Palynofossils from the Early-Middle Miocene deposits of Kachi-1 Well in Block II, Yellow Sea Basin, Korea

Sangheon Yi

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A palynofossil assemblage of twenty-nine species is described from the Early-Middle Miocene sediments of the Kachi-1 Well. The assemblage consists of two species of bryophytes, one of pteridophytes, six gymnosperm pollen and eighteen angiosperm pollen. The palynoflora of *Magnastriatites-Fupingopollenites* Assemblage Zone (468-492 m) compares closely with that of the Neogene sediments of eastern North China. This interval is characterised by the predominance of age-diagnostic taxa: *Magnastriatites granulastriatites* and *Fupingopollenites minutus* which represent Early to Late Miocene and Middle Oligocene to Middle Miocene respectively in Chinese strata. The flora indicates a sedimentary environment of a lowland swamp surrounded by slopes which were occupied by deciduous broadleaved trees under a predominantly humid warm—temperate climate.

Key-words—Palynology, Palaeoenvironment, Yellow Sea Basin, Neogene, Korea.

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साराँश

कोरिया के येलो सी बेसिन के काची–1, ब्लाक –2 कूप से प्राप्त पूर्व–मध्य मायोसीन युगीन परागाणु पादपाश्म

सांघियोन यी

काची–1 कूप से प्राप्त पूर्व मध्य मायोसीन युगीन 29 प्रजातियों के परागाणविक समुच्चय का वर्णन किया गया है। इस समुच्चय के अन्तर्गत् ब्रायोफाइट की दो प्रजातियाँ, टेरिडोफाइट की एक प्रजाति, छह अनावृतबीजी परागाणु तथा अठ्ठारह आवृतबीजी परागाणु प्राप्त हुई हैं। *मैग्नास्ट्रैटाइटिस फ्यूपिंगोपोलेनाइटिस* समुच्चय (468–492 मीटर) की परागाणविक रूपकों के गुण पूर्वोत्तर चीन के नीओजीन अवसादों से काफी साम्य रखते हैं। यह अन्तराल आयु निर्धारक वर्गकों, *मैग्नास्ट्रैटाइटिस ग्रैन्यूलास्टैटाइटिस* एवं *फ्यूपिंगोपोलेनाइटिस माइन्यूटस* की प्रचुरता से अभिलक्षणित हुआ है, जो चीनी संस्तरों में क्रमशः पूर्व से उत्तर मायोसीन एवं मध्य ओलिगोसीन से मध्य मायोसीन युग तक के समयान्तराल में प्राप्त होते हैं इस वनस्पतिजात से ज्ञात होता है कि यहाँ का तत्कालीन वातावरण ढलानों से घिरे निचले दलदली भूखण्ड के रूप में आर्द्र–उष्ण–शीतोष्ण जलवायुयुक्त था तथा यह चौड़ी पत्तियों वाले वृक्षों से घिरा हुआ था।

SEVERAL palynological investigations have been published on the Yellow Sea sediments of the east coast of China (Zheng *et al.*, 1981; Hu & Wang, 1985; Liu & Leopold, 1992; Wang 1994) for oil and geological exploration, but only a few studies have been carried out on the same of the west coast of Korea. During the last few years, comprehensive research primarily for oil exploration in the Yellow Sea, west coast of Korea, has been carried out. The present study is a part of that extended research.

The ditch cutting samples of interval 468-606 m of the Kachi-1 well (123° 20' 59" E : 35° 18' 22" N) from the Yellow Sea Basin, Korea were provided by Marathon Oil Company, USA, for palynological investigation of Tertiary sediments. The purpose of this study is to determine the age of the stratigraphic interval studied, make general palaeoenvironmental interpretations of the deposition on the basis of the assemblages recorded, and to correlate the interval with the Tertiary sediments of adjacent areas.

The standard palynological preparation technique was employed to extract palynofossils from the rock samples. HCl (35%) was used to remove any carbonate present, and HF (40%) to remove silicate minerals and to release organic material. The neutralised final residue was strewed on cover glass and then mounted on slide glass for making slides. The slides are stored at the Centre for Palynological Studies, University of Sheffield, England.

GEOLOGY

Yellow Sea Basin/Tectonics—The Yellow Sea Basin is an intracratonic pull-apart feature that is oriented generally E-W (Text-figure 1). Transtensional border faults along the northern and southern flanks of the Basin are believed to exhibit relative left-lateral movement. Tertiary extension and subsequent non-marine deposition with localised compression/ wrenching followed as the pull-apart basin evolved (Text-figure 2). Palaeogene sediments fill major part of the basin below the regional Pliocene unconformity, which marks the transition from non-marine to marine deposition. Local and sub-regional unconformities abound throughout the basin and serve to mark episodes of uplift and erosion, the most notable of which is the Neogene unconformity (Text-figure 2).

Two structural trends dominate in the Yellow Sea Basin. In the Chinese portion of the basin, a general faulting with E-W trend parallels the major border faults (Text-figure 1). Palaeogene extensional regimes dominate with relatively little wrenching evidence. In the Korean portion of the basin, faulting, probably caused by the tensional tectonic movements, created the subduction of the Kula-Pacific Ridge in Palaeogene times, generally trends NW-SE as Cretaceous through Neogene sediments are common (Kim, 1987; Han & Choi, 1992; Text-figures 1, 3). Subsequent transpressional movement along these faults caused reactivation and reversal of movement in many cases. Basement uplifts within the Basin are common, and generally are late features confined to the Neogene (Text-figure 2). In fact, compressional and transpressional tectonics within the basin appear to be primarily Neogene to Recent in age.

Tectonics/sedimentation of Block II—Block II occupies only the southeastern portion of the Yellow Sea Basin which is one of a number of Mesozoic-Tertiary, non-marine, back-arc, transtensional pull-apart basins that are distributed along a general NE-SW trend in China and into the Yellow Sea (Text-figure 1). Block II contains three sub-basinal areas within the larger Yellow Sea Basin. These sub-basins are Western, Central and Eastern Basins eastward (Text-figure 3).

The Eastern Basin is the largest of the three basins and is aligned NW-SE between Block I in the north to the border fault in the South (Text-figure 1). This area is believed to be a simple sag basin which developed in the Late Cretaceous and is filled primarily with about 6 km thick Palaeogene non-marine sediments (Han & Choi, 1992). The western extent of this basin is marked by a basement uplift which parallels the Eastern Basin and appears to be wrench-faulted along its northeast flank (Text-figure 3). Near the southern boundary of the basin, there is a series of E-W striking faults associated with the border fault. The Central basin underwent syn-rift sedimentation in the Cretaceous which is followed by the deposition of a thick (about 7 km) Palaeogene section as extensional tectonism prevailed. However, during the deposition of the Neogene, the tectonic regime changed to one of compression and transpression. Several thousands of feet of Palaeogene section were uplifted and subsequently removed by the Pliocene unconformity (Kim, 1987; Han & Choi, 1992; Text-figure 2). The western Basin, where the Kachi-1 Well was drilled, is situated in the very western portion of Block II, but extends an unknown distance to the northwest beyond the boundary of the block. It is known that the basin does dip down to the west and northwest from the western boundary of the Block. Extensional tectonics predominated in this basin from Cretaceous through Palaeocene time when non-marine sediments were

PLATE 1 ⟶

(All figures x 906, unless otherwise stated. Specimens are identified by sample/ slide number and England Finder reference. IC = Interference contrast)

1. *Laevigatosporites haardti* (Potonié & Venitz) Thomson & Pflug 1953. K1560 (B), V33.
2, 3. *Verrucatosporites favus* Potonié 1931. K1590 (A), S38/3, same specimen in different foci.
4. *Magnastriatites granulastriatus* Li 1985. K1560 (B), J34/4.
5. *Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug 1953. K1560 (A), X20/1.
6. *Inaperturopollenites hiatus* (Potonié) Thomson & Pflug 1953. K1590 (A), V48/2.
7, 8. *Pinuspollenites labdacus* f. *maximus* Potonié 1958. K1860 (A), E28, foci on central body and saccus attached distally respectively.
9. *Pinuspollenites labdacus* f. *maximus* Potonié 1958. K1560 (B), J35.
10. *Keteleeriaepollenites davidianaeformis* (Zaklinskaja) Song & Zheng 1984. K1620 (A), F23/2 (x 727).
11. *Keteleeriaepollenites minor* (Ke & Shi *in* Sung *et al.* 1978) comb. nov. K1590 (B), U50/3.

