a very shallow brackish environment. Although there is a marked lateral change in the biotopic characters, there is no noticeable change in lithology as indicated by descriptions of these sections. Thus it seems reasonable to assume that the Clearwater sea did not completely recede. A coastal swamp would account for the large amount of carbonaceous matter and fossilized wood as noted by McConnell (Ref. 25).

As the cutinized microfossils are somewhat too large to be carried any great distance by air currents as is done with pollen, it is to be expected that their distribution would be somewhat restricted regionally if deposited on land. If dropped in water, in their original state they would presumably float and their distribution would be the result of wave and current action. Regarded in this sense they would behave as plankton and the possibility of their being distributed over larger areas considerably increased. If these elements are truly planktonic organisms they may reflect the environment of the pelagic realm; and therefore be of small value in the interpretation of depositional environments.

Cutinized microfossils were noted in samples from approximately 15 localities along the Peace River representing a winding river distance of approximately 100 miles and a straight line distance of about 50 miles between the two end stations in which they were observed. Cutinized microfossils completely dominate the organic content observed in these samples.

A deepening of the Clearwater sea or a deeper local embayment is indicated to the south by the appearance of the Ammodiscus 411A subzone micro-assemblages which coincides with the upper portion of the Haplophragmoides 424 zone and it marks the interruption of cutinized microfossils at this stratigraphic horizon and geographic locality. This tenet is supported by the known occurrence of Cleoniceras at the bottom of the Radiolarian Conostrobus 388 zone which occurs in the Loon River shale at this locality in strata above the Haplophragmoides 424 zone. A short distance south the appearance of cutinized microfossils in samples from strata above the Radiolarian Conostrobus 388 zone suggests a shallow marine environment. Glauconite seen in some sample residues along with the cutinized microfossils tends to support this assumption.

Microassemblages from strata above this zone indicates a deeper marine environment and cutinized microfossils are not found with it.

APPENDIX

1. Detailed Descriptions of Lithology at each Collecting Station.

The samples of the Loon River shale from which the microorganisms for this study were obtained were collected by a Pacific Petroleums Ltd., surface party during the field season of 1950. This party consisted of Dr. Pierre Cote, chief; William Elder, George Donn and John Binnie, assistants. The samples treated in this thesis were collected from outcrops along the Peace River between Fort Vermilion and as far south to a point 10 miles north where the 25th. base line crosses the Peace River. Fort Vermilion is situated 345 miles straight line distance, north north-west of Edmonton.

The samples are from the middle portion of the Loon River shale representing a probable thickness of 300 (?) feet.

A condensation of the field descriptions of lithology at each collecting locality is included in this appendix for convenient reference. A map showing a "Key to Geographic Locations of Stations and Faunal Suites" is included with the descriptions.

SUITES 311-319

Locality O 129C, Loon River formation, Peace River, Tp.
R.19, W. 5 meridian, Alberta.

4' Shale - grey, carbonaceous, micromicaceous, fairly fissile.

Suite 311

0.2' Highly rusty layer - could not be found fresh.

11.0' Shale - dark grey, fairly coarse, slightly silty, blocky, fissile in lower portion. Shale contains carbonaceous particles, is micro-micaceous and microsilty.
Suite 312 1' down from base of above.
Suite 313 6' down from base of above.
Suite 314 10' down from base of above.
This last is a sandstone, dark grey, micromicaceous with much coarse glauconite, a mixed sample. (?).

2.0' Nodular shale - shale as above, with little glauconite and numerous small nodules up to 0" in diameter.
Suite 315

3.0' Shale - as above, but without nodules.

4.4' Shale - dark grey, silty, hard and somewhat blocky, small discontinuous nodular layer, 1.5' down.

Suite 316 1' down from base of above.

0.6 - 1.2' Ironstone layering - concretionary, discontinuous.

3.5' Shale - dark grey to black, silty, contains carbonaceous particles, also innumerable elongate nodules.

Suite 317.

6.7' Shale - as above but without nodules, contains carbonaceous particles, and is micromicaceous.
Suite 318 2' down from base of above.
Suite 319 6.7' down from base of above. (i.e. water level).
Covered to water level.

SUITES 349-358

Locality O 137A, Loon River formation, Peace River, Tp. 99, R. 19. W. 5 meridian, Alberta.

4.0' Silty shale - to shaly siltstone, friable. This might well represent the interbanded sandstone and shale at the base of the Notikewin.
Suite 349

3.4' Siltstone - light grey, argillaceous, contains carbonaceous particles.
Suite 350.

0.4' Ironstone layer - fairly discontinuous.

7.0' Siltstone - as above, but contains many rounded nodules, Suite 351

3.0' Siltstone - as above but without nodules.

Covered to water bed.

SUITES 352-358

Locality O 138A Loon River formation, Peace River, Tp. 99, R.19, W. 5 meridian, Alberta.

Recent Silts.

2.0' Shale - as below.

15.0' Shale - grey with brownish hue, slightly silty, micromicaceous and carbonaceous to coaly particles, a few nodules for 5' below base of above, medium blocky.
Suite 352 3' down from base of above.
Suite 353 8' down from base of above.
Suite 354 13' down from base of above.

1.0' Ironstone layer - concretionary, not continuous.

2.0' Shale - similar to that above, almost khaki locally.

16.0' Shale - drab to khaki, medium splintery, slightly silty, carbonaceous particles, some irridescent micromicaceous particles 6" down.
Suite 355 1' down from base of above.
Suite 356 6' down from base of above.
Suite 357 11' down from base of above.
Suite 358 16' down from base of above.

Covered to water level.

SUITES 359-370

Locality C 138B, Loon River formation, Peace River, Tp. 99, R. 19, W. 5 meridian, Alberta.

5.0'	Shale - grey, fissile to hackly, badly weathered, a few nodules.
5.0'	Shale - blocky, medium grey to brown, irridescent particles. Suite 359 2' down from base of above.
3.5'	Shale - grey, fine grained, rusty locally. Suite 360.
5.0'	Shale - drab, medium to fine, rusty weathering band, yellow decomposition product at base. Suite 361.
1.0'	Ironstone band.
12.7'	Shale - dark grey, blocky, medium to coarse, micromicaceous, carbonaceous particles, weathered into fissile shale, dark grey. Suite 362 4' down from the base of above. Suite 363 9' down from the base of above.
2.5'	Shale -dark grey, tendency to khaki, coarsely blocky.
20.0'	Shale - grey, medium blocky, becoming greenish grey, irridescent micro-particles, carbonaceous micro-particles, micromicaceous, very slightly calcareous if any. Suite 364 5' down from base of above. Suite 366 10' down from base of above. Suite 367 15' down from base of above.
5.0'	Shale - darker grey, fissile to flaky, microsilty, micromicaceous and microcarbonaceous. Suite 368.
8.0'	Shale - greenish grey, much yellow decomposition product, micromicaceous, carbonaceous, rusty weathering. Suite 369 at base of above. Suite 370 5' down from base of above.
37.3'	Covered to water level

SUITES 372-383

Locality O 154A Loon River formation, Peace River, Tp. 100, R. 20, W. 5 meridian, Alberta.

11.5' Shale - dark grey, very slightly silty in lenses, weathers light grey locally, and looks like interbanded shale and silt, micromicaceous, non-calcareous.
Suite 372 6.5' up from base of below.
Suite 373 1.5' up from base of below.

5.0' Shale - dark brownish grey, medium blocky, silty (?), micromicaceous.
Suite 374.

2.5' Shale - hard clayey to flaky, micromicaceous but no silt, much yellow decomposition product in thin layers, contains carbonaceous particles, a gradational phase into shale below.
Suite 374.

5.0' Shale - dark grey to black, coarsely blocky, fissile, rather platy, much yellow material stands out like sandstone on weathering.
Suite 376.

14.0' Shale - dark grey, medium blocky, becoming fissile, micromicaceous, contains a few carbonaceous particles.
Suite 377 5' down from base of above.
Suite 378A 10' down from base of above

18.5' Shale - dark grey, becoming finely fissile to flaky, clayey, when wet, micromicaceous, carbonaceous particles, some decomposition product.
Note: drab metabentonite layer at 3', 14' and 17' down.
Suite 378B 2' down from base of above.
Suite 379 7' down from base of above.
Suite 380 12' down from base of above.
Suite 381 17' down from base of above.

0.4' Indurated layer - anhydrite (?) crystals, highly rusty, sandy (?)
Suite 382.

6.0' Shale - dark grey to black to dirty brown, coarsely blocky, and platy. Much yellow decomposition product, some biotite, carbonaceous matter.
Suite 383.

Covered to water level

SUITES 404-406

Locality O 164X4, Loon River formation, on Wolverine River above mouth, Alberta.

15.0' Shale - blocky, medium coarse, rusty weathering. Suite 404.

0.2' Rusty weathering metabentonite - yellow to dark greenish grey.

27.0' Shale - black coarsely platy and blocky, becoming splintery in bottom 5' and showing close interbanding of silts and shales, not sampled.

0.8' Metabentonite - grey to yellow, rusty weathering becomes indurated due to sulphate content (?).

\- Shale - very coarsely blocky, black to brownish, greasy.
Suite 405
Suite 406.

SUITES 416-444

Locality O 170A, Loon River formation, Peace River, Tp. 101, R. 19, W. 5 meridian, Alberta.

5' Shale - dark grey, hard, fine to medium blocky with some coarse laminations, carbonaceous, sulphur or metabentonite in partings.
Suite 416.

5' Shale - as above, becoming more medium to coarsely blocky, rusty partings.
Suite 417.

5' Shale - as above, becoming platy as 417, weathers well.
Suite 418.

5' Shale - as above, slight increase of rust in partings.
Suite 419.

5' Shale - as above,
Suite - 420.

5' Shale - as above,
Suite 421 .

