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云南临沧晚中新世邦卖组植物群*

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提要　云南临沧中寨晚中新世邦卖组植物群总计 37 科 59 属 71 种 (含 37 新种)。其中, 蕨类植物仅有 1 科 1 属 1 种(新种); 裸子植物有 2 科 2 属 2 种; 被子植物有 34 科 55 属 67 种[其中双子叶植物 32 科 53 属 65 种(含 35 新种)和单子叶植物 2 科 2 属 2 种]; 另有分类位置不明的果实 1 属 1 种(新种)。这个植物群属于常绿和落叶阔叶混交林植被, 它反映稍湿润亚热带气候。化石植物群的特征显示当时青藏高原抬升的高度已经能够阻止印度洋暖湿大气环流的北进, 南亚和东南亚一带季风气候已经形成, 当时明显的季节性干湿更迭现象已经存在。邦卖组植物化石层的地质年代属于晚中新世, 约晚于 11.6 Ma。

关键词　古植物群　晚中新世　季风气候　古生态　云南临沧　中国西南

1　引　言

中国新生代含植物化石地层遍及全国各地, 但地层发育齐全, 出露良好的地区主要分布在我国的东北和西南地区。西北地区新生代地层沉积不够连续, 常有缺失, 又被大面积巨厚黄土层覆盖; 而东部和东南地区新生代地层常被大面积的第四纪沉积掩埋, 地层层序出露不全, 无法寻找连续的各纪地层剖面。西南地区特别是横断山脉地区曾经遭受中生代印支和燕山及新生代喜马拉雅山三次重大构造运动, 形成了宽阔的南北走向的山脉, 其间形成星罗棋布、大小不等的新生代构造盆地, 新生代地层发育齐全, 地层剖面出露较好, 富含植物化石。这些盆地蕴藏着丰富的矿产资源, 特别是煤炭资源非常丰富, 分布广泛。在星散分布的山间盆地中, 尤其是在含煤盆地地层中保存有丰富完美的植物化石, 因此, 西南地区成为我国新生代植物化石研究的良好地区。

本文研究的植物化石采自云南临沧中寨晚中新世邦卖组, 旨在研究邦卖组植物群的区系成分、植物属的分布区类型、植被类型以及它们的生态环境, 并与中国同时代的其他植物群进行对比, 推测和重建古植物群面貌、植被类型、古地理和古环境的变迁。本文是横断山区新近纪植物群研究的组成部分。

2　材料和方法

植物化石采自云南西部临沧市辖地区临沧县中寨镇邦卖村(23°54′ N, 100°01′ E, 平均海拔 1 979 m, 见插图 1), 化石产于上中新统邦卖组第五层上部的浅灰色粉砂岩及浅黄褐色粉砂质含硅藻的泥岩中。根据云南省煤田地质队的临沧冷背箐煤矿柱状图资料(冷背箐和邦卖两地相距很近, 同属一个盆地), 其地层层序自下而上分别描述如下:

上覆地层　第四系, 土黄色腐植土, 砂壤土, 碎石等。

邦卖组

5. 薄层及厚层状泥岩和粉砂质泥岩互层, 夹少量薄层细砂岩及粗砂岩, 及浅黄褐色粉砂质含硅藻泥岩, 富含植物化石。　0—60 m
4. 下部灰白色厚层石英粗砂岩, 砂砾岩, 夹少量薄层细砂岩, 粉砂岩; 上部为煤层。　30—50 m
3. 泥质砂岩, 夹砾岩透镜体, 渐变为砂砾岩, 砂岩, 灰白色粉砂岩和粉红色杂岩。　20—60 m
2. 灰白色厚层状石英粗砂岩, 夹少量灰色、浅灰色

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细砂岩, 粉砂岩和砂质泥岩。 20—80 m

1. 浅黄灰色薄层粉砂岩及细砂岩, 岩石中含有石英、长石和较多的白云母。 10—20 m

下伏地层 灰白色砂砾岩, 夹浅黄色薄层细—粗砾砂岩, 砾石成分以石英角斑岩块为主, 胶结松散, 无层理。 20—60 m

这次采集的植物化石有 500 余件, 全是叶片印痕化石, 不能做叶表皮构造和气孔器的观察和鉴定, 大多数叶化石的叶脉保存比较清晰, 也有少数化石的叶脉保存不佳。此外, 还有个别植物果实化石发现, 但保存较差, 不易鉴定其分类位置。这个地区的植物化石曾经报道和研究过(陶君容、陈明洪, 1983; 陶君容等, 2000)。云南临沧中寨邦卖组含植物化石层的地质年代属于晚中新世, 约晚于 11.6 Ma (戈宏儒、李代芸, 1999; 李余华, 2000; Hu *et al*., 2009; Jacques *et al*., 2011)。

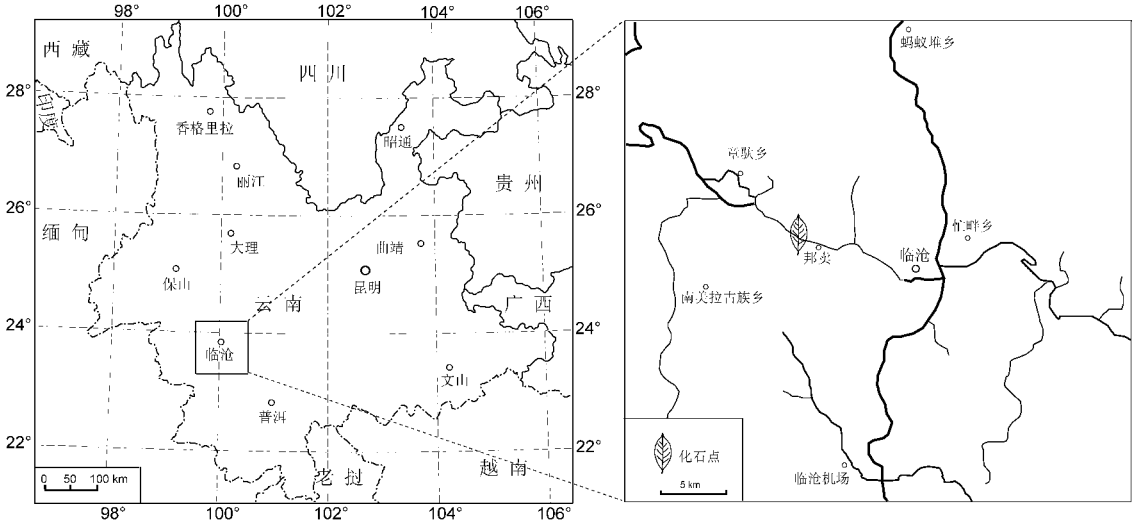

插图 1 云南临沧晚中新世邦卖组植物群植物化石产地示意图

The sketch map showing the fossil locality of late Miocene Bangmai Flora in Lincang of Yunnan, southwestern China

3 古植物群区系分析、植被类型及其古环境

3.1 古植物群成分及其生活型

邦卖组植物群包含 37 科 59 属 71 种, 其中蕨类植物有 1 科 1 属 1 新种, 即槐叶萍科 *Salvinia paralleloneura* sp. nov.; 裸子植物有 2 科 2 属 2 种, 即杉科 *Glyptostrobus europaeus* (Brongn.) Heer 和柏科 *Calocedrus lantenoisi* (Laurent) Tao。被子植物有 34 科 55 属 67 种, 其中双子叶植物 32 科 53 属 65 种(含 35 新种), 即五味子科 *Schisandra splendinervosa* sp. nov., 樟科 *Cinnamomum scheuchzeri* Heer, *C. versutifolium* sp. nov., *C. naitoanum* Huzioka and Takahashi, *Litsea grabaui* Hu and Chaney, *Neocinnamomum fuscatifolium* sp. nov., 胡椒科 *Piper lincangense* sp. nov., 山柑科(白花菜科) *Capparis lincangensis* sp. nov., 千屈菜科 *Trapa* sp., 番杏科 *Tetragonia ovatifolia* sp. nov., 海桐花科 *Pittosporum lincangense* sp. nov., 山茶科 *Ternstroemia maekawai* Matsuo, 桃金娘科 *Syzygium lincangense* sp. nov., *S. poecilophyllum* sp. nov., 使君子科 *Lumnitzera pseudoracemosa* sp. nov., *Terminalia lincangensis* sp. nov., 锦葵科 *Helicteres callineura* sp. nov., *Reevesia* sp., 绣球科 *Hydrangea lanceolimba* Hu and Chaney, 蔷薇科 *Photinia* sp., *Sorbus* sp., *Stranvaesia cosmophylla* sp. nov., 含羞草科 *Albizia scalpelliformis* sp. nov., 云实科 *Gleditsia miosinensis* Hu and Chaney, 蝶形花科 *Dalbergia sigillata* sp. nov., *Desmodium praegyroides* sp. nov., *Maackia* sp., *Millettia* sp., *Mucuna leiophylla* sp. nov., *Ormosia* sp., *Shuteria* sp., *Sophora miojaponica* Hu and Chaney, 杨柳科 *Populus glandulifera* Heer, 桦木科 *Betula mioluminifera* Hu and Chaney, 壳斗科 *Castanopsis gemmifolia* sp. nov., *C. brevijucunda* sp. nov., *Cyclobalanopsis mandraliscae* (Gaudin) Tanai, *C. paraschottkyana* (Wang and Liu) comb. nov., *Lithocarpus flexicostatus* sp. nov., *L. ravidifolius* sp. nov.,

L. renifolius Tao, *Lithocarpus* sp., *Quercus latifolia* Li, *Q. mutilatifolia* sp. nov., *Q. simulata* Knowlton, *Quercus* sp., 大麻科 *Celtis miobungeana* Hu and Chaney, 桑科 *Ficus proreligiosa* sp. nov., 冬青科 *Ilex ornatinervosa* sp. nov., 铁青树科 *Schoepfia elegantifolia* sp. nov., 桑寄生科 *Loranthus palaeoeuropaeus* Kutuzk., 鼠李科 *Berchemia calymmatophylla* sp. nov., 芸香科 *Murraya* sp., *Zanthoxylum refractifolium* sp. nov., 楝科 *Aphanamixis* sp., *Toona bienensis* (Hu and Chaney) Tao, 漆树科 *Pistacia miochinensis* Hu and Chaney, *Rhus mortinerva* sp. nov., *Toxicodendron miosuccedaneum* (Hu and Chaney) comb. nov., *T. inaequilaterum* sp. nov., 胡桃科 *Engelhardia sclerophylla* sp. nov., 山榄科 *Sinosideroxylon lincangense* sp. nov., *Chrysophyllum sinicum* sp. nov., 安息香科 *Styrax pulchellus* sp. nov., 五福花科 *Viburnum validum* sp. nov., 而单子叶植物仅有 2 科 2 属 2 种, 即拔葜科 *Smilax grandifolia* (Ung.) Heer, 莎草科 *Cyperacites* sp.。另有分类位置不明的 *Carpolithes orbitopterus* sp. nov.。植物群中双子叶植物的系统排序按 APG III 排列(The Angiosperm Phylogeny Group, 2009)。依古植物学惯例, 单子叶植物仍放在双子叶植物之后。

植物群中被子植物的标本共有 151 件, 按每个科的属种及其包含标本的数量多少排序, 壳斗科包含的属种和标本数量最多, 有 4 属 13 种标本 40 件, 依次是蝶形花科 8 属 8 种 15 件, 樟科 3 属 5 种 14 件, 桃金娘科 1 属 2 种 16 件, 此 4 科的标本合计 85 件, 占总数的 56.3%; 其余各科 1—3 件。综合起来, 邦卖组植物群中壳斗科的属种和标本数量都占绝对优势, 桃金娘科虽仅有 1 属 2 种, 但其标本数量仅次于壳斗科位列第二, 蝶形花科的属种数量仅次于壳斗科, 但标本数量却次于桃金娘科, 占据第三; 樟科排列第四。各科属种数量的多少表明该科植物生物多样性的丰度, 而各科标本数量的多寡反映该科植物属种对生态环境适应能力的程度。这 4 科植物是反映当时古环境的代表植物。这个古植物群是以常绿壳斗科植物占优势的森林, 属于常绿、落叶阔叶混交林植被类型, 反映亚热带稍湿润的气候。

3.2　古植物群属的分布区类型

植物群中属于世界广泛分布的属仅有 *Sophora*; 泛热带分布的有 15 属: 即 *Piper*, *Capparis*, *Tetragonia*, *Ternstroemia*, *Helicteres*, *Albizia*, *Dalbergia*, *Millettia*, *Mucuna*, *Celtis*, *Ficus*, *Ilex*, *Zanthoxylum*, *Chrysophyllum* 和 *Smilax*; 热带亚洲和热带南美间断分布的有 5 属: 即 *Cinnamomum*, *Litsea*, *Ormosia*, *Schoepfia* 和 *Styrax*; 旧世界热带分布的有 3 属: *Lumnitzera*, *Syzygium* 和 *Pittosporum*; 热带亚洲和热带大洋洲分布的仅有 *Toona* 属; 热带亚洲(印度–马来西亚)分布的有 10 属: 即 *Calocedrus*, *Neocinnamomum*, *Reevesia*, *Stranvaesia*, *Shuteria*, *Cyclobalanopsis*, *Stranvaesia*, *Murraya*, *Aphanamixis* 和 *Engelhardia*; 北温带分布的有 7 属: 即 *Sorbus*, *Populus*, *Betula*, *Quercus*, *Rhus*, *Toxicodendron* 和 *Viburnum*; 东亚和北美间断分布的有 8 属: 即 *Schisandra*, *Hydrangea*, *Photinia*, *Gleditsia*, *Desmodium*, *Castanopsis*, *Lithocarpus* 和 *Berchemia*; 旧世界温带分布的有两属 *Trapa* 和 *Loranthus*; 地中海、西亚至中亚分布的属只有 *Pistacia*; 东亚分布的仅有 *Maackia* 属; 中国特有分布的属是 *Glyptostrobus* (吴征镒, 1991, 1993; 吴征镒等, 2006)。可见, 邦卖组植物群属的分布区类型是多样的, 成份是复杂的, 其中热带分布的属有 33 属, 占 56.9%。按属的分布区类型来看, 邦卖组植物群的成分应该是热带或亚热带起源的, 或者是热带或亚热带的属占优势的群落类型。

3.3　古植物群的生态环境

邦卖组植物群的群落外貌类型繁多, 组成成分复杂, 生态环境多样。植物群中有一种水生蕨类植物 *Salvinia*, 两种裸子植物: *Glyptostrobus* 是沼生的半落叶乔木, *Calocedrus* 为中生的常绿乔木。被子植物中有乔木 27 种, 它们是构成群落上层的重要成分, 是群落的冠层; 这些乔木树种隶属于 *Cinnamomum*, *Neocinnamomum*, *Syzygium*, *Ormosia*, *Sophora*, *Populus*, *Betula*, *Castanopsis*, *Cyclobalanopsis*, *Lithocarpus*, *Quercus*, *Celtis*, *Ficus*, *Toona*, *Engelhardia* 和 *Styrax* 属。小乔木和灌木有 17 种, 它们是组成群落的中层成分, 分布在乔木层之间, 它们归属于 *Litsea*, *Ternstroemia*, *Lumnitzera*, *Terminalia*, *Photinia*, *Sorbus*, *Stranvaesia*, *Gleditsia*, *Murraya*, *Aphanamixis*, *Rhus* 和 *Sinosideroxylon* 属。灌木和小灌木有 12 种, 分布于乔木冠层之下, 小乔木和大灌木层之间,

形成群落的下层, 它们隶属于 *Capparis*, *Tetragonia*, *Pittosporum*, *Helicteres*, *Reevesia*, *Hydrangea*, *Maackia*, *Ilex*, *Loranthus* 和 *Viburnum* 属。木质藤本和攀援藤本植物有 7 种, 攀爬于少数灌木和小乔木的树干上或匍匐于地面, 它们分属于 *Schisandra*, *Piper*, *Dalbergia*, *Millettia*, *Berchemia*, *Zanthoxylum* 和 *Smilax* 属。陆生的草本植物有 2 种, 属于地被层, 生长在地面, 它们分属于 *Shuteria* 和 *Desmodium* 属。水生和沼生的草本植物各有 1 种, 它们生长在河湖岸边和沼泽湿地, 它们是 *Trapa* 和 *Cyperacites* 属的代表, 但有高大乔木水松与其伴生。根据上述邦卖组植物群落的属种组成、面貌和结构看, 该植物群以上层乔木树种占优势, 其间生长着小乔木、灌木、亚灌木和木质藤本植物处于中层, 疏密不等的陆生草本植物位于下层; 水生和沼生的草本植物则生长在缓流的河湖池沼中及其岸边, 它们与高大而稀疏的水松共生在一起。所以, 邦卖组植物群是属种成份和生态环境多样, 林木层片发育齐全的成熟群落。从植物化石与其相似现生种分布的海拔高度估计, 当时植物群中的乔木可能分布在海拔 1 000—1 500 m 以上的山地和山坡地带。

邦卖组植物群的木本植物主要生长于较高的山地和山坡上, 后被流水冲积到沉积盆地, 水生和沼生的草本植物则是原地埋藏于盆地之中的。从木质植物化石的叶片保存较为完整, 很少发现破碎的叶片来看, 这些植物化石叶片被搬运的距离不会太远, 否则, 即被水流冲碎, 所以, 总体上看, 植物化石属于原地埋藏。植物群的木本双子叶植物中, 常绿植物有 36 种, 占 57%, 落叶植物 27 种, 占 43%; 全缘叶植物 40 种, 约占 63.5%, 具齿缘叶植物 23 种, 约占 36.5%。这些植物的叶片以革质叶为主, 叶面积以小型和中型叶占绝对优势, 没有大型叶发现。这个植物群中只有榕属(*Ficus*)一种植物的叶片具有滴水叶尖, 这反映当时当地降水量虽然充足, 但并非丰沛, 尚未达到热带雨林的特征; 这可表示当时常年雨量可能分布不均, 显示出季节性干湿交替现象, 同时表明当时季风气候已经存在。因此, 当时邦卖组植物群的植物可能生长在中山地区, 低地是河湖沼泽, 植物的落叶随雨水涓流搬运到湖泊沼泽被埋藏保存成化石。

植物群中蒲桃属(*Syzygium*)化石虽然仅有 2 种, 但却拥有 16 件标本, 几乎占描述化石标本总数的 10%, 这两种蒲桃属植物的植株分布空间仅次于壳斗科, 它们是群落中的优势属种, 是群落生境的指示者, 气候环境的代表者, 也表明当时当地的生态环境最适宜此两种植物的生长, 它们的革质叶既可防止旱季强光的照射, 又能防止水分的过量蒸发, 同它们类似的现生种都分布在广东、广西、云南和越南地区。这些地区现在是属于南亚热带季风气候地带。现生蒲桃属植物约有 1 200 种, 几乎都是常绿的乔木和灌木, 广泛分布于非洲热带、亚洲热带至亚热带、澳大利亚、新加利东尼亚、新西兰和太平洋诸岛屿。其中, 从马来西亚到澳大利亚东北部都是该属植物种分布区的多样性中心地区。此属植物在中国有 80 种, 其中 45 种是特有种, 分布在长江以南各地, 常见于广西、广东和云南。依照邦卖组植物群的属种组成、群落结构、生活型、季相和叶相特征看, 晚中新世时邦卖组植物群的植物生长在不太湿润又不过分干旱的中生环境, 但由于革质叶的植物占优势, 表明当时阳光充足, 蒸发量偏高, 具有干旱气候特征。由此推测, 邦卖组植物群反映的年均温估计为 19—22℃, 年降水量约 1 800—2 300 mm。依据邦卖组植物群的化石成份定量恢复的古气候, 年均温是 18.5—24.7° C, 年降水量是 1 213—3 711 mm (Jacques *et al*., 2011)。现在临沧年平均温度是 16.8—17.7℃, 年降水量 864—1 789 mm, 因此, 晚中新世时临沧年平均气温和雨量都比现在高些。

3.4 同其他中新世植物群对比

山东临朐(36°32′ N, 118°40′ E, 海拔 450 m) 中中新世山旺组植物群(Hu and Chaney, 1940; 《中国新生代植物》编写组, 1978) 形成于 17—15.2 Ma 前, 当时的年均温为 12.5—15.2℃, 年降雨量为 1 107.3—1 880.0 mm (Sun *et al*., 2002; Yang *et al*., 2007), 它是中国典型的中中新世植物群的代表。该植物群包含有 43 科 87 属 125 种, 几乎全由被子植物组成, 其中桦木科有 5 属 12 种, 蔷薇科 9 属 9 种, 豆科 8 属 8 种, 榆科 4 属 8 种, 槭树科 1 属 8 种, 杨柳科 2 属 7 种。山旺组植物群的绝大多数属种由北温带落叶植物组成, 常绿植物可能只有 *Evodia*, *Ficus*, *Cinnamomum*, *Magnolia*, *Rhamnus* 等少量属种。山旺组植物群与邦卖组植物群共有的种仅 9 个, 它们均属温带种, 占邦卖组植物群种数 12.5%; 两植物群共同的属有 17 个, 即 *Cinnamomum*, *Litsea*, *Rosa*, *Hydrangea*, *Albizia*, *Gleditsia*, *Sophora*, *Populus*, *Betula*, *Quercus*, *Celtis*, *Ficus*, *Berchemia*, *Zanthoxylum*, *Toona*, *Pista-*

cia 和 *Rhus*。邦卖组植物群与山旺组植物群属的相似性指数为 21. 4%, 可见, 两个植物群之间有一些联系, 但并不太密切。其原因可能是两个植物群相距遥远, 山旺组植物群位于山东临朐临近东部沿海, 当地海拔仅有 405. 5 m。邦卖组植物群位于西部高原的云南临沧, 海拔近 2 000 m, 其中常绿植物的属种占 57%, 全缘叶植物的种类高达 67%, 而山旺组植物群中常绿植物和全缘叶植物则很少。山东临朐和云南临沧两个化石产地经纬度和海拔高度均有很大差异, 所以, 两个植物群的区系成分和重要属种的组成具有明显差别是很容易理解的。

云南开远小龙潭煤矿(23°48′45″N, 103°11′52″E, 海拔 1 050 m) 的晚中新世小龙潭组植物群位于临沧邦卖组植物群东南方向, 大约 340 km。经周浙昆研究(见陶君容等, 2000, 64—72 页; Jacques *et al*., 2011), 该植物群有 21 科 45 属 55 种, 其中蝶形花科 13 属 17 种, 樟科 6 属 9 种, 壳斗科 4 属 8 种, 其余各科仅 1—2 个属种。其标本数量依次是蝶形花科、樟科、壳斗科和木兰科占优势。属的分布区类型属于泛热带分布的有 10 属, 热带亚洲分布的有 6 属, 热带亚洲和大洋洲分布的有 5 属, 北温带分布的有 6 属, 东亚和北美间断分布的有 4 属, 温带亚洲分布的仅 1 属。从属的分布区类型看, 小龙潭组植物群中热带分布的共有 21 属, 而典型温带分布的仅有 11 属, 因此小龙潭组植物群中热带比温带分布区的属超过一倍; 其全缘叶的比例也高达 79%; 常绿的乔木和灌木有 30 种, 占总种数的 65%。这些特征都表明小龙潭组植物群具有的热带性质, 它是以蝶形花科为主、樟科和壳斗科为次的亚热带常绿、落叶阔叶混交林的植被类型。小龙潭组植物群与邦卖组植物群中共同的属有 18 个, 即 *Cinnamomum*, *Litsea*, *Machilus*, *Phoebe*, *Ficus*, *Castanopsis*, *Cyclobalanopsis*, *Lithocarpus*, *Quercus*, *Albizia*, *Dalbergia*, *Desmodium*, *Gleditsia*, *Ormosia*, *Sophora*, *Alangium*, *Berchemia* 和 *Smilax*。两个植物群属的相似性指数是 47. 3%, 远大于山旺组植物群。小龙潭组植物群中的优势科由蝶形花科、壳斗科、樟科和金缕梅科组成, 这与邦卖组植物群中的优势科由壳斗科、蝶形花科、桃金娘科、樟科和蔷薇科组成有更多的相似之处, 由此可见, 邦卖组植物群同小龙潭组植物群之间的关系远比与山旺组植物群之间的关系更为密切。但是, 邦卖组植物群同小龙潭组植物群之间在地理位置、地形地貌、海拔高度、地质年代等诸多方面也有差异, 因此, 两个植物群之间在属种的组成上仍然存在着差别。小龙潭组植物群的地质年代大约是 11—10 Ma (陶君容等, 2000), 比邦卖组植物群的地质年代晚些。小龙潭组植物群指示的古气候属于湿润的南亚热带气候。根据共存法、叶缘分析法和叶相多变量分析法得出的结果分别是16. 7—19. 2℃, 22. 3±2. 05℃, 18. 1±1. 2℃, 而开远小龙潭的现代气候年平均气温是 19. 7℃。这三种方法得出的古气候温度接近于现代的气候温度(Xia *et al*., 2009)。由此得知, 当时的气候同现在气候很接近。

近来, 对采自西藏南木林(29°42′N, 89°35′E; 海拔4 600 m) 中中新世 15 Ma(Spicer *et al*., 2003) 乌龙组的植物化石进行鉴定, 它们全由被子植物叶化石组成, 其中双子叶植物为 *Acer*, *Alnus*, *Betula*, *Carpinus*, *Corylus*, *Quercus*, *Crataegus*, *Leguminosites*, *Populus*, *Rhododendron*, *Rhamnus*, *Ribes*, *Rosa*, *Salix*, *Schisandra*, *Ulmus*, *Vitis*, 单子叶植物是 *Typha*, 共计 18 属。乌龙组植物群与邦卖组植物群没有共同的种, 只有 4 个共同的属, 即 *Betula*, *Quercus*, *Populus* 和 *Schisandra*。该植物群中的植物化石 *Betula* 和 *Carpinus* 的标本数量最多, *Alnus* 和 *Corylus* 的数量其次。这个植物群中的属种都是典型的北温带植物, 可能没有典型的常绿植物, 如果有, 可能只是杜鹃属(*Rhododendron*)。乌龙组植物群的成分主要是北半球中纬度和低纬度山地或高、中纬度平原地区植物, 它们具有纸质叶, 叶面积中、小型, 叶缘均有锯齿缘, 这些植物的特征与邦卖组植物群的特征区别很大。云南临沧与西藏南木林的距离相隔约 1 200 km, 两地的海拔高度也有很大差别, 两地相似的植物属种仅限于温带的落叶植物, 两地植物群的属种组成成分差别很大, 乌龙组植物群属于中温带落叶阔叶林的植被类型, 而云南临沧邦卖组植物群则是亚热带常绿和落叶阔叶混交林的植被类型。两个植物群的区系成分、植被类型、生态环境及其反映的气候条件大相径庭, 这可显示中新世时西藏南木林海拔高度比云南临沧要高很多。乌龙组植物群代表的年均温度是 6. 8±3. 4℃或 8. 1±2. 3℃(Spicer *et al*., 2003), 远远低于云南开远晚中新世小龙潭组植物群反映的年均温度, 也低于山东临朐中中新世山旺组植物群反映的年均温度。

4 讨论和结论

邦卖组植物群中绝大多数化石种与中国长江以南的现生植物有密切关系, 与长江以北地区相似的现生种很少, 邦卖组植物群中与西南地区相似的现生种有 37 种, 与华南地区相似的有 33 种, 与华东地区相似的有 18 种。这表明邦卖组植物群的种与我国西南和华南地区喜暖的现生植物的亲缘关系最密切; 由于该植物群与其西南邻近地区的现生植物的相似性最高, 这也表明邦卖组植物群代表的地质年代较年轻。

邦卖组植物群与山东临朐中中新世山旺组植物群相比较, 其区系成分, 群落外貌, 植被类型上都有很大差别。因为山旺组植物群位于中国东部, 与邦卖组植物群的距离相隔甚远, 地势也很低, 地质年代也早些, 植物群中的绝大多数属种成份是由暖温带落叶植物组成, 常绿植物很少, 属于暖温带落叶阔叶林植被类型。因此, 两个植物群的面貌、区系成分和植被类型均有明显差别。

与云南开远小龙潭煤矿晚中新世小龙潭组植物群比较, 两地距离最近, 只是海拔高度有些差别。小龙潭组植物群中也是以亚热带常绿的乔木和灌木植物占优势, 全缘叶植物的比例也较高, 其植物群外貌和植被类型与邦卖组植物群最接近。二者的区别是两个植物群的区系成分有明显差别, 小龙潭组植物群是以蝶形花科占优势、樟科和壳斗科为次的亚热带常绿、落叶阔叶混交林植被类型。

与西藏南木林乌龙组的植物群比较, 虽然邦卖组植物群与乌龙组植物群产地距离比邦卖组植物群与山东临朐山旺组植物群产地距离缩短一半, 但乌龙组植物群与邦卖组植物群之间仍有千余公里的距离之隔。乌龙组植物群全由温带落叶植物组成, 没有典型的常绿植物, 属于温带落叶阔叶林植被类型, 这与邦卖组植物群的特征差别悬殊。这可能反映两地当时的海拔高程差别很大, 因此, 两地植物群的面貌、区系成分和植被类型截然不同。由此可见, 植物群所反映的植物群面貌、区系成份和植被类型的差别不仅与植物群化石产地之间的距离远近有关, 也与其埋藏地的海拔高程的高低相关。