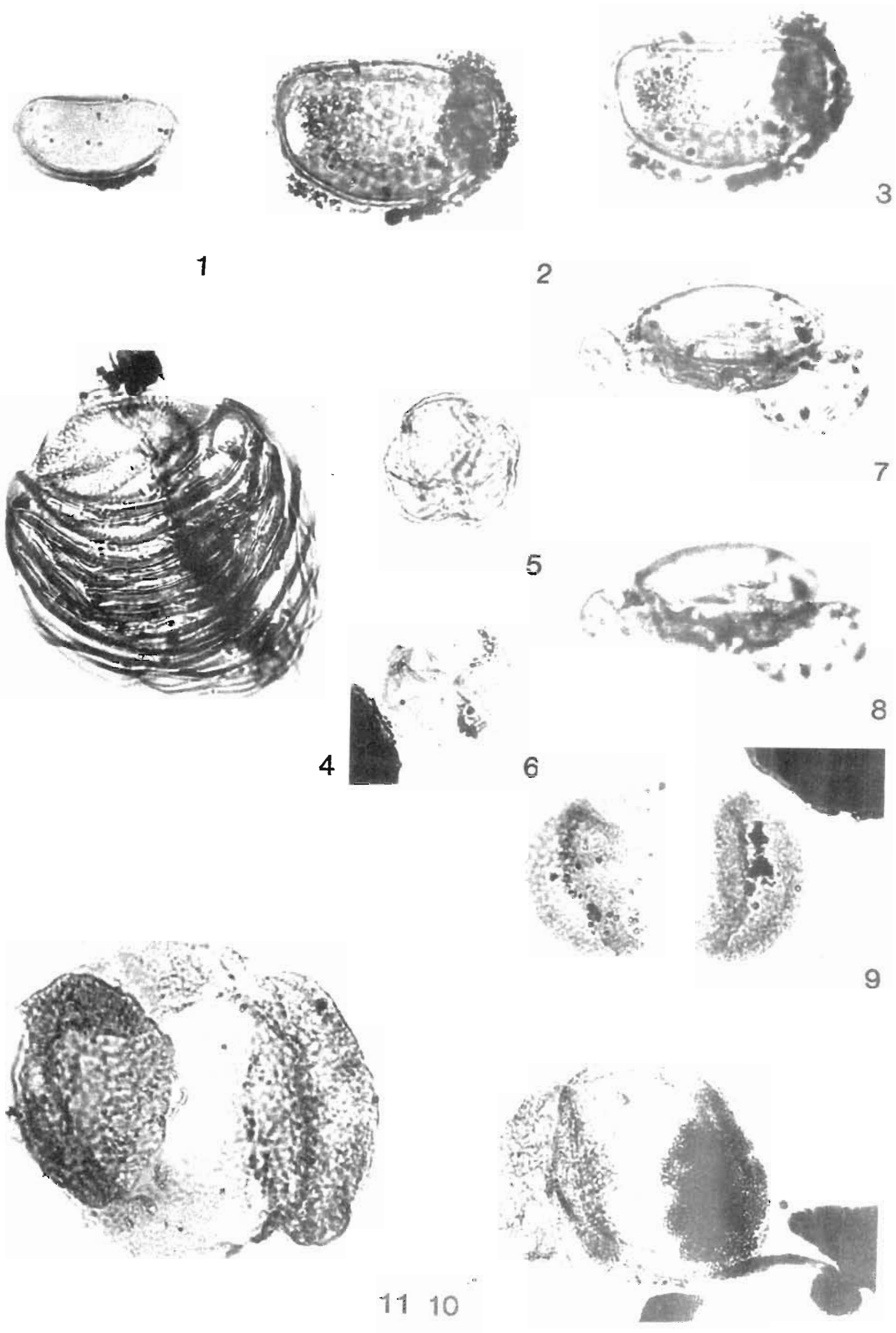
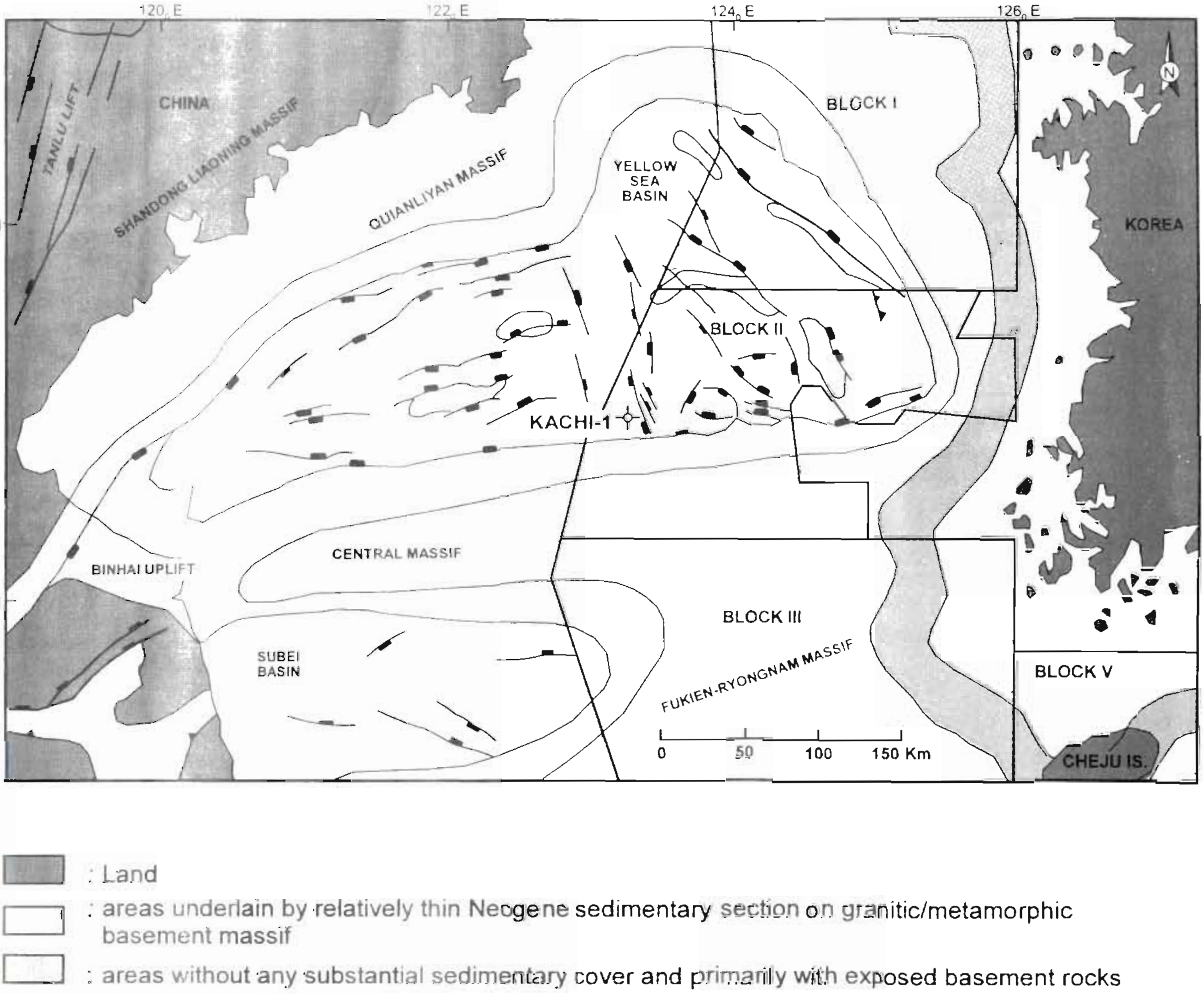


PLATE 1



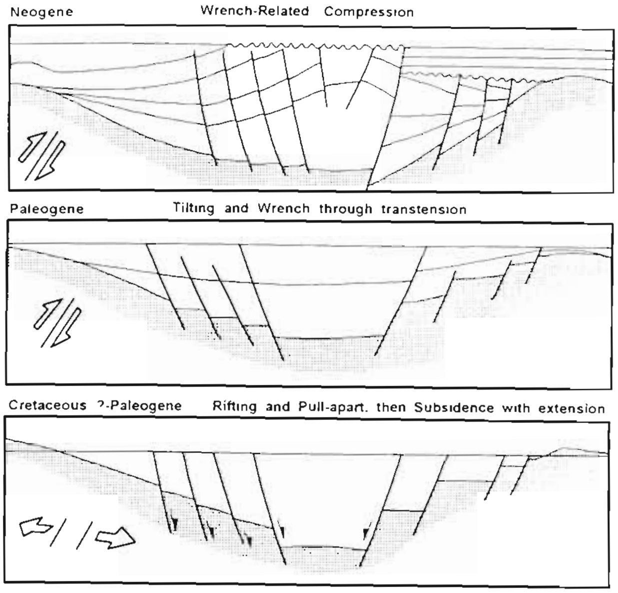
Text-figure 1—Tectonics of Yellow Sea Basin and neighbouring area (from Marathon Petroleum, Korea).

deposited (Text-figure 2). At the Kachi location, the reactivation of an old normal fault, which marked the boundary of a classic half-graben in the Cretaceous and Palaeogene, produced a large inverted structure. Transpression along this old fault began in Late Miocene and is still active at present. This fault, which trends NW-SE, displays a "Scissors-like" movement as it becomes a normal fault farther out into the basin (Text-figure 3). This Miocene to Recent strike-slip fault is probably due to left-lateral movement along the border fault to the south.

