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Early Tertiary Normapolles and Related Palynomorphs of China (1)

Song Zhichen[1]

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ABSTRACT: The Normapolles and other related palynomorphs from Paleocene to Early Eocene in China were discussed using materials mainly from Caomuhao Gypsum Mine from Otog Banner, Inner Mongolia, Funing Group of northern Jiangsu, and Menli Formation from Sanmenxia, Henan. A total of 48 genera and 152 species (including 22 indeterminable forms) were described. The distribution of the normapolles, along with other key taxa such as *Aquilapollenites* and proteaceous pollen during the Late Cretaceous to Early Tertiary, had divided China into two phytogeographic provinces-Central and Northeast. The former is characterized mainly by the presence of Normapolles and the latter by the presence of *Aquilapollenites*. The Central Province can be further subdivided into Southeast and Northwest subprovinces with *Aquilapollenites* also present in the former but absent in the latter. The representative assemblage from each province and subprovince and their climatic implication were also discussed.

KEY WORDS: Early Tertiary, Normapolles, China.

INTRODCUTION

A number of Normapolles occurrences have been documented from the Early Tertiary in northwestern and northern China; in regions north of 34° N and west of 117° E (Hao 1987; Hao and Chen, 1983; Song and Zhang, 1990; Sun *et al.*, 1979; Wang *et al.*, 1984, 1990; Zhao *et al.*, 1981, 1982). These reports have generated interests among the palynologists for two reasons, (1) the group's short geologic range and (2) the group's wide geographic distribution, particu-larly in relationship to other major floristic groups such as *Aquilapollenites* and proteaceous pollen. Short geologic range makes it ideal for age determination and the distribution indicates its dependency of the ecological and climatic conditions. The climatic dependency of Normapolles, along with that from *Aquilapollenites* and proteaceous groups during latest Late Cretaceous to earliest Early Tertiary, resulted in a division of three large floristic provinces-Northern Hemisphere's Normapolles, Northern Hemisphere's *Aquilapollenites*, and Australian *Nothofacidites*-Proteaceae (Zaklinskaya, 1966; Batten, 1984). The understanding of this phytogeography in its accurate chronostratigraphic framework could enhance our research in the stratigraphic calibration for the Chinese nonmarine strata by mean of intercontinental correlation.

1. Nanjing Institute of Geology and Palaeontology, Academia Sinica, Chi-Ming-Ssu, Nanjing 210008, The People's Republic of China.

Normapolles is a complicated group. The author began to realize its complexity after a detailed study of the group from the Caomuhao Gypsum Mine strata of the Otog Banner, Inner Mongolia in which both normal Normapolles and Normapolles-like pollen were encountered in the assemblage. Batten and Chrristopher (1981) made a similar comment and stated its multifarious and heterogeneous nature. The Normapolles-like specimens from Inner Mongo-lia are comparable with those from the Menli Formation of Henan, Funing Group of northern Jiangsu, Yuguangpo Formation of Sichuan, and Xialiushi Formation of Hunan. This finding leads to a recognition that Normapolles were distributed much more widely in China than previously believed. Most of the Chinese Normapolles, however, do not belong exactly to the types as those reported from the major Normapolles provinces. A detailed study is required to properly treat this group taxonomically.

To understand its geographic distribution, in addition to studying Normapolles, a knowledge of the Chinese proteaceous pollen and *Aquilapollenites* and their respectful geographic distributions are also necessary because these three groups occupied China in the Late Cretaceous to Early Tertiary and divided the country into major phytogeographic provinces. With regard to the distribution of the Chinese proteaceous pollen, this note is perhaps useful to reiterate here. A Few of the Song's earlier identifications on the proteaceous such as *Proteacidites adenanthoides* of the Funing Group (Song and Zhang, 1981) were incorrect. A correction on that subject which was published later, however, was made (Song *et al.,* 1990).

This paper described mainly the geologic and geographic aspects of Normapolles and other related palynomorphs, not the taxonomy. An article which will be published in the forthcoming issues of *Taiwania* will treat that subject separately. It is the author's hope that this paper will bring more interests to the Chinese palynologists and as a consequence more Normapolles pollen types will be discovered which can further our Normapolles study.

MATERIALS AND METHODS

A. Materials

The palynomorphs from Caomuhao Gypsum Mine strata of Otog Banner, Inner Mongolia contribute a bulk of the microfossils described. Another contributor is Funing Group. The following is a brief account of the stratigraphy of the three localities:

1. The Caomuhao Gypsum Mine of Otog Banner, Inner Mongolia is of lacustrine deposits, and were controlled by palaeoenvironments both in sequence and in thickness, with remarkable changes in lithological character. These deposits may be divided roughly into two parts: the upper part which is a suite of reddish brown to brick red sandy mudstone and mudstone, and the lower part which is a suite of vari-colored gypseous sandy mudstone, with unstable mudstone and conglomerate at the base. The following is a brief introduction to the sequence of the Huqiaoliang-Tolimiao Profile Section:

Overlying strata: Quaternary gravel layer

unconformity

Bed 6 Reddish brown sandy mudstone intercalated with sandy conglomerate and marlite bearing horizontal lamellae, 40m thick

