

# 论新疆北部晚石炭世早期 (Bashkirian—Moscovian) 具肋花粉优势(GSPD)组合的发现

欧阳舒 周宇星

(中国科学院南京地质生物研究所, 南京 210008)

王 智 詹家桢

(石油部新疆石油管理局勘探开发研究院, 新疆克拉玛依 834000)

## 内 容 提 要

传统观念认为 GSPD 组合始于中二叠世孔谷期, 据新疆等地资料证实此类组合的出现要早得多。准噶尔盆地在 *Profosulinella-Pseudostaffella* 带之下和相当层位的晚石炭世早期地层中存在两个孢粉组合, 即(1)早巴什基尔期巴塔玛依内山组的 *Remysporites\* varicus-Striatolebachites junggarensis* 组合(Pro-GSPD)和(2)中晚巴什基尔期—早莫斯科期车排子组的 *Prototrapoxypinus verrucosus-Hamiapollenites chepaiziensis* 组合(GSPD)。结合以往在乌拉尔东、西坡, 加拿大北极群岛和育空地区的记载, 论述了这些大体同时代 GSPD 组合在植物地理、古生态和生物地层对比上突破传统观念的重大意义, 指出亚安加拉区起源很早, 随着欧亚大陆的北移和半干旱气候带的扩张, 某些亚安加拉植物成分可能发生过向南的迁移。

**关键词** 孢粉 GSPD 组合 Bashkirian—Moscovian 北疆

长期以来, 古植物教科书(如 Gothan und Weyland, 1974)中, 在论及植被演化的阶段性时, 都提及裸子植物时代是从二叠纪、或确切地说, 以裸子植物、特别是松柏类为主的植被(即所谓“中植代”Mesophyte)是从晚二叠世(在西欧即苦灰统 Zechstein 之底)才开始的; 另一方面, 在经典孢粉著作中(Hart, 1965; Traverse, 1988), 裸子植物、尤其是具肋花粉占优势的组合(本文简称为 GSPD=Gymnospermous, especially striate pollen dominance 组合)被认为是从早二叠世晚期或中二叠世孔谷期(Kungurian)才开始出现的。这是两个相互联系而又有区别的传统观念。对这一传统观念, 近若干年来虽相继有所修正(Fredereksen, 1972; 姚兆奇、欧阳舒, 1980; Meyen, 1982, 1987; 欧阳舒, 1986), 但基本上没有突破原有的框架。人们囿于这种认识, 在孢粉方面, 以致凡发现 GSPD 组合(如准噶尔盆地西北缘), 时代差不多

• 严格地讲, 应归入 *Noeggerathiopsidozonotriletes* Lubert 1955 或 *Psilohymena* Hart 1973。

都曾定为二叠纪\*,国外也有这种情况(Barss, 1967, 1972)。可是,越来越多的资料表明,GSPD组合的出现要比传统观念认为的要早得多。

本文论及的基础材料采自新疆北部(下简称北疆)准噶尔盆地的1个露头剖面 and 3个钻孔,大体为两个地层单元,含两个不同的孢粉组合,即(1)盆地东缘奇台县克拉麦里双井子(胜利沟)巴塔玛依内山组,据上覆地层筴类等化石和下伏地层动植物化石,时代为早巴什基尔(Bashkirian)期,还有两个钻孔,一为吉木萨尔县帐篷沟帐3井(井深1370.93—2796.42m,特别是1373.93—1377.16m),一为阜康县东侧北三台井区9井(2809.46—3006.71m,主要为2809.46—2812.57m 3块样品),相关地层暂亦归入巴塔玛依内山组;(2)盆地西北缘克拉玛依市车排子地区车排子组(车25井2566.27—2568.00m),时代据共生腕足类、介形类和双壳类及孢粉定为晚石炭世早期中、晚巴什基尔—早莫斯科期。这是盆地内首次发现的时代较早的GSPD组合,詹家桢、王智等\*\*已作初步研究。

本文拟对上述材料并结合国外未被人们重视的大体同时代的孢粉资料作一综合研究,重点是讨论GSPD组合在北疆及世界其他地区的早发性及其在古植物学、植物地理、古生态和生物地层对比上的重大意义,这对今后北疆石油勘探、开发中相关地层,尤其是井下地层的划分和对比也有着现实意义。

文中涉及的孢粉属种描述拟在《新疆北部石炭系一二叠系孢子花粉的系统研究》一书中发表。在标本采集、分析、制图、照相等方面给予帮助的同志,和此研究课题进行中有关领导、课题负责人给予的关怀和支持以及经费来源等等亦将在该书中提及,我们先在这里一并表示衷心的感谢。