5' Shale - as above becoming finely blocky.
Suite 422.

5' Shale - as above, softer in weathering properties, not as many rusty partings, small amount of sulphur or bentonite present.
Suite 423.

5' Shale - as above.
Suite 424.

5' Shale - as above, medium to coarsely blocky, more rusty, weathers hard.
Suite 425.

5' Shale - as above.
Suite 426

5' Shale - as above, dark brown tinge, very platy, hard. Suite 427.

5' Shale - as above.
Suite 428.

5' Shale - as above.
Suite 429.

5' Shale - as above, rusty platy.
Suite 430.

5' Shale - as above, lighter shade of grey, medium to finely blocky, softer.
Suite 431.

5' Shale - as above, medium blocky.
Suite 432.

5' Shale - as above.
Suite 433.

5' Shale - as above, softer,
Suite 434.

5' Shale - as above, dark grey, coarsely laminated, metabentonite, finely dispersed in part, becoming silty in part.
Suite 435.

5'	Shale - not quite as platy as above, but becoming harder. Suite 436.
5'	Shale - dark to medium grey, coarsely platy with sulphur in partings. Suite 437.
5'	Shale - medium to coarsely platy, hard weathering. Suite 438.
5'	Shale - as above. Suite 439.
5'	Shale - as above. Suite 440.
5'	Shale - as above but finely blocky. Suite 441.
5'	Shale - as above but finely blocky. Suite 442.
5'	Shale - as above, medium to coarsely platy, weathers hard. Suite 443.
5'	Shale - as above, immediate below thin meta-bentonite band, very coarsely platy. Suite 444.
-	Covered to water level.

SUITES 449-456

Locality O 173A, Loon River formation, Peace River, Tp. 102, R. 19, W. 5 meridian, Alberta.

3'	Pebble clay.
7'	Shale - medium blocky, grey, brittle, weathered.
0.1'	Ironstone layer - continuous.
1.0'	Shale - brownish, blocky micromicaceous or silty, brittle, not fissile, medium to fine blocky. Suite 449-5' down from base of above. Suite 450 10' down from base of above.

5.0' Shale - as above, but becoming somewhat coarser, but considerably more resistant to weathering, cliff forming. This considered to be the top of so called Indurated shale, this shale is locally coarsely to very coarsely plated.
Suite 451.

1.0' Concretionary layer - with metabentonite shale covering.

11.0' Shale - coarsely platy as above, also very coarsely blocky, strongly micromicaceous.
Suite 452 5' down from base of above.
Suite 453 10' down from base of above.

7' Shale - similar to above, but less coarsely platy with definitely coarse splintery, otherwise quite similar but less resistant to weathering.
Suite 454 5' down from base of above.

13' Shale - as above but more finely splintery to blocky, and more crumbly.
Suite 455 3' down from base of above.
Suite 456 8' down from base of above.

20' Covered.

3' Shale - poorly exposed, very coarse. The "Burn"

Covered to water level.

SUITES 465-485.

Locality O 175B, Loon River formation, Peace River, at mouth of Big Buffalo River.

4.0' Clay - with recovered shale.

4.0' Shale - dark grey, a certain platiness, waxy, narrow yellow thin laminae, closely spaced, badly weathered.

17.0' Shale - dark grey to black, coarsely blocky, tendency to coarse splintery, not fissile, micromicaceous.
Suite 465 1' down from base of above.
Suite 466 6' down from base of above.
Suite 467 11' down from base of above.
Suite 468 16' down from base of above.

12.0' Shale - dark grey to black, less coarse in texture, medium.
Suite 469 4' down from base of above.
Suite 470 9' down from base of above.

9.0' Shale - dark grey, becoming black, coarse to very coarse tendency to fissile, thin, could be top of "Burn".
Suite 471 3' down from base of above.
Suite 472 8' down from base of above.

3.0' Shale - much finer, splintery, silty.
Suite 473.

13.0' Shale - as previous.
Suite 474 1' down from base of above.
Suite 475 6' down from base of above.
Suite 476 11' down from base of above.

8.0' Shale - dark grey, not blac, tendency to fissile, not coarse.
Suite 477 2' down from base of above.
Suite 478 down 7' from base of above.

6.0' Shale - dark grey to black, medium blocky.
Suite 479 4' down from base of above.

5.5' Shale - dark grey to black medium blocky, only very slightly laminated with silt.
Suite 480.

2.5' Shale - as above but with fairly marked tendency to rusted, joint planes, slightly laminated with silt.
Suite 481.

9.0' Shale - dark grey, blocky has rounded fractures, locally silty, only slightly laminated, but appears fairly silty, slightly calcareous.
Suite 482 4' down from base of above.
Suite 483 8' down from base of above.

2.0' Indurated layer - shale apparently with much rusty shale,
Suite 484.

3.0' Shale - dark grey, splintery as below.

6.5' Shale - dark grey, splintery, tendency to rust, Suite 485 1' down from base of above.

0.1' Ironstone layer - apparently continuous.

1.0' Covered to water level.

SUITES 485-492

Locality O 178X5A, Loon River formation, on Little Buffalo River above the mouth, Alberta.

5.0' Glacial silt - honey combed.

50.0' Covered.

4' Shale - as below.

0.2' Ironstone layer - not continuous.

21.0' Shale - black, very coarsely blocky, this is the top of the Burn.
Suite 492 1' down from base of above.
Suite 491 11' down from base of above.

0.2' Ironstone - fairly continuous.

10.0' Shale - dark grey to black, fissile, coarsely blocky,
Suite 490 5' down from base of above.

7.0' Shale - grey to dark grey, resistant to weathering, coarse, not platy nor fissile, nor very coarse, conchoidal to rounded fracture.
Suite 489 5' down from base of above.

13.0' Shale - black, fissile, almost flaky coarse, very slightly laminated.
Suite 488 8' down from base of above.

1.4' Ironstone - discontinuous , concretion.

20.0' Shale - black, fissile, much yellow decomposition product, very coarse, very slightly laminated.
Suite 487 4' down from base of above.
Suite 486 14' down from base of above.

5.0' Shale - coarse to very coarse, grey, rusty weathering, is cliff forming, clayey, micromicaceous, brittle.
Suite 485 4' down from base of above.

SUITE 493-497

Locality O 181X2B, Loon River formation, Keg River, Alberta.

-	Boulder clay.
7'	Shale - as below, but highly weathered.
0.2'	Indurated layer - rusty weathering, high in anhydrite (?).
11.0'	Shale - dark grey to black, weathers light grey platy to fissile, becomes more coarse, fissile and a little clayer towards the lower part.
0.1'	Ironstone layer - could be continuous, contains thin coaly layer.
9.0'	Shale - dark grey to black, fairly blocky. Suite 495 5.5' down from base of above.
0.1'	Ironstone layer - thin and continuous.
7.5'	Shale - as above, but more coarsely blocky, less fissile. Suite 496.
0.1'	Ironstone layer.
7.5'	Shale - as above. Suite 497.
0.1'	Ironstone layer - discontinuous, below this to water level outcrop is mainly covered or reworked.
-	Water level.

SUITES 501-506.

Locality O 185B, Loon River formation, Peace River, Tp. 105, R. 19, W. 5 meridian Alberta.

10'	Boulder Clay.
10.0'	Burn-type shale - black coarsely to very coarsely blocky, platy, weathers fissile. Suite 501 10' down from base of above.

14.0' Shale - brownish black, medium to fine blocky, very finely silty. This becomes laminated downwards due to silt content.
Suite 502 5' down from base of above.
Suite 503 12' down from base of above.

0.1' Ironstone layer.

6.0' Shale - as above, but mostly covered.

10.0' Shale - dark grey to black, brownish hue on fresh fracture, coarsely to medium rubbly, rounded fractures, not silty but micromicaceous, weatherslight grey.
Suite 504 5' down from base of above.

0.1' Ironstone layer - discontinuous, layered with very fine sandstone.

3.5' Shale - as above but appears more micromicaceous and not silty.
Suite 505.

0.1' Ironstone layer - discontinuous.

2.5' Shale - as above.

0.1' - 3.0' Ironstone layer - discontinuous.

10' Shale - dark grey with brownish hue, finely blocky, finely silty.
Suite 506 4' down from base of above.

\- Covered water level.

SUITES 507-517.

Locality O 185A Loon River formation, Peace River, Tp. 103, R. 19, W. 5 meridian, Alberta.

4' Boulder Clay - erosional unconformity.

9' Shale - black brownish hue, strongly weathered, much yellow decomposition, could be "Burn".

11.0' Shale - dark grey, micromicaceous, silty blocky to splintery, rusty joints, becomes definitely platy, medium to coarse at base.
Suite 507 from base of above.
Suite 508 5.5' down from base of above.
Suite 509 11' down from base of above.

0.05'	Metabentonite - white weathering.
7.5'	Shale - dark grey to black, coarsely platy "to rubbly", silt laminate, micromicaceous, carbonaceous particles. Suite 510 2' down from base of above. Suite 511 7' down from base of above.
0.2'	Indurated layer - rusty, weathering, shale. Locally greenish hue.
8.0'	Shale - dark grey to black, silty, slight lamination, medium to coarse, "rubbly" platiness, i. e., platy but also much rounded fracturing even along plate faces. Suite 512 5' down from base of above.
26.0'	Shale - dark grey to black, as above, but increasingly silty and brittle, also increasingly coarse in blockiness, discontinuous concretionary layer 7.0' down. Suite 513 2' down from base of above. Suite 514 7' down from base of above. Suite 515 13' down from base of above. Suite 516 18' down from base of above. Suite 517 22' down from base of above.
18'	Covered to Water Level.

SUITES 518 - 532
Locality O 187, Loon River formation, Peace River, Tp. 104, R. 19, W. 5 meridian, Alberta.