Bed 5 Brick red mudstone bearing calcareous nodules, intercalated with brownish grey sandstone lenticles, containing fossil vertebrates such as *Tsaganomys altaicus* Matthew et Granger, *T.* sp., *Desmatolagus gobiensis* Matthew et Granger, *Tataromys plicidens* Matthew et Granger, *Tachyoryctoides* sp., *Tragulina* indet., *Rhinocerotide* indet, 50m thick

Bed 4 Greyish white gypsum layer, 13m thick

Bed 3 Brick red silty mudstone, 15m thick

Bed 2 Yellow mudstone and siltstone intercalated with silty mudstone, 10m thick

Bed 1 Brown silty mudstone intercalated with multilayered gypsum, with unstable conglomerate in basal part, 29m thick

unconformity

Underlying strata: Lower Cretaceous Ejin Horo Formation. The fossil vertebrates were identified by Dr. Wang Banyue from the Institute of Vertebrate Paleontology and Palaeoanthropology, Academia Sinica, as belonging to the middle Oligocene in age. The fossil pollen grains were analyzed from the mudstone underlying the greyish white gypsum layer (Song and Zhang, 1990).

2. The Funing Group of northern Jiangsu may be divided into four formations based on lithological changes:

Formation 4, 500 m thick, grey to greyish black mudstone intercalated with thin-bedded greyish white siltstone, marlite and oil shale.

Formation 3, 280 m thick, greyish white sandstone intercalated with greyish black mudstone.

Formation 2, 300 m thick, grey to greyish black limy mudstone, intercalated with thinly-bedded biolithite, marlite and analcimized tuff.

Formation 1, 700 m thick, brown sandstone interbedded with dark brown mudstone, containing gypsum, intercalated with black mudstone at the top, probably in conformable contact (?) with the underlying strata (Song *et al.*, 1981).

3. The Menli Formation of Sanmenxia area, Henan belongs to continental clastics which is composed of diluviolacustrine thickly-bedded conglomerate, mudstone, gypseous mudstone, marlite; the lower part contains conglomerate, while the middle and upper parts contain mudstone, gypseous mudstons, marlite and argillaceous dolomite, with an overall thickness of 535 m. The basal conglomerate appears in angular unconformable contact with the underlying Permo-Carboniferous. The palynomorphs came from middle and upper parts of the Menli Formation (Hao and Chen., 1983).

B. Methods:

The samples were processed by using standard palynological preparation techniques. Following treatment in HCl and HF, the heavy liquid of $ZnCl_2$ was used to float and accumulate the organic materials (including palynomorphs). The specimens were mounted in glycerine jelly and sealed with wax.

The photography was done on a Leitz Diaplan microscope. The size of each palynomorph was measured during the observation and identification processes. With only a few exceptions, generally at least 5 specimens were measured for a new species.

RESULTS

A. Palynologic assemblages and their ages

In the Caomuhao Gypsum Mine strata of Otog Banner, Inner Mongolia, the palynoflora may be divided into three assemblages:

Assemblages 1, dominated by *Ephedripites*, conifer pollen and Ulmaceae;

Assemblages 2, dominated by *Ephedripites* and *Pseudoproteacidites*;

Assemblages 3, dominated mainly by *Ephedripites* with some *Pseudoproteacidites* and Normapolles, and a minor component of some other groups.

Song and Zhang (1990) gave a detailed floral account of these assemblages. The age of these assemblages is believed to be Late Paleocene to Eocene mainly on the basis of the palynomorphs. Other independent age-determination was available only from a vertebrate study which was assigned a Middle Oligocene age from the brick-red mudstone layer immediately above the upper gypsum bed (Song and Zhang, 1990). Stratigraphically, the variable-colored gypseous rock formation in which these three assemblages were recovered sites immediately below the upper gypsum bed.

When comparing the palynomorphs from this area with those from Europe and North America, the author found that many of those European or North American occurrences are restricted to Paleocene to Early Eocene, among them; *Basopollis basalis*, *B. orthobasalis*, and *B. obscurocostatus* (Tschudy, 1975), and *Nudopo-llis endangulatus*, *N. terminalis*, *N. thiergarti*, *Minorpollis minimus*, and *Subtrudopollis subtrudens* (Goczan *et al.*, 1967). In addition, a species of *Dermatobrevicolporites*, a genus only known to occur from India's Eocene, *D. dermatus,* was also observed in Inner Mongolia.

The palynomorph assemblage from the Menli Formation was described in Hao and Chen, 1983. In that assemblage, the spores account for 1%, mainly *Schizaeoisporites* and *Pterisisporites*; the gymnospermous pollen accounts for 34-54%, dominated by *Ephedripites* with *Podocarpidites*, *Parcisporites*, and *Taxodiaceaepollenites* being secondary, and angiospermous pollen amounts to 46-86%, which is represented by 62 genera and more than 200 species. In the angiospermous group *Quercoidites* and *Cupuliferoipollenites* occupy a dominant position, accounting for as high as 60% (averagely 30%), Ulmaceae pollen 1.2-11.4%, while Normapolles and proteaceous pollen (identified as *Pseudoproteacidites* in this paper) 5% or more. Hao and Chen (1983) considered this assemblage to be of Middle to Late Palaeocene in age.

