

辽宁西部晚侏罗世晚期义县组的似麻黄属植物^{*}

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提要 《辽西义县组单子叶植物化石的发现》中被归入被子植物门单子叶植物纲莎草科和禾本科的化石, 经与现代麻黄科植物对比研究后, 发现它们应归入裸子植物门麻黄科似麻黄属。讨论似麻黄属植物的命名、地理分布和生态环境。

关键词 似麻黄属 盖子植物纲 裸子植物门 晚侏罗世晚期 义县组 辽宁西部

半个多世纪前, 矢部长克和远藤诚道(Yabe and Endo, 1935)曾在热河凌源(现属辽宁西部)早白垩世? 狼鳍鱼层(现名义县组)发现一些保存欠佳的植物化石, 并鉴定为被子植物门单子叶植物纲眼子菜科的 *Potamogeton jeholensis* Yabe et Endo 和 *Potamogeton?* sp.。

近年来, 曹正尧、吴舜卿等(1997, 1998)在辽宁北票晚侏罗世晚期义县组中发现大量植物化石, 其中有一些被他们鉴定为被子植物门单子叶植物纲莎草科和禾本科的新属、种。这些白垩纪以前的所谓被子植物化石引起了国内学者的广泛关注。然而, 现经核查这些植物化石的特征与现代莎草科和禾本科的特征并不相符。化石与禾本科共同的特征仅是茎具节和节间, 而两者的其它特征差别甚远, 化石与莎草科的特征则毫无共同之处。实际上, 这些化石与现代麻黄科的特征颇为接近。它们应是裸子植物麻黄科的化石。

麻黄科属于盖子植物纲(Chlamydospermopsida), 又称买麻藤纲(Gnetopsida)或买麻藤目(Gnetales)。该纲或目还包含另外两科, 即百岁兰科和买麻藤科, 它们都是单属科, 是裸子植物门中最进化的类群。该纲植物化石极其稀少。目前已知麻黄科约有 16 个化石种, 它是此纲中最原始的类群。百岁兰科尚未见其化石报道。买麻藤科仅记录一种化石种(Jongmans und Dijkstra, 1973)。该科植物的叶片和具网状结构的脉序与被子植物门双子叶植物纲一

致, 二者的叶相(foliar physiognomy)特征很难区分。此外, 美国弗吉尼亚早白垩世 Potomac 群发现的具有网状脉的 *Drewria* 属被归入买麻藤科(Crane and Upchurch, 1987)。

麻黄科现代植株呈灌木, 亚灌木, 藤本或偶草本状。茎细, 圆柱状, 直立或匍匐, 具节和节间, 节间具多数细纵沟槽; 茎上的小枝对生或轮生。苗期的初生叶为针形或线形, 以后退化成膜质叶或鳞片状叶, 叶交互对生, 轮生或 2—3(4)片合成鞘状生于茎节基部或下部, 顶端具三角状齿, 叶有 1—3 条平行脉。花单性, 雌雄异株, 稀同株, 球花卵圆形或椭圆形, 生于枝顶或叶腋; 雄球花单生, 或数个丛生或 3—5 个组成复穗花序, 具 2—8 对生或 2—8 轮生(每轮 3 片)的苞片, 圆形或倒卵形, 雄球花具膜质假花被, 每个苞片生 1 雄花; 雌球花亦具 2—8 对生或 2—8 轮生(每轮 3 片)的苞片, 仅顶端 1—3 苞片生雌花; 雌花具顶端开口的革质假花被, 包于胚珠外, 珠被上部延伸成直或弯的珠被管。种子 1—3 粒。子叶 2 枚。

麻黄科现只有麻黄属(*Ephedra* Tourn ex Linn.), 含 40 余种, 广布于亚洲中、西部, 欧洲南部, 非洲北部, 北美西南部, 南美西部和南部的干旱、荒漠地区; 我国有 12 种 4 变种, 除长江下游及珠江流域外, 全国各地均有分布, 以西北和西南各地种类较多, 常生于干旱山地, 土壤贫瘠的山坡及荒漠戈壁, 是一类耐干旱的植物(郑万钧、傅立国, 1978; 郑万钧主编, 1983; 侯宽昭等, 1982)。

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盖子植物纲 Chlamydospermopsida (买麻藤纲 Gnetopsida)

麻黄目 Ephedrales

麻黄科 Ephedraceae

似麻黄属 *Ephedrites* Saporta, 1891 (non Goeppert et Berendt, 1845)

特征 茎具小枝, 茎枝通常具分散的条纹和关节, 小坚果(指雌球花)成双对生, 其表面具明显的联合缝, 背腹面类似, 基部强烈结合在一起, 初生的苞片密集, 小坚果(雌球花)的变态叶后来开放, 互生分离, 脱落。

讨论 似麻黄属(*Ephedrites*)系 Goeppert 和 Berendt (1845, 见 Berendt, 1845)依据产自德国北部中新世植物而创立的, 原模式种 *Ehedrites johnianus* Goeppert et Berendt 的标本曾被 Goeppert (1853)和 Conwentz (1886)分别改置于 *Ephedra* 和被子植物桑寄生科(Loranthaceae) *Patzea* 属, 因此, *Ephedrites* 成了裸名, 虽然如此, 至今仍有很多学者沿用此属名, 将一些与现代麻黄类似而又有所区别的植物化石归入似麻黄属(Ettingshausen, 1890; Saporta, 1891, Seward, 1919; 吴向午等, 1986; 李佩娟等, 1988; 周志炎, 1995)。特别是 Saporta (1891, p. 22)给似麻黄属以新的属征。这个新属征虽然也未完整地反映似麻黄属的特征, 并在术语和特征的认识上同现代植物还有一些差别, 但这个属征大致与现代麻黄属特征接近, 可作为似麻黄属的新属征。Saporta (1891, p. 26)并根据他的新属征将产自法国侏罗纪的标本建立一新种(*Ephedrites armaillensis*), 并对产自西伯利亚东部侏罗纪的 *E. antiquus* Heer (Heer, 1876, p. 82)重新记述和讨论。这表明 Saporta 有意将其作为本属的新的模式种(type species)对待。*E. antiquus* 具有保存很好的茎枝和种子, 本文也认为此种可选作似麻黄属的模式种。基于似麻黄属名习用已久, 虽然最初的模式标本被改归它属, 但 Saporta (1891, p. 22)重新补述和讨论了似麻黄属的属征已被后来学者接受, 并使用至今, 本文也以 Saporta 的似麻黄属属征为准。似麻黄属名语义明白, 能望文生义, 本文建议应予以保留, 若改为其他名称, 在使用上会产生诸多不便。

陈氏似麻黄(新组合) *Ephedrites chenii* (Cao et Wu) Guo et Wu X.W. Comb. nov.