5' - 15'	Boulder Clay - erosional surface.
11.0'	Shale - grey to black, with brownish hue, cliff forming on weathering, medium blocky. Suite 518 3' down from base of above. Suite 519 8' down from base of above.
0.2'	Concretionary layer - discontinuous, flat, dark limestone.
6.0'	Shale - dark grey, only finely splintery, clayey soft almost fissile. Suite 521 4' down from base of above.
0.2'	Concretionary layer - discontinuous, similar to that above.

12.0' Shale - dark grey to black, cliff forming on weathering, medium to fine blocky, clayey to splintery.
Suite 522 4' down from base of above.
Suite 523 9' down from base of above.

17.0' Shale - dark grey, as above, but coarser, more brittle, rounded fracture, coarse rubbly.
Suite 524 2' down from base of above.
Suite 525 7' down from base of above.
Suite 526 12' down from base of above.
Suite 527 16.5' down from base of above.

0.1' Rusty layer - prominent, may be due to highly weathered metabentonite. This forms base of cliff forming shale.

9.2' Shale - grey, medium to fine, platy to blocky, silty, not so prominently cliff forming.
Suite 528 5' down from base of above.
Suite 529 9.2' down from the base of above.

0.1' Concretionary layer - flat highly discontinuous.

8.2' Shale - dark grey to black as above.
Suite 530 5' down from base of above.

0.2' Shale - rusty weathering, layering.

4.0' Shale - dark grey as above, but a little more coarse.
Suite 531 3' down from base of above.

5.5' Shale - dark grey as above, but appears more cliff forming and coarser.
Suite 532.

Covered to water level.

SUITES 533-537.

Locality O 192A, Loon River formation, Peace River, Tp. 104, R.19, W. 5 meridian, Alberta.

75' Recent sediments with sand at base.

18' Shale - black with brownish hue, hard with almost brittle, coarsely laminated, blocky, some coarse plates, micromicaceous, possibly finely silty.

Suite 533 5' down from base of above.
Suite 534 10' down from base of above.
Suite 535 15' down from base of above.

8' Covered - but apparently all shale.

0'-1.5' Concretions - elongate, built around petrified layer.

17' Shale - as above, but mainly covered down to water level. The shale at water's edge appears different. Brownish, rusty, softer and crumbly.
Suite 536 3' down from base of above.
Suite 537 16' down from base of above.

1.2' Covered to water level.

SUITES 538-559

Locality O 194A, Loon River formation, Peace River, Tp. 104, R. 16, W. 5 meridian, Alberta.

2.0' Shale - as below.

0.1' Ironstone layer - fairly continuous.

6.0' Shale - black, corasely platy, slight tendency to be fissile, silty, micromicaceous, tendency to brownish hue , tough.
Suite 538

0.2' Rusty shale layer - partly indurated.

7.0' Shale - as above.
Suite 539 5' down from base of above.

0.2' Shale layer - rusty weathering, containing a few small concretions.

30.0' Shale - dark grey to black, coarsely blocky, tendency to platiness, brownish hue, silty and Several discontinuous layers of small concretions and very small isolated concretions. Shale contains a few narrow white silt laminae.
Suite 540 5' down from base of above.
Suite 541 10' down from base of above.
Suite 542 15' down from base of above.
Suite 543 20' down from base of above.
Suite 544 25' down from base of above.
Suite 545 30' down from base of above.

18.0' Shale - dark grey to black, with brownish hue, fairly silty, micromicaceous, medium rubbly, tendency to platiness, weathers fissile light grey. Very large isolated concretions, also a rusty layer seen from water.
Suite 546 5' down from base of above.
Suite 547 10' down from base of above.
Suite 548 15' down from base of above.

0.2' Indurated layer - rusty weathering.

13.0' Shale - dark grey to black, brownish hue, generally less tough than above and more apt to be crumbly and flaky when weathered.
Suite 549 5' down from base of above.
Suite 550 10' down from base of above.

31.2' Shale - as above but more coarsely blocky and platy. This could be due to the fact that it is recently eroded. Discontinuous ironstone layer 4.0' down.
Suite 551 from base of above.
Suite 552 5' down from base of above.
Suite 553 10' down from base of above.
Suite 554 15' down from base of above.
Suite 555 20' down from base of above.
Suite 556 20' down from base of above.
Suite 557 24' down from base of above.
Suite 558 29' down from base of above.
Suite 559 31.2' down from base of above. (Water level).

1.8' Covered to water level.

SUITES 560-562.

Locality O 197A, Loon River formation, Peace River, Tp. 105, R. 18, W. 5 meridian, Alta.

There is here a large outcrop of shale, but it's upper part is covered with entirely too much detritus for it to be easy to get any markers. This shale contains numerous isolated large to very large concretions.
Suite 562 10' above water level.
Suite 561 5' above water level.
Suite 560 at water level.

SUITES 565-576

Locality O 202A, Loon River formation, Peace River, Tp. 105, R. 17, W. 5 meridian, Alta.

11.0' Shale - black with brownish hue, coarse to very coarsely blocky, platy to fissile and almost flaky on weathering, slightly silty.
Suite 565 10' up from top of below.
Suite 566 5' up from base of below.
Suite 567 at top of below.

1.7' Calcareous concretion - quite hard, laminated.
Suite 568

11.0' Shale - black as above, much yellow decomposition product.
Suite 569 at base of above.
Suite 570 5' down from base of above.
Suite 571 10' down from base of above.

0.7' Concretionary layer - flat, discontinuous, highly rusty but otherwise similar to that above.

23.6' Shale - black as above, locally strongly fissile
Suite 572 3' down from base of above.
Suite 573 8' down from base of above.
Suite 574 13' down from base of above.
Suite 575 18' down from base of above.
Suite 576 23' down from base of above.

0.3' Ironstone layer - flat discontinuous, highly rusted.

3.0' Shale - cliff-forming as above.

15.5' Covered to water level.

SUITES 577-584.

Locality O 206, Loon River formation, Peace River, Tp. 105, R. 17. W. 5 meridian, Alberta.

3.0' Boulder clay.

8.5' Shale - black to dark grey, weathered, coarsely blocky, almost a conchoidal fracture, not sampled.

9.0' Shale - black, coarse to very coarse, cliff-forming brownish hue, micromicaceous, few silt laminae, tough.

Suite 577 1' down from base of above.
Suite 578 6' down from base of above.

\- Metabentonite layer - very thin, continuous.

24.2' Shale - as above, but coarser, more platy on fresh fractures, more fissile where weathered.
Suite 579 3' down from base of above.
Suite 580 8' down from base of above.
Suite 581 13' down from base of above.
Suite 582 18' down from base of above.
Suite 583 23' down from base of above.

1.0' Concretionary layer - discontinuous.

5.0' Shale - as above.
Suite 584 3' down from base of above.

\- Covered to Water Level.

SUITES 585-602.

Locality O 206G, Loon River formation, Peace River, Tp. 105, R. 17, W. 5 meridian, Alta.

3' Silt and cobble clay

2' Gravel to conglomerate - some large boulders, rusted.

5' Upper Burn-type shale - weathered.
Suite 585

0.2' Ironstone layer - apparently continuous.

4.0' Shale - Burn type, weathered.
Suite 585.

3.0' Shale - black, medium to fine.
Suite 586 1.5' down from base of above.

20.2' Shale - black medium to fine, not blocky brownish hue, crumbly to clayey.
Suite 587 4' down from base of above.
Suite 588 9' down from base of above.
Suite 589 14' down from base of above.
Suite 590 19' down from base of above.

21.6' Shale - as above.
Suite 591 5.4' down from base of above.
Suite 592 10.8' down from base of above.
Suite 593 16.2' down from base of above.
Suite 594 21.6' down from base of above.

0.2' <u>Bentonite</u> - rusty weathering, also flat concre- cretionary layer, laminated; this rock is approximately top of "Lower Burn".

23.6' <u>Shale</u> - black, coarsely platy and blocky, fissile micromicaceous, brown black.
Suite 595' 2' down from base of above.
Suite 596 7.4' down from base of above.
Suite 597 12.8' down from base of above.
Suite 598 18.2' down from base of above.
Suite 599 23.6' down from base of above.
Suite 600 29.0' down from base of above.
Suite 601 34.4' down from base of above.

2.0' <u>Shale</u> - very silty, fine.
Suite 602.

\- Covered to water level.

<u>SUITES 603-621</u>

<u>Locality</u> O 211A, Loon River formation, Peace River, Tp. 15, R. 16, W. 5 meridian, Alberta.

0.2' <u>Shale</u> - indurated, rusty with much metabentonite.

22.6' <u>Shale</u> - dark grey, brownish hue, silty laminae, tough, medium blocky fair weathering resistance.
Ironstone layer 15' down from base of above.
Suite 603 10' down from base of above.
Suite 604 20' down from base of above.

0.2' <u>Ironstone layer</u> -flat, quite resistant.

14.5' <u>Shale</u> - as above, but more platy, parallel layering more prominent, also softer and more clayey. Shale becoming blacker and more coarse towards the base.
Suite 605 7.5' down from base of above.
Suite 606 14' down from base of above.

0.25' <u>Ironstone layer</u> - quite prominent and resistant.

2.5' <u>Shale</u> - identical to above.

9.2' <u>Shale</u> - black brownish hue, medium to coarse blocky, fair platiness, hard, brittle, minute conchoidal breaks, fairly resistant to weathering.
Suite 607 5' down from base of above.

35.0' Shale - black as above but coarser, and notably more resistant to weathering, almost vertical cliff, contains several narrow ironstone layers at 10' 13' and 15' down; also two narrow rusty layers at 23.5' and 26.0' down.
Suite 608 6' down from base of above.
Suite 609 16' down from base of above.
Suite 610 26' down from base of above.