## 一、地层简况

现将本文涉及的4个地点和两个主要剖面列图如下。

### 1. 关于巴塔玛依内山组

在胜利沟-双井子一带本组与相关组的石炭纪地层层序(自上而下)是:

六棵树组

石钱滩组

巴塔玛依内山组

滴水泉组

滴水泉组超覆于泥盆-石炭纪过渡层塔木岗组之上,两者之间缺失杜内期和大部维宪期沉积。滴水泉组产植物化石,有*Lepidodendron*, *Lepidodendropsis*, *Sublepidodendron* 和 *Demetria asiatica* Zalesky 等(吴秀元等,1982;王蕙,1989),孢粉组合亦以鳞木类孢子 *Lycospora-Densosporites* 为主(王蕙,1989),时代为维宪—纳缪尔早期。

石钱滩组动物化石丰富,有筴、牙形类、菊石、非筴有孔虫和腕足类等。筴科化石有

\* 赵秀兰、金小凤,1985: 准噶尔盆地西北缘晚古生代孢粉特征及其时代探讨。

\*\* 詹家桢、王智、林树鑒、张义杰(1991, 手稿): 准噶尔盆地西北缘井下中石炭世海相动物群特征和共生孢粉化石的发现及意义。

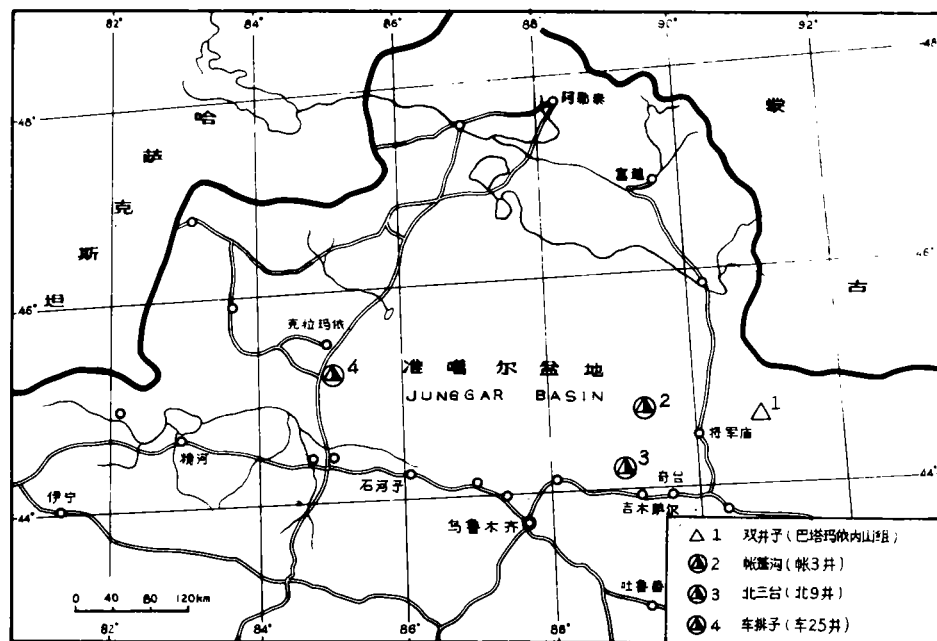


插图 1 4 个研究地点(剖面)在北疆准噶尔盆地的地理位置

Showing geographical position of the four localities (profiles) under study in Junggar Basin. N. Xinjiang

*Profusulinella*, *Pseudostaffella*, *Fusiella* 等, 其中 *Profusulinella parva*, *P. tikhonovichi* 是俄罗斯地台和中亚地区巴什基尔期中、上部的带化石, 相当华南黄龙组(或威宁组)下部的 *Profusulinella* 带。石钱滩组上部产菊石属 *Diaboloceras-Owenoceras* 组合带, 时代为巴什基尔期末—莫斯科期早期。腕足类属 *Choristites aljutorensis-Linoproductus latipianus* 组合, *Choristites* 最多。牙形类属于 *Gondollella donbassica-Streptognathus dissectus* 组合带, 似显示时代较新(北美 Atokan 或俄罗斯地台 Vereisky 期之后), 即莫期早期早中期。廖卓庭等(1990)根据各门类化石的综合分析和区域地层对比, 认为石钱滩组时代以定为巴什基尔中晚期—莫斯科早期较为适宜。