云南临沧中寨邦卖组地层过去曾被定为新近纪, 现依据卖组植物群与小龙潭组植物群两者相似性指数很高, 表明此二植物群的地质年代接近, 小龙潭组植物群时代被定为中新世晚期; 再依据邦卖组地层层序的对比及其上部地层测年, 现在认为其地质年代属于晚中新世, 大约晚于 11. 6 Ma(Jacques *et al*., 2011)。

近来, 研究甘肃秦安最完整又连续的陆相风尘堆积序列黄土- 古土壤剖面, 依据化石证据和古地磁测年是 22 —6. 2 Ma 前。这套风尘堆积物的存在表明在中新世初期至少在 14 Ma 前, 亚洲内陆已经出现荒漠化和冬季季风环流系统, 也表明在中新世早期青藏地区已经隆升到足够阻止来自印度洋和特提斯海的暖湿气流北进的高度, 并改变以前的大气环流系统而促使亚洲内陆荒漠化的形成(Guo *et al*., 2002)。这种证据也与植物化石的研究相符合(Guo, 1981)。

在研究化石植物群的过程中经常发现很多植物, 如本文研究的属级植物化石, 它们虽然发现于不同地质时期, 但是它们与其类似的现生植物之间在属级宏观形态特征上没有表现出明显的差异。尽管化石与现生植物之间相隔数百万年, 乃至千余万年, 甚至更长的时间跨度, 但是, 它们的属级宏观形态特征总是保持相对稳定状态。这种现象和事实证据, 根据天文地质学(徐道一等, 1983) 的原理, 以及生物学理论, 可以推断这种属级宏观形态特征的相对稳定似乎表明植物属级的特征是由于某种天体偶然突发事件所造成的植物基因突变而形成的, 并且自其属级特征铸成之后, 即被固定和遗传下来, 虽经漫长地史时期的演化, 其属级宏观形态特征基本保持相对稳定状态, 没有发生显著变异。这种偶然性突发事件在自然界中是客观存在和经常发生的, 譬如宇宙射线、暗物质、暗能量和微波背景辐射; 银河系的各星系和星体发射的强弱不等的各种能量及银河系的星云悬臂的旋转运动的影响; 太阳系的行星扰动及太阳活动, 诸如太阳黑子、风暴、磁暴、光斑、耀斑、谱斑、日珥、日冕、以及自然界的各种物理和化学能量的作用等等, 这些自然界的力量都可引起植物的基因发生突变, 从而造成属级特征的突发形成, 并因其能量的强弱和持续时间的长短而形成属级及其以上不同分类等级的特征。

种级特征的形成则是由于地球的激烈或缓慢地运动造成的, 诸如大陆漂移、板块构造、海底扩张、火山喷发、磁极倒转、地轴倾角等改变; 和地壳的位移、褶皱、造山、断陷、地震等导致地形地貌的变形, 以及外来天体, 如小行星、彗星, 流星、陨石撞击地球等诸多事件, 导致大气和洋流循环模式的改变, 从而引起气候发生显着变化, 造成种级特征的生成。种级以

下(亚种、变种、和变型等) 的特征是渐变的, 主要是由于地质地理和地形地貌的差异, 以及生态环境的变化引起的, 如地形地势、山水隔离、经纬距离、河湖沼泽、和气候、土壤、生物等诸多因素相互作用造成的, 这些自然因素迫使植物发生形态和生理上的细微变化, 以适应自然环境的压力而产生变异, 因此, 形成种级以下的分类单元。实际上, 地表有机物的生成和生命的起源、发展、变异、演化、灭绝都是在不同时空期间由宇宙、银河、太阳、地球等各系统之间所产生的各种物理和化学能量的相互作用使生物的遗传物质发生变异所产生对自然环境适应能力的结果。自然界中, 宇宙万物永远是处在相对平衡和互相协调的运动状态。

5　系统描述

蕨类植物门　**Pteridophyta**

真蕨纲　**Polypodiopsida(*alias* Pteridopsida, Filicopsida)**

槐叶萍科　**Salviniaceae**

槐叶萍属　***Salvinia* S guier, 1754**

平脉槐叶萍　***Salvinia paralleloneura* sp. nov.**

(图版Ⅸ, 图 6, 7, 11)

词源　*Parallele*, 拉丁语, 意思是平行的; *neurus*, 拉丁语, 意为神经、叶脉。

正模　PB 12888。

描述　漂浮叶椭圆形, 长 3. 1—3. 7 cm, 宽 2. 3—2. 6 cm, 基部截形或圆形, 叶尖钝圆, 叶缘全缘, 叶柄缺失, 叶纸质。中脉细而明显, 平直或稍弯曲; 侧脉 28– 32 对, 近乎垂直于中脉平行地伸向叶缘, 脉间的突起不明显。

讨论　该新种有三个叶片印痕化石, 它们的叶形、大小和叶脉的数量及分布与现代的 *Salvinia natens* (L.) All. 类似, 此种为标准的漂浮性水生植物, 常见于中国东北到长江以南地区, 并广泛分布于欧、亚、非三大洲, 以及南、北美洲地区的亚热带和热带的水田, 池塘和无污染的静水沼泽中。槐叶萍的植物化石最早出现于墨西哥的晚白垩世(Hall, 1974), 其化石常见于新生界(Nambudiri and Chitaley 1991)。

种子植物门　**Spermatophyta**

裸子植物亚门　**Gymnospermae**

松柏纲　**Coniferae**

杉科　**Taxodiaceae**

水松属　***Glyptostrobus* Endl., 1847**

欧洲水松　***Glyptostrobus europaeus* (Brongn.) Heer**

(图版 I, 图 1)

1978　*Glyptostrobus europaeus*,《中国新生代植物》编写组, 11 页, 图版 4, 图 3; 图版 5, 图 5。

1979　*Glyptostrobus europaeus*, 郭双兴、李浩敏, 515 页, 图版 1, 图 1—3。

1987　*Glyptostrobus europaeus*, 李浩敏等, 208 页, 图版 1, 图 9。

讨论　当前标本可能是一幼枝, 叶密而细。此种化石在北半球白垩纪—新近纪分布甚广, 我国发现于辽宁抚顺煤田始新统计军屯组(本组从原古城子组分出, 见黄振裕等, 1983, 261 页), 吉林珲春上白垩统珲春组下段, 新疆阿勒泰古新统和吉林敦化中新统土门子组(李浩敏、杨桂英, 1984)。

柏科　**Cupressaceae**

翠柏属　***Calocedrus* Kurz., 1873**

兰亭翠柏　***Calocedrus lantenoisi* (Laurent) Tao**

(图版 I, 图 5, 10, 11)

1916　*Libocedrus lantenoisi*? Colani, p. 27, 28, pl. 2, figs. 1, 2, 5—8.

1920　*Libocedrus lantenoisi*, Colani, p. 117, 118, pl. 4, figs. 7—10; pl. 11, fig. 3.

1978　*Calocedrus lantenoisi*,《中国新生代植物》编写组, 15 页, 图版 3, 图 4—6, 11, 12。

讨论　标本叶枝的形态、分枝状况、鳞形叶的形状、大小等特征, 与云南景谷渐新统蔡家冲组、宜良中新统小龙潭组的 *Calocedrus lantenoisi* (Laurent) Tao 一致, 此种化石也发现于越南古近纪—新近纪 Tonkin 植物群中。该化石种与我国云南南部的现生种 *Calocedrus macrolepis* Kurz. 接近。

被子植物亚门　**Angiospermae**

双子叶植物纲　**Dicotyledoneae**

五味子科　**Schisandraceae**

五味子属　***Schisandra* Michx, 1803**

华脉五味子(新种)　***Schisandra splendinervosa* sp. nov.**

(图版 I, 图 2)

词源　*Splendid*, 来源于拉丁语 *splendidus*, 意思是华丽的; *nervos* 来源于拉丁语 *nervus*, 意思是神经、脉管。

正模　PB 12756。

描述 叶倒卵形, 长 7 cm 左右, 宽约 2. 5 cm, 叶尖缺失, 基部楔形, 边缘具疏生腺状细齿, 叶柄保存 4 mm。叶纸质。羽状脉, 环结脉序。中脉下部粗壮, 上部渐细, 直伸, 侧脉纤细, 12—14 对, 近对生, 伸出角下部较狭, 约 30°, 向上渐宽至 50°, 伸至叶缘内侧分叉并互相连接成环结, 自环结外侧又有二级环结, 有细脉伸入腺体。侧脉间偶有间脉。三级脉形成不规则的大网。四级脉形成多边形小网。

讨论 标本的叶形、大小和脉络(architecture)与我国台湾海拔 2 100—2 300 m 林中生长的 *Schisandra arisanensis* Hayata 有些接近, 但该现生种的叶尖较长, 边缘腺体较密而明显易与化石种区别。

樟科 **Lauraceae**

樟属 ***Cinnamomum* Schaeffer, 1760**

狭叶樟 ***Cinnamomum naitoanum* Huzioka and Takahashi, 1970**

(图版 I, 图 6)

1970 *Cinnamomum naitoanum* Huzioka and Takahashi, p. 57, pl. 8, figs. 3, 4, 5a.

1978 *Cinnamomum naitoanum*,《中国新生代植物》编写组, 20 页, 图版 14, 图 136。

讨论 标本基部缺失, 依其叶形和叶脉特征与日本本州始新统 Ube 组产的 *Cinnamomum naitoanum* Huzioka and Takahashi (1970, p. 57) 一致, 它也发现于我国辽宁抚顺煤田始新统计军屯组。该种与欧洲和西亚渐新统至上新统常见的 *Cinnamomum lanceolatum* (Unger) Heer 的叶征十分相似, 后者的叶片更细长, 基部狭楔形, 而狭叶樟的叶片较宽, 基部宽楔形或浑圆而有区别。狭叶樟与我国现代南部的阴香[*Cinnamomum burmanni* (Nees and T. Nees) Blume] 和东部的天竺桂(*Cinnamomum japonicum* Siebold) 均相似, 但后二者的叶片叶尖尖锐而有区别。

琼泽樟 ***Cinnamomum scheuchzeri* Heer, 1856**

(图版 I, 图 7, 8)

1856 *Cinnamomum xcheuchzeri* Heer, s. 85, 86, taf. 91, figs. 4—21; taf. 93, figs. 1, 5.

1959 *Cinnamomum scheuchzeri*, Andreanszky, s. 66.

1974 *Cinnamomum scheuchzeri*, Takhtajan, str. 32, 33, tabl. 13, fig. 5, ris. 10(6, 7).

描述 叶椭圆形, 保存长 3. 5—4 cm, 宽 2. 5 cm 左右, 叶尖缺失, 基部楔形, 边缘全缘, 叶柄未保存。叶纸质或薄革质。掌状脉, 离基三出脉, 半聚顶脉序。中脉细, 直伸, 侧主脉细, 距叶基 3—12 mm 处伸出, 伸出角约 20°, 伸向叶上部, 中脉之上部有数对侧脉伸向叶缘, 伸出角约 30°。侧主脉无明显的外脉。三级脉细, 在中脉之两侧稍向上斜伸与侧主脉相连接。

讨论 标本保存不太完整, 依其显示的叶形、大小和叶脉特征与欧洲和中、西亚发现于始新统到中新统的 *Cinnamomum scheuchzeri* Heer (1856, S. 85, 86; Takhtajan, 1974, Ъ. 32, 33) 一致。此化石种的叶形和大小变化较大, 但其长宽比例比较稳定, 约为 2∶1。

巧叶樟(新种) ***Cinnamomum versutifolium* sp. nov.**

(图版 I, 图 13, 14)

词源 *Versuti* 来源于拉丁语, 意思是灵巧的、多才多艺的; *folium*, 拉丁语, 意思是薄片、叶片。

正模 PB 12761。

描述 叶披针形, 保存长 7—8 cm, 宽 2. 2—2. 8 cm, 叶尖急尖, 基部缺失, 边缘全缘, 叶柄缺失。叶革质。掌状脉, 三基出脉, 或离基三出脉, 半聚顶脉序。中脉中粗直伸。侧主脉自叶基部或离基伸出, 沿叶缘内侧伸向叶片上部, 未及顶端即消失于叶缘, 其伸出角约 20°, 侧主脉向外有 10 余对脉向上斜伸, 在叶缘处向上弯曲形成环结。自中脉有许多不太明显的三级脉与侧主脉相连接, 形成横向的长网。

讨论 新种的主要特征是: 叶为披针形, 中脉两侧无二级脉, 只有三级脉伸向侧主脉。依此特征可区别于樟属其它种。新种的叶形、大小和脉络与我国长江以南生长于海拔 500—1 400 m 的常绿小乔木毛桂 (*Cinnamomum appelianum* Schewe) 有些接近, 但后者的中脉顶部时有 1—2 对侧脉伸出。生长于广东海南岛的平托桂(*Cinnamomum tsoi* C. K. Allen) 的叶形和叶脉特征也有些与化石新种相似, 但现生种的侧主脉有若干较稀疏而强的外脉, 而新种的外脉细而密甚易区别。

木姜子属 ***Litsea* Lamark, 1791**

小叶木姜子 ***Litsea grabaui* Hu and Chaney, 1940**

(图版 I, 图 15, 16)

1940 *Litsea grabaui* Hu and Chaney, p. 44, pl. 18, figs. 5, 8.

1978 *Litsea grabaui*,《中国新生代植物》编写组, 23 页, 图版 11, 图 3; 图版 13, 图 5; 图版 15, 图 2, 4; 图版 17, 图 4。

讨论 标本的叶形、大小和脉络与我国山东临朐中新统山旺组的小叶木姜子基本一致, 只是当前

标本的叶面积较小些。

新樟属　***Neocinnamomum* H. Liu, 1934**

描述　灌木或小乔木。叶卵形或卵状椭圆形, 长 4—12 cm, 叶缘全缘, 坚纸质或近革质。三出脉或近基三出脉。花小, 圆锥花序。果为浆果状核果; 椭圆形或圆莆, 果托大而浅, 肉质增厚, 高脚杯状, 花被片宿存而略增大; 果梗细, 向上增大。

分布及时代　此属化石在我国系首次发现, 约 7 个现生种, 分布于我国南部和西南部; 尼泊尔、印度、中南半岛和印度尼西亚。

锈叶新樟(新种)　***Neocinnamomum fuscatifolium* sp. nov.**

(图版 II, 图 1—7)

词源　*Fuscus* 来源于拉丁语, 意思是棕色、锈色; *folium*, 拉丁语, 意思是叶片。

正模　PB 12771。

描述　叶宽椭圆形, 长 6.5—8 cm, 宽 2.5—4 cm, 叶尖渐尖, 基部楔形, 边缘全缘, 具短柄。叶坚纸或薄革质。掌状脉, 离基三出, 聚顶脉序。中脉细, 直伸, 侧主脉距基约 4 mm 处伸出, 伸出角约 20°, 侧主脉向外伸出约 10 对外脉, 其略呈弧形伸向叶缘, 并连接成脉环。三级脉细, 在中脉两旁者呈水平分布, 位于侧主脉两旁者近乎垂直于侧主脉。四级脉不清楚。

讨论　新种的叶片大小和脉络与印度、中南半岛和我国西南地区海拔 500—1 800 m 山谷溪边稀树林中现生的滇新樟 [*Neocinnamomum candatum* (Nees) Merr.] 有些相似, 但该现生种叶片卵形, 稍不对称, 中脉顶端时有侧脉。云南西部海拔 1 100—2 300 m 河谷疏林中灌木或小乔木新樟 [*Neocinnamomum delavayi* (Lecomte) H. Liu] 也可与当前化石种比较。

胡椒科　**Piperaceae**

胡椒属　***Piper* Linnaeus, 1753**

临沧胡椒(新种)　***Piper lincangense* sp. nov.**

(图版 I, 图 3, 4)

词源　*Lincang* 是化石产地的汉语拼音。

正模　PB 12773。

描述　叶椭圆形, 长 3.5—5.8 cm, 宽 2.3—3 cm, 叶尖急尖或渐尖, 基部宽楔形, 稍不对称, 边缘全缘, 叶柄 5 mm。叶纸质。羽状脉, 半聚顶脉序。中脉细, 直伸或上部稍弯曲, 侧脉 3—5 对, 基部两对侧脉紧挤近, 第 2 对侧脉粗强, 其余侧脉细弱, 伸出角一般 20°, 少数 30°, 呈弧形伸向叶上部。三级脉细, 形成隐约可见的大网。四级脉不太清楚。

讨论　标本的叶形和脉络与我国东南部的现生种山蒟 (*Piper hancei* Maxim.) 和南部的毛蒟 [*Piper puberulum* (Benth.) Maxim.] 均相似, 但前一现生种叶片中、上部的侧脉纤细而不明显, 后者的侧脉伸出角比当前化石种大, 彼此甚易区别。

胡椒属的化石种颇为罕见, 迄今已知在美国阿拉斯加古新世或始新世植物群中记载 6 种, 并得到承认 (La Motte, 1952)。前苏联阿塞拜疆巴库中新世 Sarmatian 期地层中也曾发现一未定种名的胡椒属标本。

山柑科　**Capparaceae**

山柑属　***Capparis* Linnaeus, 1753**

临沧山柑(新种)　***Capparis lincangensis* sp. nov.**

(图版 I, 图 9)

词源　*Lincang* 是化石产地的汉语拼音。

正模　PB 12774。

描述　叶长椭圆形, 长 5.8 cm, 宽 2 cm, 叶尖钝圆, 基部浑圆, 边缘全缘, 叶柄缺失。叶纸质。羽状脉, 环结脉序。中脉粗强、直伸。侧脉甚细, 12—15 对, 近对生, 伸出角约 60°, 伸至叶缘向上弯曲与相邻侧脉形成脉环, 脉环以近直角连接, 侧脉间常有间脉。三级脉纤细, 形成四边形或多边形的大网, 网眼 1.5—2 mm 长。四级脉清晰, 形成多边形的网。五级脉不明显。

讨论　标本保存完好, 叶脉清晰而精致。其叶形、大小和脉络与印度、中南半岛、马来半岛和我国南部海拔 1 000 m 以下山沟、水旁或平地湿润或隐蔽处生长的广州山柑 (*Capparis cantoniensis* Lour.) 有些接近, 该现生种的叶片为矩圆状披针形, 叶尖渐尖, 叶面积更大而与化石种不同。美国始新统 Wilcox 组 *Capparis eocenica* 层 (Berry, 1916, p. 218; pl. 44, figs. 1—3; pl. 52, fig. 5) 所产化石的叶形和叶脉特征与当前新种也类似, 但美国的化石种叶的叶尖急尖、基部楔形, 与当前新种易区别。

山柑属的化石种在美国始新统和中新统已记载 3 种(La Motte, 1944, 1952)。在前苏联阿塞拜疆的上新统发现类似山柑属的形态属种。

千屈菜科 **Lythraceae**

菱属 ***Trapa* Linnaeus, 1753**

菱(未定种) ***Trapa* sp.**

(图版 VII, 图 8)

描述 果实菱形, 中央有突起的喙, 基部截圆形, 果体高 1.5 cm。可能有 4 角, 一对短角被挤压, 长角长圆锥形, 角顶间距约 3 cm。

讨论 当前标本与陶君容、陈明洪(1983, 85 页, 照片版 19–11)定为 *Trapa protojaponica* Tao 的标本在形态上有些接近, 但后者的长角很张开而有区别。当前标本保存不佳, 暂不定名。

菱属仅有 3 现生种, 即 *Trapa bicornis*, *T. japonica* 和 *T. natans*, 都是一年生的水生漂浮草本植物, 广布于亚洲、欧洲和非洲的近海平面至 2 700 m 的山地; 并广泛栽培于东南亚的热带和亚热带地区的浅水湖泊、沼泽、池塘、河流岸边; 在北美和澳大利亚也被引种驯化, 培育众多栽培变种。菱属的化石广泛发现于新生代地层中, 在北半球分布颇广。

番杏科 **Aizoaceae**

番杏属 ***Tetragonia* Linnaeus, 1753**

卵叶番杏(新种) ***Tetragonia ovatifolia* sp. nov.**

(图版 XI, 图 5, 6)

词源 *Ovatus* 来源于拉丁语, 意思是卵形的; *folia*, 拉丁语, 即叶片。

正模 PB 12776。

描述 叶卵形, 长 4 cm 左右, 宽 3 cm 左右, 叶尖急尖, 基部歪心形, 边缘微波状, 叶柄粗, 仅存 5 mm, 叶薄纸质。羽状脉, 环结脉序。中脉细, 直伸侧脉细, 4—6 对, 半对生, 伸出角 40°—50°。伸至叶缘形成脉环。三级脉不清楚。

讨论 标本为叶的正负面, 其叶形、大小和侧脉数目及其布置与南美洲、大洋洲和我国东南部的番杏[*Tetragonia tetragoniodes* (Pall.) Kuntze]十分相似, 但该现生种的叶片顶端钝尖、侧脉整齐而有区别。番杏属约有 50—60 种, 草本或亚灌木, 分布于温带和亚热带地区, 新西兰、东亚、南非和南美, 中国仅有一种。

海桐花科 **Pittosporaceae**

海桐花属 ***Pittosporum* Banks ex Sol., 1788**

临沧海桐(新种) ***Pittosporum lincangense* sp. nov.**

(图版 XII, 图 4, 7—9)

词源 *Lincang* 为化石产地的汉语拼音。

正模 PB 12780。

描述 叶长倒卵形, 长 3—5 cm, 宽 15—20 mm, 叶尖缺失, 基部狭楔形, 边缘全缘, 叶柄 5 mm, 叶革质。羽状脉, 环结脉序。中脉中粗, 直伸, 侧脉细, 4 对以上, 近对生, 伸出角 30°—50°, 伸至叶缘内侧互相连接成脉环。脉环成直角, 并有次脉环。三级脉细, 稀疏, 横贯于侧脉间。四级脉形成不规则的网, 五级脉不明显。

讨论 标本的叶形、大小和脉络与我国华中地区山坡灌丛中的菱叶海桐花(*Pittosporum truncatum* E. Pritz)和广东海南岛生长的台琼海桐[*Pittosporum pentandrum* var. *hainanense* (Gagnep.) H. L. Li]均相似, 但菱叶海桐的叶厚革质, 叶尖渐尖, 叶脉多少隐匿, 而台琼海桐叶形较大(长 4—10 cm)、侧脉数目较多(7—10 对)而有明显区别。

茶科 **Theaceae**

厚皮香属 ***Ternstroemia* Mutis ex L. f., 1782**

前川厚皮香 ***Ternstroemia maekawai* Matsuo, 1963**

(图版 XII, 图 1)

1963 *Ternstroemia maekawai* Matsuo, p. 241, pl. 40, figs. 1, 3.

描述 叶倒卵形, 长 6.5 cm, 宽 2.4 cm, 叶尖急尖或渐尖, 基部楔形, 边缘全缘, 叶柄缺失, 叶厚革质。羽状脉, 隐匿脉序(hyphodromous), 中脉粗壮, 略弯伸, 上部骤细。侧脉细弱, 不明显。

讨论 当前标本的叶形和叶脉特征与日本本州半岛中中新统下部 Kurosedani 组的 *Ternstroemia maekawai* Matsuo (1963, p. 241) 的特征几乎完全一致, 日本的该种叶化石较当前标本略大些, 长 7.5—8.8 cm, 宽 2.2—2.8 cm, 这可能是生态环境的差异所致。

桃金娘科 **Myrtaceae**

蒲桃属 ***Syzygium* P. Browne ex Gaertn., 1788**

临沧蒲桃(新种) ***Syzygium lincangense* sp. nov.**

(图版 VIII, 图 1—13)

词源 *Lincang* 为化石产地的汉语拼音。

正模 PB 12784。

描述 叶菱形, 椭圆形, 长 4.5—6.5 cm, 宽 1.8—2.8 cm, 叶尖渐尖, 基部楔形, 边缘全缘, 叶柄 2—12 mm, 叶薄革质。羽状脉, 环结脉序。中脉粗, 直伸或弯曲, 侧脉纤细, 30 对以上, 近对生, 伸出角

70°左右, 平行伸向叶缘, 在边缘形成缘内脉环(intramarginal vein), 其环距叶缘约 1 mm, 与叶缘并行, 侧脉偶有分枝。三级脉平行于侧脉形成水平方向的网。

讨论　新种以菱形叶为主, 长与宽不超过 7 × 3 cm, 侧脉纤细而密集。这些特征与我国广东、广西和越南的现生乔木香蒲桃 [*Syzygium odoratum* (Lour.) D C.] 十分相似, 但该现生种的侧脉数目较少而有区别。

蒲桃属有 500—1 100 种, 主要分布于热带亚洲, 少数在大洋洲和非洲。我国约有 74 种, 为常绿灌木或乔木, 分布于长江以南各地, 多见于广西、广东和云南, 其化石种也颇常见。

杂蒲桃(新种)　***Syzygium poecilophyllum* sp. nov.**
(图版 IX, 图 1, 2)

词源　*Poecilo* 源于古希腊语, 意思是杂色的; *phyllum*, 希腊语, 意思是叶片。

正模　PB 12798。

描述　叶椭圆形, 长 6—7. 5 cm, 宽 2. 8—4 cm, 叶尖钝尖, 基部宽楔形, 边缘全缘, 叶柄 8 mm。叶革质。羽状脉, 环结脉序。中脉粗强, 直伸或略弯曲, 侧脉纤细, 30 对以上, 侧脉间距约 2 mm, 伸出角 70°左右, 平行伸达叶缘, 在距叶缘不足 1 mm 处形成缘内脉环, 与叶缘并行。三级脉纤细, 在侧脉间形成水平扁网。

讨论　当前新种较新种 *Syzygium lincangense* sp. nov. 叶面积大, 叶片较宽, 长宽比约为 2∶ 1, 侧脉较稀疏, 每厘米有 5 条侧脉; 新种 *Syzygium lincangense* sp. nov. 的长宽比约为 2. 6∶ 1, 每厘米有 7 条侧脉, 两新种区别明显。杂蒲桃的叶征与云南西南部 1 800—2 000 m 山坡生长的乔木短序蒲桃 (*Syzygium brachythyrsum* Merr. and L. M. perry) 相似, 唯该现生种侧脉平直而粗, 不同于杂蒲桃。陶君容、陈明洪(1983, 84 页) 记载 *Syzygium protocumini* Tao and Chen 的叶片大小与当前新种接近, 但 *Syzygium protocumini* 的叶不清楚, 难以肯定它们之间的关系。

使君子科　**Combretaceae**

榄李属　***Lumnitzera* Willd., 1803**

似榄李(新种)　***Lumnitzera pseudoracemosa* sp. nov.**
(图版 VII, 图 10, 14)

词源　*Pseudo-*, 希腊语, 意思是假的, *racemosa* 古希腊语, 现代植物种名。

正模　PB 12801。

描述　叶倒卵形, 长 4—5 cm, 宽 2—2. 8 cm, 叶尖圆形, 具浅缺刻, 基部宽楔形, 边缘全缘, 叶柄 3 mm。叶纸质。羽状脉, 环结脉序, 中脉中粗, 直伸或微弯。侧脉中粗, 5 对, 半对生, 伸向叶缘, 并向上弯曲形成脉环, 脉环以钝角相连接。叶上部有间脉。三级脉细而明显, 简单或分叉, 位于中脉两侧者, 垂直于中脉, 远离中脉者, 近乎垂直于侧脉, 形成不规则的大网。

讨论　标本的叶形、大小、侧脉数目和布置状态与亚洲、非洲、大洋洲和我国东南沿海红树林中现生的榄李(*Lumnitzera racemosa* Willdenow) 非常相似。但此现代种的叶片比化石标本的叶片更长、更窄, 侧脉数目更少, 两者则易于区别。榄李属植物包含两个现生种, 它们是红树林中的小乔木或灌木, 生长在海岸边或潮间带, 分布于中国、日本、韩国、东南亚和南亚诸国、及太平洋岛屿和东部非洲。如果当前新种与榄李间确有亲缘关系, 则现在的滇西高原在中新世可能属于海滨。

榄仁树属　***Terminalia* Linnæus, 1767**

临沧榄仁树(新种)　***Terminalia lincangensis* sp. nov.**
(图版 VII, 图 12, 13)

词源　*Lincang* 是化石产地的汉语拼音。

正模　PB 12803。

描述　叶倒卵形, 长 5 cm 以上, 宽 2. 8—3. 6 cm, 叶尖钝尖或圆形, 基部宽楔形, 边缘全缘, 叶柄缺失。叶革质。羽状脉, 环结脉序。中脉中粗, 直伸。侧脉强, 5—7 对, 近对生, 伸出角 30°—40°, 略呈弧形伸向叶缘并向上弯曲形成脉环, 环角末端为钝角。三级脉较粗, 不很明显, 垂直于侧脉。四级脉不清楚。

讨论　标本的叶形、侧脉数目和布置与印度、中南半岛及我国云南南部海拔 540—1 350 m 的落叶乔木毗黎勒 [*Terminalia bellirica* (Gaertn.) Roxb.] 相似, 但该现生种叶面积甚大, 长 18—23 cm, 宽 6—12 cm, 与化石种有很大区别。我国海南岛的现生种海南榄仁(*Terminalia nigrovenulosa* Pierre) 的叶片大小同当前标本近似, 但叶形不同, 海南榄仁叶为卵形和椭圆形。

Terminalia 属的化石曾发现于美国古新世至

中新世地层中, 记载约 10 种。此属有 250 个现生种, 广布于热带和亚热带, 我国有 8 个现生种, 分布于华南和西南。

锦葵科 **Malvaceae**

山芝麻属 ***Helicteres* Linnaeus, 1753**

美脉山芝麻(新种) ***Helicteres callineura* sp. nov.**

(图版 X, 图 6, 11—13)

词源 *Callos* 是旧希腊语 *kallos* 的变形, 意思是美丽; *neura*, 希腊语, 意思是神经、叶脉。

正模 PB 12807。

描述 叶卵形, 长 4—6 cm, 宽 2.2—4 cm, 叶尖钝尖或渐尖, 基部宽楔形, 边缘全缘, 叶柄保存 1 mm。叶纸质或薄革质。羽状脉, 曲行环结脉序。中脉中粗, 直伸或稍弯曲。侧脉 5—6 对, 互生, 基部有一对基侧脉甚粗强, 与邻近的上对侧脉有较大距离。侧脉伸出角 30°—40°, 呈弧形向上弯曲, 在叶缘处连接成脉环, 基部一对强侧脉有若干外脉伸向叶缘, 形成次级脉环, 侧脉间偶有间脉。三级脉形成不规则的大网。四级脉形成多边形中网。五级脉形成多边形细网, 每平方毫米有 4 个网格。

讨论 标本的叶形、大小和脉络与我国南部和中南半岛的小灌木山芝麻(*Helicteres angustifolia* L.)和我国海南岛生长的灌木剑叶山芝麻(*Helicteres lanceolata* L.)均有些类似。但这两个现生种的基侧脉具有较明显的外脉易与化石种区别。

梭罗树属 ***Reevesia* Lindl., 1827**

梭罗树(未定种) ***Reevesia* sp.**

(图版 X, 图 8, 9)

描述 叶披针状椭圆形, 长 6 cm 以上, 宽 1.8 cm, 上部缺失, 基部楔形, 边缘全缘, 叶柄缺失。叶坚纸质。羽状脉, 环结脉序。中脉中粗, 稍弯曲。侧脉细, 估计 8—10 对, 近对生, 伸出角 30°—40°, 稍呈弧形伸向叶缘, 沿叶缘向上弯曲形成环结, 并以钝角或平角相连。三级脉细, 简单或分叉, 与侧脉近乎成直角相连接。四级脉不清楚。

讨论 标本的叶形和脉络与我国西南海拔 550—750 m 山坡或山谷疏林中生长的梭罗树(*Reevesia pubescens* Mast. var. *pubescens*)有些接近, 但该现生种叶片宽 4—6 cm, 与当前标本有差异。梭罗树属的果实化石曾发现于捷克北波希米亚的早中新世地层中(Kvacek, 2006; Kvacek *et al.*, 2006)。

绣球科 **Hydrangeaceae**

绣球属 ***Hydrangea* Linnaeus, 1753**

披针绣球 ***Hydrangea lanceolimba* Hu and Chaney, 1940**

(图版 XI, 图 3, 4)

1940 *Hydrangea lanceolimba*, Hu and Chaney, p. 50, pl. 25, figs. 5. 6.