2.5' Shale as below but slightly more resistant to weathering.
11.5' Shale - black, brownish hue, fissile, blocky soft clayey, quite crumbly.
Suite 611 3.5' down from base of above.

0.2' Ironstone layer fairly micromicaceous and carbonaceous.

7.3' Shale - as above, but highly crumbly due to earthy platiness,
Suite 612 2' down from base of above.

7.0' Shale - brownish black, crumbly, clayey, contains a 6" layer of shale as below.
Suite 613.

5.0' Shale - black to brownish, coarse but platy to fissile.

0.3' Ironstone layer - discontinuous.

7.0' Shale - brownish black, hard to soft varying locally medium to fine blocky.
Suite 615 3' down from base of above.
6.0' Shale - with very thick silt layers, in fact interbanded.
Suite 616 1' down from base of above.

0.1' Ironstone layer - narrow.

1.4' Shale - with thin silt interlayers as above.

0.05' Metabentonite layer.

0.1' Ironstone layer.

0.3' Shale - as above.

0.2' Ironstone - layer.

2.8' Shale - quite silty, dark to black, coarse to very coarse.

0.1' <u>Ironstone layer</u> - quite continuous.

10.6' <u>Shale</u> - grey, coarse, flaky, black with brownish hue, silty.
Suite 619 5' down from base of above.
Suite 620 10' down from base of above.

0.4' <u>Ironstone layer</u> - unusual, made up of 0.1' of normal ironstone and 0.3' of highly weathered tectonic shale. This has a gentle dip to the east.

5.0' <u>Shale</u> - black, coarsely platy, highly fissile, crumbly in large plates.
Suite 621 sampled at water level.

\- Covered to water level.

<u>SUITES 623-639</u>

Locality O 219F, Loon River formation, Peace River, Tp. 100, R. 19. W 5 meridian, Alberta.

3' <u>Clay shale</u>.

12' <u>Boulder clay</u>

0.5' <u>Pebble clay</u>

1' <u>Gravel</u>

1' <u>Medium sand</u>

4.5' <u>Shale</u> - black with brownish tinge, appears silty, weathered and probably reworked.

22.0' <u>Shale</u> - black with brownish hue, silty, a few thin silty laminae, coarsely blocky, cliff forming, platy.
Suite 623 3' down from base of above.
Suite 624 9.5' down from base of above.
Suite 625 21.5' down from base of above.

7.5' <u>Shale</u> - black brownish hue, apparently blocky, but more fissile and more crumbly.
Suite 626 2' down from base of above.

8.0' Shale - black with brownish hue, probably coarsely blocky, cliff forming, also crumbly into coarsely splintery shale.
Suite 627 2' down from base of above.
Suite 628 8' down from base of above.

10.0' Shale - black as above in all but apparently not coarsely blocky, and highly crumbly.
Suite 629 5' down from base of above.
Suite 630 10' down from base of above.

0.1' Ironstone layer - narrow, fairly continuous.

15.0' Shale - as above.
Suite 631 5' down from base of above.
Suite 632 10' down from base of above.
Suite 633 15' down from base of above.

15.0' Shale - as above.
Suite 634 5' down from base of above.
Suite 635 10' down from base of above.
Suite 636 15' down from base of above.

3.0' Shale - as above, with narrow silt laminae.

12.0' Shale - black brownish hue, coarsely blocky, coarsely platy, silt laminae.
Suite 637 2' down from base of above.
Suite 638 7' down from base of above.
Suite 639 12' down from base of above.

3.2' Covered to water level.

SUITES 649-660

Locality O 233B, Loon River formation, Peace River, Tp. 107, R. 16, W. 5 meridian, Alberta.

15.' Boulder clay.

6' Shale - dark in part, reworked.

0.2' Ironstone layer, thin, fairly continuous.

1.0' Shale - as above.

0.2' Ironstone layer - quite continuous.

5.0' Shale - black series, blocky, not cliff forming.
Suite 649.

0.4' <u>Concretionary layer</u> - limestone, discontinuous. flat.

2.1' <u>Shale</u> - as above.

0.2' <u>Ironstone band</u> - continuous

7.5' <u>Shale</u> - black brownish hue, hard, fairly blocky few silt laminae.
Suite 650 5' down from base of above.

2.1' <u>Shale</u> - as above.

0.05' <u>Ironstone layer</u> - continuous

3.0' <u>Shale</u> - gradational between that above and below.

0.2' <u>Ironstone layer</u> - discontinuous.

16.0' <u>Shale</u> - dark grey, flaky, clayey, hard, fissile, cliff forming.
Suite 651 2' down from base of above.
Suite 652 9' down from base of above.
Suite 653 15' down from base of above.

2.0' <u>Limestone</u> - concretion, discontinuous.

2.5' <u>Shale</u> - as above.

0.05' <u>Ironstone layer</u>.

15.0' <u>Shale</u> - as above, highly cliff forming, fissile to splintery, clayey, much yellow decomposition product.
Suite 654 3' down from base of above.
Suite 655 8' down from base of above.
Suite 656 14' down from base of above.

4.0' <u>Shale</u> - black brownish hue, blocky,fissile very similar to that above, but not so coarse, more crumbly and not so markedly cliff forming.

1.7' <u>Limestone layer</u> - discontinuous.

1.3' <u>Shale</u> - as above.

0.4' <u>Ironstone layer</u>.

1.5' Shale - as above.

0.2' Ironstone layer - quite continuous.
Suite 657.

2.4' Shale - as above.

0.2' Ironstone layer - fairly continuous.

4.4' Shale - black to brownish, blocky but crumbly and fissile.
Suite 658 2' down from base of above.

3.0' Shale - as above but appears more blocky and cliff forming.
Suite 659

0.1' Ironstone layer.

17.0' Covered - but some shale here and there.
Suite 660 13' down from base of above.

SUITES 661

Locality O 235A, Loon River formation, Peace River, Tp. 107, Ref. 16. W. 5 meridian, Alberta.

20' Shale - with much detritus.

5' Shale - black coarsely blocky platy, cliff forming.

2.0' Limestone concretions.

7.0' Shale - as above but less coarse and platy.
Suite 661.

7.0' Shale - as previous but now definitely crumbly.

0.4' Ironstone layer - fairly continuous.

13.0' Shale - as above, but slightly less crumbly.

0.2' Ironstone Layer.

- Covered to water level.

SUITES 663-673

Locality O 241A Loon River formation, Peace River, Tp. 107, R. 15. W. 5 meridian, Alberta.

3.5' Silt

2.0' Shale - black, weathers grey, badly weathered and in part reworked.

15.0' Shale - black, brownish hue, coarsely blocky, tendency to fissility, also platy, contains fairly coarse silt laminae and in the upper 5.0'.
Suite 663 6' down from base of above.
Suite 664 15' down from base of above.

26.0' Shale - as above, numerous silt laminae, highly cliff forming, less fissile than normal, little yellow metabentonite.
Suite 665 8' down from base of above.
Suite 666 16' down from base of above.
Suite 667 25' down from base of above.

1.0' Ferruginous limestone - concretion, discontinuous.

3.0' Shale - as above.

3.0' Shale - black with brownish hue, gradational between above and below: tendency to coarse, but also crumbly and clayey.

0.3' Ironstone layer - fairly continuous.

29.0' Shale - black with brownish hue, clayey, and crumbly, only partly blocky.
Suite 669 7' down from base of above.
Suite 670 13' down from base of above.
Suite 671 21' down from base of above.

0.3' Ironstone layer - fairly continuous.

10.0' Shale - as above.
Suite 672 5' down from base of above.

0.8' Coarse limestone band - bulbous appearance.

2.0' Shale - black, semi-platy, irregular fractures, Suite 673.

\- Covered to water level.

SUITES 675 - 681

Locality O 248A, Loon River formation, Peace River, Tp. 107, R. 15, W. 5 meridian, Alberta.

2' Humus and silt.

2' Pebble silt

9.0' Shale - black, weathers grey, fairly blocky, brownish hue.
Suite 675 4' down from base of above.

0.5' Ironstone concretion - discontinuous - highly weathered.

29.5' Shale - black coarsely to very coarsely blocky, platy to fissile, much selenite.
Suite 676 3' down from base of above.
Suite 677 7.5' down from base of above.
Suite 678 13' down from base of above.
Suite 679 18.5' down from base of above.
Suite 680 24' down from base of above.
Suite 681 29.5' down from base of above.

1.0' Shale - as above.

\- Covered to water level

SUITES 682-692

Locality O 251A, Loon River formation, Peace River, Tp. 107, R. 14, W. 5 meridian, Alberta.

3' Pebble silty clay

3' Shale - grey, finely blocky, platy, layered, badly weathered but not reworked.

8.9' Shale - black, coarsely blocky, tough, platy to rubbly, contains numerous thin silt laminae, plant remains.
Suite 682 5.5' down from base of above.

2.5' Shale - as above but not quite so coarse and tough.
Suite 683 2.5' down from base of above.

0.1' Silt layer - as below.

0.8' Shale - as above.

0.7' Silt and shale - interbanded in bands 0.08' thick. Shale as above; silt is buff to khaki, often rusty, fair induration and minute cross-bedding in the silt.

6.0' Suite 604.

6.0' Shale - khaki brown to black, good primary layering, may be a clay-shale more than true shale.

becomes rusted on weathering, medium splintery, good parting, and micromicaceous.
Suite 685 4' down from base of above.

0.1' <u>Ironstone layer</u> - fairly continuous, highly weathered.

1.6' <u>Shale</u> - as above.

0.1' <u>Metabentonite layer</u> - fairly continuous

3.3' <u>Shale</u> - black, medium to coarsely blocky, fissile, generally weathered.
Suite 686 2' down from base of above.

0.05' <u>Ironstone layer</u> - narrow, quite continuous.

4.0' <u>Shale</u> - black fairly coarsely blocky, fissile, clayey and crumbly.
Suite 687.