巴塔玛依内山组分布于准噶尔盆地东北缘, 在克拉麦里山该组最厚可达 2 000m, 为陆相火山岩系, 主要为中-酸性熔岩夹碳质页岩、煤线和凝灰质灰岩。横向岩相变化较大, 由西向东, 总的趋势是由中-酸性过渡为中-基性, 碳质页岩及煤线尖灭极快; 纵向上韵律性不明显(廖卓庭等, 1990\*), 炭质页岩中产植物化石, 如: *Angaropteridium cardiopteroides*, *Angaridium potaninii*, *Mesocalamites cistiiformis* 和 *Noeggerathiopsis* sp. 等(吴秀元等, 1982; 窦亚伟等, 1985), 属于 *Angaridium-Mesocalamites-Noeggerathiopsis* 组合, 时代因有上(石钱滩组)、下(与滴水泉组大致相当的那林卡组, 产菊石 *Goniatites*, *Dombarites*, *Platygonyatites*, *Neogonyatites*, 维宪晚期—纳缪尔期 E 带)海相动物化石卡定, 被定为纳缪尔期 H + R 带, 即巴什基尔早期。孢粉属于 *Remysporites varicus-Striatolebachites*

\* 廖卓庭、杨蔚华、魏洲龄等, 1990: 新疆北部石炭系及其含矿性研究报告。

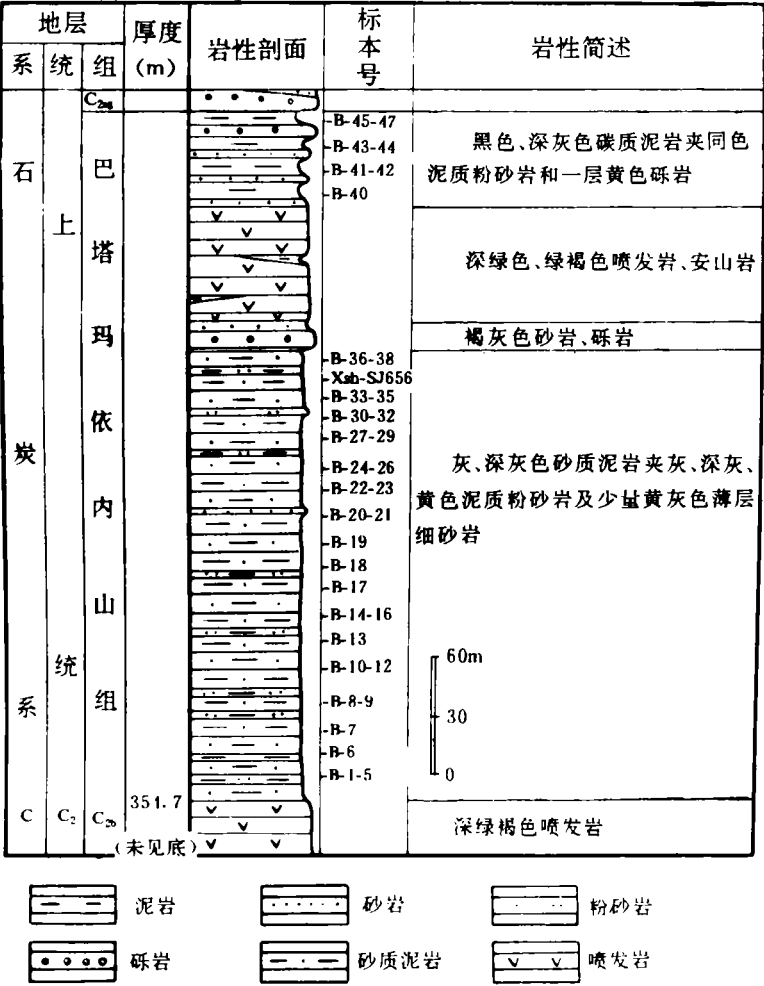


插图 2 克拉麦里双井子巴塔玛依内山组柱状剖面图

Showing lithology and sampling position in section of the Batamayineishan Formation at Kelamaili in Junggar Basin, N. Xinjiang

junggarensis 组合,面貌老于西北缘巴什基尔—莫斯科期的“车排子组”组合,故亦与上述时代结论不矛盾。

2. 关于西北缘“车排子组”

这是根据车 25 井岩芯中产出巴什基尔—莫斯科期动物化石和孢粉组合而权宜使用的一个组名,岩性见插图 3。

此组腕足类经王智鉴定,有 *Orbiculoides* sp., *Schizophoria* sp., *Dictyoclostus* sp., *Buxtonia juresanensis* (Tschern.), *Choristites radiculosus* A. Evanov et E. Evanov, *C. mansuyi borochorocusis* Yang, *Composita* sp. 和 *Dielasma millepunctatus* Hall 等; 以 *Choristites* 最多,在这一点上与前述石钱滩相近似。形类经林树鑒鉴定,有 *Healdia asper*