The assemblage from the Funing Group was described in detail in Song *et al.* (1981). In the Formations 3-4 of Funing group, Normapolles and *Pseudoproteacidites* pollen were abundant and an *Ulmipollenites-Proteacidites-Pinuspollenites* assemblage zone was recognized. Recently, from these formations a *Polypodiaceoi-sporites -Protea-cidites*? - Pinaceae assemblage and two subassemblages of *Taxodiaceae-pollenites* and *Polypodiaceoisporites-Proteacidites* ?, which are Late Palaeocene-Eocene, have been separated (Qin *et al.*, 1993).

B. Palynofloras and their provinces

The palynoflora assemblages which contain the Normapolles and *Pseudoproteacidites* pollen were discussed in Song and Zhang (1990). The assemblage suggests that the landscape was dominated by shrubs with pockets of forest locally, not thick woodland type. *Ephedra* shrubs were very abundant and proteaceous bushes were rare. Around the water area Juglandaceae and Betulaceae were growing, together with green algae growing in

bodies of water. In the highlands, Pinaceae and Podocarpaceae were prosperous. Overall, the climate reflects a semi-arid subtropical type, with a greater evaporation capacity than precipitation, causing the formation of evaporites such as gypsum (Song and Zhang, 1990). This kind of vegetation landscape was also distributed extensively in northwest China and some parts of northern China.

However, in the east and southeastern coastal area of China, the assemblages reflect a somewhat different vegetation type. It is best exemplified by Formations 3-4 of the Funing Group in northern Jiangsu; a vegetation of broad-leaved forest type, and broad-leaved and coniferous mixed forest type with Fagaceae, Juglandaceae and Ulmaceae dominated the forests and some subtropical elements mixed in between, such as those plants of the families Araliaceae, Sapindaceae, Myrtaceae, etc. (Song *et al.*, 1981). In the Sanshui area of Guangdong, the coeval vegetation also belongs to the forest type, with the main part composed of arboreous angiosperms (Song *et al.*, 1986).

The Paleocene palynofloras of China can be divided into either three or two provinces depending upon the workers. The three provinces divisions are Sun's (1979) Northeast Wet Subtropical, Warm-Temperate, and South Arid Subtropical (Semiarid) and Wang *et al.'s* (1990) Northeast, South and Norhtwest. The two divisions are identical in basic contents. The two provinces are Song *et al.s'* (1983) Northeast China Province and Central China Province.

In these two schools, the Northeast Province is basically identical, the difference lies in how to characterize the palynomorph assemblages in the remaining parts of China in order to divide the floral provinces. The division schemes may be different due to the differences at the starting points. In consideration from the angle of distribution of the Normapolles (including those formerly known as *Proteacidites* and now called *Pseudoproteacidites*), this paper proposes a scheme for the phytogeographical division as follows:

1. Northeast China Province (also called the Northeast Wet Subtropical and Warm-Temperate Floral Province). This province includes the whole northeast region, east part of Inner Mongolia, Hebei and northern part of Shandong. The palynoflora is characterized by abundant ulmaceous, betulaceous, myricaceous and fagaceous pollen, especially the triporate pollen type, along with the appearances of *Aquilapollenites*-related and occasionally *Pseudoproteacidites* (Sun *et al.*, 1980), but almost no Normapolles.

2. Central China Province. This province includes a large area of China excluding the northeast region, and Qinghai-Xizang Plateau Region which remains tentatively undivided due to lack of data at present. In this province the assemblage is characterized by abundant pollen of *Ulmipollenites minor*, *Ulmoideipites*, *Subtriporopollenites*, *Plicapollis* and *Ephedripites*, together with some tricolpate and tricolporate elements related to the families Fagaceae, Anacardiaceae, Nyssaceae and the genus *Lonicera*, reflecting a relatively arid subtropical climate (Song *et al.*, 1983). Another distinguishing feature of this province lies in the existence of Normaplles-related elements and *Pseudoproteacidites*, which can be served to further divide this province into the following two subprovinces:

(1) Southeast Subprovince. This subprovince roughly corresponds to Sun's (1979) South Arid Subtropical Palynofloristical Province or to Wang *et al's* (1990) South Palynofloral Province. It is characterized by mixed components of the palynomorph, with few Normaplolles and *Pseudoproteacidites* and rare *Aquilapollenites*, reflecting a forest type

vegetation, and a relatively humid subtropical climate (except semi-arid subtropical type in a few places).

(2) Northwest Subprovince. This subprovince roughly corresponds to Sun's (1979) Northwest Arid Subtropical Palynofloristical Province or Wang *et al.'s* (1990) Northwest Palynofloral Province, including an area from north of the Qinghai-Xizang Plateau to the middle and western parts of Inner Mongolia. Although mostly poor in palynological recovery, this subprovince, nevertheless, has displayed its unique characteristics, including appearances of relatively abundant Normapolles and *Pseudoproteacidites*, extensive distribu-tion of *Ephedripites* and *Spinotriporites*, and relatively few tricolpate and tricolporate elements (as compared with the Southeast Subprovince), reflecting the vegetation type of shrubs with tracts of forest locally, in a subtropical semi-arid climate type.