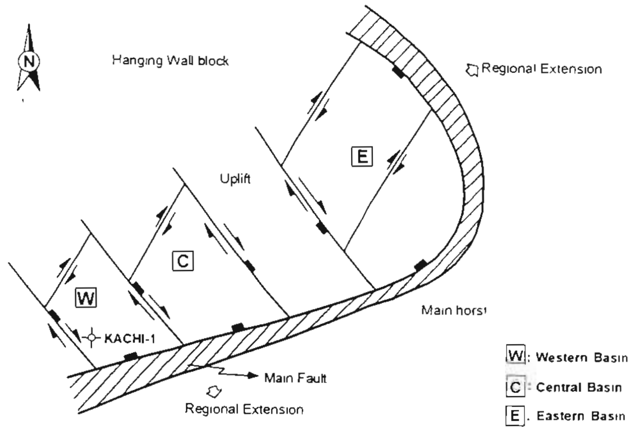
At the Kachi-1 site deposition of syn-rift fluvial/lacustrine sandstones and claystones occurred adjacent to a large northwest-southeast trending basin-bounding fault during a period of extension from the Cretaceous through Oligocene. The graben was infilled by post-rift red beds in Miocene time. The basin was inverted in the Late Miocene with the reactivation of older faults in a change to compressional and transpressional tectonics. Incursion of shallow epicontinental seas buried the structures with flat-lying Plio-Pleistocene marine sediments. Between 468 and 606 m the lithologies are primarily poorly cemented quartz sand/sandstone with minor interbeds of light grey, carbonaceous clay/claystone and woody lignite (Text-figure 4).

PALYNOFLORAL ASSEMBLAGES AND AGE DETERMINATION

The microfloral assemblages of the uppermost



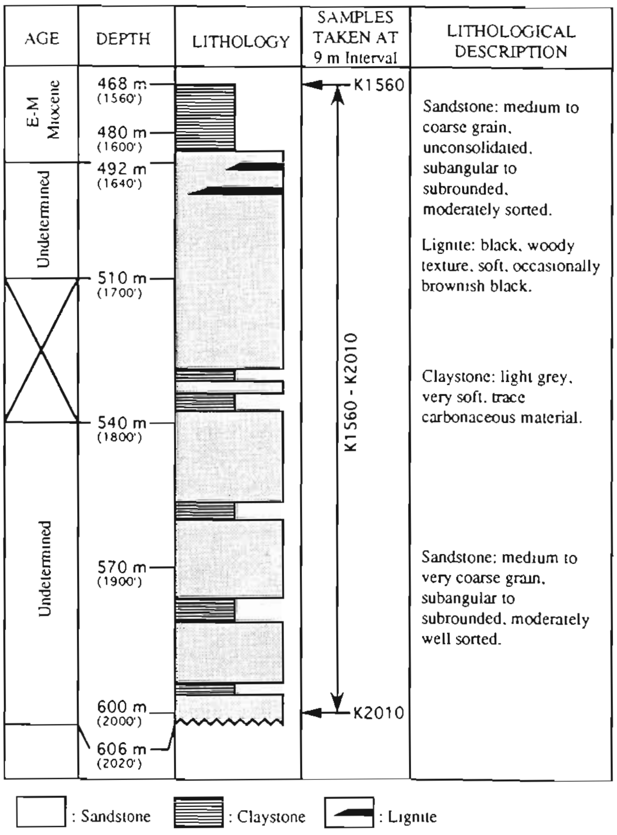
Text-figure 2—Schematic structural development of inversed normal fault (after Han & Choi, 1992).



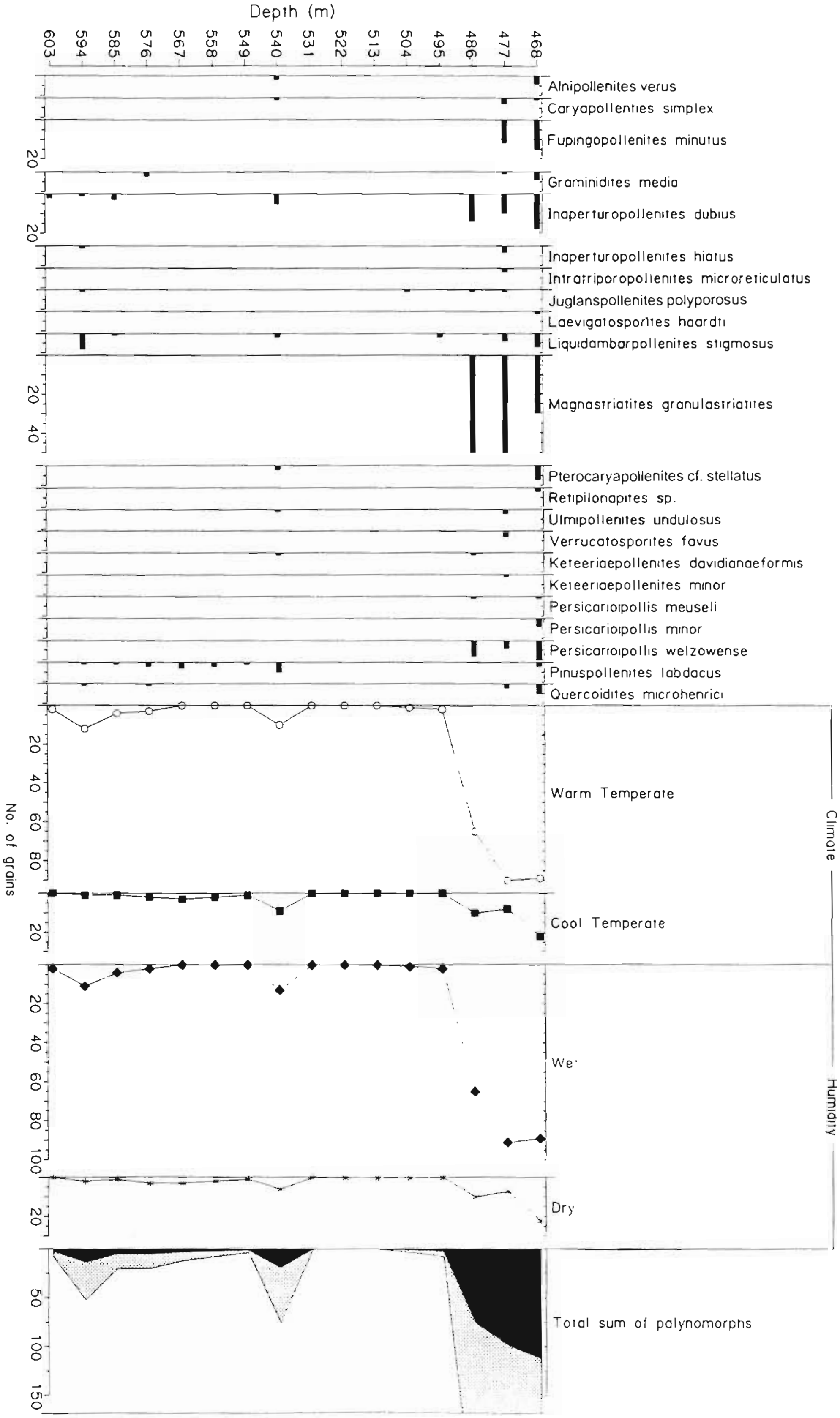
Text-figure 3—Sketch map showing western, central and eastern basin development caused by differential extension in the hanging-wall block of the main listric fault (after Han & Choi, 1993).

sections (468-495 m) compare closely with those of the Late Tertiary (Neogene) sediments from eastern North China. Age determination of the studied sections was achieved by correlation with palynological assemblages from equivalent strata of the Circum-Pacific Northern Hemisphere.

Magnastriatites-Fupingopollenites Assemblage Zone (468-492 m)—The dominance of *Magnastriatites granulastriatites* (early to late Miocene) from China (Li *in* Song *et al.*, 1985) and *Fupingopollenites minutus* (Middle Oligocene to Middle Miocene) from China (Liu, 1985; Wang, 1989) in this assemblage zone indicates an early to middle Miocene age (Text-figure 5). These two species have their last appearance within this interval. Other common taxa, including *Persicarioipollis welzowense*, *Juglanspollenites periporites* and *Pterocaryapollenites* cf. *stellatus*, have been reported from the Late Eocene to Middle Pleistocene. The assemblage of *Magnastriatites-Fupingopollenites* is very similar to that of Pinaceae-*Ceratopteris* (= *Magnastriatites*) from the Early Miocene and *Ceratopteris-Trapa-Juglans* assemblage from the middle-late Miocene described by Zheng *et al.* (1981) from China (Text-figure 6). The assemblage is comparable with the early to middle Miocene Changgi palynofloras of the Pohang Basin, Korea (Takahashi & Kim, 1979), but differs in having pre-



Text-figure 4—Generalised lithological section and sample positions, Kachi-1 Well.