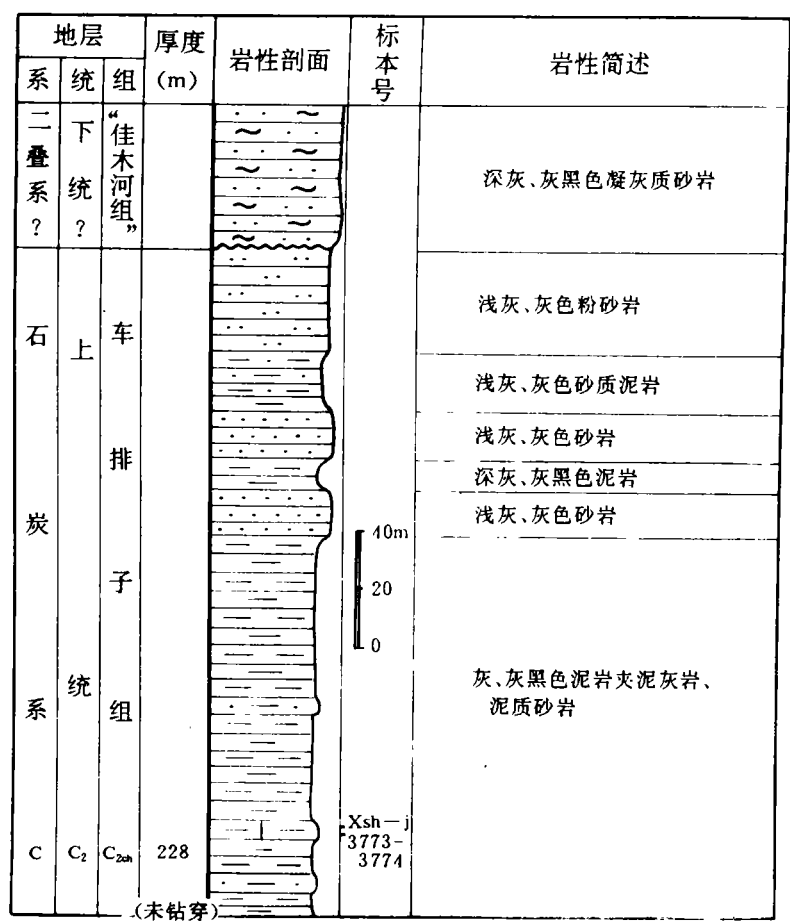


插图 3 克拉玛依车 25 井车排子组柱状剖面图

Showing lithology and sampling position in subsurface section (Well-25) of the Chepaizi Formation at Chepaizi, Karamay, Junggar Basin, N. Xinjiang

Cooper, *Oliganiscus incompta* (Kots.), *Bairdia chudolasensis* Kots., *Orthobairdia altiformis* (Knight), *Roundyella simplicissima* (Knight), *Pseudobythocypris cetralis* (Coryell et Billings), *Macrocypris menardensis* Harton, *Bairdiacypris subcunspicus* Kots. 等。双壳类经张义杰鉴定有 *Streblochondria? tenuilieata*, *Aviculopecten* cf. *exenplarius*, *Palaeoneilo* sp., *Schizodus* sp. 和 *Edmondia* sp.。腹足类经张义杰鉴定有 *Aclisina* sp., *Soleniscus* sp. 1, 2, *Zygopleura* sp.。主要根据上述腕足类和介形类,此组时代被定为中、晚巴什基尔—早莫斯科期。与这些动物化石共同产出的孢粉很多且分异度大,称之为 *Protohaploxypinus verrucosus*-*Hamiapollenites chepaiziensis* 组合。

## 二、孢粉组合特征

### 1. *Remysporites varicus*-*Striatolebachiites junggarensis* 组合

产自上述双井子剖面巴塔玛依内山组上部碳质泥岩中,主要成分见图版1。本组合组成分异度不大,包括下列属种:*Calamospora* sp., *Cyclogranisporites* sp., *Verrucosisporites* sp., *Retitriteles* sp., *Retusotriteles* spp., *Geminospora* sp., *Perotriteles* sp., *Remysporites psilopterus*, *R. multirugulatus*, *R. varicus*, *R. marginatus*, *R. marginella*, *R. rugosus*, *Potonieisporites* sp., *Florinites* sp., *Striatolebachiites junggarensis*, *S.* sp., *Protohaploxypinus* sp., *Striatoabieites* sp., *Striatopodocarpites* sp.。组合中, *Remysporites* 占 58.5%, *Striatolebachiites* 达 18%, *Protohaploxypinus* 1%。其他单囊花粉 *Potonieisporites* 和 *Florinites* (个体皆较大)仅个别见到,假如 *Remysporites* 如某些孢粉学家所推测的那样属于种子蕨是正确的话,则此组合裸子植物花粉含量已达 80%,蕨类植物孢子占 18.5%。这是目前世界上已知最早的可能以裸子植物花粉占优势的组合(似乎与安加拉早石炭世大植物化石鳞木类植物群在巴什基尔早期突然变为以贫乏化的种子蕨占优势的植物群可以对比,见 Meyen, 1982、1987),或至少是具肋花粉(达 20%)的最早记录,代表此类花粉其后进一步分异发展的较原始阶段,故本文称之为 Pro-GSPD 组合。