1940 *Hydrangea miobretschneideri*, Hu and Chaney, p. 50, pl. 25, fig. 7.

1961 *Hydrangea lanceolimba*, Tanai, p. 341, pl. 25, fig. 11a.

1978 *Hydrangea lancelimba*,《中国新生代植物》编写组, 92 页, 图版 80, 图 3; 图版 82, 图 1; 图版 86, 图 3。

讨论 当前标本的叶宏观结构特征与山东临朐中新统山旺组的 *Hydrangea lanceolimba* Hu and Chaney (1940, p. 50) 基本一致, 只是当前标本叶片更狭窄, 基部叶齿不明显, 叶尖尾尖, 这可能是生态的差异。此化石种也发现于日本北海道、本州和九州的许多中新世植物群中 (Tanai, 1961, p. 341)。

蔷薇科 **Rosaceae**

石楠属 ***Photinia* Lindl., 1822**

石楠(未定种) ***Photinia* sp.**

(图版 III, 图 11)

描述 叶长椭圆形, 长 8 cm 以上, 宽 2.9 cm 左右, 叶尖渐尖, 基部缺失, 顶部有 2—3 个不明显的锯齿, 边缘全缘, 叶柄未保存。叶革质。羽状脉, 环结脉序。中脉中粗, 直伸顶端。侧脉细, 12—15 对, 近对生, 伸出角 60°左右, 伸至叶缘向上弯曲形成脉环, 并以钝角相连。三级脉细, 形成不规则的大网。四级脉形成多边形细网。

讨论 标本的叶形和脉络与广西和贵州海拔 1 200 m以下开阔林地或河岸生长的常绿灌木或小乔木宜山石楠(*Photinia chingiana* Hand.-Mazz.)相似, 但该现生种侧脉数目较多, 有 20 对, 叶上部具细而内弯的齿与当前标本有明显区别。

花楸属 ***Sorbus* Linnæus, 1753**

花楸(未定种) ***Sorbus* sp.**

(图版 III, 图 12)

描述 叶卵状披针形, 保存长 3 cm, 宽 1.2 cm, 叶尖钝尖, 基部缺失, 边缘具齿, 上齿边极短, 下齿边甚长而直。中脉细, 直伸。侧脉颇细, 估计 10—12 对, 近对生, 伸出角约 50°, 伸至叶缘处稍向上弯曲

形成脉环, 脉环外伸出小脉入齿端。三级脉强, 形成不规则的多边形网。

讨论　标本的叶形和叶脉特征与云南西北海拔 3 000—3 600 m 山坡丛林中俅江花楸 (*Sorbus kiukiangensis* T. T. Yu var. *kiujiangensis*) 有些接近, 但该现生种仅叶上部有锯齿。

红果树属　***Stranvaesia* Lindl., 1837**

美叶红果树(新种)　***Stranvaesia cosmophylla* sp. nov.**

(图版Ⅳ, 图 9)

词源　*Cosmo* 是旧希腊语 *kosmos* 的变形, 意为宇宙、有序; *phyllon*, 希腊语, 意为叶片。

正模　PB 12814。

描述　叶长椭圆形, 长 6 cm 以上, 宽 3 cm 左右, 叶尖缺失, 基部楔形, 边缘全缘, 叶柄长 3 mm。叶薄革质, 羽状脉序。中脉中粗, 近直伸, 侧脉细, 10 对以上, 伸出角 50°左右, 伸至叶缘形成脉环。三级脉隐约可见, 与侧脉斜交。四级脉不清楚。

讨论　标本的叶形、大小、侧脉数目和布置与我国西南和西部海拔 1 000—3 000 m 山坡灌丛生长的红果树 (*Stranvaesia davidiana* Decne var. *davidiana*) 甚相似, 但现生种叶片较宽, 有明显的间脉而不同。

含羞草科　**Mimosaceae**

合欢属　***Albizia* Durazz., 1772**

刀叶合欢(新种)　***Albizia scalpelliformis* sp. nov.**

(图版Ⅱ, 图 10)

词源　*Scalpellum*, 拉丁语, 意思是解剖刀; *forma*, 拉丁语, 意为形状。

正模　PB 12816。

描述　小叶刀形, 甚不对称, 长 2 cm 左右, 宽 8 cm 左右, 叶尖缺失, 估计钝尖, 基部截圆形, 边缘全缘, 无叶柄, 叶纸质。羽状脉, 环结脉序。中脉粗强。基点具明显印痕。侧脉细, 5—7 对, 右侧基部有 2 粗强基侧脉, 最基部的 1 条与中脉呈直角伸向叶缘, 上边的 1 条约以 50°角稍呈弧形伸向叶缘, 与其上部侧脉形成脉环。左边侧脉细而短, 伸至叶缘形成脉环, 右边侧脉细而长, 伸出角 40°—50°, 伸向叶缘形成脉环。三级脉不太清楚。

讨论　标本的叶形和叶脉特征与我国中、南部生长的合欢 (*Albizia julibrissin* Durazz.) 相似, 但该现生种叶片太小, 长 6—12 mm, 宽 1—4 mm, 与当前标本有显著差别。此化石种的叶形、大小与在我国西南和华南海拔 1 000 m 山坡生长的香须树 [*Albizia oratiissima* (L. f.) Benth.] 也较接近, 但后者叶基近圆形或心形可区别于化石种。当前化石种的叶形特征介于上述两个现生种之间。

云实科　**Caesalpiniaceae**

皂荚属　***Gleditsia* Linnaeus, 1753**

中华皂荚　***Gleditsia miosinensis* Hu and Chaney, 1940**

(图版Ⅲ, 图 1)

1940　*Gleditsia miosinensis*, Hu and Chaney, p. 52, pl. 26, figs. 6, 7.

1963　*Gleditsia miosinensis*, Huzioka, p. 205, pl. 34, figs. 8, 9; pl. 35, fig. 3.

1965　*Gleditsia miosinensis*, Tanai and Suzuki, p. 34, pl. 2, fig. 4.

1978　*Gleditsia miosihensis*,《中国新生代植物》编写组, 107 页, 图版 88, 图 b; 图版 93, 图 9。

1983　*Gleditsia miosinensis*, 陶君容、陈明洪, 76 页。

讨论　该种首次发现于我国山东临朐中新统山旺组。此种在日本北海道中新世中期的 Yoshika 植物群中发现保存较好的荚果和叶化石(Tanai and Suzuki, 1965)。该种化石在日本北海道新近纪的 Shanabuchi 和 Rubushibe 植物群中及本州中新世中期的 Utto 植物群中也有发现。

蝶形花科　**Papilionaceae**

黄檀属　***Dalbergia* Linnaeus f., 1782**

印记黄檀　***Dalbergia sigillata* sp. nov.**

(图版Ⅲ, 图 2)

词源　*Sigillatus*, 拉丁语, 意为印章的。

正模　PB 12819。

描述　小叶椭圆形, 长 2.6—4.5 cm, 宽 1.1—2.1 cm, 叶尖浑圆, 基部稍偏斜, 宽楔形, 边缘全缘, 叶柄未保存, 叶坚纸质, 羽状脉, 环结脉序, 中脉粗强, 直伸或稍弯曲。侧脉细弱, 约 10 对, 近对生, 伸出角 40°—60°, 不规则地伸向叶缘, 向上弯曲形成脉环, 环外有次级脉环, 具细间脉。三级脉形成不规则的网。

讨论　此种的标本有三件, 其叶形、大小和脉络与我国西南云贵川生长的木本攀援植物滇黔黄檀 (*Dalbergia yunnanensis* Franch.) 有些类似, 但该现生种叶尖通常有明显的凹缺, 叶片近乎矩形而有别于当前化石种。

山马蝗属 ***Desmodium* Desv., 1813**

前山马蝗(新种) ***Desmodium praegyroides* sp. nov.**

(图版 III, 图 3)

词源 *Prae-* 是希腊语前缀, 是先前之意; *gyroides* 是希腊语, 现代植物种名。

正模 PB 12820。

描述 小叶卵圆形, 长 4.4 cm, 宽约 3 cm, 叶尖钝尖, 基部偏斜, 浑圆, 边缘全缘, 叶柄 2 mm。叶纸质。羽状脉, 环结脉序。中脉甚粗强, 微弯。侧脉中粗, 6—8 对, 基部 2 对较弱, 中部较强, 伸出角 40°—50°, 弧形伸向叶缘形成脉环, 其以直角或钝角相连。叶上部偶有间脉。三级脉稀疏而显著, 简单或偶有分叉, 弯曲。贯穿于侧脉间。四级脉不清楚。

讨论 标本的叶形、大小与我国西南地区的圆叶舞草[*Desmodium gyroides* (Roxb.) DC.] 有些接近, 但该现生种的叶脉较弱、叶片常为倒卵形而有别于化石种。

马鞍树属 ***Maackia* Rupr., 1856**

马鞍树(未定种) ***Maackia* sp.**

(图版 III, 图 4)

描述 侧生小叶, 宽椭圆形, 长约 6 cm, 宽 3.7 cm, 叶尖缺失, 估计钝尖, 基部楔形, 边缘全缘, 小叶柄 2 mm。叶纸质。羽状脉, 环结脉序。中脉中粗, 稍弯曲。侧脉细, 5—7 对, 近对生, 伸出角 40°—50°, 微弧形, 伸向叶缘, 形成脉环。三级脉隐约可见, 分叉或不分叉, 连接着侧脉。四级脉不清楚。

讨论 标本的叶形和大小与广东现生的华南马鞍树 [*Maackia australis* (Dunn.) Takeda] 接近, 但该现生种的侧脉数目较多, 叶基较宽而不同于当前叶化石。此外, 陕西华山生长的华山马鞍树 (*Maackia hwashanensis* W.T. Wang) 叶片特征与当前叶化石也有类似之处。

崖豆藤属 ***Millettia* Wight and Arn., 1834**

崖豆藤(未定种) ***Millettia* sp.**

(图版 III, 图 5)

描述 复叶之小叶, 长倒卵形, 保存长 7 cm, 宽 3.5 cm, 叶尖缺失, 基部破损, 估计宽楔形, 边缘全缘, 小叶柄未保存。叶厚纸质。羽状脉, 环结脉序。中脉粗强, 直伸, 侧脉 13 对以上, 近对生, 伸出角 40°—50°, 几乎平行地伸达叶缘, 叶缘向上弯曲与相邻的侧脉分枝或三级脉接合成脉环。三级脉简单或少有分叉, 弯曲, 其两端与侧脉相连。四级脉形成多边形网。五级脉不清楚。

讨论 标本的叶形、大小和脉络与广东、广西、贵州、海南、云南生长的常绿藤本植物海南崖豆藤 (*Millettia pachyloba* Drake) 类似, 但该现生种的侧脉较直而有区别。此外, 台湾崖豆藤[*Millettia taiwaniana* (Hayata) Hayata] 的叶片特征也与当前标本类似, 但前者叶型较大, 长 13—15 cm, 宽 4.5—5 cm, 也易鉴别。

油麻藤属 ***Mucuna* Adans., 1763**

光叶油麻藤(新种) ***Mucuna leiophylla* sp. nov.**

(图版 III, 图 6, 7)

词源 *Leios*, 希腊语, 意思是光滑的; *phylla*, 希腊语, 意为叶片。

正模 PB 12824。

描述 侧生小叶, 两侧不对称, 卵形, 长 6.6 cm, 宽 3.1 cm, 叶尖钝尖, 基部截圆形, 边缘全缘, 叶柄 4 mm。叶纸质。羽状脉, 环结脉序。中脉细, 稍弯曲。侧脉 5 对左右, 近对生, 伸出角 30°—40°, 伸至叶缘, 偶有分叉, 向上弯曲, 形成脉环, 一侧的基侧脉 3—5 条外脉伸至叶缘形成脉环, 另一侧不具外脉。局部可见三级脉, 简单或分叉, 与侧脉相接。四级脉形成多边形网。

讨论 标本的叶形和脉络与生长在广东海南岛的栗茸油麻藤(*Mucuna castanea* Merr.) 接近, 但该现生种叶型较大, 长 7.5—14 cm, 宽 3.5—7.5 cm, 与化石种有明显区别。

红豆树属 ***Ormosia* Jacks., 1811**

红豆树(未定种) ***Ormosia* sp.**

(图版 III, 图 8)

描述 小叶椭圆形, 长 5 cm 左右, 宽 1.5 cm, 叶尖渐尖, 基部圆楔形, 边缘全缘, 叶柄未保存。叶纸质。羽状脉, 环结脉序。中脉中粗, 直伸, 侧脉细, 6—8 对, 半对生, 伸出角 30°—40° 伸向叶缘向上弯曲与三级脉连接成脉环。三级脉常分叉 1 次, 少数 2 次, 两端与侧脉相连。四级脉形成多边形网。五级脉不太清楚。

讨论 标本的叶形、大小和脉络与广西南部海拔 900 m 疏林中的菱荚红豆 (*Ormosia pachyptera* H.Y. Chen) 接近, 但该现生种的叶形较大, 长 5.5—8.5 cm, 宽 2—2.4 cm, 易与化石标本相区别。

宿包豆属　***Shuteria* Wight and Arnott, 1834**

细叶宿包豆(新种)　***Shuteria* sp.**

(图版Ⅲ, 图 9, 10)

描述　小叶宽椭圆形, 两侧不对称, 长 5 cm 左右, 宽 3.3 cm, 叶尖缺失, 估计为钝尖, 基部宽楔形, 边缘全缘, 叶柄 2 mm。叶纸质。羽状脉, 曲行环结脉序。中脉基部强, 上部渐细弱, 侧脉细, 8 对左右, 近对生, 伸出角 45°左右, 呈弧形伸向叶缘, 并向上弯曲形成环结。三级脉不太清楚。

讨论　标本的叶形和脉络与我国云南、印度和菲律宾等地生长的西南宿苞豆(*Shuteria vestita* Wight and Arnott.)有些类似, 但现生种的侧脉数目较少, 叶片也略小些, 可与当前标本相区别。研究标本是正负两面, 暂不定名。

槐属　***Sophora* Linnaeus, 1753**

华槐　***Sophora mioj aponica* Hu and Chaney**

(图版Ⅳ, 图 1—5)

1940　*Sophora mioj aponica*, Hu and Chaney, p. 53, pl. 27, figs. 1, 3.

1961　*Sophora mioj aponica*, Tanai, p. 347, pl. 24, figs. 13, 14, 21, 22.

1963　*Sophora mioj aponica*, Tanai and Suzuki, p. 133, 134.

1982　*Sophora mioj aponica*, 陶君容、杜乃秋, 275 页。

1983　*Sophora mioj aponica*, 陶君容、陈明洪, 76 页。

讨论　标本的叶形、大小和脉络与我国山东临朐中新统山旺组的 *Sophora mioj aponica* Hu and Chaney (1940, p. 53) 基本一致。此种还发现于云南腾冲和临沧中新统, 以及日本本州中新统 Aniai 型植物群和北海道中新统 Yoshioka 植物群中。

杨柳科　**Salicaceae**

杨属　***Populus* Linnaeus, 1753**

腺齿杨　***Populus glandulifera* Heer, 1856**

(图版Ⅶ, 图 9)

1856　*Populus glandulifera*, Heer, p. 17, pl. 58, figs. 5—11; pl. 63, fig. 3.

1859　*Populus glandulifera*, Heer, p. 26, pl. 2, figs. 1, 2.

1893　*Populus glandulifera*, Knowlton, p. 104.

1936　*Populus glandulifera*, Hollick, p. 65, pl. 31, fig. 1; pl. 32, figs. 5, 6; pl. 116, fig. 1.

1940　*Populus glandulifera*, Hu and Chaney, p. 25, pl. 4, figs. 2, 3.

1959　? *Populus glandulifera*, Andreanszky, s. 124, taf. 35, fig. 6.

1978　*Populus glandulifera*,《中国新生代植物》编写组, 82 页, 图版 66, 图 1; 图版 67, 图 1, 6; 图版 68, 图 4; 图版 69, 图 5; 图版 70, 图 1。

讨论　此种我国曾发现于辽宁抚顺始新统计军屯组, 山东临朐中新统山旺组; 在欧洲发现于瑞士和匈牙利的中新统; 在美国发现于阿拉斯加的古新统或始新统、俄勒岗和华盛顿的中新统。这次发现于云南临沧的标本, 叶面积较小。

桦木科　**Betulaceae**

桦木属　***Betula* Linnaeus, 1753**

明叶桦　***Betula mioluminifera* Hu and Chaney, 1940**

(图版Ⅶ, 图 7)

1940　*Betula mioluminifera*, Hu and Chaney, p. 30, 31; pl. 5, figs. 5, 6; pl. 7, figs. 1–3.

1955　*Betula mioluminifera*, Tanai, pl. 2, figs. 7, 8.

1959　*Betula mitai*, Tanai and Onoe, p. 276, pl. 2, figs. 1–3, 4.

1961　*Betula mioluminifera*, Tanai and Onoe, p. 286, pl. 8, fig. 3.

1963　*Betula mioluminifera*, Tanai and Suzuki, p. 113, pl. 8, figs. 1, 7.

1978　*Betula mioluminifera*,《中国新生代植物》编写组, 62 页, 图版 47, 图 1, 5; 图版 48, 图 2, 4, 6, 9; 图版 50, 图 8, 10, 11; 图版 51, 图 5。

讨论　本种首次发现于我国山东临朐中新统山旺组, 后来在日本中新世地层中也广泛发现。Tanai (1961) 以为它是日本中中新世 Aniai 型植物群的代表性植物, 它与北美中新统常见的 *Betula fairii* Knowlton (Knowlton, 1926, p. 33, pl. 17, fig. 7) 和 *Betula largei* Knowlton 也很相似, 并可与广布于欧洲中新统的 *Betula prisca* Ettings. 和 *Betula brongniarti* Ettings. 比较。

壳斗科　**Fagaceae**

栲属　***Castanopsis* (D. Don) Spach, 1841**

宝石栲(新种)　***Castanopsis gemmifolia* sp. nov.**

(图版Ⅴ, 图 6, 7)

词源　*Gemma*, 拉丁语, 意思是宝石; *folia*, 拉丁语, 意为叶片。

正模　PB 12834。

描述　叶椭圆形, 长 6 cm 左右, 宽 2 cm 左右, 叶尖急尖, 基部楔形, 边缘全缘, 顶端急尖, 有 2 或 3 对小齿突, 叶柄未保存。叶革质。羽状脉, 环结脉序。中脉较强, 直伸。侧脉 10 对左右, 近对生, 伸出角 60°左右, 伸向叶缘形成脉环, 其分叉, 垂直于侧脉。四级脉形成不规则的网。

讨论　标本的叶形、大小、脉络和伸出角与云南

南部海拔 1 100—1 900 m 的小叶栲 [*Castanopsis carlesii (Hemsl.) Hayata var. spinulosa* W. C. Cheng and C. S. Chao] 相似, 但该现生种叶的叶尖尾尖, 基部宽楔形而不同于化石种。

短椆栲(新种) ***Castanopsis brevijucunda* sp. nov.**
(图版Ⅴ, 图 1—5)

词源 *Brevi-*, 拉丁语, 意思是简短的、短时的; *jucunda*, 拉丁语, 现代植物种名。

正模 PB 12837。

描述 叶椭圆形, 长 8 cm 左右, 宽 3 cm 左右, 叶尖渐尖, 基部宽楔形, 叶基部全缘, 中、上部有疏齿, 叶柄 3 mm。叶薄革质。环结—直行脉序。中脉粗强, 稍弯曲。侧脉粗壮, 14—16 对, 对生或近对生, 伸出角 45°—60°, 微呈弧形平行伸入叶缘齿端, 基部侧脉在近叶缘形成环结, 三级脉明显, 简单或偶分枝, 近乎垂直于侧脉。四级脉不清楚。

讨论 标本的叶形、叶齿和脉络与广布于我国长江以南海拔 700 m 左右山坡上生长的东南栲 (*Castanopsis jucunda* Hance) 甚相似, 但该现生种面积较大, 侧脉数目少(8—12 对), 区别显著。

青冈属 ***Cyclobalanopsis* Oersted, 1866**

歪斜青冈 ***Cyclobalanopsis mandraliscae* (Gaudin) Tanai, 1953**
(图版Ⅴ, 图 8—10)

1953 *Cyclobalanopsis mandraliscae* (Gaudin) Tanai, p. 3, pl. 1, figs. 6—9.

1970 *Cyclobalanopsis mandraliscae*, Ishida, p. 76, pl. 7, fig. 7.

描述 叶披针形, 估计长 5—8 cm, 宽 2 cm 左右, 叶尖缺失, 估计渐尖, 叶片最宽处在下部, 基部歪斜, 宽楔形, 边缘锯齿缘, 叶柄 2 mm。叶坚纸质。羽状脉, 直行脉序。中脉中粗, 稍弯曲。侧脉 8—10 对, 近对生, 伸出角 50°—60°, 直达齿端。三级脉不太清楚。

讨论 此化石种在中国首次发现。标本的叶形和叶脉特征与日本能登半岛中新统 Yanagida 组的 *Cyclobalanopsis mandraliscae* (Gaudin) Tanai (Tanai, 1953; Ishida, 1970) 较一致。日本的标本叶缘齿较尖锐, 叶柄长 1 cm, 这些可能是地区性的生态差异引起的。

古滇青冈 ***Cyclobalanopsis paraschottkyana* (Wang and Liu) comb. nov.**
(图版Ⅴ, 图 11; 图版Ⅵ, 图 1)

1978 *Quercus paraschottkyana* Wang and Liu, 《中国新生代植物》编写组, 52 页, 图版 36, 图 5; 图版 38, 图 5。

讨论 标本的叶形、大小、叶齿和侧脉数目等特征与云南景谷渐新统的 *Quercus paraschottkyana* Wang and Liu 基本一致。原定名者将此化石种与现生种 *Quercus schottkyana* Rehder and E. H. Wilson 进行比较, 因为现生种被改归 *Cyclobalanopsis* 属中, 故化石种也应易归其属名。

石栎属 ***Lithocarpus* Blume, 1825**

弯肋石栎(新种) ***Lithocarpus flexicostatus* sp. nov.**
(图版Ⅴ; 图 12, 13)

词源 *Flexus*, 拉丁语, 意思是弯曲; *costa*, 拉丁语, 意为肋骨、粗脉。

正模 PB 12849。

描述 叶倒披针形, 保存长度 8 cm, 宽 2—2.5 cm, 叶尖缺失, 估计渐尖, 基部楔形, 边缘全缘, 叶片左右不对称, 叶柄长 8 mm。叶薄革质, 羽状脉, 环结脉序。中脉粗壮, 弯曲。侧脉 10—13 对, 伸出角 40°—50°, 伸至叶缘向上弯曲形成脉环, 三级脉细而稀疏, 不太明显, 横贯于侧脉间。

讨论 标本的叶形、大小和脉络与云南中部 1 500—2 300 m向阳山坡的光叶石栎[*Lithocarpus mairei* (Schottky) Rehder] 相似, 但该现生种叶柄较长, 1—15 cm, 叶原革质, 叶缘向外翻卷, 可与化石种区别。此新种与 *Lithocarpus lancifolius* Wang 的叶形也有些相似, 但后者侧脉坚强, 排列较密。

灰石栎(新种) ***Lithocarpus ravidifolius* sp. nov.**
(图版Ⅴ, 图 14, 15)

词源 *Ravidus*, 拉丁语, 意思是浅灰色的; *folius*, 拉丁语, 意为叶片。

正模 PB 12860。

描述 叶椭圆状披针形、倒披针形, 长 6 cm 以上, 宽 1.4—2 cm, 顶端渐尖, 基部楔形, 边缘全缘, 叶柄未保存。叶革质。羽状脉, 环结脉序。中脉粗强, 直伸或稍弯, 侧脉细, 15—18 对, 近对生, 伸出角 40°—50°, 伸至叶缘向上弯曲形成脉环。三级脉简单或分叉, 垂直于侧脉。四级脉不太清楚。

讨论 标本的叶形、大小与云南东部海拔 1 100—2 400 m 山地杂木林中生长的窄叶石栎 (*Lithocarpus confinis* C. C. Chang) 接近, 但该现生种的侧脉较稀疏, 具间脉, 有别于化石种。这两种

的叶甚下延, 叶缘都微向外翻卷, 反映二者之间有一定亲缘关系。

健壮石栎 (新 种)　***Lithocarpus validifolius* sp. nov.**

(图版 Ⅵ, 图 10—12)

词源　*Validus*, 拉丁语, 强壮、健康之意; *folius*, 拉丁语, 意为叶片。

正模　PB 12861。

描述　叶宽倒披针形, 长 8 cm 左右, 宽 2. 5—3 cm, 叶尖短渐尖, 基部楔形, 边缘全缘, 叶柄 8 mm, 微弯曲。叶薄革质, 羽状脉, 环结脉序。叶脉基部粗强, 上部细弱, 直伸或稍弯曲。侧脉细, 12—15 对, 近对生, 伸出角 40°—45°, 近乎平行地伸向叶缘, 并向上弯曲形成脉环。它们以直角或钝角相连接。三级脉明显, 简单或分叉, 贯穿于侧脉间, 有时呈 S 形弯曲。四级脉不明显。

讨论　标本的叶形、大小、侧脉数目和布置相似于我国西南海拔 1 300—2 700 m 湿润山地林中的滇石栎 [*Lithocarpus dealbatus* (Hook. f. and T. Thomas ex Miq.) Rehder], 但该现生种叶片叶尖渐尖或尾尖, 侧脉数目较少, 9—12 对, 与化石种有区别。

显脉石栎　***Lithocarpus renifolius* Tao, 1983**

(图版 Ⅵ, 图 2—9)

1983　*Lithocarpus renifolius* Tao, 陶君容、陈明洪, 81 页, 照片版 14-5; 15-4。

讨论　标本的叶形、大小、侧脉数目和布置均与 *Lithocarpus renifolius* Tao 一致。此种曾发现于云南临沧勐托中新世地层中。

石栎(未定种)　***Lithocarpus* sp.**

(图版 Ⅵ, 图 13)

描述　叶宽披针形, 长 5 cm 以上, 宽约 4. 8 cm, 叶尖缺失, 估计钝尖, 基部宽楔形, 边缘全缘, 仅顶端有 2 或 3 对锯齿, 叶柄未保存。叶薄革质。羽状脉, 环结脉序。中脉中粗, 直伸。侧脉中粗, 估计 13—15 对, 近对生, 伸出角约 50°, 伸至叶缘向上弯曲形成脉环, 它们以钝角相连接。三级脉细, 在侧脉间形成大网。四级脉纤细, 形成不规则的小网。

讨论　当前标本的叶形和脉络与我国南方海拔 1 000 m 以下山坡生长的 *Lithocarpus uraianus* (Hayata) Hayata 相似, 但该现生种侧脉较粗强, 叶上部有明显锯齿而不同于当前标本。

栎属　***Quercus* Linnaeus, 1753**

宽叶栎　***Quercus latifolia* Li, 1978**

(图版 Ⅵ, 图 14)

1978　*Quercus latifolia* Li,《中国新生代植物》编写组, 50 页, 图版 29, 图 3; 图版 39, 图 2。

讨论　当前标本是保存不完整的叶化石, 其形态和脉络与产自云南景谷渐新统蔡家冲组的 *Quercus latifolia* Li 的特征甚一致。

破叶栎(新种)　***Quercus mutilatifolia* sp. nov.**

(图版 Ⅵ, 图 15, 16)

词源　*Mutilatus*, 拉丁语, 意思是破残的; *folia*, 拉丁语, 意为叶片。

正模　PB 12983。

描述　叶椭圆形或长倒卵形, 长 6 cm 以上, 宽 3—3. 5 cm, 叶尖钝尖, 基部宽楔形, 中、上部边缘有锯齿, 上齿边 1 mm, 下齿边 5—10 mm, 叶柄长 5 mm。叶坚纸质。羽状脉, 达缘脉序。中脉粗强, 直伸或稍弯, 侧脉 13 对左右, 近对生, 伸出角约 45°, 直伸叶缘齿端。三级脉细, 分叉或不分叉, 横贯侧脉间。四级脉不太清楚。

讨论　标本叶形、大小、叶基部全缘和脉络等与云南和四川海拔 1 100—2 600 m 山地生长的锥连栎(*Quercus franchetii* Skan.) 的特征接近, 但该现生种叶片较宽 (2. 5—7. 5 cm), 侧脉较少 (8—11 对), 有别于化石新种。

相仿栎　***Quercus simulata* Knowlton, 1926**

(图版 Ⅶ, 图 1, 2)

1926　*Quercus simulata* Knowlton, p. 38, pl. 22, figs. 3, 4.