At present, the boundary between the two subprovinces is not sharply defined. Roughly speaking, in the north part the boundary ranges along Taihangshan and Qinling at about 100 °E. The western part of Henan Province can be considered as a transition zone between the two subprovinces as proposed by Wang *et al.* (1990), with the assemblages mostly similar to the Northwest Subprovince in characteristics. Within the subprovince, some areas may be further separated from other parts. One example is the Hubei-Jiangxi area of the Southeast Subprovince which contains more forms of *Ephedripites*, a characteristic similar to the Southeast Subprovince. However, further regional division within a subprovince will be discussed when materials are available.

DISCUSSION

Normapolles, which contains about 80 morphological genera (Batten and Christopher, 1981) is a highly complicated palynological group, with complex and well-developed pore structure. Friis (1983) and Batten (1984) believe that this group bears some relation to the Juglandales or some old Amentiferae. Normapolles first occurred in the Middle to Upper Cenomanian both in Europe and in North America, and developed rapidly with great diversity in Turonian, and onwards towards the end of Cretaceous. After Tertiary this group became less developed and declined gradually, resulting in an almost extinction at the end of Eocene (Batten, 1984).

East of Normapolles Region in the transitional area-- so-called Turkmen-Kazakhstan Subprovince (Batten, 1984)--and further east into the *Aquilapollenites* Region, first Normapolles occurred younger and younger in that direction and were less diverse. For instance, in Kazakhstan area, palynomorphs attributable to this group first occurred in Late Maestrichtian in low abundance but increasingly diversified in Paleocene, and finally disappeared by the end of Eocene (Zaklinskaya, 1963).

Some Normapolles have been found to occur in the *Aquilapollenites* Region of China. They were first observed from Late Cretaceous in Taizhou Formation of northern Jiangsu, Dalangshan Formation in Sanshui Basin of Guangdong, Yuyang Formation in Jianghan Basin of Hubei, Guankou Formation in Sichuan, Cretaceous in Xixia County of western Henan, and Menhe Formation in Xining Minhe Basin of Qianghai (Fig. 1).

The Taizhou Formation, about 300 m in thick, may be divided into lower and upper members, with the lower member containing the *Classopollis-Exesipollenites-Schizaeoispo-*

rites assemblage and the upper member *Ulmipollenites-Podocarpidites-Jiangsupollis* assemblage. The lower member is characterized by abundant *Classopollis* and *Exesipollenites* (15-30%), *Schizaeoipollenites* (15-30%), *Pterisisporites* and *Multinodisporites* (10-