关于 *Remysporites* 的垂直分布:如 *R. psilopterus* 在原苏联库兹涅茨克盆地初现于下巴拉洪群中部(Mazurovsky 组)(*Andrejeva et al.*, 1956; Luber and Waltz, 1941),时代据 Meyen(1982)为莫斯科期,哈萨克斯坦的 Ashlyarisky 组上部(Luber, 1955),时代属维宪期,中央哈萨克斯坦的 Dolinsky 组,时代巴什基尔期(*Panova et al.*, 1990);在北疆阿希列南明水组或阿勒玛利组(廖卓庭等,1990),时代可能为维宪期。因而可以肯定地说,本属在早石炭世已出现,至晚石炭世早期分布已较广泛。此外,个体较大的 *Potonieisporites* 和 *Florinites* 在安加拉的谢尔普霍夫阶和巴什基尔阶已出现。由此可见,巴塔玛依内山组的孢粉组合,与安加拉区关系是密切的。

Meyen(1982,1987)根据大植物化石总结安加拉植物群发展阶段时曾经指出:在库兹巴斯,最重要的植物群变化是发生在早石炭世末的鳞木类组合 4 和中石炭世早期的种子蕨为主的组合之间,这一变化是与巴什基尔阶最底部的海侵和相关动物群的出现一致的,而且反映了一个很有意义的气候变凉事件(即“Osteroonian 幕”);这一事件在整个安加拉大陆都很容易追踪,且可与西欧 Namurian A/B 之间的植物群突变对比。窦亚伟等(1985a,b)在探讨北疆晚古生代植物群的演替阶段时,亦曾将早石炭世植物群称为“拟鳞木植物群”,晚石炭世至早二叠世为“淮安加拉羊齿植物群”,即植物群的突变发生在“南明水群”(包括那林卡拉组)和卡拉吉拉组之间,即 Namurian E/H+R 带之间,与 Meyen 所述一致。不过,卡拉吉拉组,根据现有资料判断(廖卓庭等,1990),应大体相当巴塔玛依内山组。无论安加拉区或北疆,后一植物群最主要代表即“淮安加拉羊齿”( *Angaropteridium* ),此属为种子蕨植物,故与前述孢粉组合反映的种子蕨优势组合的结论是不矛盾的。巴塔玛依内山组组合是否亦反映此期气候变凉事件导致的植物群贫乏化则有待研究。

北 9 井和 3 井上述层段产类似的孢粉组合,蕨类孢子占 4.5—19.5%(平均 8%),单

囊的 *Remysporites* 34.7—92.5% (平均 60%) 和 *Potonieisporites* 1—28.5% (平均 11%), 单囊具肋花粉 (*Striatolebachiiites*, *Striatomonosaccites*) 略有减少, 但双囊具肋花粉 (*Protohaploxypinus*, *Striatopodocarpites*) 有所增加 (0.5—29.5%, 平均 12.4%), 在帐 3 井还出现了一些两囊无肋花粉 *Pityosporites*, *Platysaccus*, *Limitisporites*, *Vesicaspora* 等 (图版 I)。所以北 9 井、帐 3 井有关层段时代与巴塔玛依内山组大致相当或部分稍新, 有可能为巴什基尔早、中期。

## 2. *Protohaploxypinus verrucosus*-*Hamiapollenites chepaiziensis* 组合

产自车排子组浅海相深灰色泥灰岩中, 孢粉大量, 保存完美, 分异度亦高。大致组成如下:

蕨类植物孢子和少量种子蕨前花粉, 有: *Leiotriletes* (3) (括号内数字代表种或类型数, 下同)。 *Punctatisporites* (2), *Calamospora* (4), *Gulisporites* (2), *Granulatisporites* (1), *Cyclogranisporites* (3), *Acanthotriletes* (1), *Apiculatisporis* (1), *Convolutispora* (1), *Raistrickia* (2), *Verrucosisporites* (2), *Aneurospora* cf. *greggsii*, *Lycospora* (1), *Stenozonotriletes* (1), *Rugospora* (1), *Geminospora* cf. *plicata*, *Endoculiospora* (1), *Endosporites* (3), *Laevigatisporites* (2), 即共约 19 属、33 种。