1956　*Quercus simulata*, Axelrod, p. 291, pl. 7, fig. 3; pl. 8, fig. 1; pl. 20, figs. 1—3; pl. 27, fig. 4.

1985　*Quercus simulata*, Axelrod, p. 148, pl. 10, figs. 4—6; pl. 26, figs. 6—9.

描述　叶披针状矩形, 估计 5—8 cm, 宽 1. 5 cm, 叶尖渐尖, 基部楔形, 叶片稍偏斜, 边缘全缘, 叶柄水平保存。叶革质。羽状脉, 环结脉序。中脉中粗而坚强, 上下几乎等粗, 稍弯曲。侧脉细, 估计 14—18 对, 近对生, 伸出角 60° 左右, 伸至叶缘向上弯曲形成环结。三级脉细, 简单或分叉, 垂直于侧脉。四级脉形成多边形大网。五级脉形成多边形或圆形小网。

讨论　标本的叶形、大小和叶缘特征与美国西部哥伦比亚高原中新统 Latah 组和内华达中新统至

上新统化石植物群中的 *Quercus simulata* Knowlton (Knowlton, 1926, p. 38; Axelrod, 1956, p. 291) 一致, 有些作者 (Berry, 1931, p. 36; MacGinitie, 1933, p. 53; La Motte, 1936, p. 122; Dorf, 1936, p. 155; Chaney and Axelrod, 1959, p. 171) 将一些形态不同和叶缘有齿的标本也纳入此种。但 Knowlton (1926, p. 38) 认为此化石种的叶为披针形, 边缘全缘, 笔者接受原定名者意见。《中国新生代植物》编写组(1978, 55 页)归入 *Quercus simulata* 的标本可能与 *Quercus consimilis* Newberry 有关系。

栎(未定种) ***Quercus* sp.**

(图版Ⅶ, 图 3, 4)

描述 坚果, 扁球形, 高 2.3 cm, 宽 3 cm, 叶尖略突起, 基部稍凹陷, 果体有纵纹。

讨论 标本为一坚果的正负面, 其特征与栎属坚果相似。在栎属中这样的果实甚为常见, 无法确定种级亲缘关系。

大麻科 **Cannabaceae**

朴属 ***Celtis* Linnaeus, 1753**

中新朴 ***Celtis miobungeana* Hu and Chaney, 1940**

(图版Ⅳ, 图 8)

1940 *Celtis miobungeana*, Hu and Chaney, p. 39, pl. 13, figs. 2, 5, 6.

1973 *Celtis miobungeana*, 陶君容、孔昭宸, 123 页, 图版 3, 图 2。

1978 *Celtis miobungeana*, 《中国新生代植物》编写组, 37 页, 图版 24, 图 5; 图版 26, 图 4, 5。

讨论 标本的叶形、大小和脉络与山东临朐中新统山旺组的 *Celtis miobungeana* Hu and Chaney (1940, p. 39) 基本一致, 唯一的差别是当前标本叶缘全缘, 而山旺组的标本有明显锯齿。与此化石类似的现生种黑弹树(*Celtis bungeana* Blume) 也屡见其叶缘具不明显锯齿或全缘现象。《中国新生代植物》编写组(1978, 37 页) 将此化石种名改为现生名似乎不太妥当。因为中新世中期距今将近二千万年, 在如此漫长的岁月里植物是会变化的, 从应用方面考虑, 也最好将化石种与现生种分开, 以免引起误解。当然, 如果从叶片化石形态、解剖构造和叶脉特征等诸方面确实证明与现生种完全一致, 也可以用现生种命名化石标本, 如第四纪的植物叶化石即经常用现生种命名。

桑科 **Moraceae**

榕属 ***Ficus* Linnaeus, 1753**

前菩提树(新种) ***Ficus proreligiosa* sp. nov.**

(图版Ⅳ, 图 6, 10, 11)

词源 *Pro-*, 拉丁语, 意思是居前, 领先; *religiosus*, 拉丁语, 意为虔诚, 现代植物种名。

正模 PB 12872。

描述 叶中等宽卵形至长卵形, 长 6 cm 以上, 宽 3—6 cm, 叶尖短渐尖, 基部宽楔形, 边缘全缘, 叶柄未存。叶薄革质。羽状脉, 环结脉序, 中脉较粗强, 稍弯曲。侧脉 6—9 对, 半对生, 直伸或略弯曲, 伸出角 50°—60°, 伸至叶缘微向中弯曲形成脉环在侧脉中间连接形成长方形、四方形或五边形网。四级脉形成不规则多边形网。五级脉形成多边形细网。网内有简单的盲脉。叶缘具流苏状边缘。

讨论 标本的叶形、大小, 特别是叶脉构造和布置, 与印度的现生种菩提树(*Ficus religiosa* L.) 十分相似, 但二者也有明显的区别。

Ficus proreligiosa sp. nov. 的叶片特征为: 叶形长卵形, 宽卵形; 叶基浑圆, 截圆形; 叶尖短渐尖; 基侧脉很不明显; 五级脉网孔小; 盲脉不分叉。

Ficus religiosa 的叶片特征为: 叶形为心形、三角形; 叶基心形; 叶尖尾尖; 基侧脉甚强, 并有分枝; 五级脉网孔大; 盲脉有分叉。

但无论如何, 此化石种和现生种间在叶形和叶脉构造上有很密切的关系, 菩提树的祖先在中新世可能曾分布到我国云南境内。

冬青科 **Aquifoliaceae**

冬青属 ***Ilex* Linnaeus, 1753**

细网冬青(新种) ***Ilex ornatinervosa* sp. nov.**

(图版Ⅻ, 图 5, 6)

词源 *Ornatus*, 拉丁语, 意思是装饰的; *nervosa*, 拉丁语, 意思是神经、叶脉。

正模 PB 12877。

描述 叶椭圆形, 长 6—8 cm, 宽 2—3 cm, 叶尖短渐尖, 基部宽楔形, 边缘具不明显的疏锯齿, 叶柄 5 mm。叶革质。羽状脉, 环结脉序。中脉粗而强, 直伸。侧脉细, 12—14 对, 近对生, 伸出角 60° 左右。伸向叶缘途中分叉与相连, 环外侧脉连成脉环, 它们以锐角或直角相连, 环外有一系列次级环。三级脉细, 稀疏而明显, 不规则地连接着侧脉, 形成大网。四级脉细而清晰, 形成不定形的多边形网。五级脉形成细网。

讨论 标本保存尚好, 叶脉清晰, 其叶形、大小

和叶脉构造等特征与我国长江以南的现生种冬青(*Ilex purpurea* Hassk.) 相似, 但现生种的叶齿大而明显, 侧脉伸出角较小, 40°—50°, 与化石种可以区别。

铁青树科　**Olacaceae**

青皮木属　***Schoepfia* Schreb., 1789**

优雅青皮木(新种)　***Schoepfia elegantifolia* sp. nov.**

(图版X, 图 10, 14; 图版XI, 图 1)

词源　*Elegantus*, 拉丁语, 意思是优美、雅致; *folium*, 拉丁语, 意为叶片。

正模　PB 12878。

描述　叶卵形, 长 5.3—6.5 cm, 宽 3 cm 左右, 叶尖钝尖, 基部宽楔形或浑圆, 边缘全缘, 叶柄未保存。叶纸质。羽状脉, 弧形环结脉序。中脉中粗, 直伸或稍弯曲, 侧脉细, 4—6 对半对生至互生, 伸出角 30°—40°, 基部的两对侧脉排列较紧挤, 侧脉偶有分叉, 呈弧形伸向叶缘, 并向上弯曲形成脉环。最基部一对侧脉向外有若干细的分枝, 并在叶缘处形成环结。三级脉基细, 贯穿于侧脉间。四级脉不太清楚。

讨论　标本的叶形、大小、侧脉数目及布置与生长在我国长江以南山坡 500—2 600 m 上阔叶常绿林中的青皮木(*Schoepfia jasminodora* Sieb. and Zucc.) 十分相似, 但该现生种的叶的叶尖渐尖, 叶基圆形, 叶片多少沿叶柄下延, 与化石种有明显差异。

青皮木属的化石是首次发现。此属大约有 30 种分布于热带和亚热带美洲和亚洲。中国有 4 种, 其中一种是特有种。近来, 分子生物学证据表明, 此属与铁青树科并无密切关系。

桑寄生科　**Loranthaceae**

桑寄生属　***Loranthus* Jacq., 1762**

欧洲桑寄生　***Loranthus palaeoeuropaeus* Kutuzk., 1960**

(图版XI, 图 2)

1960　*Loranthus palaeoeuropaeus* Kutuzk., Kutuzkina, str. 140, tabl. 1, figs. , B.

1964　*Loranthus palaeoeuropaeus*, Kutuzkina, str. 200, tabl. 7, figs. 15, 16.

描述　叶倒卵形, 长 3.6 cm, 宽 2.1 cm, 叶尖钝圆, 基部宽楔形, 边缘全缘, 叶柄 3 mm。叶厚纸质。羽状脉, 环结脉序。中脉基部较粗, 上部甚细, 稍弯曲。侧脉细, 但离基 5 mm 处有两对侧脉较强, 排列也较紧密, 伸出角 30°—40°, 伸至叶缘形成脉环。三级脉细, 隐约可见, 与侧脉相连。四级脉形成多边形网。

讨论　标本的叶形和叶脉构造与前苏联高加索中新世 Sarmatian 期 Armavir 植物群中的 *Loranthus palaeoeuropaeus* Kutuzkina (1964, p. 200) 的特征基本一致, 只是前苏联高加索的标本叶面积略小些, 长 2.5 cm, 宽 1.25 cm。Kutuzkina 认为此化石种与中南欧仅有的现生种 *Loranthus europaeus* L. 的叶片特征相似。

桑寄生属约有 5 种, 分布于亚洲和欧洲的温带和亚热带地区, 中国有 5 种, 其中 3 个种是特有种。

鼠李科　**Rhamnaceae**

勾儿茶属　***Berchemia* Neck., ex DC. 1825**

纱巾勾儿茶(新种)　***Berchemia calymmatophylla* sp. nov.**

(图版IV, 图 7)

词源　*Calymma* 是旧希腊语 *kalymma* 的变形, 意思是面纱; *phylla*, 希腊语, 意为叶片。

正模　PB 12882。

描述　叶椭圆形, 长 7 cm 左右, 宽约 4 cm, 叶尖缺失, 基部宽楔形, 边缘全缘, 叶柄未保存。叶坚纸质。羽状脉, 缘行环结脉序。中脉粗强, 直伸。侧脉细, 14—16 对, 近对生, 伸出角约 50°左右, 平行地伸达叶缘沿缘向上微弯形成脉环。三级脉细, 与侧脉斜交, 形成长方形网。四级脉不清楚。

讨论　标本的叶形、大小和脉络与中亚和南欧的现生种 *Berchemia scandens* (Hill) K. Kock 的特征甚接近, 它们都具有宽楔形的叶基, 但该现生种的侧脉只有 9—12 对而不同于化石种。此新种与山东临朐中新统山旺组的 *Berchemia miofloribunda* Hu and Chaney (1940, p. 65, pl. 9, fig. 5; pl. 40, figs. 2, 3) 的区别在于后者的叶基为心形。

芸香科　**Rutaceae**

九里香属　***Murraya* J. Koenig ex Linnaeus, 1771**

九里香(未定种)　***Murraya* sp.**

(图版X, 图 7)

描述　侧生小叶, 卵状镰刀形, 两侧不对称, 长 3 cm 左右, 宽约 11 mm, 叶尖钝尖, 基部歪楔形, 边缘全缘, 小叶柄甚短。叶纸质。羽状脉, 环结脉序。中脉强, 弯伸。侧脉细, 12 对左右, 伸出角约 50°, 伸至叶缘向上弯曲形成环结。三级脉细, 形成不明显的网。

讨论 标本的叶形、大小和两侧不对称性与我国广东、云南 500—1 600 m 湿生林中灌木或小乔木麻绞叶(调料九里香)[*Murraya koenigii* (L.) Spreng.]接近,但麻绞叶的小叶边缘有细钝锯齿,与化石种不同。

花椒属 ***Zanthoxylum* Linnaeus, 1753**

折叶花椒(新种) ***Zanthoxylum refractifolium* sp. nov.**

(图版X,图 2, 3)

词源 *Refractus*,拉丁语,意思是折、破;*folium*,拉丁语,意为叶片。

正模 PB 12985。

描述 侧生小叶,椭圆形,左右不对称,长 9 cm,宽约 2.8 cm,叶尖缺失,估计短渐尖或钝尖,基部楔形,偏斜,边缘具不明显的细锯齿,小叶柄仅存 4 mm。叶纸质。羽状脉,环结脉序。中脉粗强,稍弯曲。侧脉细,14—16 对,近对生,伸出角 40°—50°,侧脉伸至叶缘分叉,并互相连接成脉环,其外侧又有二、三级脉环。间脉与三级联合。三级脉细,形成不规则的大网。四级脉局部可见,形成多边形小网。

讨论 标本的叶形,特别是叶脉构造和布置与我国南方海拔 300—2 600 m 的木本攀援植物蚬壳花椒(*Zanthoxylum dissitum* Hemsl.)接近,但该现生种的小叶甚大,长 6—7 cm,宽 3—6 cm,边缘全缘或波状,与化石种有差异。云南南部的现生种云南花椒(*Zanthoxylum yunnanense* C. C. Huang)叶形、大小、叶齿和侧脉数目与化石种类似,但云南花椒的侧脉伸出角较大也易与化石种区别。

楝科 **Meliaceae**

香椿属 ***Toona* (Endl.) M. Roem, 1846**

圆基香椿 ***Toona bienensis* (Hu and Chaney) Tao, 1978**

(图版X,图 4, 5)

1940 *Cedrela bienensis*, Hu and Chaney, p. 54, pl. 30, fig. 2.

1978 *Toona bienensis*,《中国新生代植物》编写组,122 页,图版 103,图 1。

讨论 标本的叶形和大小与我国山东临朐中新统山旺组的圆基香椿基本一致,当前标本的叶缘具不明显的齿端腺体,侧脉伸出角稍大于山旺组的标本。此化石种与在我国南方海拔 100—2 900 m 生长的落叶大乔木 *Toona sinensis* (A. Jussieu) M. Roemer 类似,该现生种也分布于南亚和东南亚。

山楝属 ***Aphanamixis* Blume, 1852**

山楝(未定种) ***Aphanamixis* sp.**

(图版X,图 1)

描述 叶椭圆状矩形,两侧不对称,长 9 cm 以上,宽 3.5 cm 左右,叶尖缺失,基部歪斜,宽楔形,叶柄未保存。叶薄革质。羽状脉,环结脉序。中脉强,弯伸。侧脉细,约 16 对左右,伸出角约 60°,伸至叶缘向上弯曲汇合成脉环。三级脉细,不太清楚。

讨论 标本的叶和脉络与我国南方海拔 500—1 200 m 生长的的华山楝[*Aphanamixis polystachya* (Wall.) R. N. Parker]接近,但该现生种叶面积甚大,长 9—26 cm,宽 3—6 cm,侧脉凸起而与当前标本有很大区别。

漆树科 **Anacardiaceae**

盐肤木属 ***Rhus* Linnaeus, 1753**

多脉盐肤木(新种) ***Rhus mortinerva* sp. nov.**

(图版IX,图 5, 10)

词源 *Mort*,拉丁语,意思是多量的;*nerva*,拉丁语,意为叶脉。

正模 PB 12892。

描述 小叶椭圆形,长 7 cm 左右,宽 2.5 cm,叶尖缺失,估计渐尖,基部稍不对称,宽楔形,边缘全缘,小叶柄未保存。叶纸质。羽状脉,环结脉序。中脉中粗,直伸;侧脉纤细,15 对左右,近对生,伸出角大,70°—80°,伸至叶缘向上弯曲形成脉环,并以钝角或平角互相连接,有些侧脉之间有间脉,有些没有间脉。三级脉细,形成不规则的大网。四级脉形成多边形小网。

讨论 标本的叶形、大小和叶脉特征介于我国云南和四川海拔 350—2 300 m 现生的川麦杨(*Rhus willsonii* Hemsl.)和华中及西南海拔 2 000 m 左右生长的青麦杨(*Rhus potaninii* Maxim.)之间。当前化石种的叶基楔形,叶片两侧不对称,与川麦杨相似;而叶片大小和脉络又接近于青麦杨。

黄连木属 ***Pistacia* Linnaeus, 1753**

华黄连木 ***Pistacia miochinensis* Hu and Chaney, 1940**

(图版IX,图 8, 9)

1940 *Pistacia miochinensis* He and Chaney, p. 62, pl. 36, figs. 1, 2, 5, 9.

1955 *Pistacia miochinensis*, Tanai, pl. 14, figs. 3, 4.

1960 *Pistacia miochinensis*, Kolakovsky, str. 35, tabl. 1, fig. 1

1978　*Pistacia miochinensis*,《中国新生代植物》编写组, 115 页, 图版 95, 图 2, 3, 6; 图版 96, 图 6。

1983　*Pistacia miochinensis*, 陶君容、陈明洪, 77 页。

讨论　当前标本的叶形和叶脉特征与山东临朐中新统山旺组的 *Pistacia miochinensis* Hu and Chaney 基本一致, 当前标本的侧脉较稀疏, 伸出角较窄。此化石种也见于前苏联高加索的上新统, 日本中新统和我国云南剑川中新统双河组。

漆属　***Toxicodendron* Mill., 1754**

古野漆　***Toxicodendron miosuccedaneum* (Hu and Chaney) comb. nov.**

(图版 IX, 图 3, 4)

1920　*Rhus succedanea*, Florin, s. 22, taf. 3, fig. 13.

1940　*Rhus miosuccedanea* Hu and Chaney, p. 63, pl. 35, fig. 3b; pl. 36, figs. 6, 8; pl. 37, figs. 1, 3.

1955　*Rhus miosuccedanea*, Tanai, pl. 14, figs. 1, 4.

1978　*Rhus miosuccedanea*,《中国新生代植物》编写组, 116 页, 图版 94, 图 1—3; 图版 95, 图 1, 7。

1983　*Rhus miosuccedanea*, 陶君容、陈明洪, 77 页。

讨论　标本的叶形和叶脉特征与产自山东临朐中新统山旺组的 *Rhus miosuccedanea* Hu and Chaney 基本一致。Hu 和 Chaney 认为此化石种与野漆 *Rhus succedanea* Linn. 相似, 但野漆现被改归 *Toxicodendron succedaneum* (L.) O. Kuntze, 故此化石种也应易名。此化石种也曾见于河北张家口渐新统和日本中新统。

斜叶漆(新种)　***Toxicodendron inaequilaterum* sp. nov.**

(图版 IX, 图 12—14)

词源　*Inaequilatus*, 拉丁语, 意思是两则不对称的。

正模　PB 12897。

描述　复叶的小叶的侧生叶片长椭圆形, 斜方形, 估计长 6—10 cm, 宽 2.5—3.6 cm, 叶尖短渐尖, 基部斜楔形, 叶全缘, 叶柄长 1 cm, 叶纸质。叶脉羽状, 环节脉序; 中脉中等粗, 直伸或稍弯曲; 侧脉 14—20 对, 近对生, 自中脉的伸出角约 60° 伸至叶缘, 其末端与第三级脉相互连接形成缘内脉环, 三级脉清晰, 近轴的三级脉比远轴的较粗, 并在侧脉的中间突然变细形成轭状弯曲的网状; 第四级脉可见, 形成不规则的五边形和多边形网。

讨论　当前标本小叶的形状、大小、斜楔形叶基及侧脉的分布类似于云南和西藏现代生长于海拔 1 600 m 的 *Toxicodendron caudatum* C. C. Huang and T. L. Ming。但该现生种具有伸长的叶尖和更多的侧脉与当前叶化石有明显的区别。

Toxicodendron 属约有 20 种, 落叶灌木或乔木, 很少是木质藤本, 具有奇数羽状复叶, 三小叶或单叶, 此属的有些种在东亚和北美间断分布, 有 16 种分布在中国南部, 其中有 6 种是中国特有种。

胡桃科　**Juglandaceae**

黄杞属　***Engelhardia* Lesch. ex Blume, 1825**

硬叶黄杞(新种)　***Engelhardia sclerophylla* sp. nov.**

(图版 VII, 图 5, 6, 11)

词源　*Scleros*, 旧希腊语 *skleros* 的变形, 意思是硬的; *phylla*, 希腊语, 意为叶片。

正模　PB 12902。

描述　小叶矩形, 长 5.5—7 cm, 宽 3.5—4.2 cm, 叶尖钝圆, 偶见缺刻, 基部不对称, 宽楔形, 边缘全缘, 叶柄缺失。叶革质。羽状脉, 环结脉序。中脉粗, 直伸或上部稍曲折, 侧脉粗, 8—10 对, 互生, 伸出角 40°—70°, 自下而上变窄, 伸至叶缘向上弯曲形成脉环, 环角为直角或钝角。三级脉粗, 简单或偶分叉, 稍弯曲, 贯穿于侧脉间。四级脉隐约可见, 形成多边形网。

讨论　当前标本的叶形、侧脉数目和脉络与印度和我国西南山坡 1 400 m (最高 2 000 m) 的毛叶黄杞 [*Engelhardia spicata* var. *colebrookeana* (Lindley) Koorders and Valeton] 接近, 但该现生种的叶面积甚大, 长 5—15 cm, 宽 3—7 cm, 叶片端圆形, 可区别于化石种。黄杞属的花粉曾发现于丹麦中新世地层中(Larsson *et al.*, 2006)。

山榄科　**Sapotaceae**

铁榄属　***Sinosideroxylon* (Engler) Aubr v., 1963**

临沧铁榄(新种)　***Sinosideroxylon lincangense* sp. nov.**

(图版 XI, 图 8—10)

词源　*Lincang*, 化石产地的汉语拼音。

正模　PB 12907。

描述　叶卵状披针形, 两侧不对称, 长 3.5—7 cm, 宽 1.2—3 cm, 叶尖渐尖, 基部偏斜, 宽楔形。边缘全缘, 叶柄缺失。叶纸质。羽状脉, 环结脉序。中脉强, 弯曲。侧脉细, 曲折, 12—14 对伸出角约 50°, 伸至叶缘形成脉环, 有间脉, 三级脉不太清楚。

讨论　这个属的化石是我国首次发现。化石的

叶形和大小与美国田纳西始新统中 *Sideroxylon* (*Bumelia*) *pseudolycioides* Berry (Berry, 1930, p. 128, pl. 44, fig. 20) 的标本颇相似, 但美国标本侧脉数目较少, 也较粗, 因而, 当前标本与美国标本区别明显。

铁榄属的化石种已记载近 20 种, 它们发现于美国始新统至上新统及前苏联高加索的中新统至更新统。属名 *Sideroxylon* 在 1963 年被更改为 *Sinosideroxylon* (Engler) Aubr v, 其现生种生长于中、南美洲、西印度群岛及越南北部, 约 100 种; 我国有 3—4 种, 乔木或灌木, 分布于我国南部及西南部。

金叶树属 ***Chrysophyllum* Linnaeus, 1753**

中国金叶树(新种) ***Chrysophyllum sinicum* sp. nov.**

(图版 XI, 图 11, 12)

词源 *Sinicum*, 拉丁语, 为中国之意。

正模 PB 12909。

描述 叶椭圆形, 长 5 cm 左右, 宽 2.9 cm, 叶尖钝尖, 基部宽楔形, 边缘全缘, 叶柄长 1 cm。叶厚革质。羽状脉, 环结脉序。中脉粗壮, 基部尤甚, 稍弯曲。侧脉纤细, 20 余对, 伸出角 50°—60°, 近乎平行, 伸达叶缘, 沿叶缘形成脉环。三级脉细, 形成不规则的枝形网。

讨论 标本的叶形和叶脉构造与美国加利弗尼亚始新世或早渐新世 La Porte 组植物群中的 *Chrysophyllum conforme* Potbury (Potbury, 1935, p. 77, pl. 12, fig. 1) 有些相似, 但美国的种叶面积较大而不同。与我国南方生长的金叶树 [*Chrysophyllum lanceolatum* (Blume) A. DC. var. *stellatocarpon* P. Royen] 的叶形和叶脉构造也接近, 但该现生种叶片大, 叶尖长渐尖, 可与化石种区别。

Chrysophyllum 属与 *Syzygium* 属一些种的叶形和叶脉相似, 但前者侧脉甚密集, 侧脉在边缘处连接成缘周脉; 后者侧脉较稀疏, 形成的缘周脉同叶缘有一些距离。

安息香科 **Styracaceae**

安息香属 ***Styrax* Linnaeus, 1753**

致美安息香(新种) ***Styrax pulchellus* sp. nov.**

(图版 XII, 图 2, 3)

词源 *Pulchellus*, 拉丁语, 意为美丽、标致。

正模 PB 12912。

描述 叶椭圆形或倒卵形, 长 6 cm 以上, 宽 3—3.8 cm, 叶尖钝尖, 基部楔形, 边缘全缘, 叶柄 4 mm。叶薄革质。羽状脉, 环结脉序。中脉直伸或稍弯曲。侧脉中粗, 5—6 对, 近对生, 伸出角 35° 左右, 伸向叶缘向上弯曲形成脉环, 环角为钝角, 基部侧脉的分枝形成次级脉环。三级脉细而稀疏, 近乎垂直于侧脉。四级脉不太清楚。

讨论 标本的叶形、大小和脉络与我国南部 100—2 000 m 阔叶混交林中生长的越南安息香 [*Styrax tonkinensis* (Pierre) Craib ex Hartwich] 十分相似, 但越南安息香的叶片叶尖渐尖, 可与化石种相区别。

安息香属有 10 余个化石种, 发现于北美古新统至更新统和前苏联高加索中新统至上新统。该属有约 130 现生种, 多数是大灌木或小乔木, 主要分布于北半球温带至热带, 东亚和东南亚地区分布最广, 也横穿赤道到达南美洲; 我国约有 30 种, 主要产于长江以南各地。

五福花科 **Adoxaceae**

荚蒾属 ***Viburnum* Linnaeus, 1753**

粗荚蒾(新种) ***Viburnum validum* sp. nov.**

(图版 XI, 图 7)

词源 *Validus*, 拉丁语, 意思是粗壮的、健康的。

正模 PB 12913。

描述 叶椭圆形, 长 5.5 cm, 宽 2.5 cm, 叶尖钝尖, 基部楔形, 叶下部边缘全缘, 上部微波状缘, 叶柄未保存。叶坚纸质。羽状脉, 环结脉序。中脉中粗, 直伸。侧脉强, 5—6 对近对生, 伸出角约 40°, 平行伸至叶缘而分枝, 互相连接成脉环。三级脉细, 近乎垂直于侧脉。四级脉形成不规则的网。

讨论 标本的叶形、大小、侧脉数目和布置与我国南方海拔 600—2 000 m 生长的常绿灌木直角荚蒾[*Viburnum foetidum* Wall. var. *rectangulatum* (Graebn.) Rehder] 有些近似, 但该现生种叶上部有不规则的疏浅齿, 侧脉具明显分枝, 易与当前标本区别。此新种与美国科罗拉多古新统 Raton 组中 *Viburnum speciosum* Knowlton (Knowlton, 1917, p. 347, pl. 3, figs. 1—5) 的叶形和叶脉构造也可比较, 但后者的叶面积较大, 叶上部具粗齿, 可以区别, 后者也曾发现于我国辽宁抚顺始新统计军屯组。

单子叶植物纲 **Monocotyledonae**

菝葜科 **Smilacaceae**

菝葜属　***Smilax* Linnaeus, 1753**

壮叶菝葜　***Smilax grandifolia*** **(Unger) Heer, 1855**

(图版Ⅱ, 图 8, 9)

1855　*Smilax grandifolia* Heer, s. 82, taf. 30, fig. 8.

