

Aquilapollenites 花粉グループと Normapolles 花粉グループ

— その分布と層位学的意義 — *

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Aquilapollenites and Normapolles pollen groups

— Their distribution and stratigraphic significance — *

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Abstract

Two large angiosperm pollen groups, *Aquilapollenites*/Triprojectacites and Normapolles, are found in the late Cretaceous and early Palaeogene.

Pollen grains referable to the Normapolles group, which is composed of more than 100 genera, first appeared during the Cenomanian. After their relatively leisureed evolution during the Cenomanian, they diversified rapidly and attained to the maximal prosperity during the Santonian to Maastrichtian, but by the end of the Eocene they were virtually extinct.

They extended to the two main provinces, 1) European-Turanian and 2) East North America. The former spread more widely to China (west of Long. ca. 120° E in northern district and west of Long. ca. 100° E in southern district), Meghalaya district (India), NW Tunisia, Spitzbergen and Jan Mayen Ridge in the Maastrichtian and/or early Palaeogene, and the latter more extensively to a) Mississippi embayment area and b) area west of the axis of the Cretaceous epeiric seaway. North Atlantic Coastal Plain, Gulf Coast, and California (west San Joaquin valley) are, of course, in the Normapolles province, but only a few *Aquilapollenites* pollen grains entered into these areas during the Maastrichtian and early Palaeogene. The Normapolles pollen appeared in Colorado, Wyoming, Montana and Alberta until the Campanian (until the Maastrichtian in Utah) and after that, the *Aquilapollenites* / Triprojectacites pollen flora supplanted it and flourished during the Campanian/Maastrichtian to Palaeocene.

The *Aquilapollenites*/Triprojectacites pollen grains, which are morphologically compared with the pollen grains of the Loranthaceae and Santalaceae, appeared in Siberia, East China, Japan, Alaska, western North America, Arctic Canada, Greenland, Scotland (Mull Island),

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Barents Sea (Gusinaya Bank) etc. during the Santonian to Palaeocene/partially to Eocene.

During the early Palaeogene, the *Aquilapollenites* and/or *Pentapollenites* pollen grains are found sporadically in Hungary, Germany, Belgium, France, Spain, western China in the Normapolles province. Besides, they occurred sporadically in Egypt, Senegal, Nigeria, Gabon, Bengal (NE India), Karikal (S India), Sarawak (Malaysia), and Sergipe (Brazil) during the late Upper Cretaceous or Palaeocene, and the Normapolles pollen grains are also found in Egypt and Senegal of Africa.

Both the Normapolles and *Aquilapollenites*/Triprojectacites pollenfloras are very useful in palynostratigraphy, especially in the correlation of marine and non-marine sediments.

The oculate pollen flora, which is composed of three genera with elliptical form, binigminate aperture or flange ornamentation, occurred in company with the *Aquilapollenites*/Triprojectacites pollen flora in many cases during the Campanian to Palaeocene/partially to Eocene.

はじめに

筆者は、これまで数回にわたり、上部白亜紀から古第三紀初期における *Aquilapollenites* / Triprojectacites 花粉グループなどの地理学的分布ならびに層位学的意義について述べた (高橋, 1967, 1970, 1973, 1976, 1981, 1984, 1986)。今回は、Normapolles 花粉グループの分布域、進化ならびに層位的な問題も含めて検討を行なった。これらについては、多くの研究者の見解があるが、特に、分布域の問題については新しい見解を得ることが出来た。両花粉グループの分布域が接する地域では、両者の混在がみられ、その分布、層位、混在の内容について、特に、中国、西シベリア低地帯、ロッキー山地地帯、中・西部ヨーロッパ (古第三紀) などに重点をおいて検討を行った。両花粉グループの分布域以外に、散点的に *Aquilapollenites* の仲間が分布し、また、アフリカ北東部および北西部に Normapolles の存在が認められることにも言及する。

最後に、*Aquilapollenites*/Triprojectacites 花粉グループの分布によく共存する Oculata 花粉グループについても言及する。

Normapolles 花粉グループ

“Normapolles”の名称は Pflug (1953) によって提案された。このグループに属するものは、現在100属以上に達しており、種を入れると莫大な数となる。これは明らかに被子植物の花粉である。

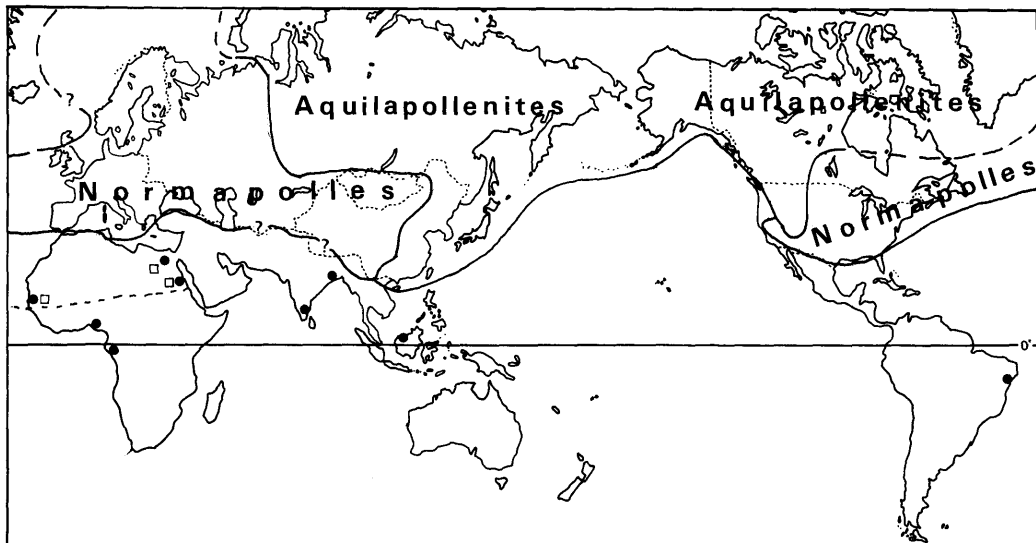
形態は大部分は三角形で、突出した孔口、壁の構造に特徴があり、Postnormapolles (通常の triporate 花粉) と容易に区別されるが、或るものについては第三紀の Postnormapolles 花粉グループとの間に大きな形態上の差がないものもある。現生植物の花粉との関係については、色々と意見が述べられているが、特に、amentiferous と proteaceous 植物の花粉との形態的類似性をもっともらしいが、系統発生的な関係は不明である。Normapolles 花粉グループは数千万年にわたり、一大グループを形成しているが、大型化石との関連が依然として不明である。これは如何なる理由であるか、又このことが何を意味するのか、重要な問題として注意して検討が行なわれねばならない。Normapolles 花粉の形態的多様性は一つの祖先から由来したのではない可能性が強いことを示しているかも知れないし、また樹木性のもではなかつ

たかも知れない。

最初の出現は、ヨーロッパ大陸において、Cenomanian 中期であり、分布範囲は、速やかに拡大し、始新世末で消滅した。Normapolles の中で、*Complexiopollis* と *Atlantopollis* の種が最初の出現としての役割をなしている。Cenomanian 中の比較的ゆっくりした進化の後、急速に多様化した。順次古い被子植物要素の大部分を置きかえた。グループ中の進化の割合は Santonian -Maastrichtian 中最大に達した。新しい形態のものが古第三紀初期に出現し続けたが、始新世の終わりで事実上消滅した。1~2 属のものが漸新世に長びいたらしい。始新世後の記録は全く稀で、多くは再堆積のものである。最近、新しい属 *Goerboepollenites* がハンガリーの中新世から Nagy (1979) により Normapolles の仲間とされた。Normapolles 花粉の進化は、孔口の構造の発展による複雑な germinal を造る方向、膜の構造の細密化などであり、これらの多くの形態的多様化が多くの属と種を区分させたのであるが、同時に、多くの taxa が短い層位的な range をもっていて、これらの多くの特徴と短い層位学的 range の組み合わせが多くの Normapolles 花粉が良い index fossils であることを意味している。ここから Normapolles 花粉の生層位学的重要性が生まれてくる。

中央部ヨーロッパが Normapolles の起源と分散の中心と考えるが、Cenomanian 中期にポルトガルから北米の North Atlantic Coastal Plain に *Complexiopollis* と *Atlantopollis* の種が移動し、北米大陸の東部に拡がった。北大西洋は白亜紀後期中拡大し、明らかに、広大な移動の障害物としての役割をなした。即ち、Normapolles province は 2 つの主要地域に分れた。