0.3' - 0.4' <u>Ironstone layer</u> - quite continuous, flat and lensy, apparently platy.

7.0' <u>Shale</u> - black, very coarsely blocky, highly fissile.
Suite 688 5' down from base of above.

0.02' <u>Silt</u> - thin layer, quite continuous.

9.8' <u>Shale</u> - black, very coarsely blocky, highly fissile.
Suite 689 2' down from base of above.
Suite 690 9' down from base of above.

0.1' <u>Metabentonite layer</u>.

0.4' <u>Shale</u> - as above.

0.05' <u>Metabentonite layer</u>

0.3' <u>Shale</u> - as above.

0.05' <u>Metabentonite layer</u>.

3.2' <u>Shale</u> - black, quite coarsely platy to fissile.

0.2' <u>Metabentonite layer</u>.

1.5' <u>Shale</u> - as above.
Suite 691.

0.1 <u>Metabentonite layer</u>.

1.5' Shale - as above.
Suite 692 1.5' down from base of above.

- Water level.

SUITES 693-699

Locality O 254D, Loon River formation, Peace River, Tp. 108, R. 14, W. 5 meridian, Alta.

3' Recent clay.

2' Shale - grey, fine, small plates weathered.

1' Shale-as below

0.1' Metabentonite layer - highly rusted and indurated.

2.0' Shale - black, very coarsely blocky and platy, fissile as below.

0.05' Ironstone layer - very thin but quite continuous.

3.0' Shale - black, as above, contains few narrow layers of metabentonite.
Suite 693 2' down from base of above.

21.3' Shale - black, very coarse, highly fissile, micromicaceous.
Suite 694 3' down from base of above.
Suite 695 8' down from base of above.
Suite 696 13' down from base of above.
Suite 697 18' down from base of above

0.2' Metabentonite layer - coarse.

0.4' Shale - as above.

0.05' Metabentonite layer.

1.5' Shale - as above.
Suite 698

0.15' Metabentonite layer - coarse.
Suite 699

0.2' Shale - as above.

0.4' Shale - indurated, highly rusted on weathering.

0.2' Shale - as above.

0.1' Metabentonite layer.

0.1' Shale - as above.

0.05' Metabentonite layer

0.2' Shale - as above

0.4' Shale - rusty weathering as above.

1.0' Shale - very coarse.

\- Covered to water level.

SUITES 700-704

Locality O 257A, Loon River formation, Peace River, Tp. 108, R. 14, W. 5 meridian, Alberta.

4' Pebble clay

0.1' Ironstone layer

3.5' Shale - black, very coarse, friable, almost coaly black, badly weathered.

0.1' Metabentonite layer.

0.5' Shale - as above.

0.1' Shale - highly rusted layer.

1.5' Shale - black, highly rusty, fine friable, crumbly, clayey, badly weathered.
Suite 700

0.1' Shale - as above.

0.1' Shale - as above.

0.05' Ironstone layer.

1.2' Shale - as above.

0.1' Ironstone layer.

0.3' Shale - as above.

0.05' Shale layer - highly rusted.

1.2' Shale - as above, but with thin rusty shale or thin ironstone layer.

0.1' Ironstone layer - as above.

0.3' <u>Shale</u> - with thin rusty laminae.

0.05' <u>Ironstone layer</u>

0.6' <u>Shale</u> - as above.

0.1' <u>Ironstone layer</u>

0.8' <u>Shale</u> - as above

0.1-0.2' <u>Ironstone layer</u> - thin, quite prominent and carbonaceous.

0.3' <u>Shale</u> - dark grey, finely splintery, silty not rusty.

0.1' <u>Ironstone layer</u>.

0.7' <u>Shale</u> - dark grey as above.
<u>Suite</u> 701

0.2-0.7' <u>Ironstone layer</u> - coarse, very prominent.

2.0' <u>Shale</u> - dark grey to black, contains three rusty ironstone layers.

0.1-0.2 <u>Ironstone layer</u>.

1.0 <u>Shale</u> - as above.
<u>Suite</u> 702.

0.1' <u>Ironstone layer</u>.

15' <u>Covered</u>.

0.3' <u>Siltstone</u> - grey, indurated.

1.0' <u>Shale</u> - grey friable, clayey.

0.1' <u>Metabentonite layer</u>

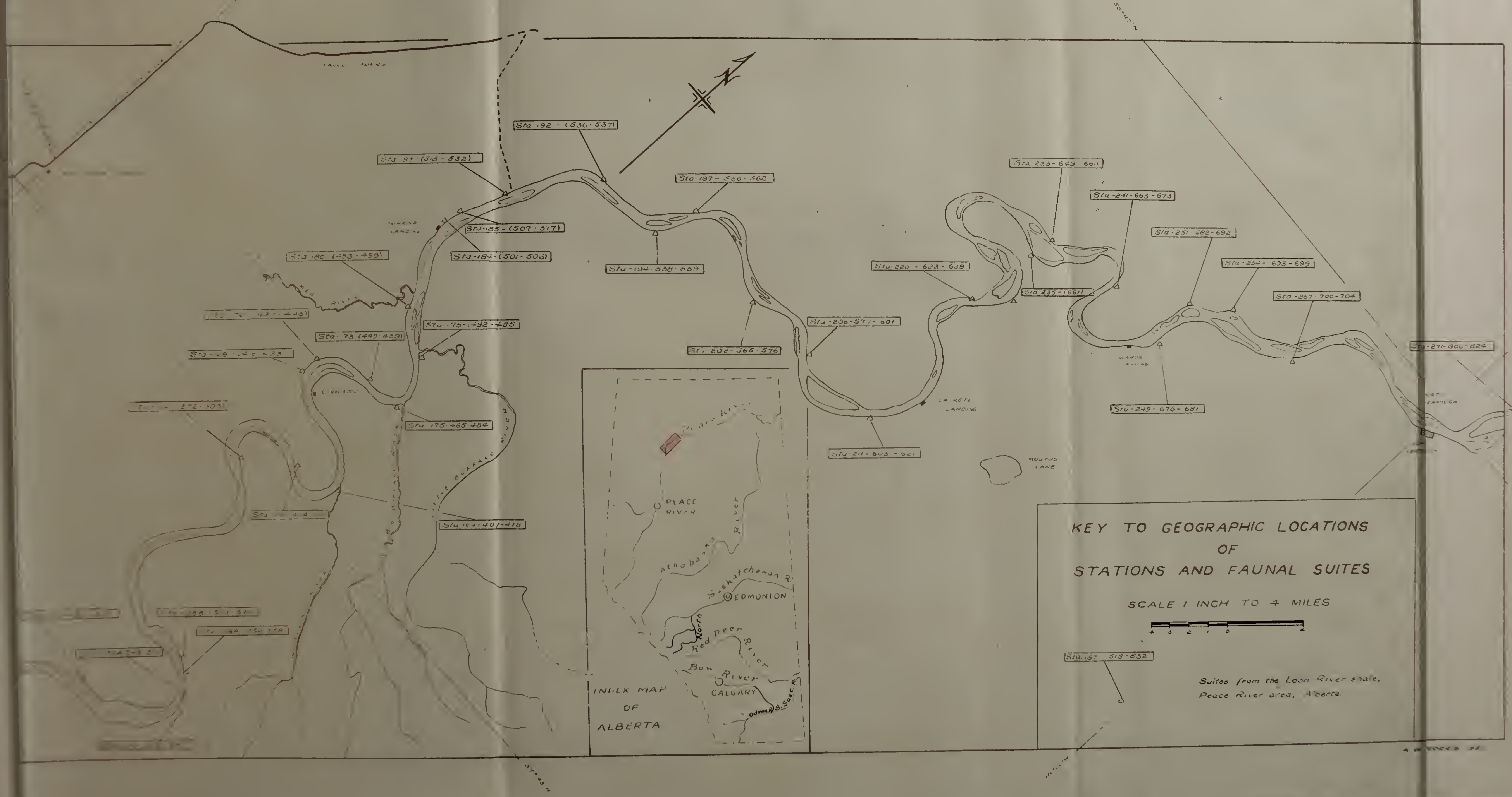
1.6' <u>Shale</u> - grey,clayey, friable.
<u>Suite</u> 704.

Water level

Map showing

KEY TO GEOGRAPHIC LOCATIONS OF STATIONS AND FAUNAL SUITES,

Loon River shale, Peace River area, Alberta.



KEY TO GEOGRAPHIC LOCATIONS OF STATIONS AND FAUNAL SUITES

SCALE 1 INCH TO 4 MILES

Sta 187 518-532

Suites from the Loon River shale, Peace River area, Alberta

STATISTICAL RECORD OF MICRO-ORGANISMS AND OTHER ELEMENTS FROM EACH SAMPLE
Loon River shale, Peace River area, Alberta.