1878　*Smilax grandifolia*, Lesquereux, p. 94.

1964　*Smilax grandifolia*, Iljinskaja, str. 129, tabl. 5, fig. 6; tabl. 6, fig. 4.

描述　叶卵圆形, 长 5 cm 多, 宽 4 cm 左右, 叶尖缺失, 基部心形, 边缘全缘; 叶柄缺失。叶革质。掌状脉, 五出, 聚顶脉序。中脉中粗, 微弯, 伸到叶顶, 内侧主脉伸出角 40°左右, 呈弧形伸向叶顶端, 外侧主脉两侧有若干纤细的侧脉, 伸出角约 60°, 与内侧主脉相连。内外侧主脉均有一些纤细的侧脉伸出。最外的侧脉在叶缘处连接成环结。三级脉紊乱, 形成不规则的多边形网。

讨论　标本的叶形、大小和脉络与发现于瑞士中新统的 *Smilax grandifolia* (Ung.) Heer 基本一致。该种也见于波兰中新统。在美国科罗拉多古新统也有此种化石发现。此化石种与现代生长在欧洲的 *Smilax excelsa* L. 类似。

菝葜属现有 300 种, 广布于南北两半球热带、亚热带和温带地区, 我国有 79 种, 39 种是特有种。菝葜属的化石最早出现于古新世和始新世的交界处(55 Mya), 此后, 该属化石在北半球各地广泛发现。

莎草科　**Cyperaceae**

似莎草属　***Cyperacites*** **Schimper, 1870**

似莎草(未定种)　***Cyperacites*** **sp.**

讨论　这个带状叶化石碎片与莎草科许多属的叶片均类似, 因保存破碎, 不能定名。似莎草属是个形态属名, 它包含与莎草科类似的器官而又无法确定其分类位置的化石。

分类位置不明的形态属　**Incertae Sedis**

石果属　***Carpolithes*** **Brongniart, 1822**

环翅石果(新种)　***Carpolithes orbitopterus*** **sp. nov.**

(图版Ⅰ, 图 12)

词源　*Orbita*, 拉丁语, 意思是圆的、环形的; *pterus*, 希腊语, 意为羽翼、翅。

正模　PB 12917。

描述　翅果圆盘状, 长约 2.8 cm, 宽 2.7 cm, 顶端缺失, 基部浑圆, 稍下延, 边缘全缘, 果柄 9 mm, 坚纸质。果翅具辐射的脉, 翅脉多少连接成网。种子位于翅果中央, 不发育。

讨论　标本保存不太完整。芸香科的 *Ptelea* 属, 莲叶桐科的 *Illigera* 属, 蓼科的 *Oxyria* 属, 鼠李科的 *Gouania* 属, 心翼果科的 *Peripterygium* 属, 使君子科的 *Combretum* 属等均有与当前翅果相似之处, 但也有很大区别, 当前标本归入形态属。

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THE LATE MIOCENE BANGMAI FLORA FROM LINCANG COUNTY OF YUNNAN, SOUTHWESTERN CHINA

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Summary

The late Miocene Bangmai Formation flora from Zhongzhai Town in the Lincang Municipality of Yunnan, southwestern China is made up mainly of fossil leaves. It comprises 37 families, 59 genera and 71 species (including 37 new species) in total. Amongst them, pteridophyte includes one family one genus and one species (new species). There are two families two genera and two species of gymnosperms. Others are all angiosperms which include 67 species attributing to 55 genera and 34 families. In them there are 32 families 53 genera 65 species (including 35 new species) of dicotyledons and 2 species allocating to 2 genera within 2 families of monocotyledons. In addition to the leaf flora, there is one species of fossil fruit *Carpolithes orbitopterus* sp. nov. of uncertain affinity. The palaeoflora represents a mixed evergreen and deciduous broad-leaved forest, indicating a slightly humid subtropical climate. The evidence from the fossil plants indicates that the uplifted altitude of the Tibetan Plateau had reached enough height to obstruct the moist Indian ocean atmospheric circulation which resulted in a monsoon climate formation in South and Southeast Asia. A dry and moist alternation of seasonal climate has already existed since then. The Bangmai flora is the late Miocene in age, about later than 11.6 Ma.

DESCRIPTION OF NEW SPECIES

Phylum Pteridophyta

Class Polypodiopsida (*alias* Pteridopsida, Filicopsida)

Family Salviniaceae

Genus *Salvinia* Seguier, 1754

Salvinia parallelloneura sp. nov.

(Plate Ⅸ, figues 6, 7, 11)

Etymology *Parallele*, Latin, means parallel; *neurus*, Latin, means neure or vein.

Holotype PB 12888.

Description Petiole lacking, floating leaves elliptic, 3.1—3.7 cm long, 2.3—2.6 cm wide, base truncate or rounded, apex blunte, margin entire, leaf texture papyraceous. Midvein thin and obvious, straight or slightly curve; secondary veins 28—32 pairs, opposite or alterate, diverging from midvein at an angle of about 70°, straightly reaching to margin, papillae amongst intercostal veins unclear.

Discussion The new species have three leaf fossil impressions. Their leaf shape, size, number of secondary veins are similar to those of living species *Salvinia natens* (L.) All. *Salvinia* living species is a floating aquatic plant that is very common from northeastern to southern China, and extensive distribution in the warm paddy fields,

ponds, pollution-free and static water swamp in Eurasia, North, Central and South America, and Africa including Madagascar. The plant remains of *Salvinia* were found from Upper Cretaceous in Mexico (Hall, 1974), very common in Cenozoic strata (Nambudiri and Chitaley 1991).

Phylum Spermatophyta
Subphylum Angiospermae
Class Dicotyledoneae
Family Schisandraceae
Genus *Schisandra* Michaux, 1803
***Schisandra splendinervosa* sp. nov.**
(Plate I, figure 2)

Etymology *Splend* comes from Latin *splendidus* which means splendid; *nervos* is derived from Mediaeval Latin *nervos* which means vein.

Holotype PB 12756.

Description Petiole 4 mm or more, leaf blade obovate, about 7 cm long and 2.5 cm wide, length and width ratio 3/1, base cuneate, apex imperfect, margin sometimes entire, or with loose thin dentates, glands at the top of dentates, leaf texture chartaceous. Venation pinnate, brochidodromous, midvein thickening downward, gradually thinning upward, straight; secondary veins relatively thin in size, 12—14 pairs, nearly opposite, diverging angles from midvein at 30°, gradually widening upward to 50°, extending, forking and connecting with each other forming a series of large and small loops at inner margin, fine veins diverging from marginal loops running into glands of teeth, occasionally interstitial veins amongst secondary veins; tertiary veins forming anomalous large meshworks; quaternary veins forming small polygonal and fine reticulations.

Discussion The leaf shape, size and venation architecture of the specimen are close to those of living *Schisandra arisanensis* Hayata which occurs at 200—2 300 m in forests and shrublands in Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hunan, Jiangxi, Taiwan and Zhejiang of China. However, the longer apex and denser marginal glands of the living species are distinct from the fossil species.

The genus *Schisandra* comprises over 22 species, shrubs and deciduous climbers, distributing in eastern and southeastern Asia, with one species in North America, and 12 endemic species in China.

Family Piperaceae
Genus *Piper* Linnaeus, 1753
***Piper lincangense* sp. nov.**
(Plate I, figures 3, 4)

Etymology *Lincang* is the locality name where the fossil plants were found.

Holotype PB 12773.

Description Petiole 5 mm long, leaf blades elliptic, 3.5—5.8 cm long, 2.3—3 cm wide, base wide-cuneate, slightly asymmetric, apex acute or acuminate, margin entire, leaf texture papyraceous. Venation pinnate, semi-acrodromous, midvein slender, straight or slightly curving upward; secondary veins 3—5 pairs, secondary veins of basal pair slender close to midvein, upper pair of secondary veins thick and strong, other secondary veins slim and weak, diverging angles from midvein at about 20°, a few of upper secondary veins widening 30°, arciform stretching upward; tertiary veins thin, forming loomed large networks; quaternary veins hardly visible.

Discussion The leaf shape and venation architecture of the specimens are similar to those of living *Piper hancei* Maxim. found in southeastern China and to *P. puberulum* (Benth.) Maxim. from southern China. The middle and upper secondary veins of former living species are more slender than those of the fossil specimens. The diverging angles of secondary veins in the latter living species are larger than that of the fossil specimens. So both living species are easily discriminated from the present fossil specimens.

The *Piper* fossils are rarely found. There are only six fossil species recognized from the strata of Palaeocene to Eocene in Alaska (La Motte, 1952). There is also an undetermined fossil specimen of *Piper* sp. found in the Middle Miocene, Sarmatian

age, in Baku of Azerbaijan.

The genus *Piper* comprises about 1 000—2 000 species of shrubs, small trees, lianas and herbs. It has a pantropical distribution, and is most commonly found in the understory of lowland tropical rainforests, but can also occur in higher elevation zones such as cloud forests. There are about 60 species in China growing mainly to the south of the Yangtze River.

Family Lauraceae

Genus *Cinnamomum* Schaeffer, 1760

***Cinnamomum versutifolium* sp. nov.**

(Plate I, figures 13, 14)

Etymology *Versutus*, Latin, means allround; *folium*, Latin, means leaf.

Holotype PB 12761.

Description Petiole lack, leaf blades lanceolate, 7—8 cm long in preservation, 2.2—2.8 cm wide, base lack, apex acute, margin entire, leaf texture coriaceous. Venation palmate, basal-triple veined or supra-basal triple veined, semi-acrodrome, midvein thick and straight, diverging angles of a pair of basal secondary veins at about 20° from base or suprabase of midvein, along inner margins extending to upper part of the blade, end of lateral midveins evanescing at apical margin, about 10 branchings in both sides of slender secondary veins originating from middle midvein, curving upward and forming many loops at the inner margin; tertiary veins irregular distribution amongst midvein and lateral midveins, interconnecting and forming transversal reticulations.

Discussion The main characteristics of the new species are leaf blade lanceolate, no lateral branchings on both sides of middle midvein, just tertiary veins amongst middle midvein and lateral midveins. These characteristics are distinct from other fossil and living species. Its leaf shape, size and venation architecture are close to those of the living species *Cinnamomum appelianum* Schewe which grows in thickets or sparse forests at an altitude of 500—1 400 m on mountain slopes or in valleys; south of the Yangtze River in southern China. The living species with one or two pairs of secondary veins diverging angle from the top of the midvein are different from the fossil specimens. The leaf shape and venation of the fossil specimens are also similar to the living *C. tsoi* C. K. Allen in Hainan Island. The lateral main vein of *C. tsoi* C. K. Allen with some loose and straight outer veins diverging angle from the blade apex is different from the fossil specimens. These outer veins of blade apex in fossil specimens are much thinner and denser.

The genus *Cinnamomum* comprises about 250—300 species growing in tropical and subtropical Asia, Australia, and the Pacific islands; 49 species, amongst them 30 endemic, grow in China. The *Cinnamomum* fossil species are found widely in both the Northern and Southern Hemispheres.

Genus *Neocinnamomum* H. Liu, 1934

***Neocinnamomum fuscatifolium* sp. nov.**

(Plate II, figures 1—7)

Etymology *Fuscus*, Latin, means brown, dark; *folium*, Latin, means leaf.

Holotype PB 12771.

Description Petiole absent, leaf blades wide-elliptic, 6.5—8 cm long, 2.5—4 cm wide, base cuneate, asymmetrical, apex acuminate, margin entire, leaf texture firm or thin coriaceous. Venation palmate, suprabasal triple veins, acrodromous, midvein slender, straight, a pair of lateral main veins originating from midvein 4 mm distance above the base, diverging angle from midvein at about 20°, secondary veins forking outer veins about 10 pairs outward, running upward slightly arched into margin, interconnecting and forming marginal loops; on both sides of lateral main veins give birth to 6—10 outer veins each; tertiary veins thin, transversing distribution amongst main vein and secondary veins, forming almost horizontal networks; quaternary veins nearly visible forming polygonal meshworks.

Discussion The leaf size and venation architecture of the fossil species are similar to those of

living Neocinnamomum candatum (Nees) Merr. which grows at an altitude of 500—1 800 m in ravines and streamsides loose shrubs in southwestern China, India, Indo-China Peninsula. The living species has ovate and slightly asymmetric blade, occasionally some branchings arising from lateral midveins and upper midvein. These characters are different from the present fossil specimens. The fossil species is close to *N. delavayi* (Lecomte) H. Liu which grows at an altitude of 1 100—2 300 m in riverain bosks in western Yunnan, southwestern China. This living species with longer leaf blades and slight asymmetric base is distinct from the fossil specimens.

The genus *Neocinnamomum* comprises about seven species of mainly evergreen shrubs or small trees which are distributed in Bhutan, China, India, Indonesia (Sumatra), Myanmar, Nepal, Thailand of China, Vietnam; five species (three endemic) in China. Leaves are alternate, entire, distichous, papery or subleathery, and strongly triplinerved.

Family Capparaceae

Genus *Capparis* Linnaeus, 1753

***Capparis lincangensis* sp. nov.**

(Plate I, figure 9)

Etymology *Lincang* is the name of the fossil site.

Holotype PB 12774.

Description Petiole lacking, leaf blade long elliptic, 5.8 cm long, 2 cm wide, base round, apex obtuse, margin entire, leaf texture papyraceous. Venation pinnate, brochidodromous, midvein thick, strong and straight; secondary veins rather thin, 12—15 pairs, nearly opposite, diverging angle from midvein at about 60°, sending to inner margin and curving upward with contiguous loops formed of secondary veins, loops connecting to each other by nearly right angles, interstitial veins always present; tertiary veins thin forming large quadrangular and/or polygonal networks, meshes 1.5—2 mm in diameter; quaternary veins clearly visible, forming polygonal meshes; quinternary veins not conspicuous.

Discussion The single specimen is preserved completely. Venation is clear and refined. Its leaf shape, size and venation architecture are close to those of living species *Capparis cantoniensis* Lour. which grows at below altitude 1 000 m in quebrada sides, humid and shelter forest in southern China and in India, Indo-China Peninsula and Malay Peninsula. However, the rectangular-lanceolate leaf blade, acuminate apex, and larger leaf area of the living species are different from the fossil specimen. The fossil *C. eocenica* Berry (1916, p. 218, pl. 44, figs. 1—3; pl. 52, fig. 5.) found in the Eocene Wilcox Formation in the Eastern United States is similar to the current specimen in its leaf shape and venation. The American fossil species with acute apex and cuneate base is distinct from the present specimen.

There are three species of fossil *Capparis* found from Eocene and Miocene in the United States (La Motte, 1944, 1952). There is one fossil organ genus similar to *Capparis* found from Pliocene in Azerbaijan.

The genus *Capparis* comprises 250—400 species. They are shrubs, small trees or vines, evergreen, erect, climbing, widely growing in the subtropical and tropical zones; but some in temperate regions; 37 species (ten endemic) in China.

Family Aizoaceae

Genus *Tetragonia* Linnaeus, 1753

***Tetragonia ovatifolia* sp. nov.**

(Plate XI, figures 5, 6)

Etymology *Ovatus*, Latin, means oval; *folium*, Latin, means leaf.

Holotype PB 12776.

Description Petiole stout, only 5 mm in preservation, leaf blades ovate, about 4 cm long and 3 cm wide, base askew cordate, apex acute, margin entire, slightly wave, leaf texture thin papyraceous. Venation pinnate, brochidodromous, midvein slender, slight zigzag, secondary veins slender, 4—6 pairs, subopposite, diverging angle from midvein at 40°—50°, running to inner margin and

forming loops; tertiary veins unclear.

Discussion Both part and counterpart are preserved. The leaf shape, size, and venation architecture of the fossil specimens are close to those of living *Tetragonia tetragonoides* (Pall.) Kuntze which grows in southeastern China, South America and Oceania. The obtuse leaf apex and tidiness of secondary veins of the living species are different from those of the fossil specimens.

The genus *Tetragonia* comprises 50—60 species of herbs or subshrubs, which grows in temperate and subtropical regions mostly of the Southern Hemisphere, in New Zealand, Australia, southern Africa and South America.

Family Pittosporaceae

Genus *Pittosporum* Banks ex Gaertn, 1788

***Pittosporum lincangense* sp. nov.**

(Plate XII; figures 4, 7—9)

Etymology *Lincang* is the name of the fossil site.

Holotype PB 12780.

Description Petiole 5 mm, leaf blades long obovate, 3—5 cm long, 1.5—2.0 cm wide, base narrow cuniform, apex imperfect, margin entire, leaf texture coriaceous. Venation pinnate, brochidodromous, midvein moderately thick, straight; secondary veins thin, 4—6 pairs, nearly opposite, diverging angle from midvein at 30°—50°, running to inner margin and interconnecting loops, loops right angular; tertiary veins thin and sparse, traversing amongst secondary veins; quaternary veins in random networks; quinternary veins not conspicuous.

Discussion The leaf shape, size and venation architecture of the specimens are similar to those of both living *Pittosporum truncatum* E. Pritz which grows at hillsides boscages in Central China and *P. pentandrum* var. *hainanense* (Gagnep.) H. L. Li. from Hainan Island. The former living species with thick coriaceous leaf, acuminate apex, and covert venation and the latter one with large leaf size, about 4—10 cm long, and more number of secondary veins, about 7—10 pairs, are distinct from the fossil species.

The genus *Pittosporum* comprises about 200 species evergreen trees, shrubs, or sometimes subshrubs, leaf blades leathery or sometimes membranous, margin entire, undulate-dentate, or rugose. The genus is probably Gondwanan in origin; its present range extends from Australasia, Oceania, eastern Asia and some parts of Africa, tropical and South Africa (including Madagascar), southwestern Asia (Yemen), Atlantic Islands (Madeira), Indian Ocean Islands (Mascarene, Seychelles), Pacific Islands. There are 46 species, including 33 endemic in China, mainly distributing to south of the Yangtze River.

Family Myrtaceae

Genus *Syzygium* Gaertn., 1788

***Syzygium lincangense* sp. nov.**

(Plate VIII, figures 1—13)

Etymology *Lincang* is the name of the fossil site.

Holotype PB 12784.

Description Petiole 2—12 mm, leaf blades rhombic, elliptic, 4.5—6.5 cm long, 1.8—2.8 cm wide, base cuneate, apex acuminate, margin entire, leaf thin coriaceous. Venation pinnate, brochidodromous, midvein thick, straight or somewhat curved, secondary veins slender and fine, over 30 pairs, nearly opposite, diverging angle from midvein at about 70°, parallelly and horizontally running toward margin, forming festoonery fimbrial veins near margin, circularity about 1 mm aparture from margin, secondary veins occasionally branching; tertiary veins horizontally distributed amongst secondary veins and forming random networks.

Discussion This fossil species is characterized by leaf rhombic, moderate size, no more than 7×3 cm in length and width, with slender and denser secondary veins. These characters are quite close to those of living *Syzygium odoratum* (Lour.) DC. which grows in evergreen broad-leaved sparse forests on mountains, valleys, streamsides below 100—400 m in Guangdong, Guangxi and Hainan,

southern China. The living species has fewer secondary veins, which differs from the fossil species.

The genus *Syzygium* comprises about 1 200 species in which 80 species (45 endemic) in China, distributing in tropical Africa, subtropical to tropical Asia, Australia, New Caledonia, New Zealand, Pacific islands; there are 80 species, including 45 endemic in China, mainly distributing to south of the Yangtze River.

***Syzygium poecilophyllum* sp. nov.**
(Plate IX, figures 1, 2)

Etymology *Poecilo*, Old Greek, means variegated, *phyllum*, Greek, means leaf.

Holotype PB 12798.

Description Petiole 8 mm, leaf blades elliptic, 6—7.5 cm long, 2.8—4 cm wide, base widecuneate, apex obtuse, margin entire, leaf texture coriaceous. Venation pinnate, brochidodromous, midvein thick and strong, straight or slightly curved, secondary veins slender, over 30 pairs, diverging angle from midvein at about 60°, space between two secondary veins about 2 mm, parallelly and horizontally running toward margin, about 1 mm distance forming festooning fimbrial veins inner margin; tertiary veins very slender, consisting of horizontal reticulations amongst secondary veins.

Discussion The present fossil species with larger leaf area, wider blade, l/w 2∶1, looser secondary veins, those of 5 pairs per centimeter is distinct from the former fossil species with lesser ratio, l/w 2.6∶1 in division, and secondary veins 7 pairs per centimeter. The characters of the species is close to those of living *Syzygium brachythyrsum* Merr. and L. M. Perry which grows in southern Yunnan. The secondary veins of living species are thick and straight in course and horizontal in arrangement. The characters of the fossil species is close to those of *S. protocumini* Tao and Chen (1983, p. 84) in its leaf size. However, other characters of *S. protocumini* are not similar to the present fossil species.

Family Combretaceae

Genus *Lumnitzera* Willd., 1803

***Lumnitzera pseudoracemosa* sp. nov.**
(Plate VII, figures 10, 14)

Etymology *Pseudo-*, Greek, means false, *racemosa* ancient Greek, name of living species.

Holotype PB 12801.

Description Petiole 3 mm, leaf blades obovate, 4—5 cm long, 2—2.8 cm wide, base widecuneate, apex roundish and retuse, margin entire, leaf texture papyraceous. Venation pinnate, brochidodrome, midvein moderate thick, straight or slightly curvy; secondary veins sparse, moderate thick, 4—5 pairs, subopposite, diverging angle from midvein about 40°—50°, running to margin, and curving upward forming loops inner margin, loops connect each other in obtuse angular, amongst secondary veins with interstitial veins; tertiary veins thin and obvious, simple and/or forking, perpendicular midvein near both sides of midvein, nearly perpendicular to secondary veins far from midvein, tertiary veins forming anomalous networks; quaternary veins unclear.

Discussion Leaf shape, size, and venation architecture of the specimens are close to those of living *Lumnitzera racemosa* Willdenow, growing in mangrove forest along tidal shores in southeastern China, Asia, Africa and Oceanica. But the leaf blades of living species are with longer, narrower in size, and lesser secondary veins in number. So it is different from the fossil species.

Only two species of *Lumnitzera* are small evergreen trees or shrubs. They grow near the banks of tidal creeks and of coastal fishponds in the mangrove forests and distribute in China, Bangladesh, Cambodia, India, Indonesia, Japan, South Korea, Malaysia, New Guinea, Philippines, Singapore, Sri Lanka, Thailand of China, Vietnam; East Africa (including Madagascar), North Australia, Pacific islands.

Genus *Terminalia* Linnaeus, 1767 nom cons.

***Terminalia lincangensis* sp. nov.**
(Plate VII, figures 12, 13)

Etymology *Lincang* is the name of the fossil site.

Holotype PB 12803.

Description Petiole lacking, leaf blades obovate, over 5 cm long, 2.8—3.6 cm wide, base wide-cuneate, apex obtuse or round, margin entire, leaf texture coriaceous. Venation pinnate, brochidodromous, midvein moderately thick, straight; secondary veins strong, 5—7 pairs, nearly opposite, diverging angle from midvein at 30°—40°, slightly arching, running to margin and light curving upward forming intramarginal loops, terminal loops obtuse angular; tertiary veins relatively thick, perpendicular to secondary veins; quaternary veins unconspicuous.

Discussion The leaf shape, and venation architecture of the specimens are close to those of the living *Terminalia bellirica* (Gaertn.) Roxb. It grows at altitude of 540—1 350 m in Yunnan, southern China, India and Indo-China Peninsula. This living species with larger leaf area, 18—23 cm long, 6—12 cm wide is somewhat different from the fossil specimens. The leaf size of the new fossil species is also close to that of living *T. hainanensis* Exell. in Hainan Island, southern China. The leaf ovate and/or elliptic in shape of the latter living species is distinct from the fossil specimens. About 10 fossil species of the genus *Terminalia* have been recorded from Palaeocene to Miocene in the United States (La Motte, 1952). The extant *Terminalia* consists of over 150 species distributed in the tropics of Africa, America, and Asia, extending to South Africa, Australia, and Pacific islands; 8 species in China.

Family Malvaceae

Genus *Helicteres* Linnaeus, 1753

***Helicteres callineura* sp. nov.**

(Plate X, figures 6, 11—13)

Etymology *Kallos*, Old Greek, means beautiful; *neural*, Greek, means vein.

Holotype PB 12807.

Description Petiole 1 mm, leaf blades ovate, over 4—6 cm long, 2.2—4 cm wide, base wide-cuneate, apex obtuse or acuminate, margin entire, leaf papyraceous to thin coriaceous. Venation pinnate, brochidodromous; midvein moderately thick, straight or slightly curved, secondary veins 5—6 pairs, alternate, a pair of basal secondary veins rather thick and strong, running along the margin, other secondary veins suprabasal, secondary veins diverging angle from midvein at 30°—40°, curving upward, running to inner margin forming loops, basal secondary veins with branchings, which some slender outer veins running to margin forming inferior loops, amongst secondary veins occasionally interstitial veins; tertiary veins forming anomalous networks; quaternary veins forming polygonal networks; quinternary veins forming polygonal reticulations, about 4 areoles per mm^2.

Discussion The leaf shape, size and venation architecture of the specimens are similar to those of both living *Helicteres angustifolia* L. which grows in southern China and Indochina Peninsula and living *H. lanceolata* DC. in Hainan Island of southern China. The basal secondary veins of the two living species are obviously branchings as outer veins. The two living species are different from the fossil species.

The genus *Helicteres* comprises 60 species distributing in the tropical zone, there are 9 species, mainly growing in hillsides of eastern, southern and southwestern China.

Family Rosaceae

Genus *Stranvaesia* Lindl., 1837

***Stranvaesia cosmophylla* sp. nov.**

(Plate IV, figure 9)

Etymology *Cosmo*, from *kosmos* in Old Greek which means order, arrangement; *phyllon*, Greek, means leaf.

Holotype PB 12814.

Description Petiole 3 mm long, leaf blade long elliptic, over 6 cm long, about 3 cm wide, base cuneate, apex imperfect, margin entire, leaf texture thin coriaceous. Venation pinnate, brochidodromous, midvein moderately thick, nearly straight; secondary veins thin, over 10 pairs, di-

verging angle from midvein at about 50°, running to margin, forming intramarginal loops; tertiary veins nearly visible, inclining to secondary veins, forming slanting networks; quaternary veins hardly visible.

Discussion The leaf shape, size and venation architecture of the specimens are quite similar to those of the living *Stranvaesia davidiana* Decne var. *davidiana* which grows at altitude of 1 000—3 000 m on shruby hillside in southwestern China and western China. The living species with broader leaf blades and obvious interstitial veins is distinct from the fossil specimens.

The genus *Stranvaesia* comprises about six species, four species (two endemic) in China, evergreen trees and/or shrubs, distributing in southern China, Southeast Asia, India, northern Burma.

Family Mimosaceae

Genus *Albizia* Durazz., 1772

***Albizia scalpelliformis* sp. nov.**

(Plate II, figure 10)

Etymology *Scalpellum*, Latin, means scalpel; *forma*, Latin, means shape.

Holotype PB 12816.

Description Petiolule absent, leaflet blade scalpelliform, rather asymmetric, about 2 cm long, 8 mm wide, base obliquely truncate-rounded, apex imperfect, margin entire, leaf texture papyraceous. Venation pinnate, brochidodromous, midvein thick and straight; secondary veins thin, 6 pairs, two pairs of basal secondary veins thicker and stronger, lowest a pair of basal lateral vein diverging angle from midvein at nearly right angle, running to margin, adjacent upper pair of basal secondary vein diverging angle from midvein at 50°, slightly curved, running to margin, other upper secondary veins slender and longer, diverging angle from midvein at 40°—50°, running to margin, interconnecting with upper secondary veins each other forming intramarginal loops; left secondary veins slim and short running to margin forming loops; tertiary veins hardly visible.

Discussion The leaf shape and venation architecture of the specimen are similar to those of living *Albizia julibrissin* Durazz. which grows in central and southern China. The leaf size, 6—12 mm long and 1—4 mm wide of the living species is different from the fossil specimen. The leaf shape and size of the specimen are somewhat close to those of living *A. odoratissima* (L. f.) Benth. which grows at an altitude of 1 000 m on hillsides in southwestern and southern China. The latter living species with rounded or cordate base is distinct from the fossil specimen.