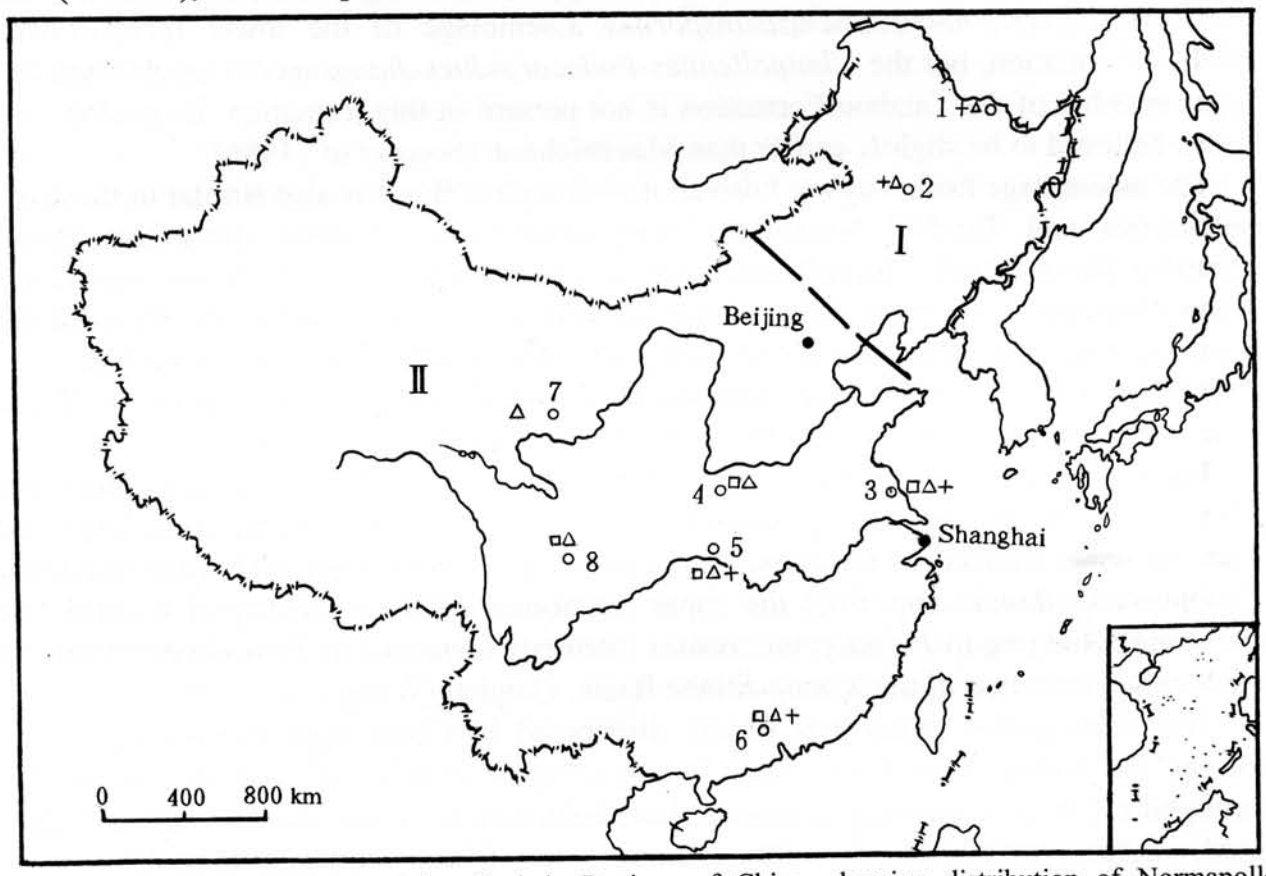

Fig.1: Map of Late Cretaceous Palynofloristic Regions of China, showing distribution of Normapolles, *Proteacidites* or *Siberiapollis* and *Aquilapollenites* during the late Late Cretaceous. I. Northeast China Region (semihumid subtropical zone), II. Central China Region (arid subtropical zone) (after Song et al., 1983, fig. 3)., showing Normapolles, *Proteacidites* or *Siberiapollis* and *Aquilapollenites* localities, □, △ and + respectively. Localities: 1-2. Jiayin Basin and Songliao Basin of Heilongjiang; 3. North Jiangsu Basin; 4. Xixia Basin of Henan; 5. Jianghan Basin of Hubei; 6. Sanshui Basin of Guangdong; 7. Xining-Minhe Basin of Qinghai ; and 8. Qionglai Basin of Sichuan.

20%), *Gabonisporis* (5-10%), minor representation of some distinctive elements, such as *Jianghanpollis*, *Aquila-pollenites*, *Mancicorpus*, *Translucentipollis*, *Wodehousia*, *Proteacidites* (or *Siberiapollis*), and a few specimens of Normapolles including *Extratriporopollenites perlucidus*, *E. thiergarti* subsp. *minor* (Song *et al.*, 1981), E.? sp., and *Pompeckjoidaepollenites* sp. (Zheng and He, 1984). The upper member is characterized by a sharp decline in the content of *Classopollis*, *Exesipollenites* and *Schizaeoisporites*, and by a sharp increase in the number of *Ulmipollenites*, *Plicapollis* and *Subtriporopollenites* (40-50%), but no Normapolles. This assemblage probably belongs to Maastrichtian. The lower member could be slightly earlier than Maestrichtian, probably Coniacian-Campanian in age (Song *et al.*, 1981, 1989).

The Dalangshan Formation, more than 300 m in thick, may also be divided into two members. The lower member is dominated by *Exesipollenites* (11.9-52.94%) and the upper member by *Classopollis* (26.08-52.58%). Both assemblages bear some common elements of *Rugubivesiculites*, *Pterisisporites* and *Schizaeoisporites* as well as some distinctive elements

such as *Sporopollis*, *Cranwellia*, *Jianghanpollis*, *Jiangsupollis* and *Aquilapollenites*, together with a few specimens of Normapolles including *Extratriporopollenites perlucidus* and *E.*? sp. (Song *et al.*, 1986). The lower and upper assemblages can be correlated with the *Classopollis-Exesipollenites-Schizaeoisporites* assemblage of the lower member of the Taizhou Formation, but the *Ulmipollenites-Podocarpidites-Jiangsupollis* assemblage of the upper member of the Taizhou Formation is not present in this formation. Its geological age, is also believed to be slightly earlier than Maestrichtian (Song *et al.*, 1986).

The assemblage from Yuyang Formation in Jianghan Basin is also similar to those of the Dalangshan and Taizhou Formations, with occurrences of some distinctive elements including *Jianghanpollis*, *Rugubivesiculites*, and *Consoliduspollenites*. In Normapolles only a few *Oculopollis* sp. have been found, but specimens of *Proteacidites microtrilobatus* Wang et Zhao are more similar to *Nudopollis* sp. based on the pore structure. In this assemblage there are also some palynomorphs of *Mancicorpus intragranulatus* Wang et Zhao and *Aquilapollenites validus* Wang et Zhao (Wang and Zhao, 1980).

There were some specimens of Normapolles belonging to *Extratriporopollenites orthobasalis*, *E.* cf. *spumeides*, *E.* cf. *atumescens* and *Papillopollis* sp. (Anonymous, 1983) found from the upper Cretaceous Guankou Formation of western Sichuan, and some belonging to *Extratriporopollenites* spp. from the upper Cretaceous of Xixia County of western Henan and some belonging to *Pseudoproteacidites* (formerly identified as *Proteacidites*) spp. from the Menhe Formation of the Xining-Minhe Basin, Qinghai (Wang *et al.*, 1990).

The Normapolles group was widely distributed in China from Paleocene to Eocene. Except for northeastern China and Xizang-Qinghai Plateau, the group can be found throughout China. Following discusses their distributions; from west to east and then to south of China, with comments on the characteristics of the assemblages (Fig. 2).