(图版 I, 图 1—7; 图版 II, 图 1—8)

1997 *Liaoxia chenii* Cao et Wu, 曹正尧等, 1764 页, 图版 I, 图 1, 2, 2a—2c。

1997 *Erogrosites changii* Cao et Wu, 曹正尧等, 1765 页, 图版 II, 图 1—3, 2, 2a—2c; 插图 1。

1998 *Liaoxia chenii* Cao et Wu, Cao et al., p. 231, pl. I, figs. 1, 2, 2a—2c。

1998 *Erogrosites changii* Cao et Wu, Cao et al., p. 231—232, pl. II, figs. 1—3, 2a—2c; Text-fig. 1。

增订特征 植物茎丛生, 保存长 3—15cm, 茎枝具节和节间; 节略膨大, 宽 1.5—6.5mm, 节间长 10—35mm, 宽 1—5mm, 具纵沟槽; 茎枝直伸或略弯曲; 侧枝以 30°—60°角自主枝节上伸出, 交互对生。叶自节基部伸出, 对生, 线形, 长 15—30mm, 宽 1mm 左右。雌球花椭圆形, 倒卵形或圆形, 长 4—7mm, 宽 2—4mm, 通常单生于小枝顶端或近顶端, 雌球花具 4—8 对交互对生的苞片, 苞片卵形至长卵形; 顶端锐尖, 长 2—5mm, 宽 1—2mm。种子? 长椭圆形, 长 2.5mm, 宽 1mm。

讨论 本文研究的标本共 8 件, 其中 PBJ31 是本所东方标本中心收藏的标本, 其余 7 件是曹正尧、吴舜卿(1997)研究过的标本, 除 2 件(PB 17805, PB 17806 即本文图版 I, 图 8—10)被原作者鉴定为“单子叶植物”, 实际上它们属于松柏类, 可能与苏铁杉有关, 本文不予描述外, 其余 6 件均是似麻黄属的球花序和茎枝标本。这些标本与现代麻黄属的特征基本一致, 即茎枝直立, 具明显的节和节间, 节间具纵沟槽, 小枝对生, 球花生于小枝顶端或近顶端; 但当前化石具一线形叶与现代多数麻黄具膜质叶或鳞片叶, 叶基部联合成叶鞘的特征有所区别, 化石的线形叶可能反映一种原始性状。德国早侏罗世的麻黄科分子 *Piroconites kuespertii* Gothan 的苞叶亦成带状, 并具多数平行脉(Van Konijnenburg-van Cittert, 1992; Kirchner, 1992; Crane, 1996)。现代麻黄也有一些具细长针形叶和线形叶的种, 如 *Ephedra foliata*, *E. fragilis*, *E. altissima* 和 *E. chilensis*, 其中有的种其叶长 30mm, 宽 1—1.5mm, 具 2—3 条平行脉(Seward, 1919; Foster and Gifford, 1974)。*Ephedra vulgaris* 和 *E. altissima* 的实生苗的几对初生叶, 也具针形或线形叶(Rendle, 1953)。因此, 当前具线形叶的标本归入似麻黄属是易于理解的。化石的雌球花与现代麻黄也很相似。化石的雌球花常生于小枝顶端或近顶端, 这与分布在我国新疆西部、俄罗斯、印度和巴基斯坦现代的细子麻黄(*Ephedra regeliana* Florin)和生于中国北部和西部及中亚的单子麻黄(*Ephedra monosperma* Gmel. ex

Mey)的特征颇相类似(郑万钧、傅立国,1978;郑万钧主编,1983)。化石中仅发现一粒,有可能是陈氏似麻黄的种子?因种子顶端延伸的珠被管未被保留而存疑,然而,这种顶端延伸的珠被管在搬运和埋藏过程中也极易受损而失落。

麻黄科麻黄属的化石现知有11种之多。通常学者将发现于第三纪的,并与现代麻黄特征颇相一致的化石归入麻黄属,目前麻黄属的化石已记录9种,它们产自美国早第三纪、德国、意大利、瑞士等地第三纪,澳大利亚早第三纪和智利第三纪地层。此外尚有2个未定名的种(Jongmans und Dijkstra, 1974, p. 352—353)。

一些产自中生代的与麻黄属接近的化石,或少数虽产自第三系,因各种原因不能确信它们可以归入现代麻黄的化石,常被归入似麻黄属(*Ephedrites*)。似麻黄属现已记录5种(Jongmans und Dijkstra, 1974)。其中2种 *E. sinensis* Wu, He et Mai 和 *E. exhibens* Wu, He et Mei 产自我国青海柴达木盆地侏罗统小煤沟组(吴向午等,1986)。其余3种,如 *E. antiquus* Heer(1876)是茎枝和雌球花化石,发现于俄罗斯西伯利亚的侏罗纪地层中,是保存最完好的标本;*E. armailensis* Saporta 是雌球果化石,发现于法国的侏罗纪地层中(Saporta, 1891; Seward, 1919; Jongmans und Dijkstra, 1974); *E. sotzkianus* Unger 常见于法国、奥地利、瑞士、意大利和罗马尼亚等地区的第三纪地层中,是欧洲的广布种(Jongmans und Dijkstra, 1974)。我们没有机会去核查所有似麻黄属种的鉴定是否都是正确的,但是,本文描述的标本确实与现代麻黄属的特征非常相似,因此,当前标本归属裸子植物似麻黄属是适宜的,它们不属被子植物中的单子叶植物是肯定无疑的。