The genus *Albizia* comprises about 150 species of mostly fast-growing subtropical and tropical trees and shrubs. The genus is pantropical in distribution, occurring in Asia, Africa, Madagascar, Central and southern North America and Australia, but mostly in the Old World tropics.

Family Caesalpiniaceae

Genus *Dalbergia* Linnaeus f., 1781

***Dalbergia sigillata* sp. nov.**

(Plate III, figure 2)

Etymology *Sigillatus*, Latin, meaning sigillary.

Holotype PB 12819.

Description Petiolule not preserved, leaflet blade elliptic, 2.6—4.5 cm long, 1.1—2.1 cm wide, base broad-cuniform and deflective, apex rounded, margin entire, leaf texture papyraceous. Venation pinnate, brochidodromous, midvein rather thick and strong, straight or/and slightly curved; secondary veins slender, about 10 pairs, subopposite, diverging angle from midvein at 40°—60°, irregular spreading to margin up-curved forming loops, interconnecting to form secondary loops, with intra-secondary veins; tertiary veins forming irregular networks; quaternary veins unconspicuous.

Discussion This species comprises three specimens. The leaf shape, size and venation architecture of the specimens are similar to those of the living *Desmodium gyroides* (Roxb.) DC. in southwestern China. The subelliptic leaf with foveate a-

pex of living species is different from the present fossil specimen.

Genus *Desmodium* Desv., 1813

***Desmodium praegyroides* sp. nov.**

(Plate III, figure 3)

Etymology *Prae-* is a Greek prefix meaning before; *gyroides* in Greek is the epithet of a *Desmodium* living species.

Holotype PB 12820.

Description Petiolule 2 mm long, leaflet blade ovate, 4.4 cm long, about 3 cm wide, base round, left lower portion lacking, apex obtuse, margin entire, leaf texture papyraceous. Venation pinnate, brochidodromous, midvein rather thick and strong, slightly curved; secondary veins moderately thick, 6—8 pairs, basal 2 pairs weaker, the others stronger, diverging angle from midvein at 40°—50°, archy-spreading to margin forming loops, interconnecting by right or obtuse angles, interstitial veins occasionally existent amongst upper secondary veins; tertiary veins sparse and obvious, simple and/or forking, zigzag scattering amongst secondary veins and linking them; quaternary veins unconspicuous.

Discussion The leaf shape, size and venation architecture in the specimen are similar to those of living *Desmodium gyroides* (Roxb.) DC. in southwestern China. The weak venation and obovate leaf shape of living species are different from the fossil specimen.

The genus *Desmodium* comprises about 280 species, in which 32 species (four endemic) are found in China. Its life form includes herbs, subshrubs, or shrubs with leaves pinnately 3-foliolate or 1-foliolate by reduction of lateral leaflets. Most of these species are distributed in subtropical and tropical regions.

Genus *Mucuna* Adans., 1763

***Mucuna leiophylla* sp. nov.**

(Plate III, figures 6, 7)

Etymology *Leios* in Old Greek means smooth; *phylla*, Greek, means leaf.

Holotype PB 12824.

Description Petiolule 4 mm long, lateral leaflets asymmetric, oval, 6.6 cm long, 3.1 cm wide, base round-truncated, apex obtuse, margin entire, leaf texture papyraceous. Venation pinnate, brochidodromous, midvein slender, slightly curved; secondary veins about 5 pairs, nearly opposite, diverging angle from midvein at 30°—40°, spreading to margin, occasionally branching, curving upward, forming intramarginal loops, basal lateral vein of the larger side, with 3—5 outer veins each side, spreading to margin forming intramarginal loops, secondary veins of the smaller side without outer veins; tertiary veins visible, simple or forking, connecting to each other with secondary veins; quaternary veins forming polygonal networks.

Discussion The two specimens are face and back parts. Their leaf shape and venation architecture are close to those of living *Mucuna castanea* Merr. which grows in Hainan Island, southern China. The leaf blades with larger (7.5—14 cm long, 3.5—7.5 cm wide) in size of living species. So it is distinct from the fossil specimens.

The genus *Mucuna* comprises 100 accepted species of climbing vines and shrubs with 3-palmate leaflets distributing worldwidely in the woodlands of tropical areas.

Family Fagaceae

Genus *Castanopsis* Spach, 1841

***Castanopsis brevijucunda* sp. nov.**

(Plate V, figures 1—5)

Etymology *Brevi-* is a Latin meaning brief, short (time); *jucunda* is Latin, the epithet of a living species of *Castanopsis*.

Holotype PB 12837.

Description Petiole 3 mm long, leaf blades elliptic, about 8 cm long, 3 cm wide, base widecuneate, apex acuminate, margin in middle and upper parts simply loosely serrate, leaf texture thin coriaceous. Venation craspedodromous, midvein thick and strong, straight and/or slightly curved, secondary veins thick, 14—16 pairs, opposite or

subopposite, diverging angle from midvein at 45°—60°, slightly curved and parallelly reaching teeth at the margin, some basal secondary veins forming intramarginal loops; tertiary veins obvious, simple or sometimes branching, percurrent, nearly perpendicular to secondary veins, forming reticulations; quaternary veins hardly visible.

Discussion The leaf shape, serration and venation architecture of the specimens are similar to those of living *Castanopsis jucunda* Hance which grows at an altitude of 700 m on hillsides in southeastern China. The living species with larger leaf blades and less secondary veins in number (8—12 pairs) is distinct from the fossil specimens. The fossils of *Castanopsis* are very commonly found in the Northwestern Hemisphere.

The genus *Castanopsis* comprises about 120 species. Amongst them there are 58 species in China, with 30 endemic species, evergreen trees, restricting to tropical and subtropical zones in eastern Asia, Indochina, Indonesia and Japan.

***Castanopsis gemmifolia* sp. nov.**

(Plate V, figures 6, 7)

Etymology *Gemma*, Latin, means precious stone; *folium*, Latin, means leaf.

Holotype PB 12834.

Description Petiole not preserved, leaf blades elliptic, about 6 cm long and 2 cm wide, base cuneate, apex acute, margin entire, with two or three pairs serrates on upper part, leaf texture coriaceous. Venation pinnate, brochidodrome, midvein thick and straight, secondary veins about 10 pairs, nearly opposite, diverging angle from midvein at about 60°, reaching to margin forming intramarginal loops; tertiary veins perpendicular to secondary veins; quaternary veins forming anomalous networks.

Discussion The leaf shape, size and venation architecture of the specimens are similar to those of living *Castanopsis carlesii* (Hemsl.) Hayata var. *spinulosa* W. C. Cheng and C. S. Chao which grows at an altitude of 1 100—1 900 m in southern Yunnan. The leaves with drip-tip and wide-cuneate base in the living species are very different from the fossil specimens.

Genus *Lithocarpus* Blume, 1826

***Lithocarpus flexicostatus* sp. nov.**

(Plate V, figures 12, 13)

Etymology *Flexus*, Latin, means curved; *costa*, Latin, means rib, refers to the veins.

Holotype PB 12849.

Description Petiole 8 mm long, leaf blades oblanceolate, 8 cm long in preservation, 2—2.5 cm wide, base cuneate, asymmetric on both sides, apex imperfect, estimated acuminate, margin entire and evaginable, leaf texture thin coriaceous. Venation pinnate, brochidodromous, midvein thick, slightly curved, secondary veins 10—13 pairs, diverging angle from midvein at 40°—50°, curved upward, spreading to the margin, forming intramarginal loops; tertiary veins thin and loose, unobvious, transverse amongst secondary veins and perpendicular to secondary veins; quaternary veins hardly visible.

Discussion The leaf shape, size and venation architecture of the fosil specimens are similar to those of living *Lithocarpus mairei* (Schottky) Rehder which grows at 1 500—2 300 m on sunshiny hillsides in central Yunnan. The living species with longer petiole, 1—1.5 cm, leaf texture thick coriaceous is different from the fossil specimens.

The genus *Lithocarpus* comprises over 300 species, about 100 Asian species, evergreen trees or rarely shrubs, arranging mainly in Asia, only one species in western North America; 123 species (69 endemic) in China.

***Lithocarpus ravidifolius* sp. nov.**

(Plate V, figures 14, 15)

Etymology *Ravidus*, Latin, means brownish; *folius*, Latin, means leaf.

Holotype PB 12860.

Description Petiole not preserved, leaf blades elliptic-lanceolate, over 6 cm long, 1.4—2 cm wide, base cuneate, apex acuminate, margin entire, leaf texture coriaceous. Venation pinnate,

brochidodromous; midvein thick and strong, nearly straight, secondary veins thin, 15—18 pairs, nearly opposite, diverging angle from midvein at 40°—50°, curving upward, spreading to margin forming intramarginal loops; tertiary veins slim, simple and/or forking, transverse amongst secondary veins and perpendicular to secondary veins; quaternary veins hardly visible.

Discussion The leaf shape, size and venation architecture of the specimens are similar to those of living *Lithocarpus confinis* C. C. Huang which grows at an altitude of 1 100—2 400 m in mesotherm mountain area in eastern Yunnan. The secondary veins relatively loose and with interstitial veins of the living species are distinct from the fossil specimens.

***Lithocarpus validifolius* sp. nov.**

(Plate VI, figures 10—12)

Etymology *Validus*, Latin, means strong, power; *folius*, Latin, means leaf.

Holotype PB 12861.

Description Petiole 8 mm, slightly curved, leaf blades broad lanceolate, about 8 cm long, 2. 5—3 cm wide, base cuneate, apex acuminate, margin entire, leaf texture thin coriaceous. Venation pinnate, brochidodromous, midvein thick and strong at base, upper part slim and weak, straight, sometimes slightly curved; secondary veins thin, 12—15 pairs, nearly opposite, diverging angle from midvein at 40°—45°, approximately parallel, spreading to margin, curved upward, forming intramarginal loops, connecting to each other by right or obtuse angles; tertiary veins obvious, simple and/or forking, transverse between secondary veins and perpendicular or S-shaped curved near secondary veins; quaternary veins hardly visible.

Discussion The leaf shape, size, the number of secondary veins and venation architecture of the fossil specimens are similar to those of living *Lithocarpus dealbatus* (Hook. f. and T. Thomas. ex Miq.) Rehder, which grows at altitude of 1 300—2 700 m in medium mountainous humid forest in southwestern China. The leaf blades with acuminate apex and less number, 9—12 pairs of secondary veins in the living species are different from the fossil specimens.

***Quercus mutilatifolia* sp. nov.**

(Plate VI, figures 15, 16)

Etymology *Mutilatus*, Latin, means mutilated; *folia*, Latin, means leaf.

Holotype PB 12983.

Description Petiole 5 mm long, leaf blades elliptic to obovate, over 6 cm long, 3—3. 5 cm wide, base wide-cuneate, apex obtuse, margin middle and upper part serrate, upper teeth 1 mm long, lower teeth 5—10 mm long, leaf texture firm chartaceous. Venation pinnate, craspedodrome; midvein thick and strong, straight or slightly curved, secondary veins about 13 pairs, straight, nearly opposite, diverging angle from midvein at about 45°, reaching to serrate tip of margin; tertiary veins thin, obvious, simple or forking, transverse amongst secondary veins; quaternary veins hard visible.

Discussion The leaf shape, size, entire base and venation architecture of the fossil specimens are similar to those of living *Quercus franchetii* Skan which grows at altitude of 1 100—2 600 m on mountains in Yunnan and Sichuan. The larger leaf blade, 2. 5—7. 5 cm long and lesser secondary veins 8—11 pairs of the living species are different from the fossil specimens. The *Quercus* leaf fossils are very common and abundant from Cenozoic Era in the Northern Hemisphere.

The genus *Quercus* comprises about 300—600 species, trees or sometimes shrubs, evergreen or deciduous leaves with serrate, lobed, or a smooth margin. The genus is widespread in the Northern Hemisphere, extending from cold to torrid latitudes in North Africa, Asia, Europe, North America, South America; 35 species (15 endemic, two introduced) in China.

Family Moraceae

Genus *Ficus* Linnaeus, 1753

***Ficus proreligiosa* sp. nov.**

(Plate IV, figures 6, 10, 11)

Etymology *Pro-* is a Latin prefix meaning forward; *religiosa*, Latin, means religion, an epithet of a living species of *Ficus*.

Holotype PB 12872.

Description Petiole not preserved, leaf blades ovate to long ovate, over 6 cm long, 3—6 cm wide, base wide-cuneate, apex acuminate, margin entire, leaf coriaceous. Venation pinnate, brochidodromous, midvein rather thick and strong, slightly curved, secondary veins 6—9 pairs, subopposite, straight or slightly curved, diverging angle from midvein at 50°—60°, spreading to margin, slightly curved upward, joining in intramarginal loops, interstitial veins amongst secondary veins; tertiary veins interconnecting amongst secondary veins in rectangular, quadrangular and/or pentagonal networks; quaternary veins forming abnormal polygonal reticulation; quinternary vein forming slim polygonal meshes in which simple ending veins. Marginal veins form festooning fimbrial veins.

Discussion The leaf shape and size, especially the venation architecture of the specimens are quite similar to those of living *Ficus religiosa* L. in India. The leaf comparative characters of both living and fossil species are as follows.

Ficus religiosa: Leaf blade cordate to triangular; base cordate; apex drooping tip; basal secondary veins stout with branches; quinternary vein larger reticulation; ending vein forking.

Ficus proreligiosa: Leaf blade long ovate to wide oval; base rounded, truncate-rotund; apex acuminate; basal secondary veins weaker: unclear branches; quinternary vein small reticulation; ending vein simple. Anyhow, this fossil species in leaf shape and venation is somewhat related to *Ficus religiosa* in affinity.

Ficus is a genus of about 800—1 000 species. They are evergreen or deciduous woody trees, shrubs, vines, epiphytes or hemiepiphytes. Its species are distributed in throughout the tropics in the world and a few species extending into the semi-warm temperate regions, particularly diverse in Southeast Asia. There are 99 species (16 endemic) in China distributing widely in southern China.

Family Aquifoliaceae

Genus *Ilex* Linnaeus, 1753

***Ilex ornatinervosa* sp. nov.**

(Plate XII, figures 5, 6)

Etymology *Ornatus*, Latin, means ornamented; *nervosa*, Latin, means nerve (vein).

Holotype PB 12877.

Description Petiole 5 mm, leaf blades elliptic, 6—8 cm long, 2—3 cm wide, base wide-cuneate, apex acuminate, margin unobviously loosely serrate, leaf texture coriaceous. Venation pinnate, brochidodromous; midvein thick, strong and straight, secondary veins thin, 12—14 pairs, nearly opposite, diverging angle from midvein at about 60°, branching and spreading to margin, interconnecting with outer secondary veins, forming intramarginal loops in acute angle or right angle, then forming a series of inferior loops within marginal loops; tertiary veins thin and sparse, irregularly combining with secondary veins forming networks; quaternary veins slim and clear, forming polygonal meshes; quinternary veins forming fine areolation.

Discussion The leaf shape, size and venation architecture of the specimens are similar to those of living *Ilex purpurea* Hassk. which grows south of the Yangtze River in southern China. The larger leaf-teeth and diverging angle of 40°—50° of the secondary veins of the living species are distinct from the fossil specimens.

The genus *Ilex* comprises approximately 500—600 species of evergreen or deciduous trees and shrubs which are widespread in tropical and subtropical to temperate regions of both the North and South Hemispheres, mainly in the tropical regions of Central and South America and Asia. There are 149 endemic in China.

Family Olacaceae

Genus *Schoepfia* Schreb., 1789

***Schoepfia elegantifolia* sp. nov.**

(Plate X, figures 10, 14; plate XI, figure 1)

Etymology *Elegans*, Latin, means charming, gracious; *folia*, Latin, means leaf.

Holotype PB 12878.

Description Petiole not preserved, leaf blades ovate, 5.3—6.5 cm long, about 3 cm wide, base wide-cuneate or round, apex obtuse, margin entire, leaf texture papyraceous. Venation pinnate, campylodromous; midvein moderately thick, straight or slightly curved, secondary veins thin, 4—6 pairs, subopposite to alternate, diverging angle from midvein at 30°—40°, two pairs of basal secondary veins closer, with some thin branches outward, other secondary veins occasionally forking, spreading to margin, and curved upward, forming intramarginal loops; tertiary veins slender, transverse amongst secondary veins; quaternary veins unconspicuous.

Discussion The leaf shape and size, as well as the venation architecture of the specimens are similar to those of living *Schoepfia jasminodora* Siebold and Zucc. which grows south to the Yangtze River in southern China. The living species with acuminate apex, round base and decurrent petiole is different from the fossil specimens. The *Schoepfia* fossils is first discovered in China. The genus *Schoepfia* comprises about 30 species from tropical and subtropical America and Asia; only four species (one endemic) in China.

Family Rhamnaceae

Genus *Berchemia* Neck., ex DC. 1825

***Berchemia calymmatophylla* sp. nov.**

(Plate IV, figure 7)

Etymology *Kalymma*, Old Greek, means veil; *phylla*, Greek, means leaf.

Holotype PB 12882.

Description Petiole not preserved, leaf blades elliptic, about 7 cm long and 4 cm wide, base wide-cuneate, apex imperfect, margin entire, leaf texture firm papyraceous. Venation pinnate, circular-brochidodromous, midvein thick, strong and straight; secondary veins pinnate, thin, 14—16 pairs, nearly opposite, diverging angle from midvein at about 50°, parallelly reaching the margin, slightly curved upward disappearing in margin; tertiary veins thin, with obliquely lateral veins, forming oblong networks; quaternary veins hardly visible.

Discussion The leaf shape, size and venation architecture of the specimen are similar to those of the living species *Berchemia scandens* (Hill) K. Koch which grows in Central Asia, southern Europe and the southeastern United States. The fossil specimen and living species are with wide-cuneate base and the analogic venation. The living species with lesser secondary veins, only 9—12 pairs is different from this fossil specimen. The fossil specimen resembles the fossil species *Berchemia miofloribunda* Hu and Chaney (1940, p. 65, pl. 9, fig. 5; pl. 40, figs. 2, 3) from the Miocene Shanwang Formation in Linqu County of Shandong, eastern China. The cordate base of *Berchemia miofloribunda* differs from the Lincang fossil specimen.

The genus *Berchemia* comprises 22 species of erect medium-sized trees, shrubs or climbing shrubs with pinnately veined leaves, strongly parallel secondary veins, base often asymmetrical, and margin entire. They occur in Africa, Asia and the Americas. There are 16 species in China mainly distributing in central, eastern, and southwestern China.

Family Rutaceae

Genus *Zanthoxylum* Linnaeus, 1753

***Zanthoxylum refractifolium* sp. nov.**

(Plate X, figures 2, 3)

Etymology *Refractus*, Latin, means broken; *folium*, Latin, means leaf.

Holotype PB 12985.

Description Petiolule 4 mm, lateral blades of leaflets elliptic, leaf blades asymmetrical, 9 cm long, about 2.8 cm wide, base obliquely cuneate, apex imperfect, apparently acuminate estimated, margin serrulate, leaf texture papyraceous. Venation pinnate, brochidodrome, midvein thick and

strong, slightly curved; secondary veins thin, 14—16 pairs, nearly opposite, diverging angle from midvein at 40°—50°, branching and spreading to margin, interconnecting forming intramarginal loops, external loops linked to inferior loops and subordinate loops, interstitial veins linked with tertiary veins; tertiary veins slender forming anomalous networks; quaternary veins partially visible forming polygonal reticulations.

Discussion The leaf shape, especially the venation architecture of the specimens are close to those of living *Zanthoxylum dissitum* Hemsl. which grows at altitude of 300—2 600 m in southern China. The size of the lateral leaflets of the living species is much larger, 7—6 cm long and 3—6 cm wide than that of fossil species, and its margin is entire or undulant. So the living species is obviously different from the fossil specimens. The leaf shape, size, teeth and number of secondary veins of another living species, *Z. yunnanense* C. C. Huang which grows in southern Yunnan are also close to those of the present fossil specimens. However, the diverging angle between midvein and secondary veins in the latter living species is much larger than that of the fossil specimens. It is also distinct from the fossil specimens.

The genus *Zanthoxylum* comprises about 250 species of spiny shrubs, small trees, and erect climbers with odd-pinnate compound leaves, rarely trifoliolate leaves, entire or serrate leaves. The genus is distributed in East Asia and North America. There are 50 species in northern and southern China.

Family Anacardiaceae

Genus *Rhus* Linnaeus, 1753

***Rhus mortinerva* sp. nov.**

(Plate IX, figures 5, 10)

Etymology *Mort*, Latin, means muti-; *nerva*, Latin, means leaf.

Holotype PB 12892.

Description Petiolule not preserved, lateral leaflets elliptic, about 7 cm long, 2.5 cm wide, base wide-cuneate, apex imperfect, probably acuminate, margin entire, leaf texture papyraceous. Venation pinnate, brochidodromous, midvein moderately thick, straight; secondary veins slender, about 15 pairs, nearly opposite, diverging angle from midvein at 70°—80°, spreading to margin, curving upward, forming obtuse angular intramarginal loops, sometimes interstitial veins present; tertiary veins slim, forming anomalous networks; quaternary veins forming polygonal meshworks.

Discussion The leaf shape, size and venation architecture of the specimens are similar to those of both living *Rhus willsonii* Hemsl. which grows at an altitude of 350—2300 m in Yunnan and Sichuan, and *Rh. potaninii* Maxim. which grows at altitude of 2000 m in central China and southwestern China. The wide-cuneate base and asymmetric leaflets of the fossil specimens are similar to the former species; the leaflet size and venation architecture is close to the latter one. Therefore, the new fossil species is related to the two living species mentioned above. Perhaps it is an ancestor of them and the latter one is differentiated into two species.

The genus *Rhus* comprises approximately 250 species of deciduous shrubs and small trees with pinnately compound leaves, though some species have trifoliate or simple leaves. They grow in subtropical to warm temperate regions throughout the world, especially in Africa and North America. There are six species (four endemic) in China.

Genus *Toxicodendron* Mill., 1754

***Toxicodendron inaequilaterum* sp. nov.**

(Plate IX, figures 12—14)

Etymology *Inaequilatus*, Latin, means not equilateral.

Holotype PB 12897.

Description Petiole 1 cm long, lateral blades of leaflets long elliptic, and rhombic, estimated 6—10 cm long, 2.5—3.6 cm wide, base slanting cuneate, apex short acuminate, margin entire, leaf texture papyraceous. Venation pinnate, brochidodromous, midvein medium thick, straight or slightly curved; secondary veins thin, slightly

curved, 14—20 pairs, nearly opposite, diverging angle from midvein at 60°, spreading to margin, with terminals combining with tertiary veins and forming intramarginal loops; tertiary veins clear, adaxial ones slightly thicker than those of abaxial ones, abruptly narrowing in center parts of secondary veins, forming yoke-shaped curved networks; quaternary veins visible forming anomalous quadrangular or polygonal meshworks.

Discussion The leaflet shape, size, slanting cuneate base, and venation architecture of the fossil specimens are quite similar to those of living *Toxicodendron caudatum* C. C. Huang and T. L. Ming which grows in forests at altitude of 1 600 m in Yunnan and Tibet in southwestern China. The long tailed apex and more number of secondary veins of the living species are distinct from those of the fossil specimens.

The genus *Toxicodendron* comprises 20 species of deciduous shrubs or trees, rarely a woody climber, with pinnately compound leaves, 3-foliolate or simple leaves. The species of *Toxicodendron* are disjunctly distributed in East Asia and North America. There are 16 species (six endemic) distributing in southern China.

Family Juglandaceae

Genus *Engelhardia* Lesch. ex Blume, 1825

***Engelhardia sclerophylla* sp. nov.**

(Plate VII, figures 5, 6, 11)

Etymology *Skleros*, Old Greek, means hard; *phylla*, Greek, means leaf.

Holotype PB 12902.

Description Petiole absent, leaflet blades oblong, 5. 5—7 cm long, 3. 5—4. 2 cm wide, base asymmetric, wide cuneate, apex obtuse, occasionally retuse, margin entire, leaf texture coriaceous. Venation pinnate, brochidodromous, midvein stout, straight or slightly curved upward in its upper part, secondary veins thick, 8—10 pairs, alternate, diverging angle from midvein at 40°—70°, narrowing from base to top, spreading to margin, curved upward, forming intramarginal loops with right to obtuse angles; tertiary veins thick, simple or occasionally branchings slightly curved, transverse amongst secondary veins, forming networks; quaternary veins nearly visible forming polygonal meshworks.

Discussion The leaflet shape, number of secondary veins and venation architecture of the fossil specimens are similar to those of living *Engelhardia colebrookeana* Lindl. ex Wall. which grows at altitude of 1 400 m (– 2 000 m) in open forests on mountain slopes or in valleys in southern and southwestern China and in India, Myanmar, Nepal, the Philippines, Thailand of China and Vietnam. The large leaflet in size, 5—15 cm long, 3—7 cm wide of the living species is distinct from the fossil specimens. *Engelhardia* pollen has recently been found in deposits of Miocene age in Denmark (Larsson *et al.*, 2006).

The genus *Engelhardia* comprises 7 species of deciduous, semi-evergreen or evergreen trees, leaves even-pinnate, rarely odd-pinnate; leaflets 2—14, margin entire or serrate, native to southeast Asia from northern India to Indonesia and the Philippines. There are 4 species including one endemic in China.

Family Sapotaceae

Genus *Sinosideroxylon* (Engler) Aubr v, 1963

***Sinosideroxylon lincangense* sp. nov.**

(Plate XI, figures 8—10)

Etymology *Lincang* is the name of the fossil site.

Holotype PB 12907.

Description Petiole lacking, leaf blades ovate-lanceolate, slightly asymmetric, about 3. 5—7 cm long, 1. 2—3 cm wide, base deflective, wide-cuneate, apex acuminate, margin entire, leaf texture papyraceous. Venation pinnate, brochidodromous; midvein rather thick, thickening downward, slightly curved upward; secondary veins thin, curved about 12—14 pairs, diverging angle from midvein at 50°, reaching to margin forming loops, amongst secondary veins always interstitial veins; tertiary veins invisible.

Discussion The *Sideroxylon* fossils were first

found in China. The leaf shape, size and venation architecture of the specimens are quite similar to those of fossil *Sideroxylon (Bumelia) pseudolycioides* Berry (1930, p. 128, pl. 44, fig. 20) from the Eocene in Tennessee of the United States. However, the secondary veins of the American species with slightly thicker and lesser secondary veins in number is obviously different from the present specimens. So the present fossil specimens should be proposed a new species.

The *Sideroxylon* Linnaeus, 1753 have been changed into *Sinosideroxylon* (Engler) Aubr v in 1963. This includes about 100 living species. They are chiefly trees or rarely shrubs with leaf blades leathery distributing in the neotropics, but also in Africa, Madagascar, and the Mascarene Islands. Some species are found in subtropical areas of North America. Four species grow in southern China as well as in northern Vietnam.

Genus *Chrysophyllum* Linnaeus, 1753

***Chrysophyllum sinicum* sp. nov.**

(Plate XI, figures 11, 12)

Etymology *Sinicum*, Medieval Latin, means China.

Holotype PB 12909.

Description Petiole 1 cm long, leaf blades elliptic, slightly asymmetric, about 5 cm long, 2.9 cm wide, base wide-cuneate, apex obtuse, margin entire, leaf texture thick coriaceous. Venation pinnate, brochidodromous; midvein rather thick, thickened downward, slightly curved upward; secondary veins thin, about 20 pairs, diverging angle from midvein at 50°—60°, almost parallelly spreading to margin, forming intramarginal loops; tertiary veins slender, forming anomalous ramiform networks.

Discussion The leaf shape and venation architecture of the specimens are close to those of the fossil *Chrysophyllum conforme* Potbury (1935, p. 77, pl. 12, fig. 1) from the Eocene or early Oligocene of the La Porte Formation in California in the United States. However, the leaf area of the fossil species in the United States is larger than that of the present fossil specimens. Both species are distinct from each other. The living *Ch. lanceolatum* A. DC. var. *stellatocarpon* P. Royen in its leaf shape and venation architecture is close to those of the present fossil specimens. However, the living species with larger leaf area and longer acuminate apex can be distinguished from them. The leaf venation architecture and parallelly secondary veins of both genera *Chrysophyllum* and *Syzygium* is similar. The difference from them is that the secondary veins are sparser, thicker, without circularly intramarginal veins of *Chrysophyllum*, the secondary veins of *Syzygium* are just reversed.

The genus *Chrysophyllum* includes about 70 species distributed in tropical and subtropical America, tropical Africa, Madagascar, and Asia; one species in China. The fossil plants of *Chrysophyllum* were rarely found. Recently, *Chrysophyllum* fossil wood and leaves were found in the Mio-Pliocene Siwalik Formation in Nepal (Prasad, 2007).

Family Styracaceae

Genus *Styrax* Linnaeus, 1753

***Styrax pulchellus* sp. nov.**

(Plate XII, figures 2, 3)

Etymology *Pulchellus*, Latin, means beautiful.

Holotype PB 12912.