The distribution of Normapolles in the northwestern China, including Xinjiang and Qinghai was given in detail by Zhao *et al.* (1981). In the Altax Formation (Paleocene) in Shache Depression, normapolles includes *Nudopollis thiergarti*, *N. terminalis*, *N. endangulatus*, *Trudopollis pertrudens*, *T. hemiperfectus*, *T. peneperfectus*, *Oculapollis praedicatus*, *Extratriporopollenites attritaeformis*, and *Pseudoplicapollis perplexus*, representing 3-4.5% of the total count (Wang *et al.*, 1990). In the overlying Qimugen Formation (Paleocene), the Normaplles includes *Nudopollis terminalis* and *N. thiergarti* (ca. 6%), and *Trudopollis obexemplum*, and *T.* cf. *platoidens* (ca. 4%) (Zhao *et al.*, 1981). In Bashibulake Formation (Eocene), few specimens of *Nudopollis* sp., representing 1% of the total count were observed. In Talake Formation in Kuqa Depression, Normapolles including *Nudopollis thiergarti*, *N. terminalis* (4%), *Pseudoplicapollis peneserta*, *Trudopollis obexemplum* (4%), *T. pompeskii* (6%), and *Extratriporopollenites* sp., were found (Wang *et al.*, 1990). In the Xiaokuzibai Formation which overlies Talake, it contains low abundance of *Trudopollis pompeckii* and *Nudopollis* sp., representing 1-2% of the total palynomorphs (Zhao *et al.*, 1981). Normapolles has been found from Qijiachuan Formation in Xining-Minhe Basin of Qinghai Province, the group includes *Complexiopollis praeatumescens*, *Basopollis* sp., and Nudopollis sp., representing 4% of the total count (Zhao *et al.*, 1981; Wang *et al.*, 1990).

The assemblages from the formations mentioned above also contain abundant *Ephedripites* and a moderate number of *Pseudoproteacidites* (formerly identified as *Proteacidites* and *Propylipollis*), forming a distinctive palynological phytogeographic region.

Similar assemblages were also reported in some localities of Inner Mongolia, Henan and Hebei (Sun *et al.*, 1979; Hao, 1987).