曹正尧、吴舜卿将当前的部分化石标本(曹正尧等,1997, 1764—1765 页;Cao et al., 1998, p. 231, 图版 I, 图 1—2, 2a—c 即本文图版 I, 图 1—4)归入莎草科的新属种(*Liaoxia chenii* Cao et Wu), 并与鳞子莎属(*Lepidosperma*)和墨莎草属(*Gnhnia*)相比较。莎草科的茎秆实心,常三(4—5)棱状或偶圆柱状,茎无节和节间;叶片狭长,或偶缺,常三列。而目前化石的茎具明显的节和节间这个重要特征排除它们与莎草科的关系。莎草科化石已报道10余属,最早出现于古新世(LaMotte, 1952)。该科的枝叶化石不易确定其属种的分类位置,其茎叶化石常归入形态属似莎草属(*Cyperacites* = *Cyperites*)。莎草科现

有70—90属,约4000种(Haywood, 1978; Cronquist, 1981), 中国有31属,670种(侯宽昭等, 1982)。

曹正尧、吴舜卿同时又将另一部分化石标本(曹正尧等,1997, 1765 页;Cao et al., 1998, p. 231, 图版 II, 图 1—3;插图 1 即本文图版 I, 图 5—7;图版 II, 图 3—8)归入禾本科的新属种 *Eragrosites changii* Cao et Wu), 并与画眉草属(*Eragrostis*)相比较。禾本科的茎虽具节和节间与当前化石类似,但禾本科的茎常中空,茎节上的侧枝通常不对称,即侧枝长短不齐,且无对生性;叶形各种各样,通常披针形,均具叶鞘和叶舌,叶互生非对生,常二列;花的苞片通常2—3片,非对生。这些禾本科的重要特征在目前化石中均未得到证实,故当前化石不应归入禾本科。禾本科的化石已报道20余属(LaMotte, 1952)。依据此科的茎叶化石很难鉴定其属的分类位置,除非果实,表皮和叶内植硅石同时发现。据Cronquist(1981)报道,禾本科最早的化石记录是晚白垩世 Senonian 期,从始新世开始逐渐丰富起来。禾本科现有500—660余属,8000—10000种,是单子叶植物中最大的科之一(Haywood, 1978; Cronquist, 1981), 中国有225属,1200余种(侯宽昭等, 1982)。

此外,曹正尧、吴舜卿还将正、反面的两个枝叶化石(曹正尧等,1997, 1965 页;Cao et al., 1998, p. 232, 图版 I, 图 3, 4, 4a 即本文图版 I, 图 8—10)称做未定名的单子叶植物也是值得怀疑的。它们应属松柏类,可能与苏铁杉类? (*Podocamites*?)的小枝有关。

段淑英(1997)也在此同一产地和同层位报道一“被子植物”新属种梁氏朝阳序(*Chaoyangia liangii* Duan)。这类化石也不像是被子植物,很可能是盖被子植物纲的植物。

三木茂(Miki, 1964, p. 3—22)记录一个产自中国东北中生代狼鳍鱼层(现辽宁义县组)的标本,并依此建立新属种 *Amphiephedra rhamnoides* Miki, 他认为化石与麻黄属接近,具有特别短的枝,但枝上无与现代麻黄近似的叶。因其标本保存破碎,特征不明显,难以确定其分类位置。

原河北凌源(现属辽宁省)早白垩世?狼鳍鱼层的标本被定名为被子植物 *Potamogeton jeholensis* Yabe et Endo 和 *Potamogeton*? sp. (Yabe and Endo, 1935, p. 274—276), 其特征或多或少地与当前标本有些接近,它们也许与似麻黄属有关。可是后来它

们又被 Miki 改归毛茛属 *Ranunculus jeholensis* (Yabe et Endo) Miki (1964, p. 19)。其真实性质和归属有待确证。

Velanovsky 和 Viniklar (1926) 根据发现于捷克白垩纪地层的化石建立拟麻黄新属种, 即 *Ephedropsis strobilifera*, 后来此种被归入杉科 (Andrews, 1970), 这个属名虽具有麻黄 (*Ephedr*) 的词干, 但它与麻黄科无关。

德国早侏罗世发现的 *Piroconites kuespertii* Gothan, 其苞叶带状, 长 9—15cm, 宽 4—5cm, 具有多数平行的不分叉的脉, 每厘米有 12—15 条; 小孢子叶有凹的新月形的基部; 雌球花鳞片长 3.5—5.5cm, 宽 2.0—3.5cm (Van Konijnenburg-van Cittert, 1992; Kirchner, 1992)。因其花粉与麻黄粉类似而归入麻黄科。此种特征与当前的标本差别甚远。

最近, 澳大利亚的维多利亚早白垩世晚期 Koonwarra 化石层发现的麻黄科植物 *Leongathia elegans* Krassilov, Dilcher and Douglas (1998), 它的茎枝有节和节间, 并具纵条纹; 叶线形, 4 叶或偶尔 2 至 3 叶交互对生排列于节上, 叶鞘退化, 这些特征与我国的标本有些类似, 但当前标本的其它特征与前者有明显区别。

Crane (1987, 1996) 指出麻黄类的花粉化石三叠纪时在北半球已经广泛分布, 在我国华北下三叠统也有记载 (Ouyang and Norris, 1988), 侏罗纪较少, 但继续发展到白垩纪, 中白垩世在低纬度较前更加丰富。据我国的孢粉学者黎文本、尚玉珂和刘兆生等面告, 我国辽宁侏罗纪义县组发现过类似于现代麻黄属具粗条纹饰的花粉化石, 其它地区侏罗纪地层中也曾发现过此类麻黄花粉化石。

在本文的研究工作中, 有关化石种的命名问题曾与本所周志炎教授和南京大学张永铭教授讨论过, 并得到他们的有益建议。本文即将完稿时, 恰逢瑞典自然历史博物馆古植物学部主任 Else Marie Friis 教授来本所访问。她仔细地观察了本文研究的标本, 对其命名、被子植物起源和早期演化等问题同作者进行了广泛讨论和交流, 事后, 又赠送有关学术论文。江苏省及中国科学院植物研究所提供查阅腊叶标本, 宋之耀拍摄照片, 本所东方标本中心张志平借用一件标本。笔者对他们的帮助表示衷心感谢。