Text-figure 5—Occurrence of palynomorphs in Kachi-1 Well.

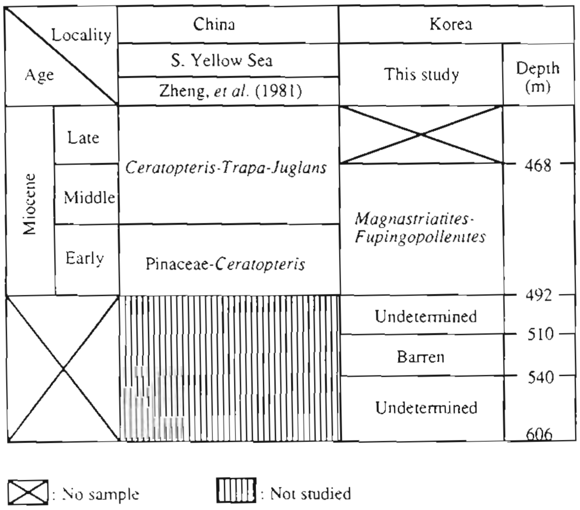
dominant taxa *M. granulastriatites* and *F. minutulus*. An unconformity between this assemblage zone and the underlying interval is not indicated as the evidence available is too meager from the samples to determine the top of the lower interval.

Low palynomorph recovery intervals (492-606 m)—Three low palynomorph recovery intervals are found and the elements of these intervals are not enough to determine the biostratigraphic age in this study. These three intervals are:

1. This interval at 492-510 m is characterised by a poor recovery of pollen grains such as *Juglanspollenites periporites* (only 2 specimens of the total count in K1650) and *Liquidambarpollenites minutus* (only 1 specimen of the total count in K1680). Therefore the age of the interval cannot be accurately determined.
2. This interval between 510-540 m is barren.
3. The interval between 540-606 m is characterised by a poor assemblage (6 species recorded only) which consists of long ranging gymnosperm taxa including *Inaperturopollenites dubius* (Early Jurassic to Middle Pleistocene), bisaccate *Pinuspollenites labdacus* f. *maximus* (Late Cretaceous to Middle Pleistocene), and angiosperm pollen such as *Liquidambarpollenites stigmosus* (Palaeocene to Middle Pleistocene) and *Quercoidites microhenrici* (Maastrichtian to Pliocene). Consequently the age of the interval cannot be accurately determined.

PALAEOENVIRONMENT AND PALAEOCLIMATIC IMPLICATIONS

Sedimentary environment—The interval 468-492 m; samples: K1560 to K1620) is represented by the assemblages with very low diversity (4-19 spp.) and moderate to relatively high dominance (41-67 %). Spores of the genus *Magnastriatites* are predominant in this interval. Small aquatic fern which produced spores of *Magnastriatites* grew in shallow-water bordering lakes and river banks (Germeraad *et al.*, 1969). In this interval pollen such as *Persicarioipollis*, *Inaperturopollenites* and *Alnipollenites* (from aquatic and swamp regions) are best represented. Pollen taxa derived from deciduous broadleaved and evergreen broadleaved vegetation of mountains, hill and lowland occur in this interval.



Text-figure 6—Correlation of palynological assemblages of interval section in Kachi-1 Well.

These include *Pinuspollenites*, *Liquidambarpollenites*, *Quercoidites*, *Betulaepollenites*, *Intratriporopollenites*, *Fupingopollenites*, *Juglanspollenites* and *Pterocaryapollenites*. *Fupingopollenites* occurs in lowland rainforests in Asia (Liu, 1988a, b). Its occurrence in high proportions in this interval indicates humid climatic conditions. Therefore it is considered to represent a lowland swamp surrounded by slopes occupied by deciduous broadleaved trees under humid climatic conditions.

Palaeoclimatic conditions—The uppermost interval (468-492 m), deposited during the early-middle Miocene, is characterised by warm temperate taxa throughout the interval. Warm climatic conditions are suggested by the predominance of *Magnastriatites* and *Fupingopollenites* with common *Inaperturopollenites* and *Liquidambarpollenites*. Small fern *Ceratopteris* (*Magnastriatites*) occurs today in tropical to warm temperate regions, and pollen of *Fupingopollenites* are found in tropical to warm temperate lowland rainforests of Asia (Liu, 1985; Wang, 1989). Additionally, the presence of common *Liquidambarpollenites*, *Quercoidites*, and *Pterocaryapollenites* indicates warm temperate climatic conditions. Wet climatic conditions are suggested by the predominance of *Magnastriatites*, *Fupingopollenites*, *Inaperturopollenites*, *Liquidambarpollenites* and *Juglanspollenites*, even though a few pollen indicating a drier climate such as *Persicarioipollis*, *Quercoidites* and *Pinuspollenites* are also presents. It should be noted that the frequency of taxa indicating warm temperate climate with humid conditions decreases in the upper section, whereas taxa indicating cool temperate or dry climate increase in frequency in the upper section (Text-figure 5). It is considered that the upper section was deposited under predominantly humid warm temperate dry climatic conditions.

SYSTEMATIC PALYNOLOGY
Spores

Genus—*Laevigatosporites* (Ibrahim) Schopf, Wilson & Bentall 1944

Laevigatosporites haardti (Potonié & Venitz) Thomson & Pflug 1953
Pl. 1, fig. 1

Remarks—Wilson (1978, p. 117-118) and Srivastava (1977, p. 51) placed *L. gracilis* Wilson & Webster and *L. ovatus* Wilson & Webster in synonymy with *L. haardti* (Potonié & Venitz) Thomson & Pflug, based on similar morphologies, shapes and size ranges for all the three species. However, I do not agree with their consideration, because the differences in shape, exine thickness and proximal laesural exine thickening observed among these species *L. haardti* differs from *L. ovatus* in having its characteristic bean-shape and by the presence of thicker exine in the proximal area. *L. haardti* can be distinguished from *L. gracilis* which lacks proximal laesural exine thickening.

Size range—38 (44) 50 μm X 22 (26) 28 μm (10 specimens measured).

Botanical Affinity—Polypodiaceae (Stanley 1965).

Genus—*Magnastriatites* Germeraad, Hopping & Muller 1969

Remarks—This genus differs from *Cicatricosisporites* Potonié & Gelletich 1933 in having a large size, small number of coarse striae and a circular ridge surrounding the smooth proximal contact areas.

Magnastriatites granulastriatus Li 1985
Pl. 1, fig. 4

Description—Trilete anisopolar spore consisting of a rounded distal pole and more or less pointed proximal pole. Circular to subtriangular in polar view. Laesurae enclosed by elevated thin lips, sometimes open, extend to the equator. Coarsely striate sculpture covering overall surface except on the contact areas. Contact areas psilate to granulate and surrounded by a circular ridge. Striae 2-3 μm high, 1 μm wide, continuous; grooves 3-4 μm wide. Striae occasionally branched in interradial regions. Exine 1 μm thick.

Remarks—The species occurs continuously and abundantly throughout the studied Neogene Kachi here section. It is characterised by granular contact areas. Specimens encountered are usually preserved laterally. Specimens observed are comparable to the specimens described by Li *in* Song *et al.* (1985) from the Yuquan Formation of the E. China Sea in all

PLATE 2 ⟶

(All figures x 906, unless otherwise stated. Specimens are identified by sample/slide number and England Finder reference. IC = Interference contrast)

1. *Alnipollenites verus* (Potonié) Potonié 1960. K1590 (A), F21/4.
2. *Alnipollenites verus* (Potonié) Potonié 1960. K1590 (B), N20/3.
3. *Caryapollenites simplex* (Potonié) Raatz 1934. K1800 (A), B37/3.
4. *Caryapollenites* sp. K1590 (C), O34/4.
5, 6. *Fupingopollenites minutus* Liu 1985, same specimen in different magnification; 6 (x2111).
7. *Graminidites media* (Cookson) Potonié 1960. K1560 (A), U47/3.
8. *Graminidites* sp. K1560 (B), D38/3.
9. *Juglanspollenites* sp. K1590 (B), H38/2.
10. *Liquidambarpollenites stigmosus* (Potonie) Raatz 1939. K1980 (A), D30/3.
11. *Liquidambarpollenites stigmosus* (Potonie) Raatz 1939. K1800 (A), H22/2; showing pores covered with thin endoexine perforation.
12. *Persicarioipollis welzowense* Krutzsch 1962. K1590 (A), T31/1+3.
13, 14. *Persicarioipollis minor* Krutzsch 1962. K1560 (A), 27/1; same specimen in different foci.
15. *Persicarioipollis meuseli* Krutzsch 1962. K1590 (C), D21.
16. *Pterocaryapollenites* sp. K1590 (A), D19/3.
17. *Quercoidites* spp. K1560 (A), X21/3.
18. *Retipilonapites* sp. K1560 (A), X31/3.
19. *Ulmipollenites* sp. K1800 (B), J35/2.
20. *Intratriporopollenites microreticulatus* Mai 1961. K1590 (B), G19/4.
21. *Diporisporites* sp. K1590 (A), K27/4 (fungal spore).
22. *Tetraploa* sp. K1620 (A), T34.