裸子植物单囊花粉: *Cordaitina* (5), *Florinites* (3), *Parasaccites* (3), *Plicatipollenites* (3), *Virkkipollenites* (2), *Crucisaccites* (1), *Potonieisporites* (3), *Samoilovitchisaccites*? (1), *Vesicaspora* (2), 共约 9 属 23 种。

两囊无肋或具单裂花粉 *Klausipollenites* (3), *Voltziaceasporites* (1), *Falcisporites* (1), *Pityosporites* (3), *Platysaccus* (3), *Lamellosaccites* (1), *Alisporites* (2), *Piceapollenites* (2), *Abiespollenites* (1); *Vestigisporites* (2), *Limitisporites* (3), *Gardenasporites* (5); 共计 12 属 27 种。

单囊具肋花粉: *Striatomonosaccites* (2), *Striatolebachiiites* (2) 和两囊具肋花粉 *Chordasporites* (1), *Illinites*? (1), *Protohaploxypinus* (13), *Striatoabietites* (5), *Striatopodocarpites* (7), *Hamiapollenites* (7), *Lunatisporites* (?) (5), *Vittatina* (2), 共计约 10 属 45 种。

单沟花粉: *Cycadapites* (3) 和疑源类 *Schizosporis* sp.。

本组合共达约 50 属 130 种 (型), 本文重点是讨论 GSPD 组合的早发性问题, 故种的名单未列, 图版 II, III 仅列举一部分代表性分子。

经统计两块样品, 其组合组成、含量相近, 平均含量如下: 蕨类植物孢子 21%, 裸子植物花粉近达 77% (其中单囊 14%、单囊具肋 1%、两囊具肋 44%、二囊无肋 18%), 单沟花粉等占 2%; 如按种的组成计, 仍以裸子植物花粉为主 (近 2/3)。

这个组合令人惊奇, 如果没有多门类海相动物化石共生, 按传统观念, 大多数孢粉学家将定其时代为二叠纪。但前述动物化石和区域地层对比, 明确指示其时代为中、晚巴什基尔期—早莫斯科期。共生的动物化石不可能是再沉积的, 例如图版 II 图 11 的 *Bouxtonia juresanensis* (Tsch.) 具纤细的刺状纹饰, 图版 III 图 6 的 *Orbiculoides* sp. 壳膜很薄, 如果它们脱离母岩, 再经过搬运、沉积, 是不会保存如此完美的; 此外, 支持本组合为原生的另一证据是类似的 GSPD 组合新近已在东缘的石钱滩组发现。

这一组合很可能为种子蕨花粉占优势 (仅具肋纹花粉即达 45%), 因为安加拉区的植物

原位孢子研究证明, *Protohaploxylinus* s. l. 和 *Vittatina* 等具肋纹花粉乃产自种子蕨, 如盾籽目(Peltaspermales), 部分单囊(如 *Vesicaspora* )、两囊甚至单沟花粉亦复如此(Meyen, 1982, 1987)。

分异程度如此之高的植物群产生在巴什基尔—莫斯科期是与 Meyen(1987)对大植物化石的总结一致的, 例如, 他说“中石炭世植物群最完整的代表当属巴什基尔期—早莫斯科期, 此期之分异度达到顶峰(数百种)”, 而且, “在巴什基尔—莫斯科期之交(Westphalian B 之内), 美国 Illinois 的煤炭沼泽植物群显示出‘第一次较干旱期’”。

我们根据前述巴塔玛依内山组的 Pro-GSPD 组合的发现, 以及与车排子组组合类似组合在国外的记载, 现在可以大胆突破前人的观点, 得出这样的结论: 即 GSPD 组合在晚石炭世早期、即巴什基尔—莫斯科期已在北半球若干地区或生态带内出现。

### 三、国际对比及其他

与上述车排子组合近似的孢粉组合不仅在北疆(特别是克拉玛依油田的钻孔中)不只一次见到, 在国外也有报道, 不过, 原苏联和北美作者的发现, 由于种种原因, 长期以来并未引起人们注意。现举例说明如下。