参考文献

- 吴向午, 何元良, 梅盛吴, 1986. 似麻黄属 *Ephedrites* 在青海下侏罗统小煤沟组的发现. 古植物学与孢粉学文集, 第 1 号. 南京: 江苏科技出版社. 13—22, 图版 1—3。
- 李佩娟, 何元良, 吴向午, 梅盛吴, 李炳有, 1988. 青海柴达木盆地东北缘早、中侏罗世地层及植物群. 南京: 南京大学出版社. 1—232, 图版 1—140。
- 侯宽昭, 吴德邻, 高蕴璋, 陈德昭, 1982. 中国种子植物属词典. 北京: 科学出版社. 1—632。
- 郑万钧, 傅立国, 1978. 裸子植物志, 中国植物志. 第 7 卷. 北京: 科学出版社. 1—542。
- 郑万钧主编, 1983. 中国树木志. 第 1 卷. 北京: 中国林业出版社. 1—929。
- 段淑英, 1997. 最古老的被子植物——具三心皮结构的生殖器官化石. 中国科学. D 辑, **27**(6): 519—524。
- 周志炎, 1955. 侏罗纪植物群. 见: 李星学主编, 中国地质时期植物群. 广州: 广东科学技术出版社. 206—301。
- 曹正尧, 吴舜卿, 张平安, 李杰儒, 1997. 辽西义县单子叶植物化石的发现. 科学通报, **42**(16): 1764—1766, 图版 1—2。
- Andrews H N, 1970. Index of generic names of fossil plants, 1820—1965. Geol. Serv. Bull., **1300**: 1—353。
- Berendt G, 1845. Die im Bernstein befindlichen organischen Reste der Vorwelt. Berlin. 125pp. 79pls.
- Cao Zhengyao, Wu Shunqing, Zhang Ping'an, Li Jieru, 1998. Discovery of fossil monocotyledons from Yixian formation, western Liaoning. Chinese Science Bull., **43**(3): 230—232。
- Conwentz H, 1886. Die Flora des Bernsteins. Band 2, Die Angiospermen des Bernsteins; Danzig, Wilhelm Engelman, 1405, 13 taf.
- Crane P R, 1987. Vegetational consequences of the angiosperm diversification. In: Friis, E. M., et al., (ed.): The origin of angiosperms and their biological consequences. Cambridge: Cambridge Univ. Press. 107—144。
- Crane P R, Upchurch G R, 1987. *Drewia potomacensis* gen. et sp. nov., an Early Cretaceous member of Gnetales from the Potomac Group of Virginia. Amer. Jour. Bot., **74** (11): 1722—1736。
- Crane P R, 1996. The history of the Gnetales. Intel. Jour. Plant Sci., **157**(6 Suppl.): 550—557。
- Cronquist A, 1981. An integrated system of classification of flowering plants. New York: Columbia Univ. Press, 1262pp.
- Ettingshausen C, 1890. Die fossile Flora von Schoenegg bei Wies in Steiermark. Kgl. Akad. Wiss. Wien Denkschr., **57**: 61—112, pls. 1—4。
- Jongmans W J, Dijkstra S J, 1973. Fossilium Catalogus. Pars **82**, Uitgeverij Dr. W. Junk. N. V. S-Gravenhage. 307—422。
- Foster A S, Gifford E M Jr, 1974. Comparative morphology of vascular plants. (李正理等译, 1983. 维管植物比较形态学, 北京: 科学出版社. 1—647。
- Goeppert H R, 1853. Über die Bernsteinflora. Monatsh. K. Akad., p. 450—477. Schlesischen Gesell. Vaterl. Kultur Jahresber. **31**, 1834, 46—62。

- Haywood V H. 1978. Flowering plants of the world. London: Oxford Univ. Press. 335pp.
- Heer W. 1876. Beiträge zur Jura-Flora Ostsibiriens und des Amulan- des. Amen. Acad. Imp. Sci. St. Petersburg, ser., 7, **22**(12): 1—122, 31pls.
- Kirchner M. 1992. Untersuchungen an einigen Gymnospermen der Fränkischen Rhät-Lias-Grenzsichten. Palaeontographica, Abt. B **224**: 17—61.
- Krassilov V A, Dicher D L, Douglas J D. 1998. New ephedroid plant from the Lower Cretaceous Koonwarra fossil bed, Victoria, Australia. Alcheringa, **22**(2): 123—133.
- LaMotte R S. 1952. Catalogue of the Cenozoic plants of North America through 1950. Geol. Soc. Amer. Memoir 51: 1—381.
- Miki S. 1964. Mesozoic flora of *Lycoptera* beds in South Manchuria. Bull. Mukogawa Women's Univ., **12**: 13—22, pls. 1—3 (in Japanese with English description).
- Ouyang Shu, Norris G V. 1988. Spores and Pollen from the lowers Triassic Heshanggou Formation, Shanxi Province, North China. Rev. Palaeobot. Palynol., **54**: 187—231.
- Rendle A B. 1953. The classification of flowering plants. vol. I, Cambridge Univ. Press. (钟补求译, 1958. 有花植物分类学, 第一册, 北京: 科学出版社. 1—377.)
- Saporta L. 1891. Paléontologie française ou description des fossiles de la France. Tom. 4. Paris: Librairie de L'académie de Médecine. 547pp. pls. 229—300.
- Seward A C. 1919. fossil plants. Vol. 4, Cambridge: Cambridge Univ. Press. 453pp.
- Van Konijnenburg-van Cittert JHA. 1992. An enigmatic Liassic microsporophyll, yielding *Ephedripites* pollen. Rev. Palaeobot. Palynol., **71**: 239—254.
- Velenovsky J, Viniklár L. 1926. flora cretacea bohemiae. Czechoslovakia Statniho Geol. Ustav. Rozpravy, pt. 1, 54pp. 7pls.
- Yabe H, Endo S. 1935. *Potamogeton* remains from the Lower Cretaceous? *Lycoptera* Bed of Jehol. Proc. Jap. Acad. Tokyo, **11**(7): 274—276.
- Zhou Zhiyan. 1995. Jurassic floras. In: Li Xingxue (Ed.). fossil floras of China through the geological ages. Guangzhou: Guangdong Science and Technology Press. 343—399.