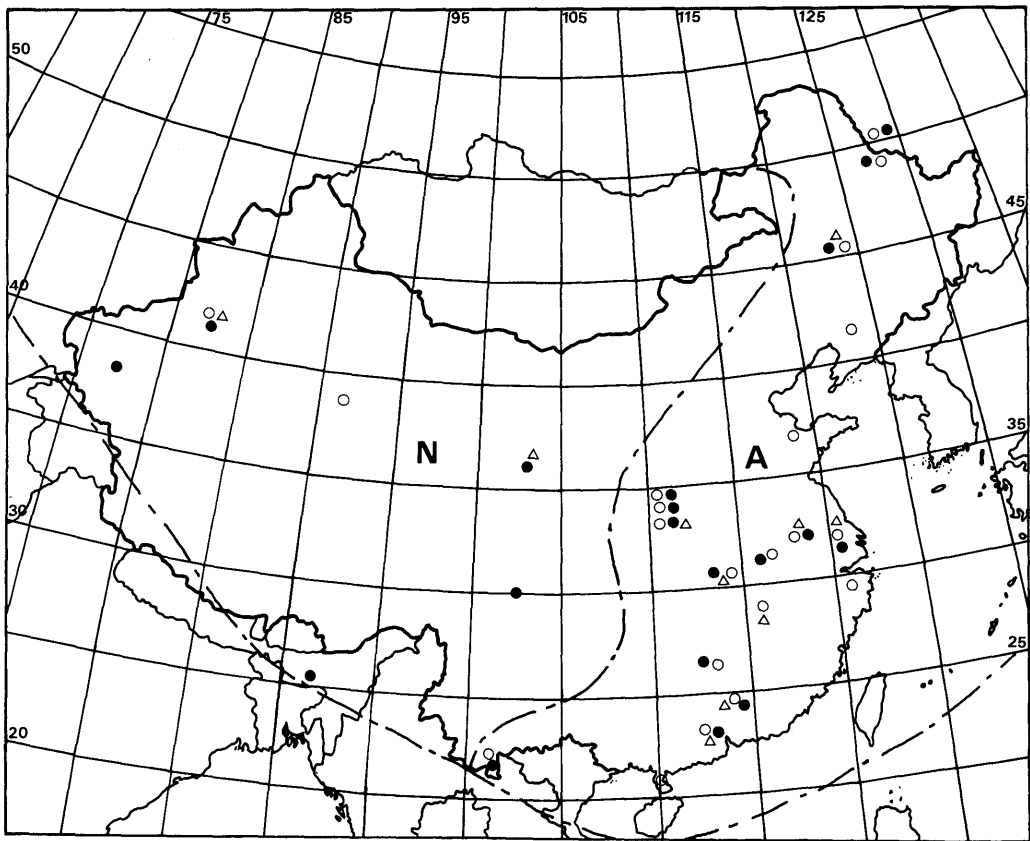
1) European-Turanian 地域と 2) Eastern North America 地域である。両者は異なる。多くの層位学的に重要な taxa が両者に共通であるが、また多くの属種に違いがある。Post-Turonian には完全な分離発展が起こったためである。



第 1 図. 上部白亜紀末期および古第三紀初期における *Aquilapollenites* 花粉と Normapolles 花粉の地理学的分布.

- : province 外における *Aquilapollenites* 花粉の産地
- : province 外における Normapolles 花粉の産地

European-Turanian 地域は Maastrichtian ~ 古第三紀初期になると中国（北部で東経120°以西、南部で東経100°以西）にまでその勢力が広がった。それより東は *Aquilapollenites* province であるが、Normapolles 花粉が多く地域で混在する（第1~3図、第2, 3表参照）。また、インド北東部の Meghalaya 地方の Mahadek 層（上部 Maastrichtian）に Normapolles 花粉が産する（第2図、第8表参照）。これは Normapolles province の南限と考えられ、データに乏しいが、境界は Turkmen-Kizilkum の南を通り、クリミヤは Normapolles 花粉を産し、トルコには報告がないことを考慮して、カスピ海-黒海の南を通り、トルコを迂回して、地中海に入り、Tunisia の北西部の上部 Maastrichtian-Danian に Normapolles 花粉を産するので、この地域は Normapolles province に入ると考える。エジプトの Maastrichtian ~ 古第三紀に Normapolles が *Aquilapollenites* と混在している報告があるが、この地域の研究が進み、データが多くなれば、将来 Normapolles province の南限になるかも知れない。セネガールには Post Middle Eocene に Normapolles 花粉が知られているが、これは時代が明らかでない。Normapolles province 外と考えている（第1, 3図、第8表参照）。



第2図. 中国およびその周辺地域の上部白亜紀末期および古第三紀初期の Normapolles 花粉, *Aquilapollenites* 花粉などの地理学的分布.

A : *Aquilapollenites* province N : Normapolles province

○ : *Aquilapollenites* / *Triprojectacites* 花粉の産地

△ : 中国特有種の産地

● : Normapolles 花粉の産地

表1. 上部白亜紀末期および古第三紀初期における Normapolles 花粉と Triprojectacites 花粉の混在地域の比較 (I)

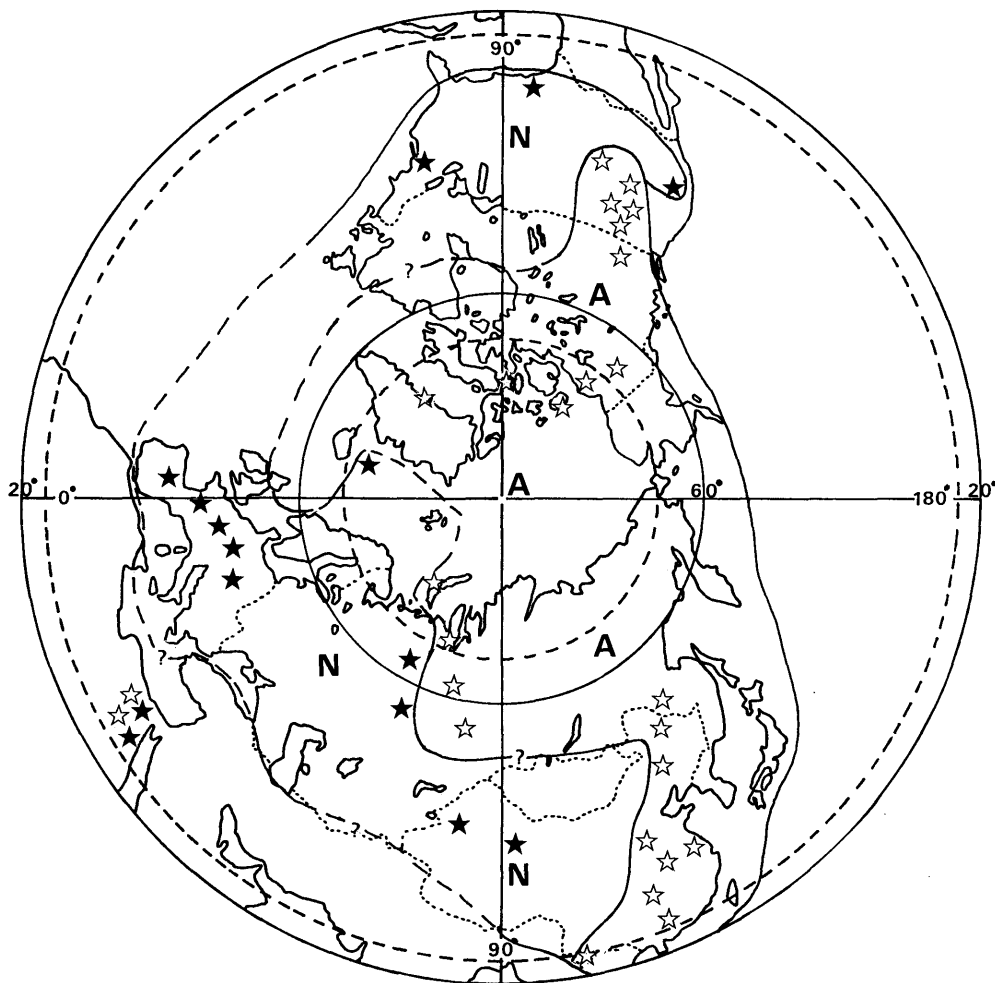
	WESTERN SIBERIAN LOWLAND		KAZAKHSTAN		East Kizilkum
	East - Southeast	North - West - Middle			
Eocene			(Toktuigatsk Fm. low. Eocene) Nudopollis terminalis Trudopollis pompekii		
Paleocene	Aquilapollenites unicus A. quadricretaeus A. punctatus Integricorpus abscisum Orbiculapollis lucidus Fibulapollis evanidus F. mirificus Wodehouseia elegans W. vera Expressipollis ambagiosus Extratropipollenites spp.	Aquilapollenites spinulosus Wodehouseia excelsa Extratropipollenites sp.	(Amangelbinsk Fm.) Conclavipollis sp Nudopollis sp. Trudopollis sp. T. cf. parvotrudens T. anoculus T. aff. arector Oculopollis sp. Nudopollis ornatus	(up. Paleocene) Trudopollis sp. (Danian-low. Paleocene) Oculopollis pertinax Extratropipollenites vestifex E. rostratus Conclavipollis purgatus Nudopollis terminalis	(Danian-low. Paleocene) Extratropipollenites rostratus Nudopollis terminalis Oculopollis sp.
Maastrichtian	Aquilapollenites unicus A. regularis I. mtchedlishvili A. quadricretaeus Fibulapollis mirificus A. asper F. punctatus A. cruciformis F. plicatilis A. granulatus F. enodatus A. insignis Orbiculapollis latus A. latilobus O. globosus Hemicorpus solidum O. faber H. tenue O. lucidus H. notabile O. minutus H. senonicum Cranwellia striata Mancicorpus unicum F. evanidus M. glabrum Wodehouseia aspera M. minimum W. gracilis M. ancoriforme W. vera Triprojectus crassus W. elegans T. dispositus Papillopollis sp. T. magnus T. ovalis Integricorpus reticulatum I. abscisum I. bellum	Aquilapollenites subtilis Integricorpus striatum Triprojectus echinatus Orbiculapollis sp. Azonia calvata	(Ashutusk Fm.) Aquilapollenites latilobus Wodehouseia spinata Oculopollis sp. Betpakdalina sp.	(Maastrichtian-Campanian) Aquilapollenites granulatus Wodehouseia spinata Plicapollis certa Trudopollis sp. Oculopollis sp. Betpakdalina sp.	(Maastrichtian-Campanian) Oculopollis sp. Betpakdalina tetraborbata
Campanian (Senonian)			(Zginsaisk Fm. Coniac.-Santon.) Trudopollis sp. Vacuopollis sp.		