Description Petiole 4 mm long, leaf blades elliptic to obovate, over 6 cm long, 3—3.8 cm wide, base cuneate, apex obtuse, margin entire, leaf thin coriaceous. Venation pinnate, brochidodromous, midvein straight or slightly curved; secondary veins moderate thick, 5—6 pairs, nearly opposite, diverging angle from midvein at 35°, spreading to margin, curving upward, forming intramarginal loops, loop obtuse angular, basal secondary veins branching and forming inferior loops; tertiary veins slim and sparse, nearly perpendicular to secondary veins; quaternary veins hardly visible.

Discussion The leaf shape, size and venation architecture of these specimens are quite similar to

those of the living *Styrax tonkinensis* (Pierre) Craib ex Hartwich which grows at 100—2 000 m in mixed forests in southern China, Cambodia, Laos, Thailand of China and Vietnam. The living species with acuminate apex and sometimes apically serrate margin is different from the fossil specimens. *Styrax* has over 10 fossil species (La Motte, 1952). They are found from Palaeocene to Pleistocene in North America and from Miocene and Pliocene in Caucasia.

The genus *Styrax* consists of about 130 living species from East Asia, North and South America and the Mediterranean Basin. Amongst them there are 31 species distributed in tropical and subtropical regions in Southern China.

Family Adoxaceae

Genus *Viburnum* Linnaeus, 1753

***Viburnum validum* sp. nov.**

(Plate XI, figure 7)

Etymology *Valid*, from Latin *validus*, means strong, robust.

Holotype PB 12913.

Description Petiole not preserved, leaf blades elliptic, 5.5 cm long, 2.5 cm wide, base cuneate, apex obtuse, lower part of margin entire, upper part slightly waved, leaf texture firmly papyraceous. Venation pinnate, brochidodromous; midvein moderately thick, straight; secondary veins strong, 5—6 pairs, nearly opposite, diverging angle from midvein at 40°, parallelly spreading to margin with branchlets, interconnecting and forming intramarginal loops; tertiary veins slender, nearly perpendicular to secondary veins; quaternary veins forming irregular networks.

Discussion The leaf shape, size and venation architecture of the specimen are similar to those of living *Viburnum foetidum* Wall. var *rectangulum* (Graebn.) Rehder which grows at altitude of 600—2 000 m in evergreen shrubs in southern China. The leaf blades with irregular, sparse and shallow teeth and secondary veins with obvious branchings in the living species are distinct from the fossil specimen. A fossil species, *V. speciosum* Knowlton (1917, p. 347, pl. 3, figs. 1—5), from the Palaeocene Raton Formation in Colorado in the United States is rather similar to the present specimen in its leaf shape and venation. However, the leaf blades with larger area and thick teeth at upper blade of the American fossil species are different from the present specimen.

The genus *Viburnum* consists of about 200 species of erect evergreen, semi-evergreen and deciduous shrubs and rarely small trees which with many different leaf characters from leathery to glaze to variegated. The species of *Viburnum* are distributed in temperate to subtropics of the Northern Hemisphere. There are 74 species distributed in northern and southern China.

Incertae Sedis

Genus *Carpolithes* Brongniart, 1822

***Carpolithes orbitopterus* sp. nov.**

(Plate I, figure 12)

Etymology *Orbita*, Latin, means circle; *pterus*, Greek, means wing.

Holotype PB 12917.

Description Fruit samara dise-shaped, about 2.8 cm long, 2.7 cm wide, base rotundate, slightly decurrent, apex lacking, margin entire, samara texture thick papyraceous, fruit stalk 8 mm. Samara wing slightly thick with thin radiate veins interconnecting meshworks. Seed in center, not developed.

Discussion Many different genera, such as *Ptelea* of Rutaceae, *Illigera* of Hernandiaceae, *Oxyria* of Polygonaceae, *Gouania* of Rhamnaceae, *Peripterygium* of Cardiopteridaceae, and *Combretum* of Combretaceae are all with dise-shaped samara. However, the shapes of their samara are obviously distinct from the fossil samara which is thus temporarily assigned to incertae sedis.

图版说明(Explanation of Plates)

化石产自云南西部临沧邦卖上中新统邦卖组第五层浅灰色粉砂岩及浅黄褐色粉砂质含硅藻泥岩中。全部标本均保存在中国科学院南京地质古生物研究所模式标本库内。比例尺= 1 cm (The fossil plants are situated at Bangmai in Lincang, western Yunnan. They are collected from the greyish siltstone and yellowish-brown arenaceous and diatomaceous mudstone in the fifth layer of the Upper Miocene Bangmai Formation. The fossil specimens are stored in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences. Registration Number is prefixed by PB. Scale bar= 1 cm)。

图 版 Ⅰ (Plate Ⅰ)

1. *Glyptostrobus europaeus* (Brongn.) Heer
PB 12752.
2. *Schisandra splendinervosa* sp. nov.
PB 12756 (Holotype).
3, 4. *Piper lincangense* sp. nov.
3. PB 12772 (Paratype); 4. PB 12773 (Holotype).
5, 10, 11. *Calocedrus lantenoisi* (Laurent) Tao
5. PB 12753; 10. PB 12754; 11. PB 12755.
6. *Cinnamomum naitoanum* Huzioka and Takahashi
PB 12757.
7, 8. *Cinnamomum scheuchzeri* Heer
7. PB 12758; 8. PB 12759.
9. *Capparis lincangensis* sp. nov.
PB 12774 (Holotype).
12. *Carpolithes orbitopterus* sp. nov.
PB 12917 (Holotype).
13, 14. *Cinnamomum versutifolium* sp. nov.
13. PB 12760 (Paratype); 14. PB 12761 (Holotype).
15, 16. *Litsea grabaui* Hu and Chaney
15. PB 12763; 16. PB 12764.

图 版 Ⅱ (Plate Ⅱ)

1—7. *Neocinnamomum fuscatifolium* sp. nov.
1. PB 12765; 2. PB 12766; 3. PB 12767; 4. PB 12768; 5. PB 12769; 6. PB 12770 (Paratype); 7. PB 12771 (Holotype).
8, 9. *Smilax grandifolia* (Unger) Heer
8. PB 12914; 9. PB 12915.
10. *Albizia scalpelliformis* sp. nov.
PB 12816 (Holotype).

图 版 Ⅲ(Plate Ⅲ)

1. *Gleditsia miosinensis* Hu and Chaney
PB 12817.
2. *Dalbergia sigillata* sp. nov.
PB 12819 (Holotype).
3. *Desmodium praegyroides* sp. nov.
PB 12820 (Holotype).
4. *Maackia* sp.
PB 12821.
5. *Millettia* sp.
PB 12822.
6, 7. *Mucuna leiophylla* sp. nov.
6. PB 12823 (Paratype); 7. PB 12824 (Holotype).
8. *Ormosia* sp.
PB 12825.
9, 10. *Shuteria* sp.
A couple of specimens with positive and negative. PB 12826.
11. *Photinia* sp.
PB 12762.
12. *Sorbus* sp.
PB 12813.

图 版 Ⅳ(Plate Ⅳ)

1—5. *Sophora miojaponica* Hu and Chaney
1. PB 12827; 2. PB 12828; 3. PB 12829; 4. PB 12830; 5. PB 12831.
6, 10, 11. *Ficus proreligiosa* sp. nov.
6. PB 12872 (Holotype); 10. PB 12873; 11. PB 12874 (Paratype).
7. *Berchemia calymmatophylla* sp. nov.
PB 12882 (Holotype).
8. *Celtis miobungeana* Hu and Chaney
PB 12871.
9. *Stranvaesia cosmophylla* sp. nov. PB 12814 (Holotype).

图 版 Ⅴ(Plate Ⅴ)

1—5. *Castanopsis brevijucunda* sp. nov.
1. PB 12836; 2. PB 12837 (Holotype); 3. PB 12838 (Paratype); 4. PB 12839; 5. PB 12840.
6, 7. *Castanopsis gemmifolia* sp. nov.
6. PB 12834 (Holotype); 7. PB 12835 (Paratype).
8—10. *Cyclobalanopsis mandraliscae* (Gaudin) Tanai
8. PB 12843; 9. PB 12844; 10. PB 12845.
11. *Cyclobalanopsis paraschottkyana* (Wang and Liu) comb. nov.
PB 12846.
12, 13. *Lithocarpus flexicostatus* sp. nov.
12. PB 12848 (Paratype); 13. PB 12849 (Holotype).
14, 15. *Lithocarpus ravidifolius* sp. nov.
14. PB 12859 (Paratype); 15. PB 12860 (Holotype).

图 版 Ⅵ(Plate Ⅵ)

1. *Cyclobalanopsis paraschottkyana* (Wang and Liu) comb. nov.
PB 12847.

2—9. *Lithocarpus renifolius* Tao
2. PB 12850; 3. PB 12851; 4. PB 12852; 5. PB 12853; 6. PB 12854; 7. PB 12855; 8. PB 12856; 9. PB 12857.

10—12. *Lithocarpus validifolius* sp. nov.
10. PB 12861 (Holotype); 11. PB 12862; 12. PB 12863 (Paratype).

13. *Lithocarpus* sp.
PB 12864.

14. *Quercus latifolia* Li
PB 12865.

15, 16. *Quercus mutilatifolia* sp. nov.
15. PB 12983 (Holotype); 16. PB 12984 (Paratype).

图版 Ⅶ(Plate Ⅶ)

1, 2. *Quercus simulata* Knowlton
1. PB 12866; 2. PB 12867.

3, 4. *Quercus* sp.
3. PB 12869; 4. PB 12870.

5, 6, 11. *Engelhardia sclerophylla* sp. nov.
5. PB 12902 (Holotype); 6. PB 12903 (Paratype); 11. PB 12904.

7. *Betula mioluminifera* Hu and Chaney
PB 12833.

8. *Trapa* sp.
PB 12775.

9. *Populus glandulifera* Heer
PB 12832.

10, 14. *Lumnitzera pseudoracemosa* sp. nov.
10. PB 12801 (Holotype); 14. 12802 (Paratype).

12, 13. *Terminalia lincangensis* sp. nov.
12. PB 12803 (Holotype); 13. PB 12804 (Paratype).

图版 Ⅷ(Plate Ⅷ)

1—13. *Syzygium lincangense* sp. nov.
1. PB 12784 (Holotype); 2. PB 12785; 3. PB 12786 PB; 4. PB 12787; 5. PB 12788 (Paratype); 6. PB 12789; 7. PB 12790 PB; 8. PB 12791; 9. PB 12792; 10. PB 12793; 11. PB 12794; 12. PB 12795; 13. PB 12796.

图版 Ⅸ(Plate Ⅸ)

1, 2. *Syzygium poecilophyllum* sp. nov.
1. PB 12798 (Holotype); 2. PB 12799 (Paratype).

3, 4. *Toxicodendron miosuccedaneum* (Hu and Chaney) comb. nov.
3. PB 12895; 4. PB 12896.

5, 10. *Rhus mortinerva* sp. nov.
5. PB 12891 (Paratype); 10. PB 12892 (Holotype).

6, 7, 11. *Salvinia parallelonerua* sp. nov.
6. PB 12888 (Holotype); 7. PB 12889; 11. PB 12890 (Paratype).

8, 9. *Pistacia miochinensis* Hu and Chaney
8. PB 12893; 9. PB 12894.

12—14. *Toxicodendron inaequilaterum* sp. nov.
12. PB 12897 (Holotype); 13. PB 12898 (Paratype); 14. PB 12899.

图版 Ⅹ(Plate Ⅹ)

1. *Aphanamixis* sp.
PB 12887.

2, 3. *Zanthoxylum refractifolium* sp. nov.
2. PB 12884 (Paratype); 3. PB 12985 (Holotype).

4, 5. *Toona bienensis* (Hu and Chaney) Tao
4. PB 12885; 5. PB 12886.

6, 11—13. *Helicteres callineura* sp. nov.
6. PB 12805; 11. PB 12806; 12. PB12807 (Holotype); 13. PB 12808 (Paratype).

7. *Murraya* sp.
PB 12883.

8, 9. *Reevesia* sp.
8. PB 12809; 9. PB 12810.

10, 14. *Schoepfia elegantifolia* sp. nov.
10. PB 12878 (Holotype); 14. PB 12879.

图版 Ⅺ(Plate Ⅺ)

1. *Schoepfia elegantifolia* sp. nov.
PB 12880 (Paratype).

2. *Loranthus palaeoeuropaeus* Kutuzk.
PB 12881.

3, 4. *Hydrangea lanceolimba* He and Chaney
3. PB 12811; 4. PB 12812.

5, 6. *Tetragonia ovatifolia* sp. nov.
5. PB 12776 (Holotype); 6. PB 12777 (Paratype).

7. *Viburnum validum* sp. nov.
PB 12913 (Holotype).

8—10. *Sinosideroxylon lincangense* sp. nov.
8. PB 12905; 9. PB12906 (Paratype); 10. PB 12907 (Holotype).

11, 12. *Chrysophyllum sinicum* sp. nov.
11. PB 12909 (Holotype); 12. PB 12910 (Paratype).

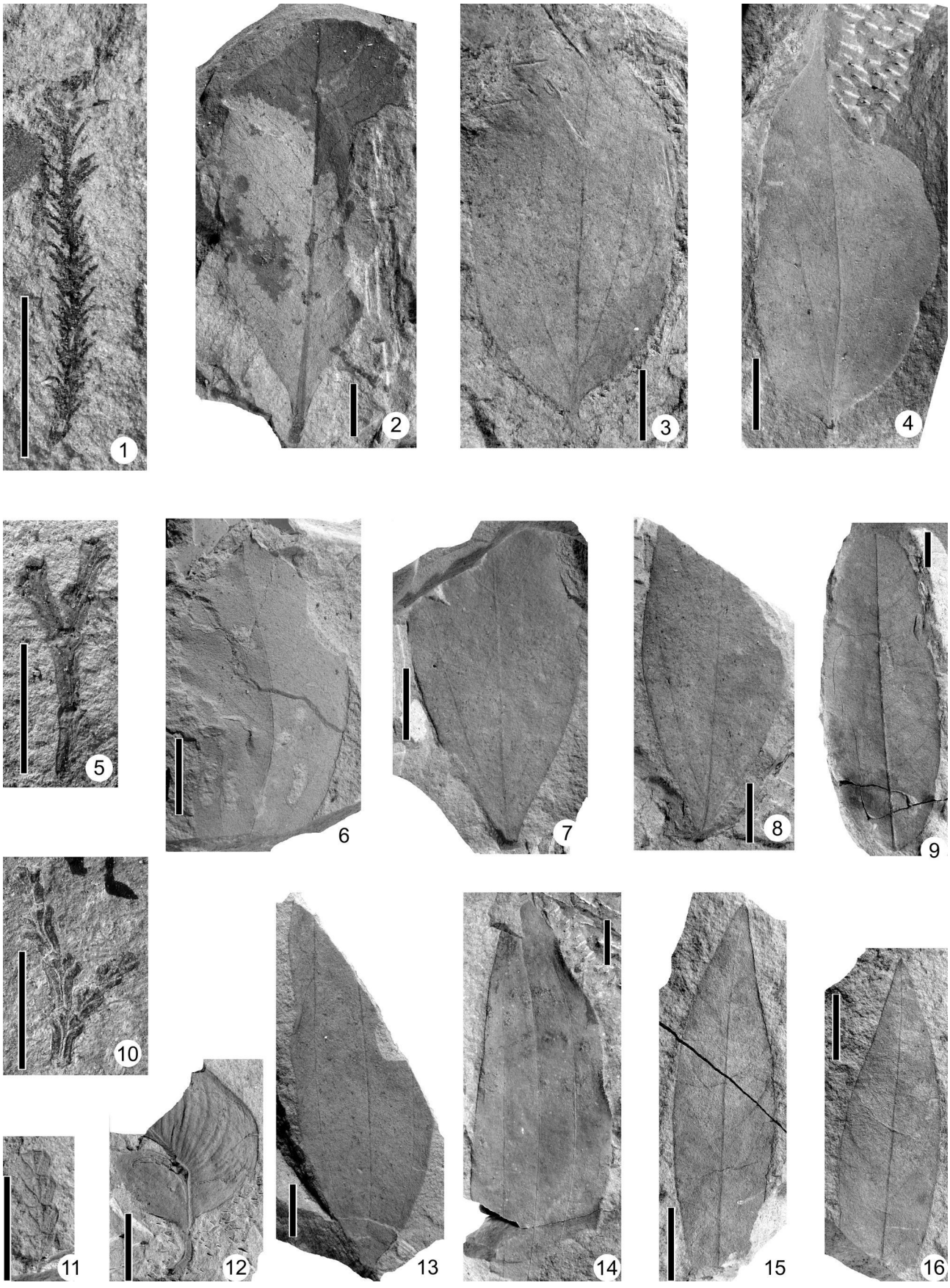
图版 Ⅻ(Plate Ⅻ)

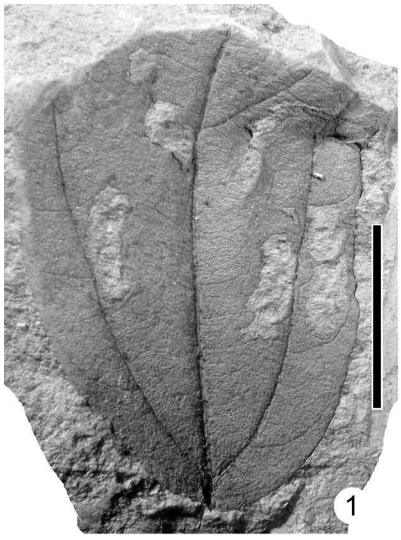
1. *Ternstroemia maekawai* Mutsuo
PB 12782.

2, 3. *Styrax pulchellus* sp. nov.
2. PB 12911(Paratype); 3. PB 12912 (Holotype).

4, 7—9. *Pittosporum lincangense* sp. nov.
4. PB 12778; 7. PB 12779; 8. PB 12780, (Holotype); 9. PB 12781 (Paratype).

5, 6. *Ilex ornatinervosa* sp. nov.
5. PB 12876 (Paratype); 6. PB 12877 (Holotype).

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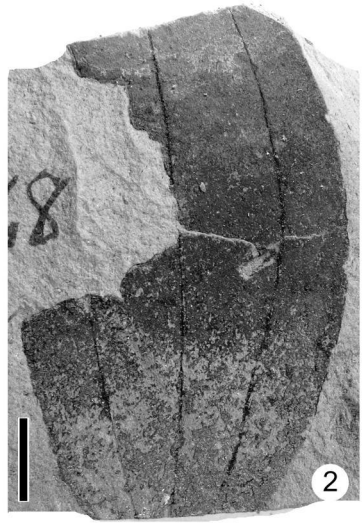
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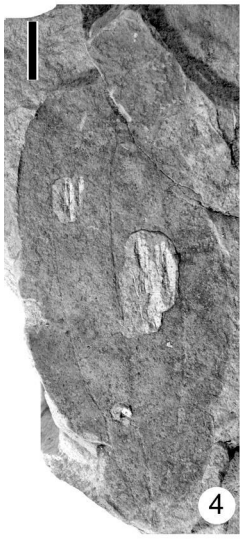
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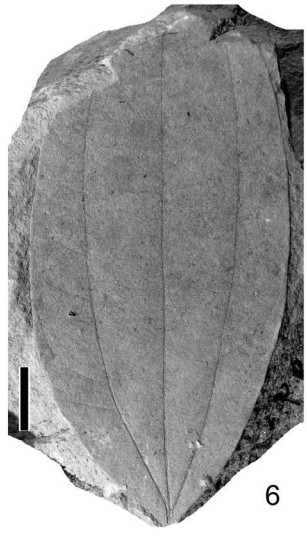
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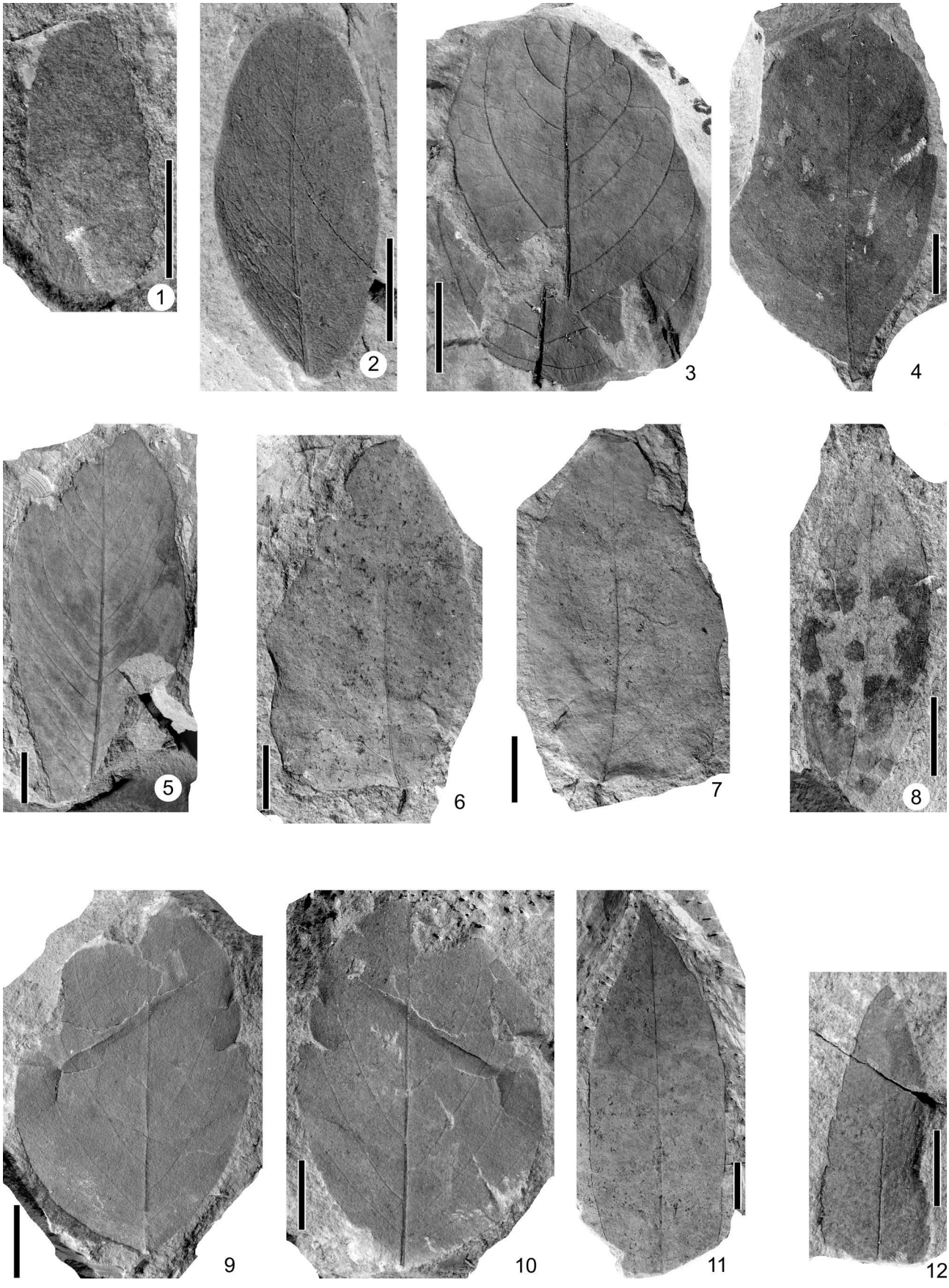


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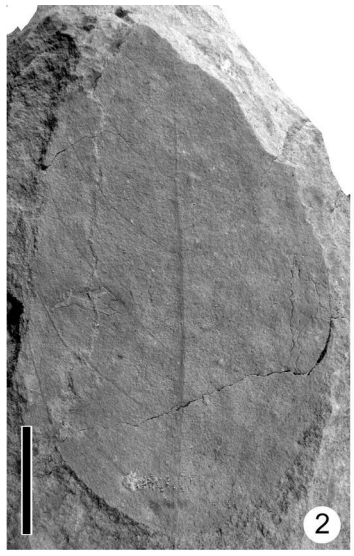
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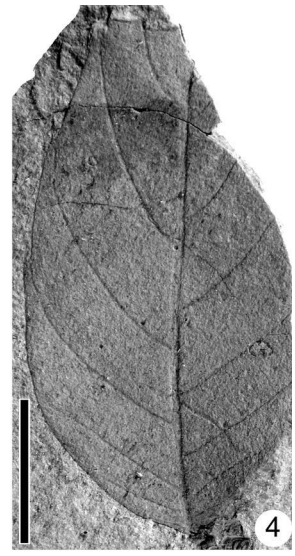
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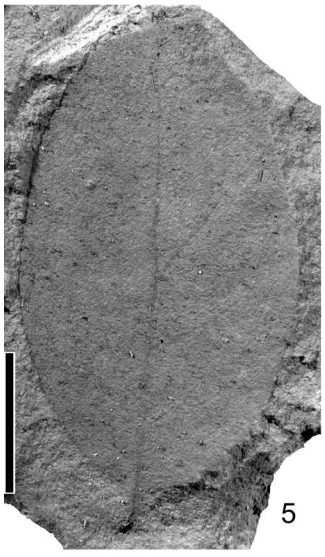
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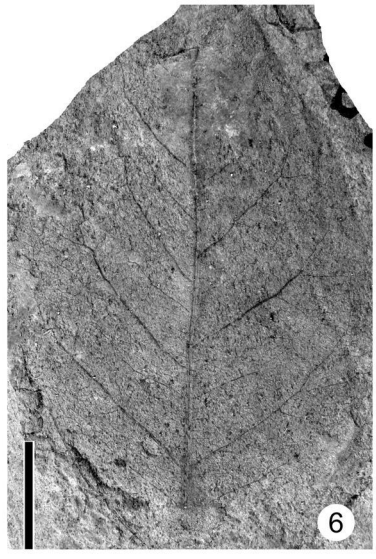
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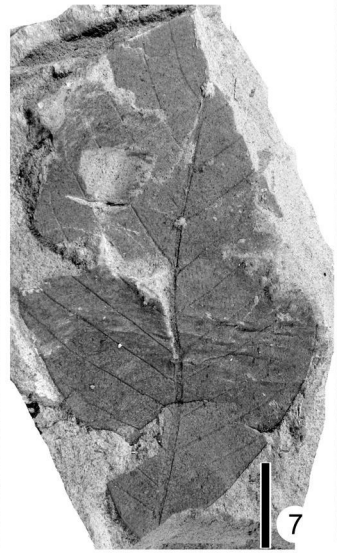
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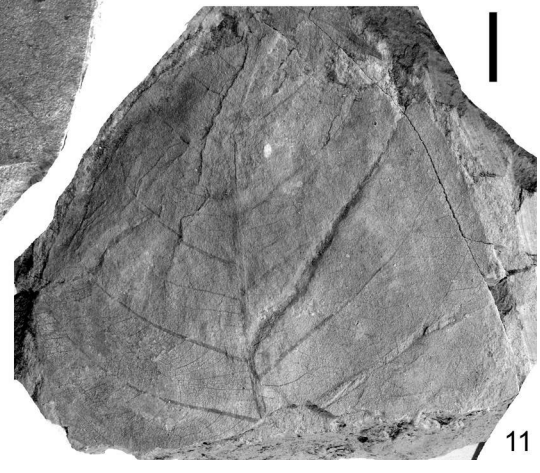
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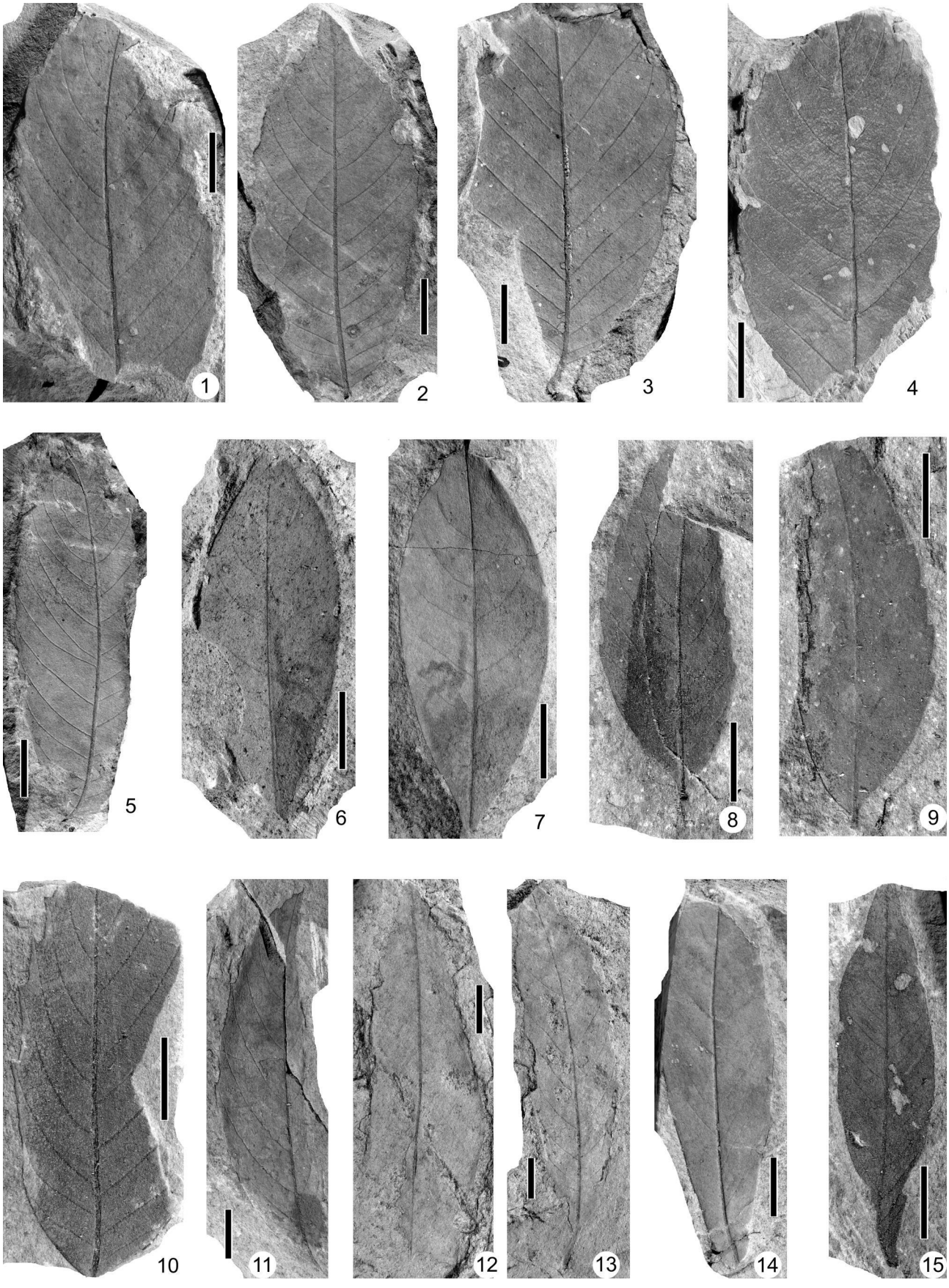