EPHEDRITES FROM LATEST JURASSIC YIXIAN FORMATION IN WESTERN LIAONING, NORTHEAST CHINA

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Key words: *Ephedrites*, Chlamydospermopsida, Gymnosperm, Latest Jurassic, Yixian Formation, Western Liaoning

Over half of a century ago, some fossil plants in bad preservation discovered from the Lower Cretaceous? *Lycoptera* Bed in Lingyan County of Jehol (now Western Liaoning) was identified as *Potamogeton jeholensis* Yabe et Endo and *Potamogeton* sp. (Yabe and Endo, 1935, p. 274—276) belonging to family Potamogetonaceae of monocotyledon of angiospermae. This report had not attracted attention from palaeobotanists.

In recent years, a great number of fossil plants have been found from the Latest Jurassic Yixian Formation in Yixian county of Liaoning Province, Northeast China. Among them, some of specimens were identified as monocotyledons of angiosperm by Cao Zhengyao, Wu Shunqing and others (1997, 1998). These “monocotyledons” fossils were separately named two new genera *Liaoxia* of Cyperaceae and *Eragrosites* of Gramineae (Poaceae) (Cao Zhengyao, Wu Shunqing and others, 1997, 1998). However many characters of these so-called mono-

cotyledonous fossils are actually close to the living *Ephedra* of gymnospermae rather than monocotyledonous plants of angiospermae. Their morphological characters of stems, branches, leaves and infructescences are much different from both families Cyperaceae and Gramineae.

Ephedraceae belongs to Chlamydospermopsida (Gnetopsida or Gnetales) which is composed of three families, the other two families being Welwitschiaceae and Gnetaceae. Each family contains only one genus. This class is the most advanced group in gymnospermae. The fossil plants of this class are rare. So far as we know there are about 16 fossil species of Ephedraceae. Fossil of Welwitschiaceae has not been known yet. Only one fossil species of Gnetaceae has been discovered in the passed years (Jongmans und Dijkstra, 1974). Recently, a new fossil genus *Drewria* with reticulate veins was attributed to Gnetaceae. It was discovered from the Early Cretaceous Potomac Group in Virginia of the United States

(Crane and Upchurch, 1987). The Gnetaceae leaves with reticulate veins are corresponding to those of dicotyledons. Both of them are hardly to distinguish in their foliar physiognomy from each other.

The living ephedraceans are represented by woody shrubs, subshrubs, vines and occasionally herbs. They are characterized by the following features: stem slender, cylindraceous, upright and prostrate; nodes and internodes with longitudinal ridges; branches diverging from stem in pairs or whorled. Primary leaves subuliform or linear in seedling, later reduced to scale or membranous leaf, opposite or in whorl of 2 to 3 (4) with their bases combining together to form sheath at nodes, and triangularly toothed at apex, 1–3 parallel-veined. Flower normally dioecious, rarely monoecious or hermaphrodite, born on terminal of branches or axillary; male strobile solitary, some clustered, or 3–5 forming spiculate spike, 2–8 opposite or 2–8 whorled bracts (three bracts per wheel), rounded or obovate, one male flower per bract; male flower with pseudo-perianth in membrane; female strobile 2–8 opposite or 2–8 whorled bracts (three bracts per wheel); female flower only born at apical 1–3 bracts, female flower with an apical ora formed by cystic-coriaceous false perianth surrounding ovule; integument with elongate, erect or curve tube in its apex, Seed 1–3. Cotyledon two.

The extant genus *Ephedra* has over 40 species. It is widely distributed in arid and desert areas of Central and West Asia, South Europe, North Africa, southwestern part of North America, southern and western parts of Latin America. There are 12 living species and 4 varieties in China. With exception of valleys of the Yangtze and Zhujiang Rivers, they are widely distributed everywhere of China. However, they are mainly growing in droughty land, barren slopes, Gobi and desert of northwestern and southwestern parts of China (Zheng and Fu, 1978; Zheng, 1983; Huo, 1982).

Class Chlamydospermopsida (Gentopsida)

Order Ephedrales

Family Ephedraceae

Genus *Ephedrites* Saporta, 1891, non Goeppert et Berendt, 1845

Diagnosis: Rami remulique plerumque distracti striati articulati; nukulæ binæ geminatim appositæ,

facie commissuralli plana adpresse convenientes, basi extrema cohaerentes, bracteis primum stipatæ; nukulæ bracteaque post anthesim ab alterutra liberæ, deciduæque.

Discussion: The above diagnosis of *Ephedrites* was given as a new definition by Saporta (1891). The original diagnosis of *Ephedrites* established by Goeppert et Berendt (1845 see Berendt, 1845) was based on the Miocene plants from northern Germany. Later, the specimens of the type species *Ephedrites johannianus* Goeppert et Berendt were separately transferred to the living *Ephedra* and *Patzia* of Loranthaceae of angiospermae (Conwentz, 1886). The genus *Ephedrites* becomes an empty name (nomen nudum). However, the fossil plants more or less similar to the living *Ephedra* have still been attributed to *Ephedrites* by many palaeobotanists since then (Ettingshausen, 1890; Saporta, 1891; Seward, 1919; Wu et al., 1986; Li et al., 1988; Zhou, 1995), especially after Saporta (1891, p. 22) given a new definition and supplemented new characters of *Ephedrites*. He has redescribed and discussed the Jurassic species *E. antiquus* Heer from eastern Siberia in detail at the same time. The generic name *Ephedrites* used in the present article is in Saporta's sense with the well-preserved *E. antiquus* Heer as the type species. Saporta (1891, p. 26) also established a new species *Ephedrites armaillensis* based on some specimens collected from Jurassic in France.

Ephedrites chenii (Cao et Wu) Guo et Wu X. W. comb. nov.

(Pl. I, figs. 1–7; Pl. II, figs. 1–8)

1997 *Liaoxia chenii* Cao et Wu, p. 1764–1765, pl. I, figs. 1, 2, 2a–2c.

1997 *Eragrostes changii* Cao et Wu, p. 1765, pl. II, figs. 1–3, 1a, 2a–2c; text-fig. 1.