表2. 上部白亜紀および古第三紀初期における Normapollis 花粉と Triprojectacites 花粉の混在地域の比較 (II)

	X I N J I A N G (新疆)		Q I N G H A I (青海)		S I C H U A N (四川)	Y U N N A N (云南)	H E N A N (河南)			H U B E I (湖北)		H U N A N (湖南)	A N H U I (安徽)	
	Shache Basin (莎車盆地)	Kuche Basin (庫車盆地)	Qaidam Basin (柴達木盆地)	Xining-Minghe Basin (西寧 - 民和盆地)	Chongrai-Yaan (邛崃 - 雅安)	Mengla (勐臘)	Tantou Basin (澗頭盆地)	Lingbao Basin (灵宝盆地)	Dayu small Basin Lushi Region (戶氏大峪小盆地)	Jiangnan Basin (江漢盆地)		Hengyan (衡陽)	合肥盆地	天長盆地
EOCENE	巴什布拉克層 (Basibulake Fm. late Eocene) Trudopollis pompeckii Nudopollis sp.	(Xiaokuzibai Fm.) 小庫孜拜層 Pentapollenites jiangsiensis Nudopollis thiergartii Interpollis tenuiplicus Trudopollis sp. Jianhanpollis sp.	路禾河層上部 (Lulehe Fm.) Pentapollenites Paradolium	(Qijiachuan Fm. low. Eocene - Paleocene) Callistopollenites radiato-striatus	(Yuguanpo Fm.) 余光坡層 Cranwellia striata C. retiformis		(Tantou Fm.) Aquilapollenites granobaculus Pentapollenites jiangsiensis Atlantopollis sp.	(Xiangchen Gr. IV) 項城群 Pentapollenites jiangsiensis Papillopollis sp. Nudopollis sp. Trudopollis sp.					(Dingyuan Fm. III, late Eocene - Oligocene) 定遠層三段 Oculopollis baculotradens Lonicerapollis intrabaculus L. echinatus, L. simplex, Pentapollenites dongtaiensis P. sp.	(Funing Fm. III, IV) 阜寧層第3, 第4 Plicapollis sp. Lonicerapollis echinatus L. parvus, L. intrabaculus Extratripoporopollenites basalis multus, E. sp. Pentapollenites sp.
PALAEOCENE	(Qimugen Fm. late Paleocene) Nudopollis terminalis 齊姆根層 N. thiergartii Trudopollis obexemplum T. hemiperfectus T. platoides Interpollis primigenius I. velum	(Talake Fm.) 塔拉克層 Pentapollenites Trudopollis jiangsiensis obexemplum P. pentangulus Extratripoporopollenites Complexiopollis prae-atumescens Pseudoplicapollis peneserta Nudopollis thiergartii N. terminalis Trudopollis aksuensis Tetrapollis sp. Thomsonipollis sp.		Cranwellia sp. Nudopollis thiergartii N. spp. Trudopollis sp. Basopollis atumescens B. spp. Extratripoporopollenites spp. Atlantopollis praeatumescens Complexiopollis praeatumescens C. spp. Jiangnanpollis Interpollis sp., ringens		(up. Up. Cretaceous - early low. Tertiary) Aquilapollenites rombicus Integricorpus cf. striatum I. cf. dolium I. spp. Extratripoporopollenites sp. Trudopollis pompeckii	(Dazhang Fm.) 大章層 Aquilapollenites granobaculatus Atlantopollis sp. Jiangnanpollis henanensis J. luanchuanensis	(Xiangchen Gr. III) Pentapollenites jiangsiensis Aquilapollenites spinulosus Aquilapollenites pentapollenites jiangsiensis Interpollis tenuplicus Trudopollis aksuensis Nudopollis sp.	(Hejiangou Fm.) 何家溝層 Aquilapollenites spinulosus pentapollenites jiangsiensis Interpollis tenuplicus Trudopollis aksuensis Nudopollis sp.	Jiangnanpollis sayangensis	(Xingouju Fm.) 新溝咀層 Pentapollenites jiangsiensis P. hubeiensis P. pentangulus P. dungtaiensis P. sp. Extratripoporopollenites basalis	(Shiaryushi Fm.) 霞流市層 Aquilapollenites granobaculus A. sp. Pentapollenites pentangulus P. jiangsiensis P. projecientis P. dungtaiensis P. cf. regulatius P. sp.	(Dingyuan Fm. II, middle-late Eocene) 定遠層二段 Lonicerapollis echinatus L. simplex, Pentapollenites dongtaiensis, P. sp. (Dingyuan Fm. I, late Paleocene - early Eocene) 定遠層一段 Plicapollis trinus Lonicerapollis sp., Extratripoporopollenites sp., Pentapollenites spp., P. dongtaiensis	(Funing Fm. I, II) Jiangnanpollis striatus minor, Jiangnanpollis radiatus, Pentapollenites sp.
M A S T R I C H T I A N				(Minghe Fm. (late Cretaceous) Callistopollenites sp. Crassimarginipollenites mirus C. psilatus C. sp. Jiangnanpollis arciformis J. sp. Morinoipollenites normapollis M. spp.	(Guankou Fm.) 灌口層 Tetrapollis sp. Papillopollis sp. Extratripoporopollenites cf. atumescens E. cf. orthobasalis E. cf. spumeides					Morinoipollenites normalis M. minor M. polyprojectus M. rhombiformis Jiangnanpollis ringens J. mikros, J. arciformis J. radiatus is J. sayangensis Crassimarginipollenites reticulatus C. mirus C. psilatus Integricorpus wangii I. psilatum I. striatum I. mirum Aquilapollenites sp. Orbiculapollis striatus Callistopollenites radiato-striatus	(Yuyang Fm.) 漁洋層 Mancicorpus intragranulatum Callistopollenites radiato-striatus C. crassixinus C. sp. Cranwellia striata C. sp. Crassimarginipollenites reticulatus C. psilatus C. mirus Jiangnanpollis mikros J. radiatus	(Tontang Fm. Up. Cretaceous) Callistopollenites sp. 車塘層		(大王廟) Pentapollenites dongtaiensis Translucentipollis granulatus Plicapollis sp. Jiangnanpollis radiatus Cranwellia striata
CAMPANIAN										C. crassixinus C. comis C. sp.				

表 3. 上の白亜紀末期および古第三紀初期における Normapolles 花粉と Triprojectacites 花粉の混在地域の比較 (Ⅲ)