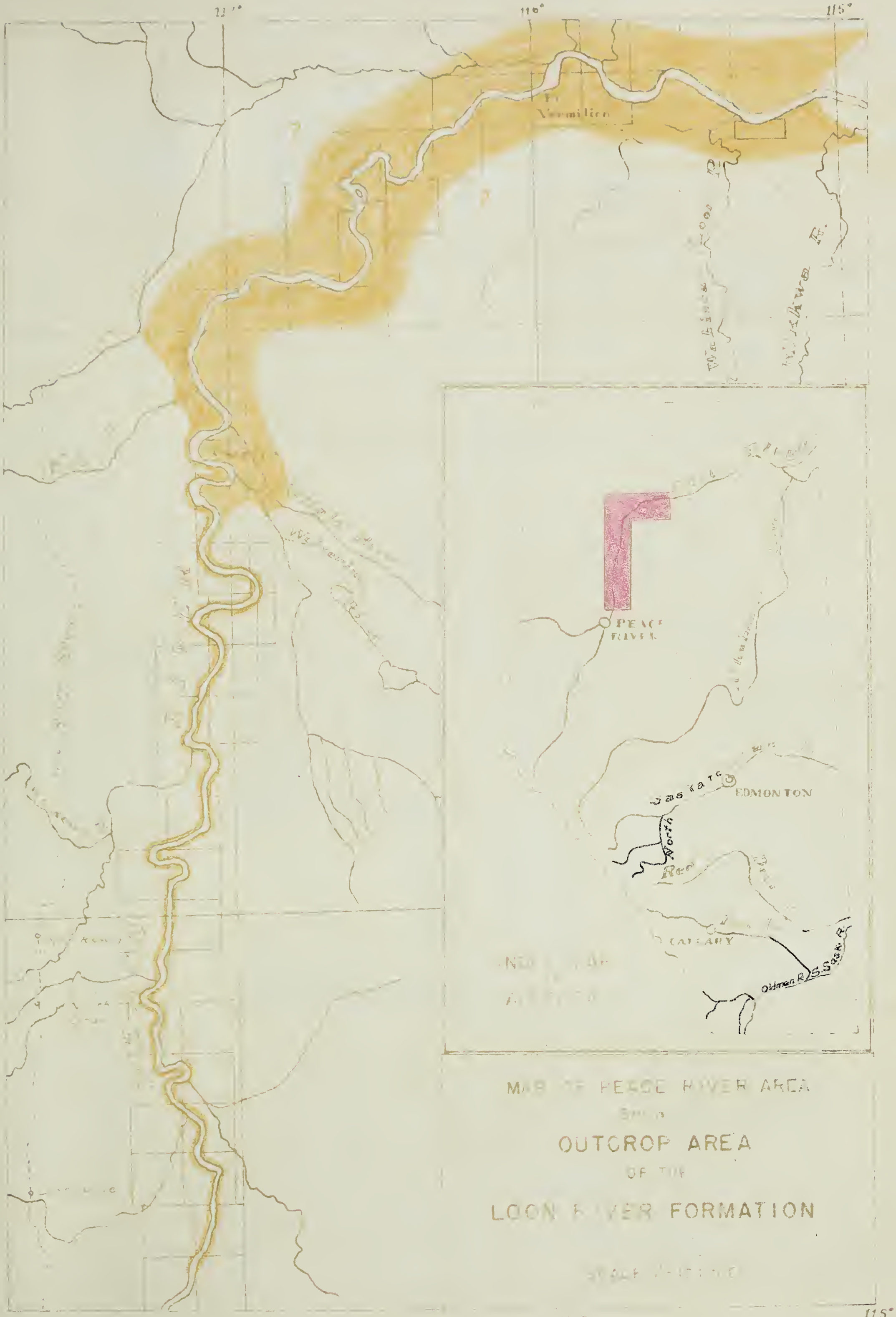
404			3	3					5		12	1							
405			40	35	1	4								F					
408											6	1							
407	X2	80											10	F		G			
	X6	150																	
409											10								
410	X2	150							2	6	170	2							7
411	X2	80																	
	X2	100																	
	X3	150							2	27	66		2			G			
412										2	15				3				
413	X2	150						1	1	3	149	2	1						1
414			1		1					5	156	1							
415	X2	150									30								
416			7	7		4		2			27								
417			1	1					7			1	1						
418			3	2		1			3		12								
419			4	4					4		15								
420	X2	150	7	4	1	2			5		119								
421	X2	150	7	5	1	1			1		5								
423			2	1	1						370	1		F					
424			8	3		3		2			157								
426			47	20	3	11	4	3				1							
427	X2	150	13	6	1	6			6				4	F					
428			11	2	3	6			8		1		2	F					
429			8	4	3			1	7				3	F					
450	X2	100			3	5		6	2	2				F					
451			23	14	1	7	1		7	1				F					
452	X4/3	100	58	33	4	4	16	1	12					F					
	X7/2	150																	
453	X2	120	44	29	8	5		2	6	1		2		F					
454	X2	100																	
	X2	150	42	17	7	13	4	1	9		10	2	6	F					
455			34	20	4	8	1	1	6				3	F				S	
456	X2	100																	
	X2	120	68	44	7	4	2	11	6		8		3	F					
457	X5/4	120		7	1	2		1	4		4		3	F					
459	X2	100																	
	X2	150		5		1			6		6	2					S		
468			38	16	2	13	4	3	7		1			F			S		
469			149	67	17	57		8	9					F			S		
470			206	72	26	67	15	26	2	4			1	F			S		
471	X2	150	146	75	12	27	20	12	3			4	5	F			S		
472	X2	150	396	203	11	146		36	10					F			S		
474	X2	100																	
	X2	150	75	39	11	25			12		5		1	F			S		
475	[illegible]	[illegible]	190	121	8	38	1	11	10				6	F			S		
476	X2	150	56	77	12	16		1	3					F			S		
477			70	25		31	6	5	4										
478			5	15	3	3	2	11			6	1							
479	X2	100	37	26	8	3			4										
480	X2	100																	
	X3	150	84	54	8	20		2	12	4				F					
481			56	46	4	6		2	5		1		1						
482		43	32	76	5	7			6										
483				77	10	2		2	6		12								
485			17	11	1	5	1		15	2				F					
486			7	4	1			6			1								
487			7	4		2	1		2					F					
488	X3	150		3					3	1	3		3	F					
489			3	2		1			5					F					
490									4					F					
491			2	2				2	8		11	2		F					
492			2					2	1										
493			2	1		1			1		3	1	2	F					
494									3		1		2	F					
495									1		2								
496			19	8	1	8	2		2					F					
497			24	12		5	1	3	3					F					
498	X2	150	27	11		16			2		1		2						
518			135	5			130												
519			3				3				?								
520			1	1							P								
521			1	1															
523			14				14				13	1							
524			22	1			21												
525			45	6			39				7				2				
527			68	1	1		66												
528			34	4		1	29				9								
529			65				60	5			66								
530	X2	150	252	18	2		232		1		12								
531			70	3	1		66												
532	X2	150	268	125	3		119				25								
538			19	8			15				15			F					
539			19	8			11		1		34				1				
540			17	4	1	1	10												
542			8	3			3	2			4								
543			7	3		1		3											
544			9	4	1		3	2	1										
545			13	3	7	1	1	2											
546			40	18		12	9	1	2		13								
547	X3/2	150	24	6	8	2	8				4			F					
548			24	11	5		6	2	1										
549			34	7		5	21	1											
550			20	3			17		6		2			F					
552			34	3	5	3	15	13					4						
553			59	4	7	7	40	1											
554			9	2	3	4													
558			16			5	4		3										
559			11		3		7	1						F					
565			61	8	14	11	8	20											
566			32	4	2	8	7	11	2										
567	X5	150	266	11			254		2										

TS FROM EACH SAMPLE
erta.

Sample	Correction Factor	Mesh Size	Total Cutinized Microfossils	*Sporangitoides lenticulare* n. sp.	*Sporangitoides ellipsoprolata* n. sp.	*Sporangitoides circulare* n. sp.	*Sporitoides discus* n. sp. and *Sporitoides spinus* n. sp.	Undifferentiated Cuticular Remains	Seeds	Bones	Foraminifera	Radiolaria	Carbonaceous Matter	Fish Scales	Spheres (?)	Glauconite	Selenite	Cylindrical Tubes (?)
311	X2	150									200							
312	X2	120							1		150	1						
313	X2	150									77							
314	X2	80									129					G		
	X2	100																
	X4	150																
315	X4	150									189					G		
316	X2	48																
	X5/2	80																
	X5/2	100																
	X4	150									369							
317			(No Sample)															
318	X2	100									211				8			
	X2	150																
319	X2	48									276							
	X2	100																
	X4	150																
350											7		1					
351	X14/5	100																
	X4	150									297							
360	X2	100																
	X7/2	150							1	2	320				2			
361	X14/5	100									297							
362	X5/2	100									297							
	X2	150																
363	X2	100								2	155							
364	X2	120								2	434				5			
365	X2	100								1	344				2			
	X2	120																
366										1	401							
367									8	1	47	1						
368			2			2			1	6	18	8				G		3
369										4	46	5				G		
370	X2	48									2	2						
	X2	100																
372	X3	120	23	6	1	1		9			9							
373			4	4					1		1		1					
374			48	39	4			6				2						
375	X15	150				21		10	6									
376			396	306	26	49		20	1					F			S	
377			136	100	6	18			6		18	4						
378			67	54	13				1									
379			19	14	2	3			2		13					G		
380	X2	100	9	4				4	3		8	2						
	X2	120																
381	X3	120	2	1		1		3			16							
383	X2	100	30	28				2	1			2		F			S	
	X2	150																
384	X2	100										27						
	X2	150																
388	X2	100																
	X3	150									3	35						
391									1		12	8	1					
392	X2	100																2
	X2	120																
393	X2	120									3							
404			3	3					5		12	1						
405			40	35	1		4							F				
408											6	1				G		
407	X2	80											10	F				
	X6	150																
409											10							
410	X2	150							2	6	170	2						7
411	X2	80																
	X2	100																
	X3	150							2	27	66		2			G		
412										2	15				3			
413	X2	150						1	1	3	149	2	1					1
414			1		1					5	156	1						
415	X2	150									30							

STATISTICAL RECORD OF MICRO-ORGANISMS AND OTHER ELEMENTS FROM EACH SAMPLE (Continued
Loon River shale, Peace River area, Alberta.