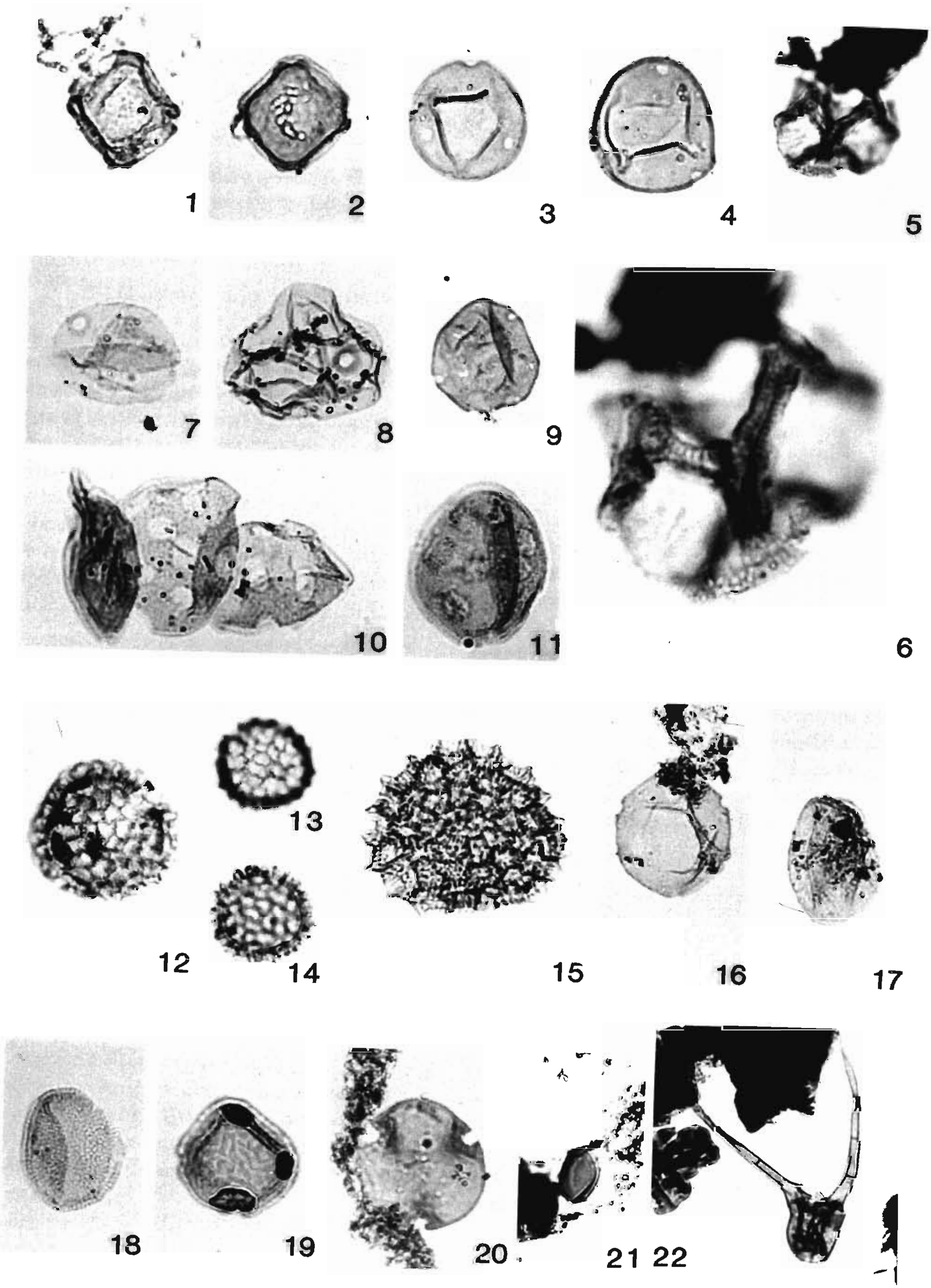


PLATE 2

respects.

Size range—80 (90) 93 μm (25 specimens measured).

Botanical affinity—Parkeriaceae—*Ceratopteris* (Germeraad *et al.*, 1969).

Known range—Early to Late Miocene.

Stratigraphic distribution—Early to Late Miocene, E. China Sea (Li *in* Song *et al.*, 1985).

Genus—*Verrucatosportites* Pflug & Thomson in Thomson & Pflug 1953

1953 *Polypodiidites* (Ross) Couper, p. 28.

1956 *Polypodiisporites* (Potonié) Potonié, p. 80.

Remarks—There is confusion over the generic name for these spores, *Verrucatosporites* Pflug & Thomson and *Polypodiisporites* Potonié. Potonié (1966, p.103) considered that the genera *Polypodiidites*, *Verrucatosporites* and *Polypodiisporites* are synonyms. However these generic names have been maintained by other authors. Authors have used different generic names for the same species. For instance in general, the American and Asian authors have used; *Polypodiisporites favus* Potonié (Sung *et al.*, 1978; Song *et al.*, 1985; Takahashi & Kim, 1979; Zhu *et al.*, 1985), *Polypodiisporonites favus* Potonié (Frederiksen (1980b), whereas European authors; *Verrucatosporites* (*Polypodiisporites*) *favus* (Potonié) Thomoson & Pflug (Thomson & Pflug, 1953; Krutzsch, 1967; Thiele-Pfeiffer, 1980). The treatment given by Potonié (1960) is accepted in this study.

Verrucatosporites favus (Potonié) Thomson & Pflug 1953
Pl. 1, figs 2, 3

Description—Monolete spore, more or less bean-shaped, anisopolar, convex undulating distal outline and straight proximal outline in lateral view. The laesura distinct and narrow, length 3/4 of spore length. Exine 2.5-3 μm thick, verrucate, verrucae low, flat and polygonal, verrucae diameter 2-5 μm, verrucae approximately 5 μm wide on distal area, but decrease gradually to 2 μm size on proximal surface. The height of verrucae also decreases toward proximal area.

Remarks—The specimens observed have flatter verrucae than *V. favus* (Potonié) Thomson & Pflug of other published areas.

Size range—54 μm X 36-39 μm (2 specimens only).

Botanical affinity—Polypodiaceae (Thomson & Pflug 1953).

Known range—Palaeocene to Late Pliocene.

Stratigraphic distribution—Middle Eocene to Late Pliocene, Qinghai, China (Zhu *et al.*, 1985); Miocene, Germany (Thomson & Pflug, 1953); Early to Middle Oligocene, East China (Ke & Shi *in* Sung *et al.*, 1978); and Early Miocene to Late Pliocene, East China Sea (Song *et al.*, 1985).

GYMNOSPERMAE

Genus—*Inaperturopollenites* Pflug & Thomson in Thomson & Pflug 1953

Inaperturopollenites dubius (Potonié & Venitz) Thomson & Pflug 1953
Pl. 1, fig. 5

Synonymy : See Takahashi (1991, p. 274-275)

Remarks—Specimens assigned to this species occur throughout the sections of Kachi-1.

Size range—38 (40) 47 μm (20 specimens measured).

Botanical affinity—Possibly Cyperaceae.

Known range—World-wide distribution from Early Jurassic (Hettangian) to Middle Pleistocene.

Inaperturopollenites hiatus (Potonié) Thomson & Pflug 1953
Pl. 1, fig. 6

1931a *Pollenites hiatus* Potonié, p. 5, fig. 27.

1933 *Taxodium hiatipites* Wodehouse, p. 493, fig. 17.

1950 *Taxodioidites hiatus* (Potonié) Potonié, Thomson & Thiergart, p. 49, pl. A, fig. 23.

1951 *Taxodioipollenites hiatus* (Potonié) Potonié, p. 143, fig. 17.

1953 *Inaperturopollenites hiatus* (Potonié) Thomson & Pflug, p. 65, pl. 5, figs 14-20.

1965 *Thuja*? *hiatus* (Potonié) Stanley, p. 272, pl. 38, figs 1-3.

1971 *Cupressacites hiatipites* (Wodehouse) Krutzsch, p. 41.

1979 *Inaperturopollenites pseudodubius* Takahashi:

Takahashi & Kim, p. 33, pl. 7, figs 3, 5-8, 10-13; pl. 8, fig. 8.