	Q U A N G D O N G (広東)			J I A N G X I (江西)	Z H E J I A N G (浙江)	J I A N G S U (江蘇)	B O H A I (渤海)	F U S H U N	S O U T H S O N G H U A (松花江南部)	H E I L O N G J I A N G (黒友江)	A M U R
	Sanshui Basin (三水盆地)	Leizhou Peninsula (雷州半島)	Nanxiong Basin (南雄盆地)		Hangzhou Gulf (杭州湾)		Coastal Region	抚顺煤田	Songliao Basin (松辽盆地)	Furao Area (富綏地区)	Zeya - Bureya
EOCENE	(Huayong Fm. early Oligo.-late Eocene) Pentapollenites magnus (华南層) P. minor, P. pentangulus (Xibu Fm. middle-late Eocene)西岫層 Pentapollenites laevigatus P. minor, P. pentangulus P. ? sp.	流沙港層下部 (Early Eocene) Aquilapollenites sp. Pentapollenites sp.	(Danya Fm. middle-late Eocene) 丹霞層 Jiangsupollis striatus striatus J. sp., Cranwellia striata Plicapollis serta (Lofochai Fm. early Eocene) 罗佛寨層 Aquilapollenites sp., Cranwellia striata Pentapollenites rhomboius, P. jiangsiensis		(Changhe Fm.) 長河層 Pentapollenites minor P. dungtaiensis P. jiangsiensis P. pentangulus P. cf. dolium P. sp.	(Funing Gr. III, IV) 阜宁層群第 3, 第 4 層 Pentapollenites dontaiensis Cranwellia granobaculus	(Kongdian Fm.) 孔店層 Aquilapollenites spinulosus A. obesus	(Guchengzi Fm.) Aquilapollenites spinulosus			(Kvdinsk Fm. Paleocene-Eocene) Aquilapollenites spp. Fibulapollis mirificus Pentapollenites rhombicus P. sp.
PALEOCENE	Jianghanpollis ? sp. (Buxin Gr. II+III. early Eoc.-middle 柿心層群第 2, 第 3 層 Eocene) P. dolium, P. pentangulus, P. cf. sanshuiensis, P. dungtaiensis P. triangulus, P. laevigatus, P. minor Aquilapollenites ? sp., Jiangsupollis striatus medius, J. striatus striatus (Buxin Gr. late Paleocene) 柿心層群第 1 層 Pentapollenites laevigatus, P. minor P. pentangulus, P. cf. triangulus Jiangsupollis striatus medius J. striatus striatus				(Funing Gr. II) 第 2 層 Pentapollenites dontaiensis P. paradolium Cranwellia striata C. yizhenensis C. ? sp. (Funing Gr. I) 第 1 層 Pentapollenites dongtaiensis P. paradolium Cranwellia striata C. yizhengensis C. ? sp.				(Wuyin Fm. Paleocene) 烏云層 Aquilapollenites spinulosus, Plicapollis sp. (Up. Furao Fm. Danian) 富綏層上部 Aquilapollenites subtilis, A. cf. augustua, A. coriaceus, A. granobaculus, A. spinulosus, A. cf. cruciformis, A. attenuatus, A. spp., Integricorpus amoenus, I. striatus, I. mirus, Bratzevaea jiayingensis, Mancicorpus sp. Orbiculapollis globosus, Plicapollis serta		
M A S T R I A N	(Dalangshan Fm.) 大塋山層 Aquilapollenites crassus Pentapollenites minor Cranwellia striata Jiangsupollis striatus medius J. striatus minor J. striatus stratus Jianghanpollis mikros J. ringens Extratriporopollenites perlucidus E. ? sp.				(Taizhou Fm.) 泰州層 Aquilapollenites rigidus A. spp. Pentapollenites cf. regulatus Mancicorpus solidium M. trapeziforme M. sp. Fibulapollis granulatus F. striatus Wodehouseia spinata Singularia ? sp. Callistopollenites radiostriatus Jianhanpollis radiatus J. ringens, J. mikros Jiangsupollis striatus striatus J. striatus minor, J. major minutus J. striatus medius Extratriporopollenites thiergartii E. perlucidus Betpakdalina triangulata B. sp. W. circinata, W. zoros, W. jiangsuensis, W. stanleyi, W. asper, W. gracile, W. sp.	(north) Aquilapollenites bibacillus A. cf. crassatus A. cf. stelckii A. absidatus A. juvenis A. tenuicatenus A. trigonos A. eurypteronus A. conatus, A. rigidus A. cruciformis, A. cf. amplus Hemicorpus kurtos Pseudointegricorpus toretes Fibulopollis sp. Orbiculapollis globosus Wodehouseia octospina W. spinata Callistopollenites sp. Jianghanpollis ringens Betpakdalina tetrabarpata			(Mingshui Fm.) 明水層 Aquilapollenites quadrilobus, A. minor, A. turbidus, A. punctatus, A. stelckii, A. attenuatus, A. minstriensis, Integricorpus reticulatus, I. bellum, Bratzevaea amurensis, Mancicorpus tenuis, Orbiculapollis globosus, O. proejcientus, O. lucidus, O. subbratus, Fibulapollis regularis, Triprojectus echinatus, Morinoipollenites minor, M. normalis Callistopollenites radiostriatus, Plicapollis sp., Nudopollis sp., Interpollis tenuiplicus (Sifangtai Fm. middle-late Senonian) 四方台層 Aquilapollenites sp., Callistopollenites radiostriatus, Interpollis tenuiplicus (Nenjiang Fm. early-middle Senonian) 嫩江層 Aquilapollenites crassatus, A. quadrilobus, A. minor A. spinulosus, A. stelckii, A. rhombicus, A. nenjiangensis, A. punctatus, A. rigidus, Integricorpus reticulatus, I. spp., Mancicorpus polaris, M. triangulus, M. tenuis, M. solidum, M. spp., Pentapollenites sp., Orbiculapollis globosus, O. lucidus, O. proejcientus, O. scabratus, Fibulapollis mirificus, F. plicatilis, F. regularis, F. scabratus, F. enodatus, A. callimosus, F. sp., Triprojectus echinatus Callistopollenites radiostriatus, C. comis, C. tumidoporus	(Low. Furao Fm.) 富綏層下部 Aquilapollenites attenuatus, A. cf. datongensis A. cf. granulatus, A. insignis, A. quadrilobus A. asper, A. granulatus, A. subtilis A. cf. punctatus, Fibulapollis mirificus, F. rhombicus Integricorpus bertillonites, I. bellus, Pseudo-integricorpus clavireticulatus, Bratzevaea amurensis, Mancicorpus cf. borealis, M. tenue, F. enodatus, F. cf. granulatus, Triprojectus reductus, Orbiculapollis lucidus, O. globosus, Pseudoaquilapollenites striatus, P. conatus, Wodehouseia spinata, W. stanleyi, Cranwellia cf. bacata, C. striata Plicapollis sp., Interpollis sp.	(Tsagaiansk Fm.) Aquilapollenites insignis, A. cruciformis, A. quadrilobus, A. polaris, A. asper, A. granulatus, A. subtilis A. spinulosus, A. spp., Hemicorpus tenue, H. notabile, H. solidum, H. spp., Integricorpus dolium, I. reticulatum, I. spp., Bratzevaea amurensis, Fibulapollis mirificus, Orbiculapollis globosus, O. lucidus, Pentapollenites rhombicus, P. spp., Cranwellia striata, Wodehouseia spinata, W. cirrifer, Callistopollenites radiostriatus, Vacuopollis sp.
CAMPANIAN (SENONIAN)				(Zhoujiadian Fm. Albian-Turonian) 周家店層 Orbiculapollis cf. scabratus Cranwellia striata, C. jiangxiensis, C. cf. yizhengensis, C. conspicuus, C. rumseyensis, C. spp. Jiangsupollis cf. striatus							(Zavitinsk Fm. low. Senonian) Aquilapollenites sp.



第3図. 上部白亜紀末期および古第三紀初期の *Normapolles* province と *Aquilapollenites* province の北極を中心とした地理学的分布

A : *Aquilapollenites* province N : *Normapolles* province

☆: *Aquilapollenites* province 内における *Normapolles* 花粉の混在

★: *Normapolles* province 内における *Aquilapollenites*/*Triprojectacites* 花粉の混在

北海地域については、最近の北海油田開発のボーリング試料から得られたデータによれば、北海の北半分は *Aquilapollenites* 花粉を産し、南半分は *Normapolles* province に入ると言う。両者は漸移していると言う。また、Scotland の Mull 島の Maastrichtian 層および Shetland 諸島の西部地域は *Aquilapollenites* 花粉を産し、*Normapolles* province と区別した方が良いと考えられる。さらに、Iceland 島の始新統では、*Trudopollis probetuloides*, *T. fossulatrudens*, *Oculopollis ostryaeformis* などの *Normapolles* 花粉が報告されているが (Pflug, 1959)、

これらが Normapolles に属するのは疑問である。Manum (1962) も同じ意見をのべている。従って、Iceland 島を Normapolles province に入れるのは難点がある。しかし、Jan Mayen 島と Iceland 島の間にある海底の Iceland Plateau-Jan Mayen Ridge のボーリング試料によれば、始新世の堆積物に Normapolles 花粉の多くと若干の *Aquilapollenites* とその仲間を産する (Koreneva et al., 1976; 第 1, 3 図, 第 6 表参照)。これは Spitzbergen の暁新世～始新世堆積物と共に Normapolles province のものとする。要するに、European-Turanian 地域は Maastrichtian および古第三紀初期になるとその分布域を上述の地域に拡大していった事が分かる。

北米大陸では、Normapolles 花粉は、次の 3 つの地域に拡大し、発展した。a) North Atlantic Coastal Plain, b) Mississippi embayment area, c) area west of the axis of the Cretaceous epeiric seaway である。

a) North Atlantic Coastal Plain: 被子植物起源の問題は下部白亜紀にさかのぼるが、この地域では、この問題についての研究材料を提供してくれる地域の 1 つである。Patuxent-Arundel flora (Barremian?-Lower Albian) は *Clavatipollenites* を含む、これは monosulcate 花粉であるが、彫刻は被子植物の特徴をもつ最も古い花粉である。明らかに双子葉植物の網目状の tricolpate 花粉は Patapsco 層の基底 (Lower-Middle Albian) に出現する。Tricolpate 花粉は上部 Patapsco 層 (Upper Albian-Lower Cenomanian) に多様化している。Tricolporate 花粉は Raritan 層への漸移層から産する。これは下部 Raritan 層 (Middle-Upper Cenomanian?) で最初の triporate 花粉 *Complexiopollis* と *Atlantopollis* に結びつくことになる。この地域が、北米大陸での Normapolles 花粉移住の最初の地と考えられる。この地域では Campanian-Maastrichtian に *Aquilapollenites* とその仲間が若干混在している (第 5 表参照)。

その他、Long 島, Block 島, Rhode Island および Grand Banks から Normapolles 花粉が報告されている (Sirkin, 1974; Williams & Brideaux, 1975; 第 5 表参照)。

b) Mississippi embayment area: この地域は Normapolles province に属するが、Gulf Coast 地区では若干の *Aquilapollenites* およびその仲間が混在する。また、Kemp 層 (Maastrichtian) および上部 Wilcox 層群 (始新世) には *Wodehouseia* 花粉が知られている (第 5 表参照)。

c) Area west of the Cretaceous epeiric seaway: この地域の南部の New Mexico では、San Juan 盆地の東側で、Nacimiento 層 (暁新世) からは Normapolles 花粉 *Extratropipollenites* sp. が知られている (Anderson, 1960; 第 5 表参照)。また、Arizona では Black Mesa 地域の Mesaverde 層群 (Coniacian) の Toreva 層および Wepo 層から *Plicapollis sertae* が産出している (Romans, 1975)。両地域とも *Aquilapollenites* の報告がなく、Normapolles province に入るものと思われる。California では Drugg (1967) により Escarpado Canyon の Marsha shale (Maastrichtian) および Dos Palos shale (Danian) から Normapolles 花粉の報告がある (第 5 表参照)。 *Aquilapollenites* の報告はない。また、西 San Joaquin 谷の Uhalde 層と Moreno 層から *Aquilapollenites* とその仲間および Normapolles 花粉の混在が報告されている (Chmura, 1973; 第 5 表参照)。これらの地域は Normapolles province と考えた方が良いと思う (第 1, 3 図参照)。