Sample	Correction Factor	Mesh Size	Total Cutinized Microfossils	Sporangitoides lenticulare n. sp.	S. ellipsoprolata n. sp.	S. circulare n. sp.	Sporitoides discus n. sp. and S. spinus n. sp.	Undifferentiated Cuticular Remains	Seeds	Bones	Foraminifera	Radiolaria	Carbonaceous Matter	Fish Scales	Spheres (?)	Glauconite	Selenite	Cylindrical Tubes
572			31	9	2	4	16		4				35		F			
574			14	8	2	4			1		1		7		F	2		
575			36	9			27		2				6		F			
576			28	1		5	8	14	8				23		F			
577	X5	150	61	11		3	37	10		1	10				F			
578													1					
580			10	6		1		3					3		F			
581			12	7		3		2					1		F			
582			17	1	3	1	12		2				1					
584			23	1	1	5	13	10	3				1					
586			25	3	2	6	6	8	8									
587			33	13	4	5	1	10	1				3					
588																		
593			17	7	3	2		5			1							
594			35	15	6	6		8	2			66	7					
596			10		4			6	1				2		F			
597			3	1		2							1		F	1		
598					6			4	4				10			2		
600			28	7	10	4		7	5		1							
601			48	23	12	11		3	4									
603			7	3	4				1									
604			5	2		1		3										
606			34	23	3	7												
607			31	27		1	2	1										
608			11	6	2	3			1									
609			13	5	4			2				2						
610			29	18	4	5					2							
611			27	19	5	1	1											
612			76	46	13	11		6										
613			126	70	18	28		14			1							
614			72	47	2	5	14	6				1						
615			132	89	20	29			2									
617			148	122	7		19		4		2							
618			8	154	121	9	15		4		2							
619			1	13	5	4	1	2										
620				38	15	12		10		38					F			
624			54	10	3	20		21	2									
625			20	4			6	8				3						
626			21	7	4	1		9										
627			26	9	3	4		14	3									
628			21	17	3	1			2					14				
630	X3/2	150	23	13	3		7		1					13				
631			2					2	1		1							
632			18	6	2	4		6	1					4				
633			5		2	1		2	1					8				
634			10		6	2	1		2					3	F			
636			14	6	2				4					3				
639			52	26	6	12		6						2				
649			5	2		3			1					1				
651			4	1		1		2	3									
652			14	6	2			4	2					6			S	
653			13	6	3			3			3			14	F			
654			16	2	3	4		6	1		1				F			
656			16	2	1	5		6						17			S	
657			26	13	2	1	3	7						13			S	
658			22	9		2	2	7						13				
659			10	1	1	5	1	2						10	F			
660			2	1							1							
665			107	51	13	22	15		14					13				
666			77	25	21	16					2	2						
667			88	47	9	17		4	3					2				
668			118	42	15	26		34	1		6			5				
669			14	6	2	4	1							1				
670			29	9		10		2	1					4				
671			23	7	5	3		8										
672			3		2			1	2					7	F			
673			9	3		2		4	1				1	4	F			
683			34	25	5	3		1						1				
686			4	3		1				66					F			
687										33			1	1	F			
688			15	5	6	3		1		20				7	F			
689			10	10										7	F			
690			9	3	3			3		3	1(?)			3			S	
691			57	43	5	8	1			7	1			2	F			
692	X3	100												5	F			
700																		
701			6	3	3				1	1	23		1					
702			1					1	1		1							
704	X18/11	120								66	4		495					



MAP OF PEACE RIVER AREA

OUTCROP AREA

OF THE

LOON RIVER FORMATION

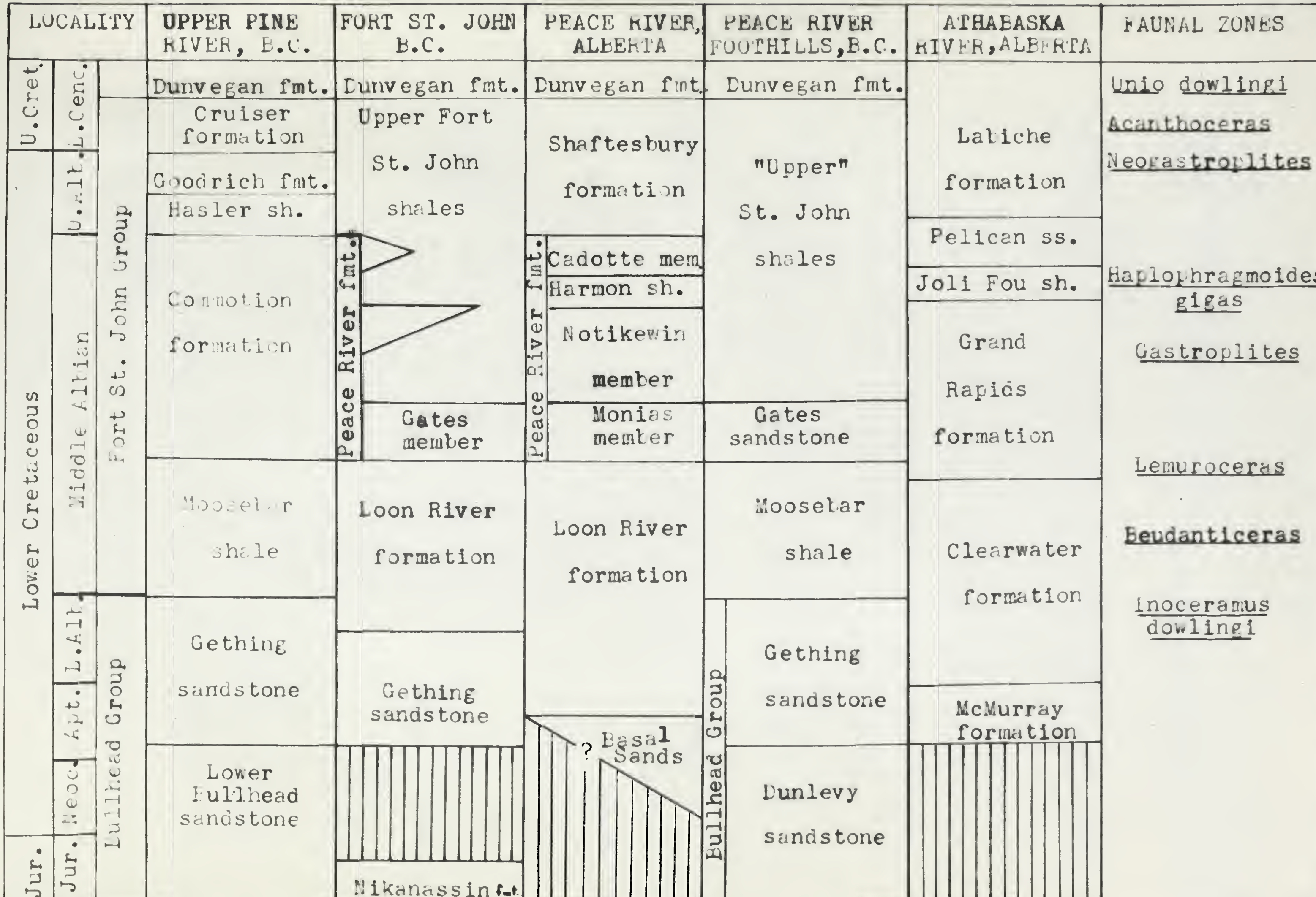


Figure 2. Terminology of the Fort St. John Group in Peace River and Athabaska River Areas

6. GLOSSARY OF TERMS

Acolpate, without furrows or pores.

Angiosperms, flowering plants.

Anther, the region of the microsporophyll bearing sporangia.

Antheridium, an oogonium and an antheridium of an algae, each invested by a protecting jacket of cells, would represent the essential idea of the sex organs of liverworts. The male sex organ continues to be called the antheridium, but the female organ is now called an archegonium.

Apogamy, ferns are apogamous, the gametophyte prothallium produces sporophytes without the sex act.

Apospory, in ferns, apospory is a common phenomenon which means that the sporophyte produces gametophytes without using spores; that is, a gametophyte buds out directly from a sporophyte.

Capsule, a dry dehiscent fruit (pod).

Carpel, (Carpidium), The ovuliferous organ of the flower; a closed macrosporophyll (megasporophyll), a simple pistil. Each megasporophyll (often called scale) of a cone bears one or more megasporangia. These megasporangia were called ovules long before their real nature was known, and the megasporophyll was called a carpel or pistil.

Carpogonium, (Gr. karpos, fruit + gonos, producing), female gametangium (in red algae). p. 621, (Ref. 19).

Caryopsis, the grain, (fruit) of grasses.

Cell. In taxonomy usually referring to the seed-cavity or locule of an ovary, or to the pollen chambers of an anther, or to the air-spaces in the stem of some aquatics.

Colpate , possessing germinal furrows or harmomegathi, generally used with numerical prefixes as mono-, di-, and tri-, signifying the number of furrows. (Gr., a fold).

Conspecific, belonging to the same species.

Coriaceous, of leathery texture.

Cotyledon , a seed-leaf, the temporary, usually distinct - ive, first leaf or leaves of an embryo.

Culm, the stem of grasses and sedges.

Dehiscent, splitting open by valves or slits, said of anthers and capsules.

Diagnostic - defining, determining, or distinguishing, referring to the taxonomic characters.

Differentiate, to distinguish or separate on diagnostic characters.

Discoid, having the shape of a disc.

Dorsal, belonging to or appertaining to the back of an organ.

Embryo, the undeveloped dormant plant within the seed.

Embryo-sac, the gametophytic part of the ovule in which the embryo develops.

Endosperm, the reserve food-storage tissue or "albumen" of a seed.

Epicarp, the outer layer of the pericarp of fruits.

Epicotyl, that portion of an embryo above the cotyledonary node: plumule.

Epidermis, the outermost layer of cells of an organ.

Equator , the great circle midway between the two poles and dividing the grain into two polar hemispheres.

Exfoliated, peeling off in thin layers.

Exocarp, the outer layer of a fruit.

Flaccid, like a loose, papery sack; lax.

Fruit, the seed-bearing organ of a plant.