1998 *Liaoxia chenii* Cao et Wu, p. 231, pl. I, figs. 1, 2, 2a–c.

1998 *Eragrostes changii* Cao et Wu, p. 231–232, pl. II, figs. 1–3, 1a, 2a–2c; text-fig. 1.

Emended diagnosis: Stem cluster, upright or slightly curved, 3–15 cm long, with nodes and internodes; nodes a little expanded, 1.5–6.5 mm wide; internodes 10–35 mm long, 1–5 mm wide, with longitudinal ridges and grooves; stem and branches straight or a little curved; lateral branches diverging from stem nodes at angles of 30° to 60°, opposite-decussate. Leaves diverging from base of node, linear, opposite in pair, 15–30 mm long and 1

mm wide. Female strobile elliptical, obovate and subrotund, 4—7 mm long and 2—4 mm wide, borne at terminals or near apices of branches; female flower with 4—8 decussate bracts; bracts ovate to narrow-ovate, acute at apex, 2—5 mm long, 1—2 mm wide; seed? elliptical, 2.5 mm long, 1 mm wide.

Discussion: In total, 8 specimens may be attributed to the present species. Among them, one specimen (PBJ³¹) is collected by Oriental Collections of Fossil and Craft in our Institute. Other 7 specimens were studied by Cao and Wu, S. Q. *et al.*, (1997, 1998). Two (PB 17805, PB 17806) of 7 specimens were attributed to “monocotyledons” by Cao and Wu, S. Q. *et al.*, (1997, 1998). In fact, the two specimens should be referable to conifers and might be related to *Podozamites*. The other 5 specimens are generally identical with living *Ephedra* in the following characters: stem upright, stem and branches with distinct nodes and internodes, internodes with longitudinal ridges and grooves, and branches opposite in pair. However, one of the present fossils with a linear leaf (pl. I, figs. 1, 2) is somewhat different from those most living species of *Ephedra* with scale and membranous leaves combined in sheath at base. This linear leaf might reflect a primitive characteristic of *Ephedra*. The Early Jurassic ephedralean fossils, described as *Piroconites* (male reproductive organ), and *Bernettia* (female reproductive organ) are also believed to have paired *Desmiophyllum*-like leaves (Van Konijnenburg-van Cittert, 1992; Kirchner, 1992; Crane, 1996). Even so, such linear leaves are also found in some extant species of *Ephedra*, e.g. *Ephedra chilensis*, *E. foliata* and *E. fragilis* bearing linear leaves 30 mm long and 1—1.5 mm wide, and with 2—3 parallel veins (Seward, 1919; Foster and Gifford, 1974). In addition, such linear leaves are also present in the seedling of *Ephedra altissima* and *E. vulgaris* (Rendle, 1953). Therefore, the present fossil specimens are morphologically close to *Ephedra*. The strobiles attached at the top or near the top of branches in the present specimens are also similar to those of extant species of *Ephedra*. These characteristics can be seen in living *Ephedra regeliana* Florin growing in Xinjiang, Northwest China, Kazakhstan, Pakistan and India and *Ephedra monosperma* Gmel. ex Mey. growing in North and West China and Russia (Cheng and Fu, 1978; Cheng Wanchun (Ed. in Chief),

1983). There is only one doubtful seed discovered in the present specimens. Its apical-stretched tube of integument was not preserved.

There are about 11 fossil species of *Ephedra* of Ephedraceae so far as we have known. Usually, the fossil plants from Tertiary are quite similar to modern *Ephedra* and are attributed to *Ephedra* Tournef. ex Linn. 9 fossil species of *Ephedra* have been recorded from the Early Tertiary strata in the United States and Chile and from Tertiary in Germany, Italy, Switzerland and Australia. In addition, there are 2 undeterminable species (Jongmans und Dijkstra, 1974, p. 352—353).

The fossil plants found from Mesozoic, or even from Tertiary, which are hardly identical with *Ephedra* or in poor preservation were always attributed to the fossil genus *Ephedrites*. So far, there are 5 species of *Ephedrites* (Jongmans und Dijkstra, 1974). *Ephedrites antiquus* Heer (1876) is represented by some branches and strobiles in good preservation discovered from the Jurassic strata of Siberia, Russia. *E. armaillensis* Saporta is composed of fossil strobiles collected from the Jurassic strata in France (Saporta, 1891; Seward, 1919; Jongmans und Dijkstra, 1974). *E. sotzkianus* Unger is a widespread species discovered from Tertiary strata of France, Australia, Italy, Switzerland and Rumania of Europe (Jongmans und Dijkstra, 1974). In China there are two species, *Ephedrites sinensis* Wu, He et Mai and *E. exhibens* Wu, He et Mai (1986) collected from the Lower Jurassic Xiaomeigou Formation, Qinghai, West China. We have no opportunity to examine all species of *Ephedrites* identified formerly and check whether they are entirely correctly identified or not. Anyhow, the present specimens are most close to modern *Ephedra* in their characters of stems and strobiles. They can be undoubtedly and affirmatively attributed to *Ephedrites* of Gymnospermae instead of monocotyledons of angiospermae. As stated above, we proposed to use the name *Ephedrites* in Saporta's (1891) sense and not in the original sense of Goepfert and Benerendt (1845). Else M. Friis (personal communication) suggests to give a new genus name for such fossils. No matter what name should be used for them, the resemblance between the present specimens and living *Ephedra* is definitive.

Cao and Wu, S. Q. *et al.*, wrongly compared the present specimens with Cyperaceae of mono-

cotyledon and assigned some specimens (in pl. 1, figs. 1—4) to a new genus and species *Liaoxia chenii* Cao et Wu (1997, p. 1764—1765; 1998, p. 231, pl. I, figs. 1, 2 2a—c) of Cyperaceae. However, these specimens are not similar to Cyperaceae at all, whose stem is solid, thriquetrous, without nodes and internodes. The family Cyperaceae consists of 4 000 living species belonging to 70—90 genera (Haywood, 1978; Cronquist, 1981). There are 31 surviving genera and 670 species in China (How *et al.*, 1982). Over 10 fossil genera of this family have been recorded. They first appeared in Palaeocene (LaMotte, 1952). One common genus of this family is a form genus *Cyperacites* (*Cyperites*).