Utah, Colorado, Wyoming, Montana および Alberta などでは、Normapolles 花粉の侵入があり、Campanian (Utah では Maastrichtian まで) には明らかに Normapolles 花粉が産出し、同時に、Campanian 以降 *Aquilapollenites* /Triprojectacites 花粉グループの主要分布地域の 1 つとなった。 *Aquilapollenites* /Triprojectacites 花粉の出現は Senonian 中であり、従って、Normapolles の侵入が早かったと考えるが、上部白亜紀末期にはほぼ完全に *Aquilapollenites* /Triprojectacites 花粉グループによって交代した。

表5. 北米大陸における上部白垩紀末期および古第三紀初期の Normapollis province 内の各地域の比較

	C A L I F O R N I A		NEW MEXICO	MISSISSIPPI EMBAYMENT	SE M I S S O U R I	G U L F C O A S T		SOUTH CAROLINA	NE VIRGINIA	ATLANTIC COASTAL PLAIN		GRAND BANKS	O N T A R I O
	Western San Joaquin Valley	Escarpado Canyon		Missouri-Kentucky-Tennessee-Mississippi	New Madrid Test Well 1-X	Texas - Arkansas - Louisiana - Mississippi - Alabama		Clubhouse Crossroads C.	Oak Grove Core	Maryland - Delaware - New Jersey			South Moose River Basin
EOCENE				(Yazoo clay, up. Eocene) Plicapollis spatiosa			(Claiborne Gr. middle Eocene) Nudopollis terminalis Thomsonipollis ? crockettensis (up. Wilcox Gr.) Aquilapollenites spp., Thomsonipollis magnificoides Wodehouseia spp. T. magnificus, Trudopollis T. sabinetowensis, Nudopollis thiergartii Plicapollis sp., Basopollis atum		(Nanjemoy Fm.) Nudopollis terminalis Trudopollis plena Basopollis obscurocostata Thomsonipollis magnifica Interpollis microsupplingensis				
PALEOCENE	(Dos Palos sh. Danian) Nudopollis terminalis Plicapollis thornei	(Nacimiento Fm. Ojo Alamo s.s.) Extratripopollenites sp.	(Clayton Fm. + Porters Creek clay) Interporopollenites sp. Latipollis sp. Extratripopollenites spp. Trudopollis sp.	(Porters Creek clay) Nudopollis thiergartii Interporopollenites turgidus Nudopollis terminalis Trudopollis plena (Clayton Fm.) Therpollis paleocenica	(Midway-low. Wilcox Gr., Kincaid Fm.) Thomsonipollis magnificus, T. magnificoides Nudopollis thiergartii, N. terminalis Trudopollis pertrudens, Basopollis basalis B. atumescens, Plicapollis spp. (Rockdale lignite, Palaeocene) Trudopollis pertrudens, Nudopollis thiergartii N. terminalis, Plicapollis sp. Extratripopollenites basalis, E. alabamicus	(Midway-low. Wilcox Gr., Kincaid Fm.) Aquilapollenites attenuatus, A. spinulosus, A. quadrilobus, A. spp., Triprojectus sentus, T. conatus, Hemicorpus delicatum, H. striatum, H. senonicum, Integricorpus catanireticulatum, I. reticulatum, Cranwellia striata, Wodehouseia spinata, Extratripopollenites sp., Choanopollenites eximus, Ch. sp.	(Paleocene) Choanopollenites alabamicus Thomsonipollis magnifica Trudopollis plene Nudopollis terminalis N. endangulata Pseudoplicapollis limitata, P. serea Interpollis paleocenica I. microsupplingensis	(Marbolo clay, up. Paleocene; Aquia Fm., Paleocene) Nudopollis terminalis, N. thiergartii Trudopollis plene Pseudoplicapollis cf. endocuspis Choanopollenites alabamicus Piolencipollis endocuspoides	(Brightseat Fm.) Latipollis conspicuus Extratripopollenites andax E. sp. Plicapollis silicatus		Extratripopollenites spp.		
M A A S T R I C H T I A N	(Uhalde Fm. + Moreno Fm.) Aquilapollenites latilobus A. sp. Hemicorpus sp. Integricorpus reticulatus Mancicorpus sp. Plicapollis thornei P. sp. Trudopollis speciosus	(Marca sh.) Vacuopollis sp. Plicapollis thornei	(Owl Creek Fm. + McNairy sand) Plicapollis sp. Interporopollenites spp. Oculopollis spp. Trudopollis sp.	(Maastrichtian + up. Campanian) Pseudoplicapollis serena Interpollis paleocenica Extremipollis vivus Vacuopollis munitus Interpollis cf. supplingensis Pseudovacuoipollis involutus Plicapollis usitatus Secuioculopollis sp. (lower Campanian) Pseudoplicapollis serena Bohemiapollis ? sp. Plicapollis usitatus Pseudovacuoipollis involutus		(Kemp Fm.) Aquilapollenites quadrilobus, A. attenuatus, Triprojectus conatus, Hemicorpus delicatum, H. senonicum, Integricorpus reductum, I. reticulatum, Cranwellia striata, Wodehouseia spinata			(Red Bank Sand) Aquilapollenites sp. (Monmouth Gr.) Aquilapollenites sp. Integricorpus reticulatum			Extratripopollenites spp.	(Maastrichtian-Campanian) Basopollis sp. Endopollis sp. Extratripopollenites sp. Nudopollis sp. Oculopollis sp. Plicapollis sp. Trudopollis sp.
CAMPANIAN (SENONIAN)									(low. Maastrichtian-Campanian) Basopollis sp. Choanopollenites discipulus, Ch. transitus, Complexiopollis sp. Plicapollis spp. Trudopollis sp.			Extratripopollenites spp.	(post-Albian and Santonian) Extratripopollenites spp.
									(Mt. Laurel-Navesink Fm. late Campanian) Trudopollis conformis Plicapollis silicatus (Wenonah Fm. + Marshalltown Fm. up. Campanian) Aquilapollenites sp.	Endoinfundibulapollis sp., Pseudatlantopollis sp. Interpollis sp., Bohemiapollis, Extremipollis, Praebasopollis, Osculapollis, Pseudoculopollis, Longanulipollis Pseudovacuoipollis		Extratripopollenites spp.	

表6. グリーンランド海およびその周辺地域の Normapolles 花粉と Triprojectacites 花粉

	SCOTLAND	SPITZBERGEN	NORWEGIAN- GREENLAND SEA	GREENLAND		BARENTS SEA
	Mull Island		Jan Mayen Ridge	North	West	Gusinaya Bank
EOCENE		(Palaeocene- Eocene) Trudopollis bar- entsii, T. resistens T. rotundus T. spp. Tetrapollis conspectus T. quadratus T. sp.	(Eocene) Interpollis supplingensis Trudopollis per- trudens Interporopolle- nites sp., Vacuopollis semi concavus Complexiopollis sp., Tetrapol- lis sp., Plica- pollis spp., P. carpinoides Pentapollenites laevigatus Aquilapollenites subtilis Tricojectus sp.			
PALAEOCENE					(Quikavsak Member, Low. Palaeocene) Trudopollis sp (Late Cret. and Palaeoce- ne)	
MAASTRICHTIAN	Aquilapollenites cruhellerensis A. petasus A. proteus A. subtilis Integricorpus striatum			(Kap Washing- ton Group, Campanian- Maastrichtian) Aquilapollen- ites sp., Mancicorpus sp Triprojectus sp.	Aquilapollen- ites sp. cf. A. amplus, A. rectus, A. sp. Pseudointegri- corpus clari- reticulum Wodehouseia spinata	
CAMPANIAN					(upper Senonian) Aquilapollenites amplus, A. attenuatus, A. quadrilobus, A. spinulosus, A. unicus, A. re- gularis, Hemicorpus senonicum, H. tenue, Mancicorpus sp., Integricorpus reticulatum, I. dodium, I. bellum, I. sp., Kurtzipites plicatilis, K. sp. K. evanidus, K. mirificus, Orbiculapollis sp., Azonia fabacea, A. munita, A. ovalis Wodehouseia calvata, Cranwel- lia striata, Loranthacites pilatus, L. macrosolenoides, Expressipollis ocliferius, E. accuratus, E. cybaeus, E. sp. Vaculopollis sp., Oculopollis sp., Trudopollis hemiperfect- us, T. variabilis, T. sp., Plicatopollis silicatus	
SANTONIAN						