1980a *Taxodiaceaepollenites hiatipites* (Wodehouse) Frederiksen, p. 151, pl. 1, figs 4, 5.

Description—Inaperturate pollen grain, subspherical to oval in outline. Exine ca. 0.5 μm thick, psilate or scabrate. Exine characteristically ruptured with secondary folds. The split is commonly open more than a half of diameter of the grain. Ligula or germinal aperture absent.

Remarks—This species is recorded in association with *Inaperturopollenites dubius* throughout the section.

Size range—25 (37) 48 μm (10 specimens measured).

Botanical affinity—Taxodiaceae (Hedlund, 1966).

Known range—Berriasian to Pliocene, world-wide distribution.

Genus—*Keteleeriaepollenites* Nagy 1969

Remarks—Genus *Keteleeriaepollenites* consists of large pollen (usually larger than 60 μm) with central body more or less oblate in lateral view and subspherical in polar view without cappa or a thin cappa (about 1-2 μm thick), and distally attached sacci. Sacci are subglobular and smaller than the central body. It differs from *Abiespollenites* Thiergart emend. Potonié 1958 in having thick cappa of the central body (usually thicker than 5 μm), and from *Abietineaepollenites* Potonié ex Delcourt & Sprumont, 1955 having proximally attached sacci.

Keteleeriaepollenites davidianaeformis (Zaklinskaja) Song & Zheng *in* Song *et al.* 1984
Pl. 1, fig. 10

Synonyms : See Zhu *et al.* (1985, p. 111)

Remarks—Specimens are comparable with Chinese specimens in all respects (Ke & Shi *in* Sung *et al.*, 1978; Song *et al.*, 1985; Zhu *et al.*, 1985). This species differs from *K. minor* (Ke & Shi *in* Sung *et al.*, 1978) comb. nov. in having a much larger size.

Size range—Overall length 105-130 μm, breadth of central body 78-91 μm, length of central body 0-92 μm, height of central body 69 μm, length of saccus 50-72 μm, breadth of saccus 35-50 μm, height of saccus 54 μm, cappa 0.5-2 μm thick (5 specimen measured).

Botanical affinity—Pinaceae—*Keteleeria* (Nagy, 1969)

Known range—Early Tertiary to Pliocene.

Stratigraphic distribution—Early to Late Oligocene, China (Ke & Shi *in* Sung *et al.*, 1978; Song, Li & Zhong, 1986); Miocene to Pliocene, China (Song *et al.*, 1985; Zhu *et al.*, 1985).

Keteleeriaepollenites minor (Ke & Shi *in* Sung *et al.* 1978) comb. nov.
Pl. 1, fig. 11

1978 *Keteleeria minor* Ke & Shi *in* Sung *et al.*, p. 86, pl. 26, figs 3-4.

Description—Bisaccate pollen with spherical central body in polar view. Sacci slightly smaller than central body, coarsely reticulate and more than hemispherical. Distal furrow widely parallel sided. Exine of central body finely reticulate. Cappa not developed on the proximal surface of the central body.

Remarks—Specimens encountered in this study are similar to specimens described under *Keteleeria minor* by Ke & Shi *in* Sung *et al.*, 1978 from the Oligocene of Bohai, China. *Keteleeriaepollenites minor* (Ke & Shi *in* Sung *et al.* 1978) comb. nov. has distal sacci strongly pendant on the central body and a moderately narrow furrow.

Size range—Overall length 68-85 μm, breadth of central body 59-70 μm, length of central body 56-70 μm, length of saccus 48-62 mm, breadth of saccus 29-30 μm (5 specimens measured).

Botanical affinity—Pinaceae—*Keteleeria* (Nagy, 1969).

Known range—Early Cretaceous to Late Oligocene.

Stratigraphic distribution—Early Oligocene to Late Oligocene, Bohai, China (Sung *et al.*, 1978).

Genus—*Pinuspollenites* Raatz 1937 ex Potonié 1958

Pinuspollenites labdacus f. *maximus* Potonié 1958
Pl. 1, figs 7-9

Remarks—This species differs from *P. labdacus* f. *minor* Potonié 1958 in having a larger overall size. Present species is recorded throughout the section studied.

Size range—Overall length 85-90 μm, breadth of central body 46-51 μm, length of central body 36-48 μm, length of saccus 36-40 μm, breadth of saccus 37-

43 μm, breadth of saccus (in later view) 25 μm, cappa 2-3 μm thick (8 specimens measured).

Botanical affinity—Pinus (Potonié 1958).

Known range—Early Cretaceous to Late Pliocene.

Stratigraphic distribution—Neogene, Qinghai, China (Zhu *et al.*, 1985); Early Miocene to Late Pliocene, E. China Sea (Song *et al.*, 1985); and Pliocene, Germany (Potonié, 1951).

ANGIOSPERMAE

Genus—*Alnipollenites* Potonié 1931

1931a *Alnipollenites* Potonié, p. 4.

1937 *Alnuspollenites* Raatz, p. 20.

1953 *Polyvestibulopollenites* Thomson & Pflug, p. 90.

Remarks—Frederiksen and Ames (1979) discussed the validity of Potonié's (1931a) genus *Pollenites* and the nomenclatural confusion surrounding this genus. The authors considered that Potonié did not validly publish *Pollenites* in April 1931, but did it in May 1931 when he referred to *Pollenites verus* Potonié 1931b as *Alnipollenites verus*. Frederiksen and Ames (1979) and Jansonius and Hills (1980, Card no. 3633) considered that *Polyvestibulopollenites* Pflug 1953 and *Alnuspollenites* Raatz 1937 are junior synonyms of *Alnipollenites* Potonié 1931a. I also agree with their consideration.

Alnipollenites verus (Potonié) Potonié 1960
Pl. 2, figs 1, 2

1953 *Polyvestibulopollenites verus* (Potonié) Thomson & Pflug, p. 90, pl. 10, fig. 73.

1962 *Alnus quadrapollenites* Rouse, p. 202, pl. 2, figs 9, 36.

1967 *Alnipollenites quadrapollenites* (Rouse) Srivastava, p. 530, pl. 7, fig. 3.

1979 *Polyvestibulopollenites emiens* Takahashi—Takahashi & Kim, p. 58, pl. 21, figs 9-15.

Size range—20-25 μm in equatorial diameter (10 specimens measured).

Botanical affinity—Betulaceae—*Alnus* (Potonié 1931b).

Genus—*Caryapollenites* Raatz 1937 ex Potonié 1960

Remarks—This genus consists of pollen having a subcircular amb with one or two of the three pores situated subequatorial. The pores are distributed on the hemispherical of the grain.

Caryapollenites simplex (Potonié) Raatz 1937
Pl. 2, fig. 3

Remarks—The present specimens compare well with the specimens described by the Sung *et al.* (1978) and Song *et al.* (1985, 1986) in having thin exine (1-1.5 μm). *C. simplex* differs from *C. triangulus* (Pflug) Krutzsch 1961 in having a triangular field of thin exine with the angles pointing to the radial corners of the grain. *C. simplex* has a polar central thin exine field with the angles pointing to the interradial corners of the grain.

Size range—30-32 μm in equatorial diameter, 2-4 μm in pore diameter (6 specimens measured).

Botanical affinity—Juglandaceae—*Carya* (Takahashi & Kim, 1979).

Known range—Palaeocene to Middle Pleistocene.

Stratigraphic distribution—Palaeocene, Gulf Coast, U.S.A. (Fairchild & Elsik, 1969); Late Eocene to Early Oligocene, East China (Song *et al.* 1986); Late Eocene to Middle Pleistocene, East China Sea (Song *et al.*, 1985); Early to Late Oligocene, East China (Sung *et al.*, 1978); Oligocene & Miocene, Germany (Potonié, 1931b); and Miocene, Korea (Takahashi & Kim, 1979).

Caryapollenites sp.
Pl. 2, fig. 4

Description—Triporate pollen grain, amb subcircular; pores 3-4 μm long, oval in shape, all pores on one hemisphere, one pore at equator and the two other pores subequatorial, pores situated inter-radially, exine smooth, translucent, approximately 0.5 μm thick, two-layered. The other hemisphere broken off in this specimen. A triangular thin area occurs in polar areas.

Remarks—Specimen studied here has three pores situated subequatorially on one side. The specimen is poorly preserved.

Size—33 μm (1 specimen only).

Botanical affinity—Juglandaceae—*Carya*.

Genus—*Fupingopollenites* Liu 1985

Fupingopollenites minutus Liu, 1985
Pl. 2, figs 5, 6

1985 *Fupingopollenites minutus* Liu, p. 64-65, pl. 1, figs 1-4, 8.