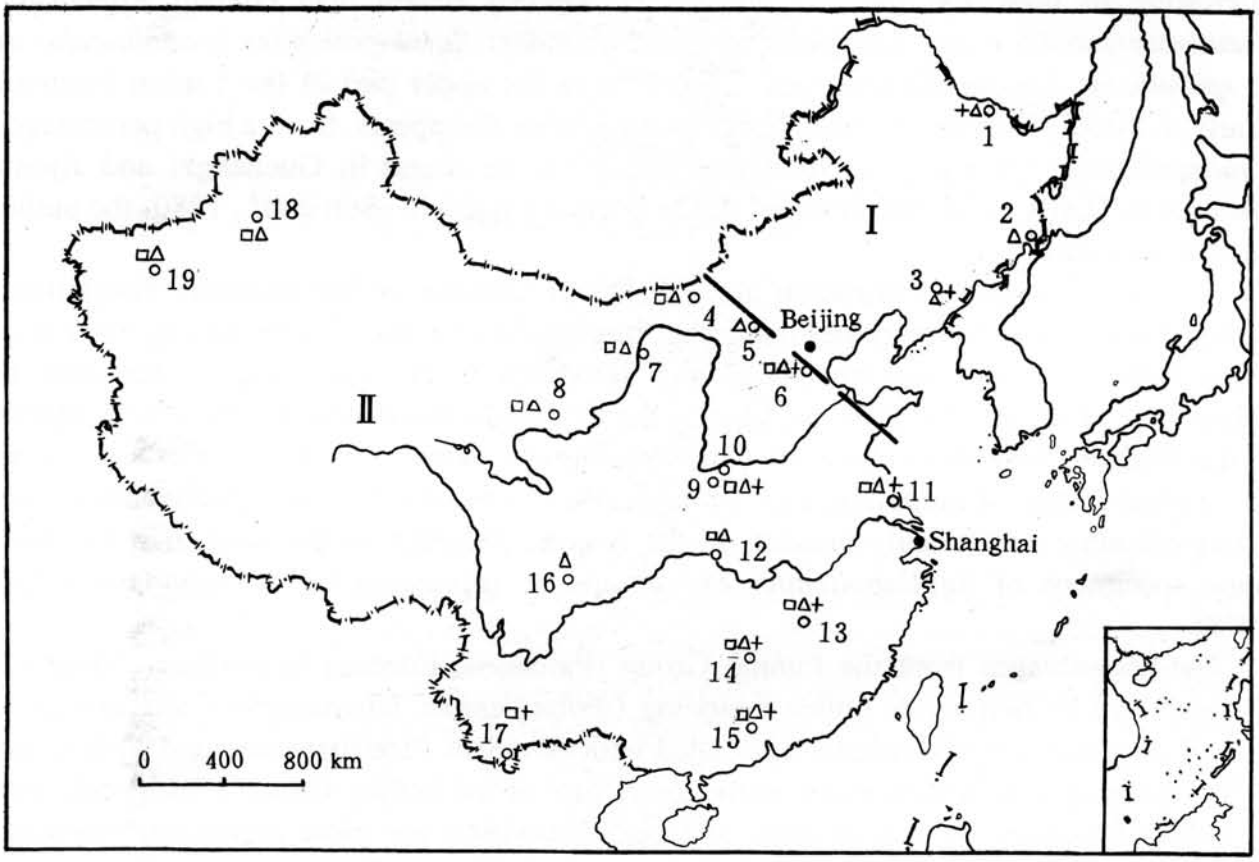

Fig.2: Map of Paleocene Palynofloristic Regions of China, showing distribution of Normapolles, *Pseudoproteacidites* and *Aquilapollenites* during Paleocene. I. Northeast China Region (humid temperate--warm temperate zone), II. Central China Region (arid subtropical zone) (after Song *et al.*, 1983, fig. 4)., □, △ and + showing Normapolles, *Pseudoproteacidites* and *Aquilapollenites* localities respectively. Localities: 1. Jiayin Basin of Heilongjiang; 2. Hunchun Basins of Jilin.; 3. Fushun Basin of Liaoning; 4-5. Erlian and Huade Basin of Nei Moggol; 6. Central Hebei Basin; 7. Otog Basin of Nei Moggol; 8. Xining-Minhe Basin of Qinghai ; 9-10. Linbao and Sanmenxia Basin of Henan; 11. Northern Jiangsu Basin; 12. Jianghan Basin of Hubei; 13. Central Jiangxi Basin; 14. Southern Hunan Basin; 15. Sanshui Basin of Guangdong; 16. Ya'an Basin of Sichuan; 17. Mengla Basin of Yunnan; 18-19. Kuqu and Shache Basin of Xinjiang.

In Naomugen Formation of Early Tertiary of western Inner Mongolia a number of palynomorphs of *Ephedripites* and *Pseudoproteacidites* were discovered, usually associated with some Normapolles including *Atlantopollis* sp., *Pseudoatlantopollis* cf. *simulatus*, *Choanopollenites* cf. *transisus*, (Sun *et al.*, 1979) and *Extratriporopollenites basalis*, *Nudopollis* sp., *Basopollis* cf. *orthobasalis* and *Complexiopollis praeatumescens*, (Song and Zhang, 1990) along with some species described in this paper.

From the Lower Tertiary of western Henan some normapolles, such as *Nudopollis thiergarti*, *N.* spp., *Basopollis* sp., and *Complexiopollenites* sp., were also observed. (Hao and Chen, 1983). They were found in the upper part of the Menli Formation in Sanmenxia Basin, representing about 1% of the total count. The assemblage contains *Ephedripites* (5-13%), *Quercoidites* (30-60%), *Pseudoproteacidites* (5-13%), and *Ulmipollenites* (1.2-11.4%), (Hao *et al.*, 1983). Similar palynomorphs of Normapolles were also found in the Lower Tertiary of Tantou and Linbao Depressions in western Henan. The Lower Tertiary is

called Dazhang Formation (Paleocene) and Tantou Formation (Eocene) in Tantou and the Xiangcheng Group in Linbao (Wang *et al.*, 1984, Hao, 1987; Sun *et al.*, 1985). It is interesting to note that the assemblages in western Henan also contain *Ephedripites*, *Pseudoproteacidites*, and *Ulmipollenites*, and abundant *Aquilapollenites granobaculus* and *A. spinulosus*; *Aquilapollenites* may reach 35% in the upper part of the Tantou Formation (Early to Middle Eocene), at which point Normapolles disappears. Such a high percentage of *Aquilapollenites* (probably *A. spinulosus*) also can be found in Guchengzi and Jijuntun Formations (Early to Middle Eocene) of the Fushun Coalfield (Sun *et al.*, 1980; the author's unpublished data).

From the Kongdian Formation and the fourth Member of the Shahejie Formation in central Hebei, some Normapolles including *Atlantopollis* sp. and *Trudopollis* sp. were found along with some *Pseudoproteacidites* and *Triatriopollenites* occurring in the same bed (Zhao *et al.*, 1982). In the First Member of the Kongdian Formation and the fourth Member of the Shahejie Formation along the Coastal Region of Bohai, the assemblage is dominated by *Ephedripites*, *Ulmipollenites*, *Ulmoideipites, Rhoipites* and *Quercoidites*, with *Pinuspollenites* occasionally present. In the Second Member of the Kongdian Formation, some specimens of *Aquilapollenites obesus* and *A. spinulosus* were found (Anonymous, 1978).

The assemblages from the Funing Group (Paleocene-Eocene) in northern Jiangsu are characterized by rich porate pollen including *Ulmipollenites*, *Ulmoideipites, Plicapollis* and *Subtriporopollenites*, and usually associated with abundant *Pterisisporites*, and *Ephedripites*. In the first and second formations in the lower part of the Funing Group, tricolporate forms, including *Rhoipites*, *Pentapollenites*, and *Sapindaceidites* are more dominant; whereas in the third and fourth formations in the upper part of the Funing Group, some pollen grains of *Pseudoproteacidites* (formerly identified as *Proteacidites*), with a few specimens of *Aquilapollenites* are frequently discovered. The Normapolles found in the Funing Group includes only a few pollen grains of *Atlantopollis* sp. and *Extratriporopollenites* sp., with some amount of *Romeinipollenites* sp. (Song *et al.*, 1981; Qin *et al.*, 1993) and some species described in this paper.