表7. ヨーロッパの Normapolles province 内における古第三紀における *Pentapollenites* の混在の比較

	H U N G A R Y			G E R M A N Y			B E L G I U M			F R A N C E			S P A I N					
E O C E N E	Pentapollenites laevigatus (Bakony Mts.) (Dorog) P. triangulus, P. pentangulus, P. regulatius Plicapollis pseudoexcelsus Minorpollis spp. Basopollis spp. Interpollis supplingensis Interpollis supplingensis I. velum Nudopollis endangulus Pseudoplicapollis sp. Pompeckjoidaepollenites subhercynicus Minorpollis gallicus			Plicapollis pseudoexcelsus Minorpollis sp., Lonicerapollis gallwitzii, Olaxipollis matthesi, Interpollis velum, I. microsupplingensis, Corsinipollenites oculusnoctis, Tetrapollis validus Pentapollenites pentangulus, P. regulatius, P. triangulus			Pentapollenites laevigatus, P. macroreticulatus, P. pentangulus, P. punctoides, P. regulatius, P. retangulus, P. semistriatus, P. triangulus, P. striatus, P. verrucatooides, P. belgicus, Trudopollis oculoides, T. pertrudens, T. subtrudens, T. parvotrudens, Vacuopollis concavus, Interpollis microsupplingensis, I. supplingensis, I. velum, Nudopollis endangulatus, N. terminalis, N. thiergarti, Minorpollis sp., Interporopollenites magnoides, I. initium, Interpollis messelensis, Tetrapollis megavalidus, T. validus, Pseudoplicapollis sp., Thomsonipollis magnificoides, T. magnificus, Basopollis ornatus, B. basalis, B. erthobasalis			(Ypresian) Interpollis supplingensis Plicapollis pseudoexcelsus minor P. pseudoexcelsus turgidus P. pseudoexcelsus pseudoexcelsus Pompeckjoidaepollenites subhercynicus P. peneperfectus			(Lutetian, Bouxwiller) Pentapollenites pentangulus Nudopollis terminalis Minorpollis minimus Plicapollis pseudoexcelsus pseudoexcelsus P. pseudoexcelsus turgidus P. pseudoexcelsus microturgidus P. pseudoexcelsus minor P. pseudoexcelsus luteticus Pompeckjoidaepollenites subhercynicus					
	Minorpollis sp.			Pentapollenites spp., Pseudotrudopollis pseudoalnus, P. pseudoalnooides, Trudopollis crassotrudens, T. oculoides, T. pertrudens, T. subtrudens, T. subhercynicus, T. parvotrudens, Oculopollis sp., Vacuopollis concavus, Interpollis microsupplingensis, I. supplingensis, I. velum, Nudopollis endangulatus, N. terminalis, N. symmetricus, N. thiergarti, Basopollis atumescens, Plicapollis pseudoexcelsus, Minorpollis sp., Thomsonipollis gracilis, Tetrapollis praevalidus, T. validus, Bohemiapollis palaeocalnicus, Extratriporopollenites andax/vestifex, Interporopollenites initium,			(up. Landenian, Epinois+Loksbergen) Pentapollenites pentangulus microstriatus, P. pentangulus crassicus, P. cf. verrucatooides, P. striatus, P. regulatius, P. belgicus Interpollis supplingensis, I. microsupplingensis, Vacuopollis concavus, Minorpollis spp., Tetrapollis validus, T. megavalidus, Basopollis orthobasalis, B. basalis, B. atumescens, B. spp., Trudopollis eocaenicus, T. cf. succedanus, Plicapollis cf. conserta, P. pseudoexcelsus, Nudopollis endangulatus, N. terminalis, N. thiergarti, N. basaloides, N. ? eximoides, N. granuloides, N. trugoides (Montian + Landenian, Hainaut) Nudopollis thiergartii, N. pseudothierygarii, N. terminalis, N. endangulatus, Stephanopropollenites hexaradiatus tribinae, S. hexaradiatus semitribinae, Trudopollis hammenii, T. kunertii, Basopollis atumescens, B. basalis, B. orthobasalis, Plicapollis pseudoexcelsus, Interpollis supplingensis, Pompeckjoidaepollenites subhercynicus, P. peneperfectus			(Sparnacian, Woolwich beds) Pentapollenites laevigatus laevigatus Plicapollis pseudoexcelsus pseudoexcelsus, P. pseudoexcelsus semiturgidus Nudopollis endangulatus, Interpollis supplingensis (Sparnacian, Corbieres-Minorvoie) Plicapollis pseudoexcelsus turgidus P. pseudoexcelsus semiturgidus P. pseudoexcelsus pseudoexcelsus P. pseudoexcelsus minor			Basopollis orthobasalis B. sp., Nudopollis terminalis, N. minutus, Nudopollis pseudoexcelsus semiturgidus N. eximoides, Minorpollis gallicus M. sp., Vacuopollis concavus, Interpollis supplingensis (Sparnacian, Corbieres-Minorvoie) Plicapollis pseudoexcelsus turgidus P. pseudoexcelsus semiturgidus P. pseudoexcelsus pseudoexcelsus P. pseudoexcelsus minor			(Sparnacian, Tremp, Can Morebey, Campo) Pentapollenites sp., P. cf. rodaensis Plicapollis pseudoexcelsus turgidus P. pseudoexcelsus semiturgidus P. pseudoexcelsus pseudoexcelsus Basopollis sp., Nudopollis terminalis hastaformis Minorpollis sp., Interporopollenites proporus, Interpollis sp., Extratriporopollenites pompeckji		
PALAEOCENE	(low. Maastr., SW Hungary) Pseudopapillopollis sp. Nudopollis sp., Atlantopollis sp., Convexipollis convexigerminalis Pseudoplicapollis peneconcaipollis sinus Pompeckjoidaepollenites sp. (up. Camp./low. Maastr.) Oculopollis sp., Krutzschipollis sp., Semioculopollis minimus, Coronatipollis coronatus, Longanulipollis lenneri, L. sp., Extratriporopollenites sp. Hungaropollis sp., H. bac-salmasi, Vacuopollis percentus, Arcanupollis sp. Minorpollis sp., Trudopollis maastrichticus, T. sp. Suemegipollis triangularis S. minor, Complexiopollis complicatus, Interporopollenites sp., Pseudoplicapollis sp., Endopollis sp. Pseudopapillopollis praesubhercynicus, Cf. Interpollis sp., Plicapollis sp. (up. Campanian, SW Hungary) Schulzipollis pannonicus, Laudaypollis clarus Capipollis sp., Santonipollis sp., Primpipollis sp., Bakonyipollis galerus			(Campanian, Uppong Mts.) Longanulipollis sp. Trudopollis sp. T. minimus Oculopollis cf. devecsereensis, O. minimus, O. clausus, O. globosus, O. santonicus, O. serratus, O. regularis, O. scandalus O. orbicularis, O. auritus O. brevioculus, O. kopeki O. zaklinskajae, O. microserratus, O. rictus, O. micrclausus, O. sp. Hungaropollis krutzschii H. ajkanus, H. mikrokrutzschii, H. minimus, H. oculus, H. retilineus, H. simus, H. salebrosus, H. concavus minor, H. glomeratus, H. semiglobosus, Complexiopollis sp., Krutzschipollis sp., Pseudoplicapollis sp., Interporopollenites extensus, I. santonicus, I. vinculatus I. sp., Cuneipollis medius			Plicapollis silicatus, P. peneserta, P. sarta, P. conserta, Pseudoculopollis minimus, Vacuopollis concavus, V. procentus, Minorpollis minimus, M. sp., Trudopollis subhercynicus, T. parvotrudens, T. retigressus, T. hemiperfectus, T. capsula, T. ? triplex, T. pertrudens, T. sp., Suemegipollis triangularis, S. sp., Hungaropollis sp., Extratriporopollenites ? epistula, E. ? animus, E. primigenius, E. maastrichtiensis, E. convexigerminalis, E. altmarkensis, E. gracilis, E. sp., Oculopollis concentus, O. ? principalis, O. cardinaloides, Interporopollenites initium, I. oebisfeldensis, I. cretaciensis, I. tenuis, Extremipollis oebisfeldensis, Pseudotrudopollis concavoides, P. crassexinus, P. baculatus, P. sp., Pseudoplicapollis maastrichtiensis, P. pflugi, P. pseudoalnus, P. pseudoalnooides, P. complexus, P. sp., Interpollis supplingensis, I. microsupplingensis, I. sp., Magnoporopollis minor, M. sp., Bohemiapollis compactus, B. oebisfeldensis, B. sp., Oculopollis microoculus, Magnoporopollis oebisfeldensis, Concavipollis sinus, Complexiopollis sp., Latipollis sp., Turonipollis sp., Pseudovacuoipollis sp., Oculopollis sp., Semioculopollis sp.,			(Maastrichtian, SE France and NE Spain) Heidelbergipollis sp. Oculopollis maximus								
	(up. Senonian, S-Hungary) Cf. Longanulipollis sp. Rom-einipollenites hungaricus, Magnoporopollis krutzschii Complexiopollis lusitanicus, Interporopollenites zaklinskaiae, I. csavolyensis, I. Stanleyi, Endoinfundipollis distinctus, E. sp., Pseudosculapollis tschudyi, P. sp., Suemegipollis triangularis, Vacuopollis prezensis, Plicapollis silicatus, P. sarta, Verruoculopollis sp., Papillopollis csavolyensis csavolyensis, P. csavolyensis magna, Elsikipollenites maastrichtiensis, Trudopollis hojrupensis, T. triangulus, T. lativerrucatus, T. proparvus, T. hemiparvus, T. sp., Hofkeripollis capsula			Trudopollis mechanicus, T. multiplex, T. articulus, T. artifex, T. absurdus, T. retigressus, T. hemiperfectus, T. capsula, T. ? triflex, T. sp., T. subhercynicus, T. parvotrudens, Latipollis normis, L. sp., Semioculopollis oculoides, S. sp., Oculopollis fastidicus, O. pneumaticus, O. cardinalis, O. suboculus, O. aethericus, O. balbosus, O. antibulbosus, O. concentus, O. ? principalis, O. sp., Interporopollenites primigenius, I. parvus, I. elector, I. aachenensis, I. initium, Pseudoplicapollis ? proparvus, P. competitor, Vacuopollis pyramis, V. proconjunctus, V. graciconcavus, V. percentus, V. orthopyramis, V. fabellus, V. semiconcavus, V. procentus, Plicapollis conserta, Hungaropollis sp., Vacuopollis pyramis, Pseudovacuoipollis intraconcavus, Papillopollis regulus, P. aregulus, Extrapollis hastaclarus, Bohemiapollis arector, Interporopollenites proporus, I. nimbus, Extratriporopollenites ? epistula, E. ? animus, E. primigenius, E. maastrichtiensis, Extremipollis oebisfeldensis, Trudopollis pertrudens, Magnoporopollis oebisfeldensis, M. sp., Oculopollis microoculus, Plicapollis silicatus, P. peneserta, Pseudoculopollis minimus, Vacuopollis concavus, Plicapollis sarta, Minorpollis minimus, Complexiopollis sp., Turonipollis sp., Pseudoplicapollis sp., Pseudotrudopollis sp., Extratriporopollenites sp., Suemegipollis sp.			(Santonian or early Campanian, Hergenrath Beds/Aachen Fm.) Trudopollis hemiperfectus, T. sp. cf. T. orthomechanicus, T. retigressus, T. sp., T. protrudens, T. nonperfectus, T. geometricus, Extratriporopollenites pelucidus, Vacuopollis sp. cf. V. venustus, V. concavus, V. pyramis, V. sp. cf. V. semiconcavus, Cf. Conclacipollis (=Vacuopollis) purgatus, Oculopollis sp. cf. O. cardinalis O. sp. cf. O. concentricoides, O. concentus, Interporopollenites group, I. zaklinskaiae, I. turgidus, I. sp., Extrapollis hastaclavus, Papillopollis clarescendus, Pseudoculopollis principalis			(Campanian, Vendee) Semioculopollis minutus Oculopollis parvoculus Interporopollenites spp. Pseudoplicapollis serenus Magnoporopollenites gerni-crassus, M. praemagnoporatus Heidelbergipollis sp., Extremipollis cf. caminus Megatriopollis santonius M. sp., Papillopollis weylandii, Quedlinburgipollis sp., Vancampollenites subporatus, V. triangulus (Sant./Camp., Vendee) Extrapollis bohemicus E. quedinburgensis, E. sp., Interporopollenites turgidus I. vancampoae, I. elector I. spp., Osculapollis aequalis Trudopollis hemiperfectus,			(Campanian, Fuvélien, SE France + NE Spain) Heidelbergipollis sp., Trudopollis cf. pertrudens, Pseudopapillopollis praesubhercynicus, Pompeckjoidaepollenites sp., Cf. Mediopollis sp., Convexipollis sp., Nudopollis sp., Semioculopollis minimus, Cf. Minorpollis sp., Cf. Nudopollis venustus, Latipollis sp., Cf. Papillopollis Pseudoculopollis sp. (Valdonnien) Interporopollenites sp., Suemegipollis sp., Trudopollis cf. portrudens, Vacuopollis sp., Papillopollis sp., P. cf. budejovicensis, P. cf. solidus, P. cf. clarescendus, Interpollis sp., Extratriporopollenites cf. spumoides, E. sp., Trudopollis sp., Cf. Hungaropollis sp., Cf. Quedinburgipollis sp., Pseudopapillopollis praesubhercynicus					