The other specimens (in pl. I, figs. 5—7; pl. II, figs. 3—8) were attributed to another one new genus and species *Eragrosites changii* Cao et Wu (1997, p. 1765; 1998, p. 231—232; pl. II, figs. 1—3, 1a, 2a—c; text figure 1) of Gramineae (Poaceae). The specimens have a little analogy to Gramineae just for their stem with nodes and internodes, but in other characters, they are all different from Gramineae. The stems of Gramineae are always hollow. The lateral branches of Gramineae are asymmetrical, always with twigs of unequal length, and not opposite. The leaves are mainly lanceolate, alternate and distichous with sheath and ligule. The flowers are with 2—3 not opposite bracts. These main characters of Gramineae are not seen in the present specimens. So these fossil specimens should not be attributed to Gramineae. Gramineae (Poaceae) is one of largest family in monocotyledons consisting of 500—660 living genera and 8 000—10 000 species (Haywood, 1978; Cronquist, 1981; How and others, 1982). Over 20 fossil genera of this family have been recorded. According to Cronquist (1981), the earliest fossil record of Gramineae was found from Senonian stage of Late Cretaceous. Since Eocene on this family gradually became flourished.

In addition, some fossil specimens (in pl. I, figs. 8—10) were assigned to monocotyledonous leaves by Cao and Wu (1997, p. 1765; 1998, p. 232, pl. I, figs. 3, 4, 4a). In fact, they are of conifer and might belong to *Podozamites*.

Duan Shuying (1998) has also got a specimen from the same formation and same locality. She also considered it to be an oldest angiosperm in the world and gave a new genus and species *Chaoyangia liangii*

Duan for it. Her specimen might also be not related to angiosperm. It may be a taxon of Chlamydospermopsida (Gnetopsida).

A new ephedroid plant species, *Leongathia elegans* discovered recently from the lower Aptian Koonwarra fossil Bed in Victoria of Australia was studied by Krassilov, Dilcher and Douglas (1998). The Australian species is characterized by slender shoots, longitudinally ribbed stems, linear leaves, four-leaved, occasionally two-three leaved, whorled arrangement on nodes, with reduced sheaths. These characters are superficially similar to the present fossil specimens, but they are much different from the present specimens in the strobiles.

Miki (1964, p. 13—22) has also described a new genus and species *Amphiephedra rhamnoides* based on a specimen found from the *Lecoptera* Bed in South Manchuria (Northeast China). The *Lecoptera* Bed is actually the same stratum of the present fossil plants. Miki considered that his fossil plant bears a resemblance to *Ephedra*. However, *Amphiephedra rhamnoides* is too bad in preservation without enough good characters of stems, leaves and strobiles to erect a new genus and species.

Yabe and Endo (1935, p. 274—276, pl. 1) have ever described two species, *Potamogeton jeholensis* Yabe et Endo and *Potamogeton*? sp. collected from the Lower Cretaceous? *Lycoptera* Bed in Lingyuan county of Jehol (now Liaoning), Northeast China. Both species may be collected from the same strata and same locality of the present specimens. They are little bit similar to the present specimens. They are perhaps relevant to *Ephedrites*, but they were transferred to *Ranunculus jeholensis* (Yabe et Endo) by Miki (1964, p. 19).

Velanovsky and Viniklar (1926) created a new genus and species *Ephedropsis strobilifera* based on fossil plants from Cretaceous strata in Czech, but this species has been attributed to Taxodiaceae (Andrews, 1970).

Piroconites kuespertii Gothan found from the lower Jurassic of Germany is a ephedroid plant. Its bracts are 9—15 cm long and 4—5 cm wide. The bracts show numerous parallel, unforked veins (12—15 per cm). Its microsporophylls show a concave, crescent-shaped base. Its strobolaceous scales are 3.5—5.5 cm in length and 2.0—3.5 cm in width (Van Konijnenburg van Cittert, 1992; Kirchner, 1992).

these characters are very different from the present specimens.

Crane (1987, 1996) has indicated that *Ephedra*-like pollen fossils first became common during the Triassic and are widely distributed in Northern Hemisphere, and has been recorded from the Lower Triassic in North China (Ouyang and Norris, 1988). During the Jurassic, *Ephedra*-like pollen fossils are less common. However, the pollen record still extended into Cretaceous. During the Mid-Cretaceous, ephedroid pollen became more abundant in lower latitude areas. Recently, Chinese palynologists Li Wenben, Shang Yuke and Liu Zhaosheng told us that fossil *Ephedra*-like pollen have been found from the Jurassic Yixian Formation in Liaoning and from the Jurassic strata in other areas of China.

* * * * *

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图版说明 (Plate Explanation)

所有标本均保存在中国科学院南京地质古生物研究所。除注明放大倍数外, 图片均代表标本的原大 (All specimens are stored in the collection house of Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences. With the exception of the enlarged photographs, other specimens are natural size)。

图版 I (Plate I)

- 1—7. 陈氏似麻黄 *Ephedrites chenii* (Cao et Wu) Guo et Wu X. W.
 - 1. 标本原大 (Natural size)。登记号: PB 17800, Holotype。
 - 2. 系图 1 放大, $\times 3$, 示图 1 下部茎节上的线形叶 (Enlarged from figure 1, $\times 3$, showing the linear leaf on the lower part of specimen)。
 - 3. 系图 1 放大, $\times 3$ 示枝中部茎节, 节间和球花序 (Enlarged from figure 1, $\times 3$, showing the middle part of branches, nodes, internodes and strobiles)。
 - 4. 系图 1 放大, $\times 2$, 示枝顶球花序 (Enlarged from figure 1, $\times 2$, showing the strobiles of apical branches)。
 - 5. 标本原大 (Natural size)。正面。登记号: PB17802。
 - 6. 系图 5 放大, $\times 2$, 示枝和球花序 (Enlarged from figure 5, $\times 2$, showing the branches and strobiles)。
 - 7. 系图版 II, 图 6 中间标本放大, $\times 2$ (Enlarged from plate II figure 6 in the middle part of specimen, $\times 2$)。
- 8—10. 苏铁杉? (未定种) (*Podozamites?* sp.)
 - 8. 标本原大 (Natural size)。正面。登记号: PB 117805。
 - 9. 系图 8 放大, $\times 3$, 示枝叶 (Enlarged from figure 8, $\times 3$, showing branches and leaves)。
 - 10. 系图 8 标本原大, 反面 (The counterpart of figure 8, natural size)。登记号: PB 17806。