Remarks—Specimens studied here are tricolpate with narrow and straight colpi. Exine has 5-7 depressed fields bordered by well developed infracolumellae bands (2-3 μm high) over the entire body. The exine of the depressed area is thin (1 μm) and surface scabrate or finely granulate. Liu (1985) differentiated *F. minutus* from *F. wackersdorfensis* on the basis of its size (mean standard 40 μm); smaller size and relatively narrower thickening bands. Specimens encountered here are closely comparable with the species described by Liu (1985) from the Upper Oligocene sediments of Fuping Formation, China. However, the present specimens have poorly visible pores.

Size range—26 (31) 37 μm in equatorial diameter (20 specimens measured).

Botanical affinity—Unknown.

Known range—Middle Oligocene to Middle Miocene.

Stratigraphic distribution—Middle to Late Oligocene, Fuping Formation, China (Liu, 1985); Early to Middle Miocene, Guangxi, China (Wang, 1989).

Genus—*Graminidites* (Cookson) Potonié 1960

Graminidites media (Cookson) Potonié 1960
Pl. 2, fig. 7

1947 *Monoporites* (*Graminidites*) *media* Cookson, p. 134, pl. 15, figs 41, 42.

1966 *Gramineae* Martin & Rouse, p. 201, figs 112, 113, 118.

1978 *Graminidites* sp. Sung *et al.*, p. 150, pl. 55, fig. 20.

1979 *Graminidites* sp. Takahashi & Kim, p. 62, pl. 24, fig. 7.

Remarks—This species is characterised by faintly granular exine with secondary folds.

Size range—31-34 μm, pore ca. 3 mm in diameter, annulus 2 mm wide (3 specimens measured).

Botanical affinity—Gramineae (Cookson, 1947).

Known range—Late Eocene to Pliocene.

Stratigraphic distribution—Tertiary, Kerguelen Archipelago (Cookson, 1947); Late Oligocene, Gulf of Bohai, China (Sung *et al.*, 1978); Late Miocene to Early Pliocene, British Columbia (Martin & Rouse, 1966); and Middle Miocene, Korea (Takahashi & Kim, 1979).

Graminidites sp.
Pl. 2, fig. 8

Description—Monoporate, more or less spherical outline with a single pore with an annulus; diameter of pore 4 μm and annulus 2 μm thick. Exine thickness less than 1 μm, microgranulate, with a number of secondary folds.

Remarks—Only a single specimen was found. *Graminidites* sp. is characterised by its large size and numerous secondary folds.

Size—40 μm (1 specimen only).

Botanical affinity—Gramineae.

Genus—*Intratriporopollenites* Pflug & Thomson 1953 emended Mai 1961

Remarks—Mai (1961) restricted the genus *Intratriporopollenites* to tilioid pollen material which is accepted here. According to Mai (1961) and Krutzsch (1961), the type of the genus *Tiliaepollenites* Potonié 1931 is a contaminated grain of modern *Tilia* pollen. Therefore they considered that *Tiliaepollenites* is an obligate junior synonym of *Tilia*. This genus consists of oblate form with rounded triangular to subcircular amb, smooth to reticulate exine, and three apertures varying from broad pores to short colpi. Combinations of both types of apertures located in the middle of the grain sides rather than at the amb corners. The pores are vestibulate and usually have an annulus.

Intratriporopollenites microreticulatus Mai 1961

Pl. 2, fig. 20

1961 *Intratriporopollenites microreticulatus* Mai, p. 64, 69, pl. 10, figs 6-7.

1978 *Tiliaepollenites microreticulatus* (Mai) Ke & Shi *in* Sung *et al.*, p. 136, pl. 46, figs 24-25.

Remarks—Specimens studied here always appear triporate but are in fact tricolporate. This species is characterised by its finely reticulate exinal sculpture.

Size range—29-31 μm in equatorial diameter (5 specimens measured).

Botanical affinity—Tiliaceae—*Tilia* (Mai, 1961).

Known range—Palaeocene to Late Pliocene.

Stratigraphic distribution—Early Eocene, N.

Germany (Fechner & Mohr, 1988); Eocene, central Europe (Mai, 1961); Early Tertiary, E. China (Ke & Shi *in* Sung *et al.*, 1978); and Early to Late Pliocene, East China Sea (Song *et al.*, 1985).

Genus—*Juglanspollenites* Raatz 1937

Remarks—This genus contains polyporate pollen with oval to subcircular to polygonal outline. Pores are about 6-8 in number, irregularly distributed over the surface of pollen but often absent on proximal hemisphere. *Juglanspollenites* differs from the genus *Pterocaryapollenites* Raatz ex Potonié 1960 with pores regularly distributed on the equator (stephanoporate).

Juglanspollenites polyporosus Takahashi *in* Takahashi & Kim 1979
Pl. 2, fig. 9

1979 *Juglanspollenites polyporosus* Takahashi *in* Takahashi & Kim, p. 60, pl. 22, figs 13-15.

Remarks—Specimens studied here agree with the original description of the species given by Takahashi (1979). *J. polyporosus* has 6 equatorial pores, 2 on one hemisphere without an annulus and vesticulum. The pores are elliptical, 2-2.5 μm in size. These morphological features can distinguish this species from other species.

Size range—25-27 μm in maximum equatorial diameter, exine 1 μm thick (3 specimens only).

Botanical affinity—Juglandaceae—*Juglans* (Takahashi *in* Takahashi & Kim, 1979).

Known range—Miocene.

Stratigraphic distribution—Miocene, Korea (Takahashi & Kim, 1979).

Genus—*Liquidambarpollenites* Raatz 1937 ex Potonié 1960

1937 *Liquidambarpollenites* Raatz, p. 17.

1953 *Periporopollenites* Thomson & Pflug, p. 111.

1960 *Liquiambarpollenites* Potonié, p. 134.

Liquidambarpollenites stigmosus (Potonié) Raatz 1937
Pl. 2, figs 10-11

1931b *Pollenites stigmosus* Potonié, p. S332, pl. 2, fig. 1.

1937 *Liquidambarpollenites stigmosus* (Potonié) Raatz, p. 17, fig. 26.

1953 *Periporopollenites stigmosus* (Potonié) Thomson & Pflug, p. 111, pl. 15, fig. 58.

1961 *P. asiaticus* Takahashi, p. 332-333, pl. 26, figs 34-36, pl. 27, figs 1 9.

Remarks—Specimens encountered vary considerably in overall size. Ke and Shi *in* Sung *et al.* (1978) noted that whereas the species is based on its size range only, *L. minutus* is less than 30 μm in size ; *L. stigmosus* is more than 30 μm. I do not agree with their criteria of distinction between the two species, because it may not be practicable for, determining stratigraphic ranges and palaeoenvironment.

Size range—26 (33) 39 μm (17 specimens measured).

Botanical affinity—*Liquidambar* (Takahashi & Kim, 1979).

Known range—Palaeocene to Middle Pleistocene.

Stratigraphic distribution—Late Eocene to Middle Pleistocene, East China Sea (Song *et al.*, 1985); Oligocene, Bohai, China (Ke & Shi *in* Sung *et al.*, 1978); Miocene, Germany (Potonié, 1931b); Miocene, Korea (Takahashi & Kim, 1979); and Middle Miocene, SW Germany (Thiele-Pfeiffer, 1980).

Genus—*Persicarioipollis* Krutzsch 1962

Persicarioipollis meuseli Krutzsch 1962
Pl. 2, fig. 12

1962 *Persicarioipollis meuseli* Krutzsch, p. 282, pl. 8, figs 9-16.

Description—Multiporate pollen with circular amb. A mesh of palisades covered with coarse reticulum is developed over the grain. Muri (ca. 5 μm high, 1 μm wide) with irregular pentagonal lumina. Pallisades with distinct baculae are higher at the corners of the meshes. Aperture very small, distinct or indistinct. Exine (2 μm thick) two-layered, ektexine (1.5 μm) slightly thicker than endexine (0.5 μm). Inner wall layer thin and smooth.

Remarks—*P. meuseli* differs from *P. welzowense* Krutzsch, 1962 in having larger size.

Size—50 μm in diameter (1 specimen only).

Botanical affinity—Polygonaceae—*Polygonum*

(Krutzsch, 1962).

Known range—Miocene.

Stratigraphic distribution—Miocene of Germany (Krutzsch, 1962).

Persicarioipollis minor Krutzsch 1962
Pl. 2, figs 13-14

1962 *Persicarioipollis minor* Krutzsch, p. 284, pl. 9, figs 1-5

Description—Multiporate with circular to oval, ornamented by a mesh of pallisades covered with reticulum formed by sinuous multibaculae. Muri ca. 2 mm high, lumina irregular and pentagonal. Aperture very small, distinct or indistinct. Exine 2 µm thick, two layered; ektexine slightly thicker than endexine. Inner wall layer thin and smooth.

Remarks—The present specimens are slightly smaller in size than the specimen described by Krutzsch (1962).

Size range—23-27 µm in diameter (4 specimens).

Botanical affinity—Polygonaceae—*Polygonum* (Krutzsch, 1962).