Fusiform, spingle-shaped.

Gametes, sexual cells.

Gemma, a leaf-bud; a bud by which a plant propagates itself vegetatively.

Gemmules, a diminutive of gemma.

Germinal aperture, a hole in the furrow membrane through which the germ pore protrudes. The term is also used to designate the rounded apertures which frequently occur in the general surface of the exine in the absence of germinal furrow.

Germinal furrow, a longitudinal groove or opening in the exine, either enclosing a germ pore or serving directly as the place of emission of the pollen tube, also generally serving as a harmomegathus.

Germination, the extraseminal development of an embryo.

Glume. a rigid, chaff-like or scale-like bract, referring especially to the two empty bracts at the base of the spikelet in grasses.

Grain, the fruit or caryopsis of grasses.

Haptotypic characters, those which are due to internal or prenatal environment, such as the stimuli received by a developing pollen grain from contacts with its neighbors, make an impression.

Haulm, a dead and dried herbaceous stem like that of grasses and sedges.

Herb, a plant which is not a tree or a shrub, and is usually of relatively soft texture, producing relatively little woody tissue.

Hypocotyl, the part of an embryo below the cotyledons and including the cotyledonary node; the stem of the embryo.

Indehiscent, not splitting open; remaining closed, as an achene.

Indusiate, furnished with a cover.

Indusium, membranous outgrowth of the epidermis of a fern leaf which covers the sori.

Macrosporangium, an ovule, megasporangium.

Macrosporophyll, a carpel.

Mesocarp, the middle coat or layer of a fruit.

Monocolpate, having a single germinal furrow or harmomegathus on one side of the grain. If the grain is encircled by a single furrow, it is regarded as dicolpate or zonate.

Monocotyledonous, having the characters of a moncotyledon.

Muriform, arranged like bricks in a wall, referring to the markings on the surface of small seeds and achenes.

Nervation, the system of venation of a leaf.

Nerve, the vein of a leaf or bract.

Nitidous, having a smooth or glossy surface, as some seeds.

Nodulose, having small knots or knobs.

Nut, a hard-shelled indehiscent fruit; dimunitive, nutlet.

Ovary, part of a carpel or genoecium containing the ovules and seeds.

Ovule, the macrosporangium (megasporangium)

Papilla, a nipple-like prominence on the surface of a leaf or petal.

Papillate, bearing or furnished with papillae.

Pedicel, the flower-stalk.

Pedicellate, furnished with a pedicel.

Peduncle, the stalk of an inflorescence.

<u>Pericarp</u>, the wall of the ovary, referring to a fruit,

<u>Petiole</u>, a leaf stalk.

<u>Phaenogam</u>, a flowering plant, <u>Phanerogam</u>.

<u>Phylogeny</u>, race history of a plant or group: genealogy (Phylogenetic).

<u>Pistil</u>, the ovuliferous or seed-bearing organ or organs of a flower; carpel; gynoecium.

<u>Pistillate</u>, bearing the gynoecium only; carpellate.

<u>Placenta</u>, the part of the locule of an ovary on which the ovules are borne.

<u>Plumule</u>, the epicotyl of an embryo.

<u>Pod</u>, a dehiscent fruit.

<u>Pole</u>, one of the extremities of the axis of symmetry of radiosymmetrical pollen grains. If there is more than one such axis of symmetry, the word applies only to the extremities of the axis which is directed toward the center of the tetrad or was so directed during the grain's formation. From these tetrad relations the two poles and two hemispheres may be designated as inner and outer or proximal and distal, though in mature pollen grains that are not shed in tetrads the hemispheres are rarely distinguishable.

<u>Pollination</u>, transferring of pollen from the anthers to the stigma.

<u>Punctate</u>, marked with very small dots or glands or translucent spots.

Rhizome, a subterranean stem or branch.

Rugose, wrinkled.

Ruminate, mottled.

Sac, a cavity or vesicle.

Saccate, sac-shaped; bag-shaped.

Scarious, dry, thin, scale-like membranaceous.

Scrobiculate, having small pits or depressions.

Seed, an embryo and investing parts of the ovule.

Sheath, the tubular basal portion of a leaf or a grass or sedge, which invests the culm.

Spermatophyte, a seed plant.

Sporophyll, a spore bearing leaf,

Stamen, the anther-bearing organ of a flower.

Stigma, that part of the style which is modified for the reception and germination of the pollen.

Stipel, a small stipule, like the small appendages at the base of the leaflets of some compound leaves.

Stipule, a leaf-like appendage of the base of the petiole of leaves.

Strobilus, a cone-like inflorescence; a flower.

Style. the contracted upper part of a carpel or gynocoenum which supports the stigma.

Suberous, of corky texture.

Suture, the line of dehiscence of dry fruits, the line of junction or of cleavage of two united organs.

Tegman, the second coat of a seed.

Tercine, the third coat of the ovule or seed.

Testa, the outer, usually hard, coat of a seed.

Theca, a pollen sac of an anther. Thecal, belonging to a theca.

Tricolpate, possessing three meridionally arranged germinal furrows.

Tumid, swollen.

Type, that specimen or individual plant in a collection of specimens of a supposed species which in the judgement of the taxonomist is the most ideal representative of the species as a whole; or the specimen or individual plant of a collection, which formed the basis of the description of the species. A type may be only a single specimen of the plant, not previously described. In constructing a new genus the type is selected from the most representative species.

Valve, a section of a dry, dehiscent fruit, (capsule)

Utricle, an inflated achene-like fruitlet.

Verrucose, covered with wart-like protuberances or excrescences.

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"Two kinds of organic matter are discernible in thin sections of the oil shale; one is massive and structureless and is the matrix of the other, which has definite form and consists of organisms or fragments of them. The microflora of the Green River formation contains two forms that are doubtfully referred to bacteria and many

fungi spores of which 13 are illustrated and compared with living genera. In addition to the spores there are also many fragments of the vegetative parts of fungi. Of the algae, all of which are microscopic, one flagellate, a naked protoplast, five blue-green algae, and five green algae are described and referred tentatively to living genera of fresh-water algae and compared with living species. Five forms, probably all algae, which are too indefinite to be assigned to any position in the natural system are also illustrated and described. According to the numbers of individuals found the blue-green algae appear to have dominated the microflora. No diatoms were found. Of the higher plants spores and pollen are plentiful. Eight spores and three parts of reproductive organs, all probably belonging either to mosses or to ferns, are described, and some of them are compared with the pollen of living plants. A fragment of bark, a part of a spiral tracheid, and a few stellate hairs are the only parts of the tissues of plants higher than the mosses and ferns that have been found."

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*10. Cushman, J.A., 1950, "Foraminifera, Their Classification and Economic Use", 4th edition, revised and enlarged, with an illustrated key to the genera, Cambridge, Massachusetts, Harvard University Press.

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fungi spores of which it are illustrated and compared with living plants. In addition to the spores there are also many fragments of the vegetative parts of fungi. Of the algae, all of which are microscopic, the diatoms, a [illegible], five yellow-green algae, and five green algae are described and referred tentatively to living genera of fresh-water algae and compared with living species. The larger, probably all algae, which are too imperfectly to be assigned to any position in the natural system are also illustrated and described. According to the nature of [illegible]ly, fungi the blue-green algae appear to have [illegible] the [illegible]. [illegible] Fungi. Of the higher plants spores and pollen are discussed. Plant parts and other parts of reproductive organs, all probably [illegible] are described, and some of them are compared with the [illegible] of living plants. [illegible] have been found.

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pp. 374-375.
"It is to be observed, in conclusion that the spore cases of plants, in their indestructibility and richly carbonaceous character, only partake of qualities common to most suberous and epidermal matters. Such epidermal and cortical substances are extremely rich in carbon and hydrogen. They are also very little liable to decay, and they resist more than other vegetable matters aqueous infiltration; properties which have caused them to remain unchanged and resist the penetration of mineral substances more than other vegetable tissues."

p. 375.
Dr. T. Hunt says: "The outer bark of the Cork tree and the cuticle of many if not all other plants consist of a highly carbonaceous matter, to which the name suberin has been given. The spores of Lycopodium also approach to this substance in composition."

"They in fact approach closer in composition to resins and facts than to wood, moreover like those substances repel water, with which they are not easily moistened, and thus are able to resist those atmospheric influences which effect the decay of woody tissue."

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"ABSTRACT - Post-Madison, pre-Belden plant spores from Daggett County Utah, are described and illustrated. The assemblage is compared to British, Polish, and Russian assemblages of similar age. Two new genera are proposed, <u>Rotaspora</u> and <u>Tripartities</u>."

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Dolerotheca includes a group of pteridosperms, (Medullosaceae) characterized by very large and unusual pollen-bearing organs.

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Chief emphasis in this paper is devoted to a review of plant microfossil investigations and it covers literature not previously reviewed by reference 31, or since 1943.

"One of the greatest difficulties in using this material (plant microfossils) for correlations for extending our knowledge of the plant composition of coal has been in systematic (taxonomic) treatment of the materials. The review of recent literature are presented chiefly with reference to the diverse systematic approaches of various authors. The contrast between ess-

entially nonbotanical or morphologic classification schemes, which are simpler to apply and which may serve adequately for local correlational studies, and those studies conceived on a more fundamental basis of plant taxonomy, for paleogeographic and ecologic interpretation of botanically related groups is presented."

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This reference pertains to an experimental study done on oil-bearing shales from the Devonian of Illinois, Indiana and Kentucky containing a high content of microplant material.
"From the small amount of work that has been done on the chemical composition of spore-walls and cuticles of living plants it is shown that these are composed largely of the esters of the higher fatty acids, that is oils and waxes". (p. 298).

*45. Thom son, R. B., 1927, "Evolution of the Seed Habit in Plants", Trans. R. S. C., vol. 21, section 5. pp. 229-272.

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