表8. Normapolles と Triprojectacites provinces 以外の地域における両花粉の出現

		A F R I C A				I N D I A			MALAYSIA	B R A Z I L	
		Tunisia	E g y p t	Senegal	Nigeria	Gabon	Meghalaya	Bengal Basin	Karikal	Sarawak	Sergipe (Alagoas)
OLIGOCENE			(Abu Rauwash, Moquattam Region) Pentapollenites laevigatus laevigatus, Minorpollis gallicus, Plicapollis pseudoexcelsus, P. pseudoexcelsus turgidus, P. pseudoexcelsus semiturgidus	(post Middle Eocene) Trudopollis sp. Plicapollis sp. Minorpollis sp. Oculopollis sp. cf. Suemegipollis sp. cf. Pseudoplicapollis sp.							
	EOCENE		(Giza-Duwi) Plicapollis pseudoexcelsus	cf. Nudopollis sp.							
PALAEOCENE	(up. Maastrichtian -Danian, Kef, NW Tunisia) Cf. Elsikipollenites, Hofkeripollenites, Lusatipollis	(Farafra, Oweina) Trudopollis sp. Minorpollis sp. Oculopollis sp. Plicapollis pseudoexcelsus								(Palaeocene-Senonian) Aquilapollenites wilfordi	
MAASTRICHTIAN	Magnoporopollis Minorpollis Nudopollis Oculopollis Plicapollis Pseudoculopollis Semioculopollis Stephanoporopollenites, Trudopollis	(Borehole Younis North near Quseir) Aquilapollenites cf. senegalensis, Plicapollis pseudoexcelsus, Minorpollis sp. (Oweina) Plicapollis pseudoexcelsus, Oculopollis sp., Basopollis spp. (Farafra) Basopollis sp.	(upper) Aquilapollenites senegalensis A. minimus, A. alveolatus	(upper) Aquilapollenites minimus	Aquilapollenites minimus, Fibulapollis plicatilis	(upper Maastrichtian) Pseudoplicapollis sp., ? Basopollis sp. Pecakipollis sp. Plicapollis sp. Triangulipollis sp. Complexipollis sp.		(Up. Cretaceous-Danian) Aquilapollenites quadrilobus			
CAMPANIAN					A. minimus, F. plicatilis			(Upper Cretaceous) Aquilapollenites indicus, A. bengalensis			
SANTONIAN					A. minimus, F. plicatilis (Coniacian-Santonian) Oculopollis tropicus					(upper Senonian) Aquilapollenites sergipensis	

ヨーロッパに産出がなく、北米大陸から新属として記載された8属は *Endoinfundibulapollis* (R.H.Tschudy, 1975), *Osculapollis* (R.H.Tschudy, 1975), *Praecursipollis* (R.H.Tschudy, 1975), *Pseudatlantopollis* (R.H.Tschudy, 1975), *Kyandopollenites* (Stover in Stover et al., 1966), *Choanopollenites* (Stover in Stover et al., 1966), *Montanapollis* (B.D.Tschudy, 1971), *Siberiapollis* (B.D.Tschudy, 1971) であるが、*Montanapollis* と *Siberiapollis* は北米大陸では西部に限られた分布を示し、他の6属は西部には産出しない。

上記3地域以外では、カナダの Ontario の South Moose River 盆地の Campanian-Maastrichtian から Normapolles 花粉の報告があり (Norris et al., 1980; 第5表参照)、また、南部 Manitoba の Vermilion River 層の Morden 部層 (late Turonian) から *Complexiopollis* sp. が報告されている (Singh, 1975)。

Arctic Canada では Horton River および Somerset Island などの上部白亜紀～第三紀初期に僅かに Normapolles 花粉が見られ、北東 Yukon の Peel River と Wind River 地区では暁新世に *Extratropopollenites* が見られる (第4表参照)。Greenland 西岸では Quikavsak 部層 (Lower Palaeocene) に僅かに *Trudopollis* sp. が見られる (第6表参照)。これらの地区は、勿論、*Aquilapollenites* province に入ると考えられるところである。

ウラル山脈が Normapolles と *Aquilapollenites* provinces の境界になるが、その両側の地区には両者が混在している地域が存在する。Kazakhstan では Normapolles 花粉が主要であるが、Ashutusk 層 (Maastrichtian) などでは *Aquilapollenites* や *Wodehouseia* の侵入が見られる (第1表参照)。

Aquilapollenites/Triprojectacites 花粉グループ

Aquilapollenites という属名は Rouse (1957) により、3つの翼と3つの溝をもつ花粉に与えられた。その後、この仲間と考えられる形態をもった花粉が報告され、この花粉グループは Triprojectacites (Mchedlishvili 1961 emend. Stanley 1970) という名称で一括されている。

現在、筆者はこの花粉グループに属するものは11属と考えている: *Aquilapollenites* (Rouse 1957 emend. Stanley 1970), *Triprojectus* (Mchedlishvili 1961 emend. Stanley 1970), *Hemicorpus* (Kruttsch 1970 emend. Takahashi 1982), *Mancicorpus* (Mchedlishvili 1961 emend. Takahashi 1982), *Pseudointegricorpus* (Takahashi 1982), *Bratzevaea* (Takahashi 1982), *Pentapollenites* (Kruttsch 1958 emend. Takahashi 1982), *Kurtzipites* (Anderson 1960) [= *Fibulapollis* (Chlonova 1961 emend. Stanley 1970)], *Orbiculapollis* (Chlonova 1961 emend. Takahashi 1982), *Jiangsupollis* (Song 1980) である。最後の属は中国のみに見られる。この他、中国には、中国にのみ産する *Morinoipollenites* と *Jianghanpollis* の記載があるが、これらは tricolporate の型であるので、上記花粉グループに入れられない方がよいと考える。また、筆者 (1982) は *Cranwellia* を上記花粉グループに入れて考えたことがあるが、これは別にした方がよいと考える。この奇妙な形態をもった花粉グループは Santonian にシベリアとカナダ西部で出現し、Campanian にその属・種の多様化が進み、分布域も拡大し、Maastrichtian にその繁栄の頂点に達した。暁新世に入り急激に減少し、始新世まで続いたが、この時代には散点的に見られるに過ぎない。

Aquilapollenites/Triprojectacites 花粉は現生植物との関連は必ずしも明らかでないが、これまでの比較では、Pinaceae (マツ科) (Radforth & Rouse 1954) や Dipsaceae (まつむしそう科) (Rouse 1957) の花粉との類似が述べられたが、その後、Santalaceae (びやくだん科) 中の物に似ている事が述べられた (Funkhouser 1961; Norton & Hall 1969)。Chlonova