1) Barss(1967, 1972; Bamber and Barss, 1969)先后报道了加拿大育空地区 Ettrain 组(总厚达 652m, 下部主要为粉砂岩、页岩, 上部为灰岩夹钙质页岩)的孢粉组合, 计蕨类孢子  $\geq 5$  种, 单囊 3 种, 单囊具肋 1 种, 两囊具肋  $\geq 18$  种, 两囊无肋  $\geq 7$  种, 共计  $> 34$  种。名单如下: 孢子 *Leiotriletes* sp., *Lophotriletes* spp., *Endosporites* sp., *Latosporites* sp.; 单囊花粉 *Cordaitina* (3), *Potonieisporites* (2), *Striomonosaccites* (1), *Florinites* (1); 两囊具肋花粉有 “*Lueckisporites virkkiae*”, *Protohaploxylinus* ( $\geq 4$ ), *Striatoabeites* ( $\geq 4$ ), *Striatopodocarpites* (2), *Tumoripollenites* (1), *Hamiapollenites* (1), *Costapollenites* (1), *Vittatina* (4); 两囊无肋花粉有 *Pityosporites* (1), *Piceapollenites* (1), *Vestigisporites* (4), *Gardenasporites* (1) 等等。即裸子植物花粉种数占总数约 85%, 其中具肋花粉种数占 55%。

除孢子组成较贫乏、属种分异度较低, 且未见(?)安加拉分子 *Remysporites* 和冈瓦纳色彩的分子 *Parasaccites*, *Plicatipollenites* 和 *Virkipollenites* 等外, 这个 GSPD 组合表现出与车排子组组合有惊人的相似性, 其中绝大多数属皆见于后一组合; 种也有些相同, 如 *Florinites eremus*, *Striatoabeites striatus* 等。Barss 鉴定的 *L. virkkiae* 与本文图版 III 图 1 酷似, 应归入 *Gardenasporites*。

育空这一组合, Barss(1967; Bamber and Barss, 1969)在与加拿大大西洋省和美国、西欧、中欧已知晚石炭世组合比较之后, 鉴于其中缺乏后者的那些典型属(如 *Lycospora*, *Torispora*, *Thymospora*, *Vestispora* 等), 定其时代为早二叠世(Wolfcampian); 他认为与孢粉组合共生的鲢、腕足类不无再沉积的可能。后来, 他(1972)略略改变了自己的观点, 谓根据孢粉组合将 Ettrain 组定为早二叠世也可能是错误的。有趣的是, 直到最近, 还有的孢粉学家(Wood et al., 1991)视其为早二叠世。只有 Kremp(1974)从不同的气候、生态背景来解释育空这一组合, 他指出“Barss 拿来作比较的孢粉植物群乃来自热带雨林气候带(Af)或来自 Savana 气候带(Aw), 但育空地区是属于半干旱或干旱气候带。……假如 Barss 在 1970 年写他的论文时, 能够将他的阿拉斯加微体植物群与俄罗斯地台晚 Pennsylvanian 的组合比较



的话,也就会发现两者之间的确有相似性。……那时俄罗斯地台属于干旱气候带,其孢粉植物群也富含 *Vittatina* 和两囊具肋花粉。”不过, Kremp 文中并未举出俄罗斯地台晚石炭世类似孢粉组合的例子。

Ettrain 组与孢粉共同产出的筴有: *Profusulinella*, *Pseudostaffella* 和 *Fusulinella*。古动物学家认为其时代为中 Pennsylvanian 期;前两属乃准噶尔盆地石钱滩组的带化石, *Fusulinella* 层位稍偏高(Moscovian)。故育空这一地层时代定为晚巴什基尔—莫斯科期应无多大问题。

2)加拿大北极群岛 Ellesmere 岛的 Otto Fiord 组上部(灰岩的页岩夹层中,灰岩上下皆为硬石膏)的孢粉(Utting, 1985a),亦为 GSPD 组合,但属种较少、且保存不好,未引起人们注意。Utting 谓其时代不老于 Westphalian C,即不老于莫斯科期中期,但据最近资料,此组产筴、头足类、腕足类、牙形类等,其时代为早石炭世末 Serpukhovian 至 Moscovian 早期(Rui *et al.*, 1991),这意味着含孢粉组合层位时代更老一些,即莫斯科期早期,甚至跨入巴什基尔期。

再如加拿大北极群岛 Melville 岛石炭纪—三叠纪孢粉组合(Utting, 1985b),有两点值得注意,一是其最下部的 Canyon Fiord 组(最上部?)的组合,除少量孢子外,亦为 GSPD 组合,包括有 *Cordaitina*, *Striomonosaccites*, *Protohaploxylinus*, *Striatoabieites*, *Hamiapollenites*?, *Vittatina* 和 *Weylandites* 等。在层型地区本组产 Bashkirian—Sakmarian 期动物群,因而根据孢粉组合将其最上部(?)定为 Asselian—Sakmarian 是妥当的;但本组中上部(产孢粉剖面)无动物化石,故其确切时代有待进一步研究,目前不能排除更老的可能。二是 Utting 报道的整个“二叠系”(除个别层位)一般均为 GSPD 组合,这方面很可以与北疆上石炭系—二叠系组合比较。