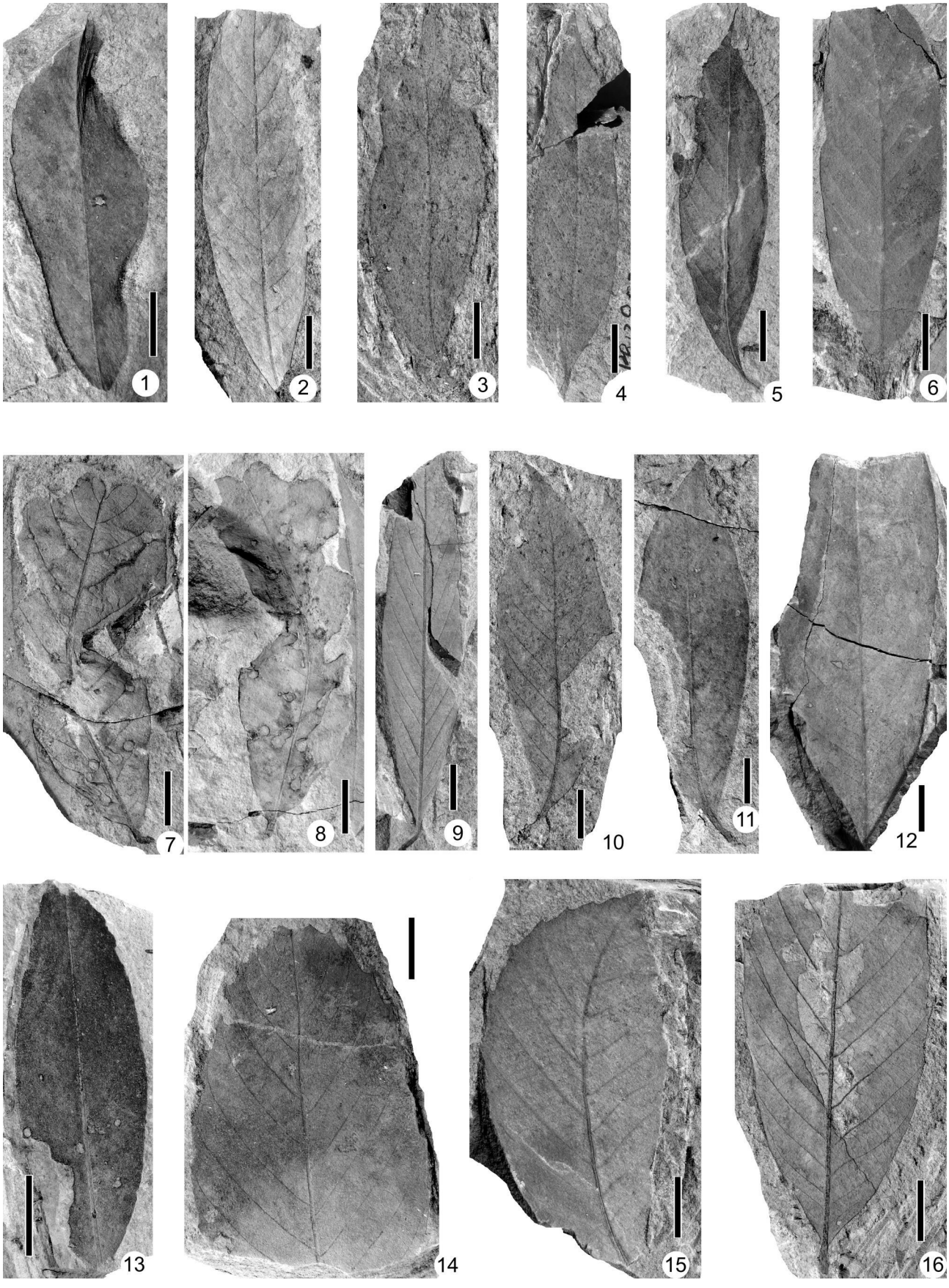


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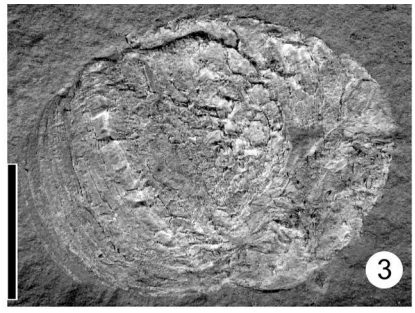
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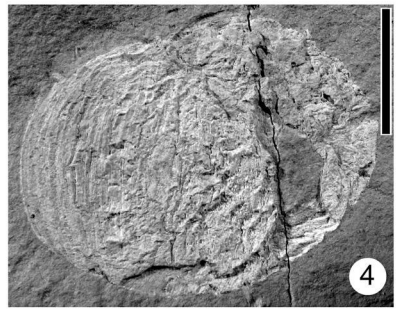
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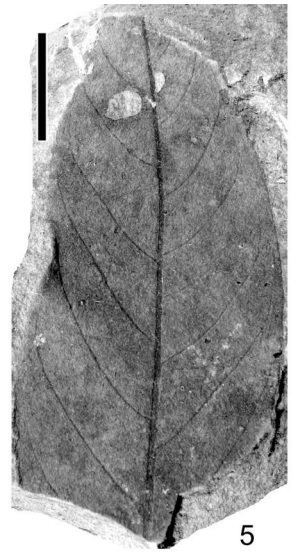
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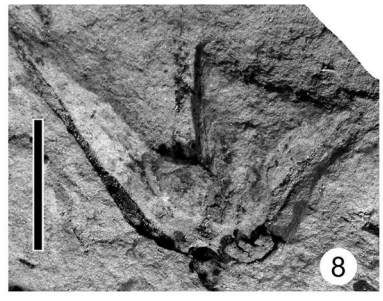
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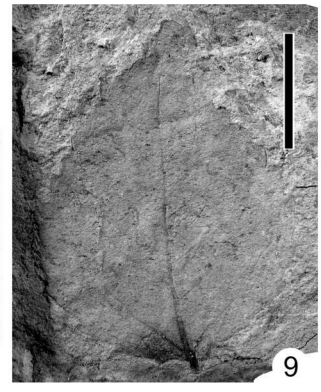
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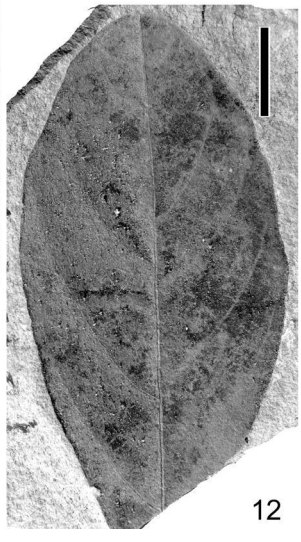
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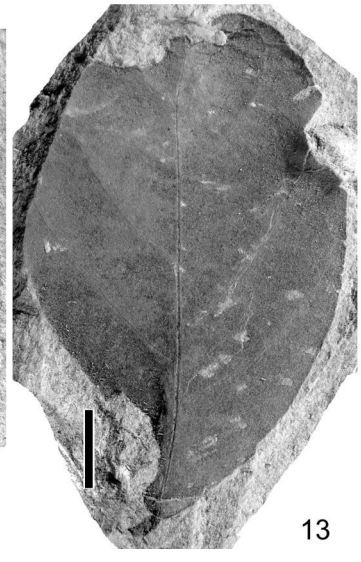
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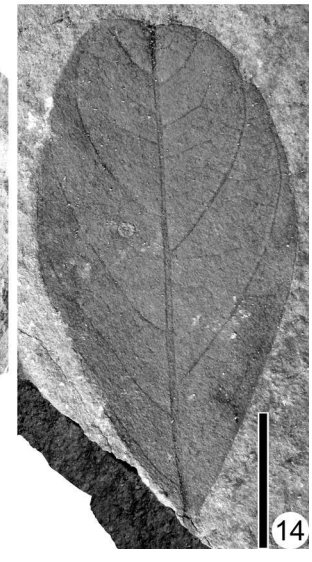
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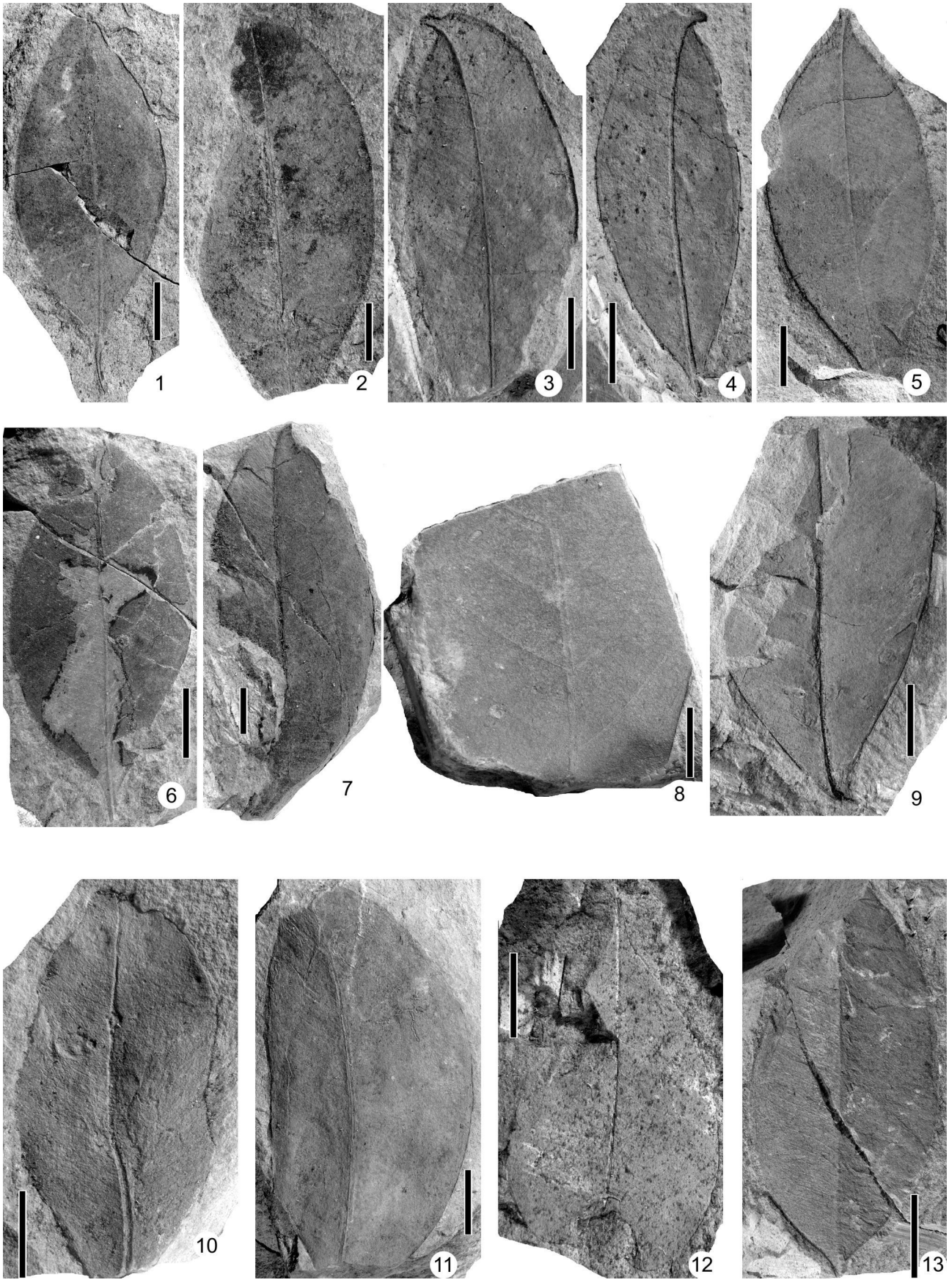

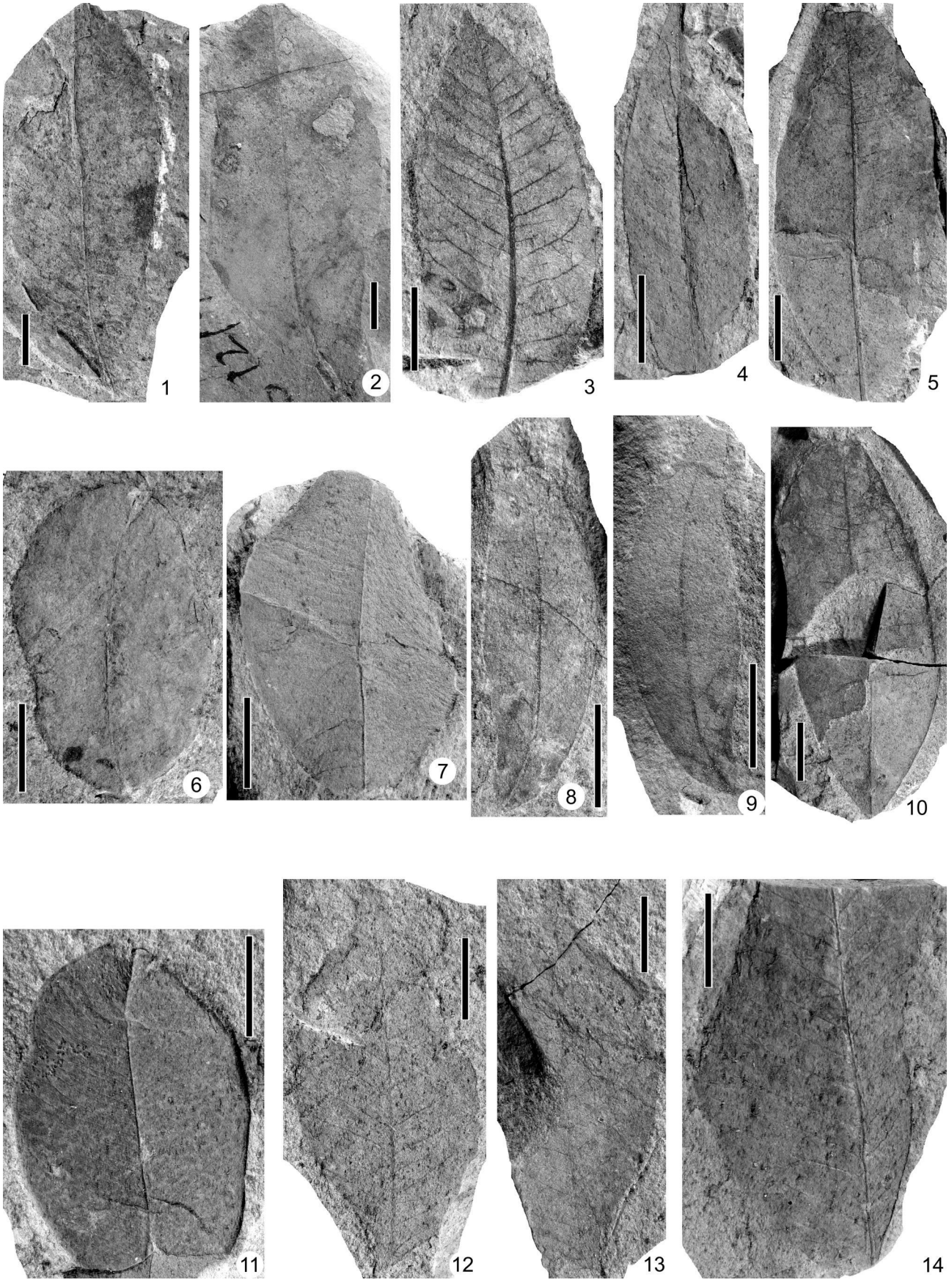

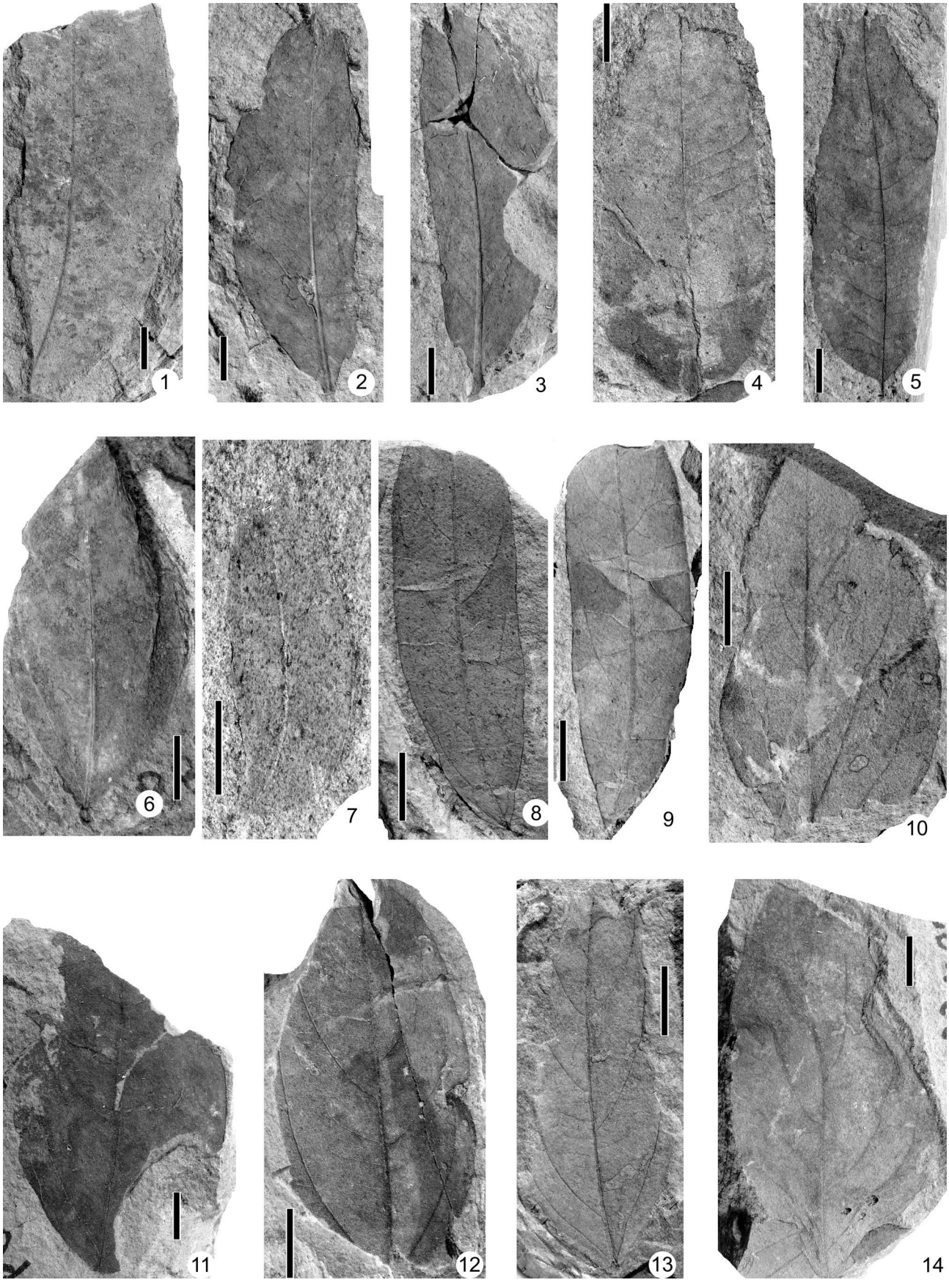

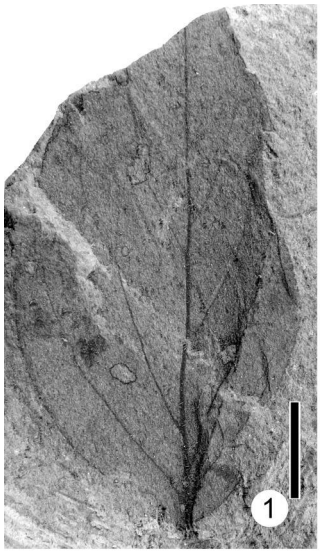

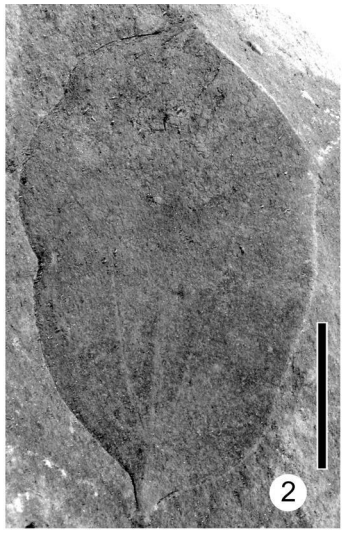

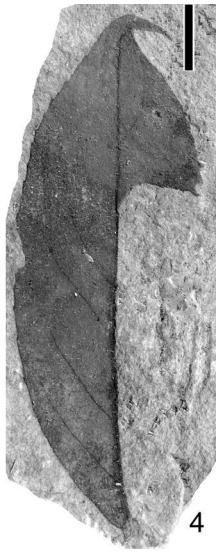

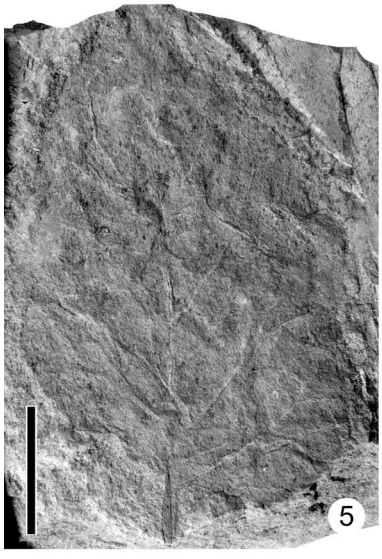

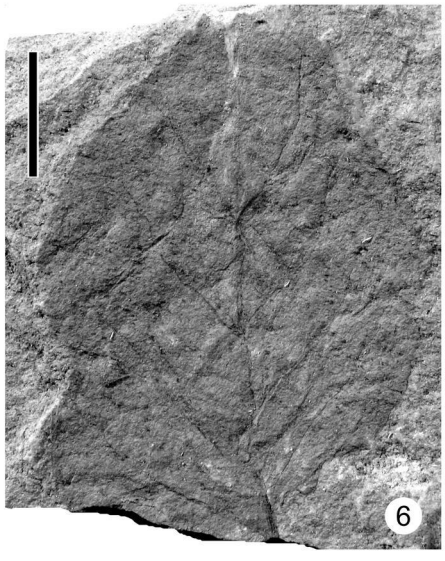

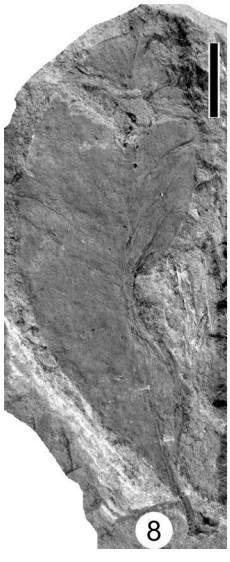

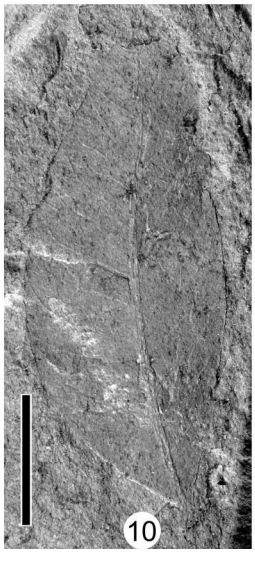

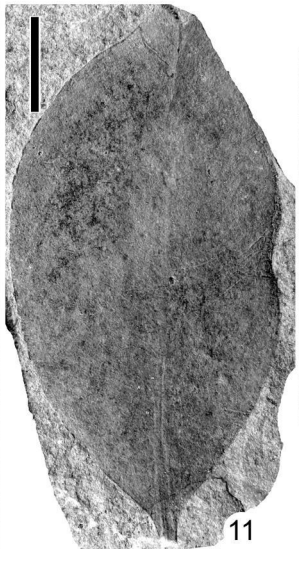

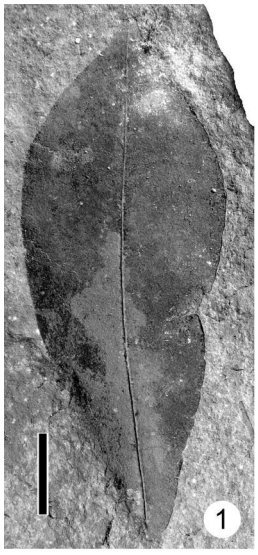
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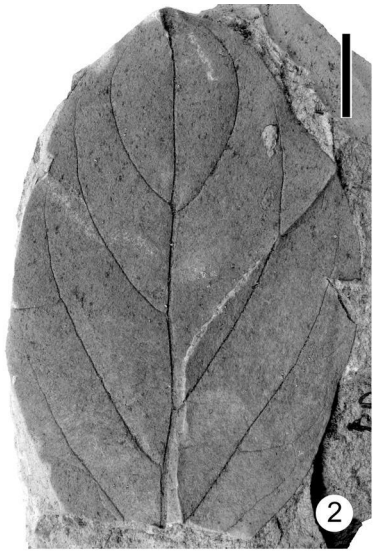
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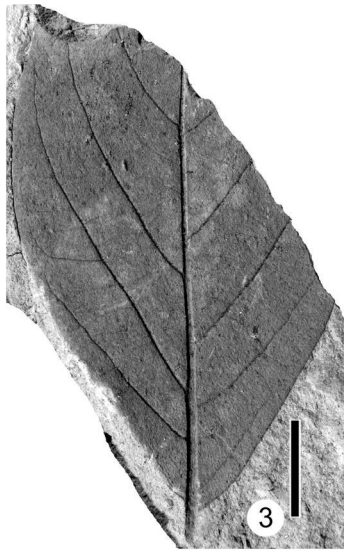
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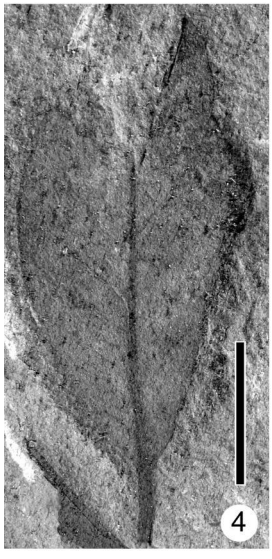
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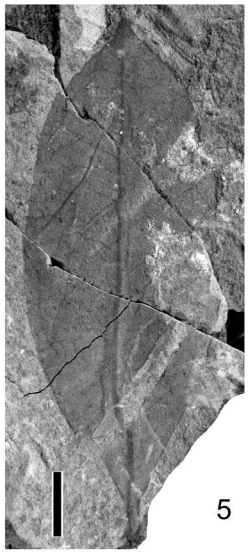
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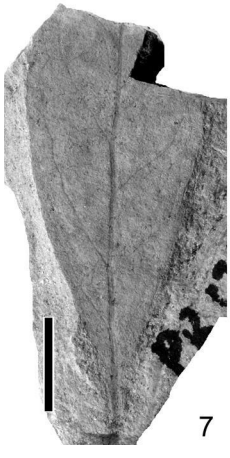
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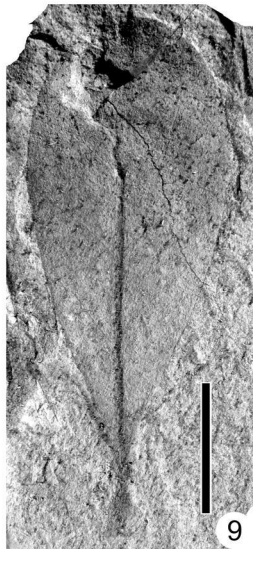
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