Known range—Late Eocene to Middle Pleistocene.

Stratigraphic distribution—Late Eocene to Middle Pleistocene, East China Sea (Song *et al.*, 1985); Miocene, Germany (Krutzsch, 1962).

Persicarioipollis welzowense Krutzsch 1962
Pl. 2, fig. 15

1962 *Persicarioipollis welzowense* Krutzsch, p. 284, 304, pl. 9, figs 6-12.

1979 *P. polygonoides* Takahashi *in* Takahashi & Kim, p. 61, pl. 24, figs 12-13.

Description—Multiporate pollen, amb circular to oval. Reticulate sculpture with sinuous multibaculate muri. Pallisades with distinct bacula increase in length towards the corner of the meshes, ca. 4 µm high. Lumina irregular and pentagonal. Aperture small, distinct or indistinct. Exine ca. 1.5-2 µm thick, two-layered; ektexine somewhat thicker than endexine; inner wall layer smooth.

Remarks—Takahashi *in* Takahashi and Kim (1979) created *P. polygonoides* for polyporate pollen. I, however, do not find any difference in the sculptures of the two species *P. polygonoides* and *P. welzowense*. Therefore *P. polygonoides* should be a Junior synonym of *P. welzowense*. The specimens encountered here are slightly smaller than the type material of Krutzsch (1962).

Size range—35-38 µm in diameter (11 specimens measured).

Botanical affinity—Polygonaceae—*Polygonum* (Krutzsch 1962).

Known range—Late Eocene to Middle Pleistocene.

Stratigraphic distribution—Late Eocene to Middle Miocene, East China Sea (Song *et al.*, 1985; Zhou *et al.*, 1985); Early Miocene, Germany (Krutzsch, 1962); Middle Miocene, SW. Germany (Thiele-Pfeiffer, 1980); and Miocene, Korea (Takahashi & Kim, 1979).

Genus—*Pterocaryapollenites* Raatz 1937 ex Potonié 1960

Pterocaryapollenites cf. *P. stellatus* (Potonié) Thiergart 1938
Pl. 2, fig. 16

Description—Stephanoporate, amb pentagonal, hexagonal and subcircular. Pores number variable from five to seven, mostly five, regularly distributed close to equator, the distance between the pores 9-14 µm (4 specimens measured). Exine psilate to finely scabrate, 0.5-1 µm thick, slightly thickened up to 1.5 µm at the pores. Thinner exine with secondary folds in the centre of the grains.

Remarks—Specimens encountered here have considerable sculptural variation. Some specimens have thinner exine in the polar area. Specimens studied here could be transitional forms between *Pterocaryapollenites* and *Caryapollenites*.

Size range—19 (30) 33 µm in equatorial diameter, pores 1.5-3 µm in diameter.

Botanical affinity—*Pterocarya* (Frederiksen, 1980b).

Stratigraphical occurrence—Middle Eocene, Guandong, China (Song *et al.*, 1986); Late Eocene, Western and Eastern Mississippi (Frederiksen, 1980b); Late Eocene to Late Oligocene, Bohai, China (Sung *et al.*, 1978); Oligocene, British Columbia (Piel, 1971); Miocene, Germany (Potonié, 1931b; Thiele-Pfeiffer, 1980); Late Miocene to Early Pliocene, British

Columbia (Martin & Rouse, 1966); and Late Miocene to Middle Pleistocene, East China Sea (Song *et al.*, 1985).

Genus—*Quercoidites* Potonié, Thomson & Thiergart 1950 ex Potonié 1960

Remarks— Genus *Quercoidites* is characterised by prolate tricolpate pollen grains with long, narrow distinctly geniculate colpi reaching polar areas. This genus closely resembles *Fraxinoipollenites* Potonié 1951 ex Potonié 1960 in having prolate, tricolpate with distinct long, narrow colpi extending to the poles, but differs from the latter in having the geniculate colpi and granulate or scabrate exine. Specimens observed here belonging to *Quercoidites* do not show genicules, but most morphological features conform with the diagnosis of the genus. Although species does not have geniculate colpi, the present specimens with granulate or scabrate exine are treated here under *Quercoidites*.

Quercoidites microhenrici (Potonié) Potonié 1960
Pl. 2, fig. 17

1931c *Pollenites microhenrici* Potonié, p. 26, pl. 1, fig. V19c.

1934 *Pollenites henrici microhenrici* (Potonié) Potonié & Venitz, p. 27.

1953 *Tricolpopollenites microhenrici* (Potonié) Thomson & Pflug, p. 96, pl. 11, figs 62-110.

1960 *Quercoidites microhenrici* (Potonié) Potonié, p. 93.

Description—Tricolpate, prolate to subprolate with somewhat broad polar area in equatorial view and circular in polar view. Colpi distinct, narrow, long extending nearly to the poles without a margo and geniculus. Exine ornament scabrate or granulate, exine two-layered (1-2 μm thick); endexine thin (ca. 0.5 μm thick), smooth; ektexine infragranulate.

Remarks—Specimens encountered here have variation in exine thickness, but all other morphological features conform with the type material.

Size range—25 (28) 31 μm in polar diameter, 16 (20) 25 μm in equatorial diameter (10 specimens measured).

Botanical affinity—Fagaceae—*Quercus* (Frederiksen, 1980b).

Known range—Maastrichtian to Pliocene.

Stratigraphic distribution—Tertiary, Qinghai, China (Zhu *et al.*, 1985); and Late Eocene to Late Pliocene, East China Sea (Song *et al.*, 1985).

Genus—*Retipilonapites* Ramanujam 1966 ex Potonié 1970

1966 *Retipilonapites* Ramanujam, p. 153.

1967 *Potamogetonacidites* Sah, p. 48.

1970 *Retipilonapites* Ramanujam ex Potonié, p. 87.

Remarks—Genus *Retipilonapites* consists of pollen having spherical to subspherical outline with nonaperturate, retipilate or baculate ornamentation. The pila are arranged into a reticulate ornamentation. Pila heads are free or fused. Genus *Potamogetonacidites* Sah 1967 is simplibaculate forming finely reticulate pattern. Overlapping morphological features occur in intermediate forms between these two genera. The two form genera are considered to have same botanical affinity with *Potamogeton*. Therefore the two genera are treated here as synonyms.

Retipilonapites sp.
Pl. 2, fig. 18

Description—Inaperturate, subspherical, retipilate or baculate ornamentation with a central depression on one side. Exine 2.5 μm thick; ektexine 2 μm thick, endexine 0.5 μm, intectate. Simplibaculate, baculae 2.5 μm high and 0.5 μm wide forming reticulation with discontinuous muri.

Remarks—*Retipilonapites*. sp. is characterised by its muri being discontinuous.

Size range—29-35 μm in diameter (3 specimens measured).

Botanical affinity—Potamogetonaceae.

Genus—*Ulmipollenites* Wolff 1934

Ulmipollenites undulosus Wolff 1934
Pl. 2, fig. 19

Synonymy : See Takahashi (1991, p. 380).

Remarks—Specimens observed contain subcircular outline (in polar view) with 4 pores and rugulose exine. Pores are slightly protruding, meridional, situated at the equator, 2 μm in diameter, 4 in number. The pores, surrounded by annulus are interconnected by weak or distinct arcus between the pores. Exine 1 μm thick, exinal thickened around pores. Exine ornamentation rugulate, rugulae arranged in an irregular pattern, rugules 1.5 μm wide.

Size range—29 μm in equatorial diameter (2 specimens measured).

Botanical affinity—Ulmaceae—*Ulmus* (Takahashi, 1991) or *Zelkova* (Norton & Hall, 1969).

Known range—Maastrichtian to Pliocene.

Stratigraphic distribution—Middle Eocene to Middle Oligocene, Bohai, China (Sung *et al.*, 1978); early Miocene to Pleistocene, East China Sea (Song *et al.*, 1985); Miocene, Germany (Thomson & Pflug, 1953, Meyer, 1956, Thiele-Pfeiffer, 1980); Miocene, Korea (Takahashi & Kim, 1979); and Pliocene, Germany (Thomson & Pflug, 1953).

Fungal Remains

Genus—*Diporisporites* van der Hammen 1954 emend. Elsik 1993

Diporisporites sp. B
Pl. 2, fig. 21

Remarks—Monocellate fungal spore contains oval outline with truncated ends. Pores are relatively larger and situated at the ends of long axis. Surface of wall is psilate.

Size—15 μm long, 10 μm wide, 4 μm in pore diameter (1 specimen only).

Genus—*Tetraploa* Berkeley & Broome 1850

Tetraploa sp.
Pl. 2, fig. 22

Remarks—Specimen encountered has only two projections, because other two projections are broken off.

Size—Main body 23 μm long, 20 μm wide, hypha 70-75 μm long, 6 μm wide at base, 3.5 μm wide at tip.

Known range—Miocene to Recent (Elsik 1993).

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