图版 II (Plate II)

- 1—8. 陈氏似麻黄 *Ephedrites chenii* (Cao et Wu) Guo et Wu X. W.
 - 1. 标本原大 (PB J31) (Natural size)。登记号: PB J31。
 - 2. 系图 1 放大, $\times 2$, 示茎枝, 节和节间 (Enlarged from figure 1, $\times 2$, showing branches, nodes and internodes)。
 - 3. 标本原大 (Natural size)。登记号: PB 17801。
 - 4. 系图 3 放大, $\times 3$, 示枝和球花序 (Enlarged from figure 3, $\times 3$, showing branches and strobiles)。
 - 5. 标本原大 (Natural size)。登记号: PB 17802。
 - 6. 标本原大 (Natural size)。登记号: PB 17804。
 - 7. 标本原大, 右侧 (Natural size, right part)。登记号: PB 17803。
 - 8. 标本原大, 左侧 (Natural size, left part)。登记号: PB 17803。





Chaoboridae. Its strange wing venation should be wrong drawn. Both the two, Paratendipedidae and Sinotendipedidae, are based on short-horned flies rather than representatives of Chironomoidea. Zhang and other (1993) indicated that Protabanidae is erected based on a cicada, not a short-horned fly. It should be pointed out that there have still been numerous so-called new families and new genera established based on this sort of “standard” in Hong’s papers and books besides these taxa mentioned above. This author will give comments regarding them in other articles.

The genus *Sunaphis* Hong *et* Wang, 1990 from the Laiyang Formation in Laiyang of Shandong province, China has been placed in the extant family Aphididae. Owing to possessing a close similarity in the main characteristics, especially in the pattern of antenna (secondary rhinaria ranging irregularly) to those of Sinaphididae, it can now be transferred to Sinaphididae.

They have been thrown into self-contradictory over the descriptions and text-figures about the *Petiolaphis* Hong *et* Wang, 1990 and the *Petiophioides* Hong *et* Wang, 1990 from the same locality like *Sunaphis*. This author has failed to identify what the basic character actually is. For example, in description, *Petiophis* possesses the antennal secondary rhinaria ranging irregularly; but in text-figure, it appears to be annular. Both genera do not belong to the extant family Hormaphididae. Nevertheless, until further investigations of the specimens are possible, they are of uncertain at familial status.

The species *Expansaphis laticosta* Hong *et* Wang, 1990 was also derived from the identical location and strata (Laiyang Formation) and placed in the genus *Expansaphis* Hong *et* Wang, 1990 within Oviparosiphidae. There has been some confusion concerning its description and text-figure. For instance, in the former the antennal secondary rhinaria are of transverse arrangement, but in the latter ranging irregularly. It is difficult to see from the illustration how it might be related to the extinct family Oviparosiphidae, let alone the genus *Expansaphis*. Its taxonomic position is uncertain not only at generic but at familial levels before a reexamination of the type specimen can be made.

Lin (1980) described a new genus *Penaphis* Lin, 1980 from the Shouchang Formation in Zhejiang province, China, which he considered to be a member of the extant family Aphididae. Jarzembowski (1989) regarded Oviparosiphidae as a junior synonym of Callaphididae, and *Penaphis* could be transferred to Callaphididae. Lin (1995) chimed in with Jarzembowski’s (1989) opi-

nion. Hong (1998) agreed that *Penaphis* is a representative of Callaphididae. However, Zhang and others (1989) recognized the mistaken classification and placed it in the Oviparosiphidae. Ren (1995) placed *Penaphis* also into this extinct family. Carpenter (1992), Ren (1995), An-sorge (1996), and Heie and Wegierek (1998) admitted the family Oviparosiphidae being well founded, respectively. The present writer believes that, with a great deal of primeval characteristics, Oviparosiphidae is easily distinguished from Callaphididae: 7-segmented antenna with annular, secondary rhinaria not only on the 3rd but also on the following segments, in fore wing Rs straight and long arising from middle of pterostigma and ending near wing top, M arising from base of Pt, both CuA₁ and CuA₂ originating independently from a common stem Sc + R + M but for a rather short distance each other, ovipositor large whereas cauda and caudal plate absent or poorly developed. Meanwhile, *Penaphis* bears close resemblance in forewing venation to those of Oviparosiphidae: the straight and long Rs, arising from middle of Pt, M arising from base of Pt, both CuA₁ and CuA₂ arising from almost same point on Sc + R + M; and then it may be placed in Oviparosiphidae (see Text-figures 1, 2).

Heie (1985) listed 26 plesiomorphous characters for reconstruction of a primitive aphid. Here are provided some additional items which are most likely of primeval features: the last segment of antenna normal, not subdivided (processus terminalis wanting or poorly developed); the antennal secondary rhinaria usually same or similar in shape, size, and arrangement on the 3rd and the following segments; in forewing Pt laying near middle of wing; Rs elongated and straight, ending near wing top.

Lin (1995) and Hong (1998) respectively regarded the Yixian Formation in Liaoning province to be Upper Jurassic—Lower Cretaceous, and the Laiyang Formation in Shandong province to be Lower Cretaceous and younger than the former. But they did not provide any direct evidence of stratigraphical dating. Recently, an important and famous fossil bird, the *Confuciusornis santus* Hou *et al.*, has been discovered from the above-mentioned strata (Hou, 1997); thus both should be the same in geological age. In addition, a geographically widespread species of fossil dragonfly, *Aeschnidum heishankowense* (Hong), has already been recognized by the present author (Zhang, in press), which exists simultaneously in the two strata. It is related to the *Aeschnidum densum* Hagen from the Lower Tithonian of Solhofen, Germany, and thus the Yixian and Laiyang formations can be regarded as the Middle-Upper Tithonian deposits.