A small number of Normapolles, such as *Extratriporopollesnites basalis* and *Oculopollis* sp, similar to those of the Funing Group, occurred in the Xingouzui Formation in the Jiang-han Basin of Hubei (Wang and Zhao, 1980). The assemblage of this formation is characterized by abundant *Ephedripites*, *Ulmipollenites*, *Ulmoideipites, Quercoidites*, and *Triporopolleni-tes.*

Although no Normapolles has been reported from the Paleocene of Jiangxi and from the Lower Tertiary of the Sanshui Basin in Guangdong, the palynomorphs identified as *Psilabrevitricolpites tenuicolpatus* Sun et He from Jiangzxi (Sun and He, 1980) and *Lonicerapollis* sp. from the Sanshui Basin (Song *et al.*, 1986) are very similar to and could be identical to *Romeinipollenites* spp. from the Funing Group in northern Jiangsu. In the Paleocene of Jiangxi some pollen of *Pseudoproteacidites* (formerly identified as *Proteacidites*) and *Jiangsupollis striatus* (which were identified as *Striatriporites* sp.) were found (Sun *et* He, 1980). With regard to *Aquilapollenites*, a few pollen grains of the two genera mentioned above, together with *Aquilapollenites*? sp. were also found from Lower Tertiary of the Sanshui Basin.

But some Normapolles elements including *Extratriporopollenites* cf. *spumeides* and *Nudopollis* cf. *terminalis* occurred in the Xialiusi Formation of southern Hunan Province, with some species of *Pseudoproteacidites* (formerly called *Proteacidites*) and a few specimens of *Aquilapollenites* occurring in the same bed (Anonymous, 1978). The assemblage of this formation can be roughly compared with that of the Xingouzui Formation in the Jianghan Basin.

A few problematic forms of Normapolles containing *Extratriporopollenites*? sp. have been found from the Lower Tertiary in the Mengla County of southwestern Yunnan, with some pollen of *Aquilapollenites rombicus* and *Jiangsupollis striatus* occurring in the same bed, which were originally identified as *Parviprojectus* cf. *striatus* and *P.* sp.1 (Song *et al.*, 1976). It is interesting to note that in the Lower Tertiary Yuguanpo Formation in the Yaan County of western Sichuan, some pollen grains of *Proteacidites microverruciformis*, *P. orthobasalis*, *P. anchoralis* and *Propylipollis microspiniformis*, (all of which now might be included in *Pseudoproteacidites*), were found. But Normapolles was not found in the same bed.

The following conclusions can be drawn on the distribution of Normapolles in China.

1. Probably sometime earlier than the Maestrichtian, Normapolles first appeared in southeastern China, but in low abundance. During Paleocene, especially in Late Paleocene, it developed rapidly in northwestern and northern China, and along the southeast as well, with more diversity and more abundance. The group began to decline afterward and disappeared in the late Middle Eocene to early Late Eocene. The history of Normapolles development in China seems to follow closely to that in Kazakhstan Area (Zaklinskaya, 1963).

2. Low abundance of Normapolles were found from the Late Cretaceous in the area south of 33 °N. and east of 100 °E., where it coexisted with *Aquilapollenites* and *Proteacidites* (or *Siberiapollis*). Such mixture are distinctive to the Central China Region. But in northeastern China, *Aquilapollenites* is in abundance dominated the Late Cretaceous Palynofloristic Province (Song *et al.*, 1983, fig. 3). In that region, no Normapolles were found. This evidence suggests that in East Asia the distribution of Normapolles and *Aquilapollenites* Palynofloristic Kingdoms was controlled by climate as proposed by Batten (1984), although some mixture of the two elements can be found in some localities in southeastern China.

3. In Paleocene and Eocene Normapolles were distributed from Shache and Kuqa Depressions in western Tarim Basin in the west, to Coastal Region of Bohai in Hebei and northern Jiangsu in the east, to Jiangxi and the Sanshui Basin of Guangdong in the south and to Sichuan and Yunnan in the southwest. All over these areas they were always found to be associated with abundant tricolporate forms, *Ephedripites, Ulmipollenites, Ulmoideipites* and *Pseudoproteacidites*, and in some places, also with *Aquilapollenites*, forming a distinctive palynophytogeographic region which characterize the Normapolles-*Pseudoproteacidites* assemblage. The characteristics can be compared with the Turkmen-Kazakhstan Subprovince of Late Cretaceous and earlist Tertiary in Central Asia. It is likely that the former was probably evolved from the latter. In the eastern part of this phytogeographic region (lying to the east of 110 °E. in the north and the east of 100 °E. in the south), the palynomorphs of normapolles, *Pseudoproteacidites* and *Aquilapollenites* also display a mixed character.

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中國早第三紀正型粉類及相關孢型

宋之琛[1]

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摘　　要

本文研究了中國一些地區古新統及下始新統的正型粉類及其相關的一些孢型，共描述48屬152种(包括22個未定种)。本文依据目前資料，詳細論述了正型粉類於晚白堊世和早第三紀早期在中國的分布；同時依据正型粉類的分布劃分中國古新世孢粉植物區系為：(1)東北區，以不含正型粉而僅有 *Aquilapollenites* 為特徵；(2)中原區，以僅含有正型粉類為特徵，又分為東南亞區和西北亞區，*Aquilapollenites* 在前一亞區內多少存在，在後一亞區缺乏而相區別。有關各區的孢粉組合及其所代表的植物群及氣候，本文也作了必要的對證。

關鍵詞：第三紀，正型粉類孢粉型，中國。

1. 中國科學院南京地質古生物研究所，南京北京東路39號，中華人民共和國。