(1962)は *Aquilapollenites* が Proteaceae (やまもがし科), Rubiaceae (あかね科), Santalaceae, Sapindaceae (むくろじ科) や Pinaceae と比較されうると述べているが、また、Erdtman (1971) は Loranthaceae (やどりぎ科) に系統的關係をもつ事を述べた。Jarzen (1973) は *Aquilapollenites* と化石および現生の Loranthaceae 花粉を比較検討しその類似性を示した。Santalaceae と Loranthaceae の花粉が *Aquilapollenites* などの仲間の花粉と形態的に関連があることを認めている。特に、Santalaceae の *Arjona* の花粉がよく類似していると言う。*Aquilapollenites*/Triprojectacites 花粉の isopolar form のものが Loranthaceae の花粉によく比較され、heteropolar 或いは subsipolar form のものが Santalaceae の *Arjona* の花粉によく似ている (Jarzen 1977)。

これら両者はいずれも寄生植物であり、はたして、その様な植物が一大花粉グループを形成して、可成りの期間続いたと考えるのか？ しかし、大型植物化石との関連が不明なことを考えると、普通の本木類でなかったのではないかとむしろ草本類、寄生植物と言った大型化石としては残りにくい性質をもった植物を考える事も一理はあると思われる。

Aquilapollenites province については、これまで、いくつかの提案がなされている (Zaklinskaja, 1962, 1966, 1967; Samoilovich, 1967; Srivastava, 1967, 1972, 1975, 1978, Hengreen & Chlonova, 1981; Takahashi, 1967, 1970, 1973, 1976, 1981, 1984, 1986; Kedves, 1985, 1987; Song et al., 1983; Zhou, 1986, ; Frederiksen, 1987)。

Aquilapollenites/Triprojectacites 花粉グループの主要分布地域はウラル山脈以東のシベリア全域、中国の東部 (北部で東経120° 以東、南部で東経100° 以東)、日本、アラスカ、北米大陸西部 (ロッキー山地)、カナダ北極圏地域、グリーンランド、スコットランド付近などである。

西シベリア低地帯は Maastrichtian ~ 暁新世に Normapolles の侵入がみられ、逆に Kazakhstan の Maastrichtian には *Aquilapollenites* の侵入が見られる (第1表参照)。

Barents Sea の Gusinaya Bank は Kolguev 島の北の Barents Sea の東部にある。Bratzeva (1985) によれば、上部 Senonian から多くの *Aquilapollenites* とその仲間、Oculata 花粉および Normapolles 花粉を産する。これは明らかに *Aquilapollenites*-Normapolles の混在地区を示しており、西シベリア低地帯と同じ混在地区の延長として把握される (第6表参照)。

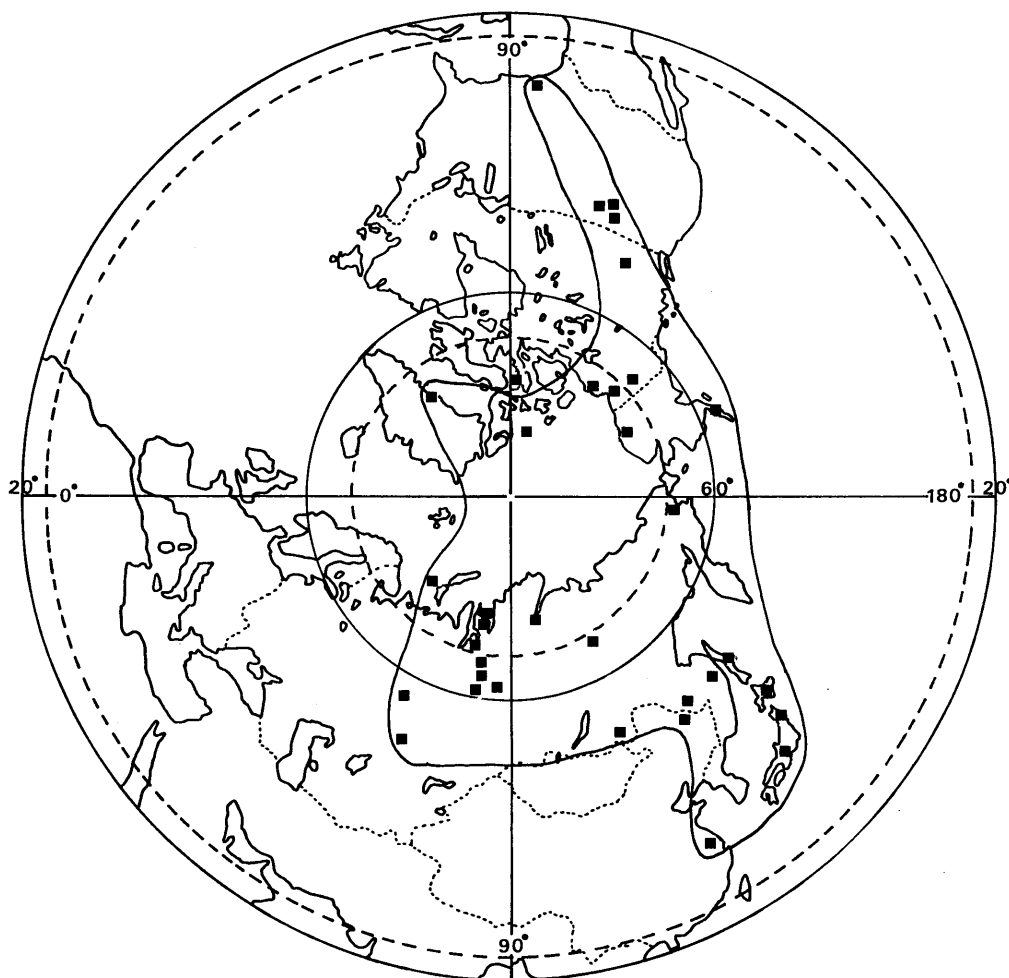
Mongolia はデータがないので不明であるが、一応、Normapolles province と考えると、Amur, 黒炭江, 松花江南部, 抚順炭田 (始新世), 渤海湾岸 (始新世), Jiangsu (江苏), Zhejiang (浙江, 杭州湾), Jiangxi (江西), Guangdong (広東), Anhui (安徽), Hunan (湖南), Hubei (湖北), Henan (河南), Yunnan (云南) などが *Aquilapollenites* province に入ると考えられ、これらの地区で全く Normapolles 花粉の報告のないのは江西, 浙江, 渤海湾岸, 抚順炭田で、他の地区には僅かの Normapolles 花粉が報告されている。また、中国特有の種類 *Jiangsupollis*, *Jianghanpollis*, *Morinoipollenites* が産出する地区は河南, 湖北, 安徽, 広東, 江西, 江苏, 松花江南部であり、Normapolles province の青海, 新疆 (庫車盆地) にまで延びている (第2図, 第2, 3表参照)。日本のものについては高橋 (1981) の第1表を参照されたい。Normapolles の混在は認められない。

アラスカ, 北米大陸の西部地区, カナダ北極圏, ユーコン, グリーンランド, スコットランド (Mull 島) などは *Aquilapollenites* province に入るが、これらについてのデータは高橋 (1981) の第2表, 本論文の第4, 6表を参照されたい。

ヨーロッパ大陸においては、ハンガリー, ドイツ, ベルギー, フランス, スペインの古第三紀 (暁新世~始新世) に *Pentapollenites* を代表とする *Aquilapollenites* の仲間が若干産出する事は全く奇妙である (高橋, 1981, 1984 および本論文第3図, 第7表参照)。

上記の *Aquilapollenites* province 以外の地区で、散点的に *Aquilapollenites* およびその仲間が産出するところがある。アフリカではエジプト、セネガル、ナイジェリア、ガボン、インドではベンガル盆地ならびに南部のカリカル、マレーシアのサラワク、ブラジルのセルジープで、いずれも上部白亜紀末期か、暁新世であり、エジプトで漸新世に一部見られるのは再堆積の可能性もあるかも知れない（第1図、第8表参照）。

Aquilapollenites/Triprojectacites 花粉は約2000万年の間に多様化が頂点に達し、上述の分布域に広く分布し、特異の植物相を形成した。後述の *Oculata* 花粉と共に生層位的に有用な化石として価値がある（高橋 1984）。特に、上部白亜紀後期～古第三紀初期の海成層と非海成層の対比の問題には有効な化石と言えよう。



第4図. 上部白亜紀末期および古第三紀初期における *Oculata* 花粉の北極を中心とした地理学的分布。

■ : *Oculata* 花粉の産地

Oculata 花粉グループ

Oculata 花粉の最初の出現は Santonian 後期に記録され、Campanian を経て、Maastrichtian で最も多様化し、暁新世（一部始新世）まで続いた。最初の出現は *Azonia* である。現在、Oculata 花粉に属するものは 3 属があり、*Azonia*, *Wodehouseia* および *Singularia* である。現世植物との関係は不明であるが、Chlonova (1967) はこれを現世植物の *Jollydora* [Connaraceae, 熱帯にあり、アフリカに限られて分布する。木本生で、灌木、矮小な灌木, リアナ (熱帯のつる植物)] と *Impatiens* (Balsaminaceae ツリフネソウ科, 熱帯～亜熱帯にあり、草本生) の花粉に比較している。

Oculata 花粉の形態は小判状の形を呈し、germinal aperture は binigeminate aperture (pore 又は colpus で、2 つの対をなす) を呈し、Wodehouseian 花粉は flange をもっている。

この花粉グループの分布域は第 4 図に示す通りで、*Aquilapollenites* province と重なる部分が多い。

生層位学的には、*Wodehouseia aspera*, *W. edmontonicola*, *W. gracilis*, *W. stanleyi* が Maastrichtian にのみ出現し、*W. elegans*, *W. fimbriata*, *W. spinata* は Maastrichtian および暁新世にみられる。*Azonia calvata*, *Az. fabacea* は Campanian および Maastrichtian に、*Az. jacutense*, *Singularia aculeata* は Maastrichtian にのみ限定されている。

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