3)原苏联乌拉尔地区也有类似例子,一是乌拉尔东坡 Sinar 河晚古生代组合(Chuvashov *et al.*, 1979; 1984),这里从陆相—海相交互相—膏盐层—膏盐层之上共划分出 3 个组合。第一组合(陆相)孢子组成较丰富,但裸子植物花粉已出现 *Potonieisporites*, *Florinites*, *Pityosporites*, *Limitisporites*, *Schopfipollenites*? 和两囊具肋花粉 *Protohaploxylinus*; 时代被定为莫斯科期。

与我们的讨论最有关系的是第 2 组合(自下而上分为 3 个亚组合)、特别亚组合 B(即相当 Chuvashov *et al.*, 1979 的碳酸岩相—陆相的组合 I)。组合中蕨类孢子有光面、粒面、刺面、瘤面、网面三缝孢,但裸子植物花粉占优势(65—73%),具肋(主要为两囊)花粉达 40—46%,除 *Illinites*(= *Kosankeisporites* 或 *Complexisporites*)之外,有 *Striomonosaccites*, *Protohaploxylinus*, *Striatoabieites*, *Striatopodocarpites*, *Hamiapollenites*, *Vittatina* 等;单囊花粉(25—27%)有 *Florinites*, *Potonieisporites* 和 *Crucisaccites*;两囊无肋花粉有 *Platysaccus*, *Limitisporites* 和 *Gardenasporites* 等;还有 *Schopfipollenites* 和单沟花粉 *Cycadopites*。组合面貌与车排子组相近。这一组合以筴科化石为依据确定时代,原定为 Moscovian 中期(即 Kashrsky—Podolsky)。有趣的是,这里筴科化石亦以 *Profusulinella* 为主,并有 *Fusulinella* 和 *Fusulina*,因而此层及下伏陆相沉积(产亚组合 A,亦以裸子植物花粉为主,但属种较少)之和大致与加拿大育空地区 Ettrain 组对比或略高一些。

在乌拉尔西坡(Chuvashov and Djupina, 1973; Djupina, 1979)有筴科化石确定时代(“中

石炭世面貌”或在 *Triticites arcticus* 之下)的莫斯科期沉积中的组合,有时亦以裸子植物花粉为主( $\geq 50\%$ ),包括单囊 *Potonieisporites*(多), *Florinites*, *Schulzospora* 和 *Remysporites*, 两囊无肋的 *Platysaccus*, 两囊具肋的 *Illinites*, *Protohaploxypinus*, *Striatopodocarpites*, *Hamiaipollenites* 及 *Vittatina* 等。在上石炭统 Kasimovian 阶裸子植物花粉更占优势,两囊具肋可达 40%。

裸子植物花粉占优势的组合还见于中央哈萨克斯坦西部的杰兹卡甘,那里据海相有孔虫时代属巴什基尔期(Chuvashov *et al.*, 1984)。

由此可见,在有直接或间接䇥科化石为证据的巴什基尔—莫斯科期或莫斯科期沉积中, GSPD 组合并不是个别偶然出现。现将与车排子组组合较为相似的几个组合的对比情况及裸子植物花粉属的组成列表如下[表 I 和表 II (英文)]。

表 I 示裸子植物花粉属在北疆(车排子组)、育空(Ettrain 组)和乌拉尔东坡 (I, I 组合)3 个孢粉组合中的出现情况

Showing occurrences of gymnospermous pollen genera in Chepaizi Formation (N. Xinjiang), Ettrain Formation (Yukon Territory) and assemblages I, I of Chuvashov *et al.* 1984 (E. slope of Ural)

地 区 (Region)	北疆 (N. Xinjiang) Chepaizi Fm.	育空 (Yukon) Ettrain Fm.	乌拉尔东坡 (E. slope of Ural) Assemblages I, I
属 (Genus)			
<i>Remysporites</i>	+		
<i>Cordaitina</i>		+	+
<i>Crucisaccites</i>	+		+
<i>Potonieisporites</i>	+	+	+
<i>Florinites</i>	+	+	+
<i>Parasaccites</i>	+		
<i>Plicatipollenites</i>	+		+
<i>Virkkipollenites</i>	+		
<i>Samoilovitchisaccites?</i>	+		
<i>Vesicaspora</i>	+	+	
<i>Klausipollenites</i>	+		
<i>Abiespollenites</i>	+		
<i>Piceapollenites</i>	+	+	
<i>Falcisporites</i>	+		
<i>Pityosporites</i>	+		+
<i>Platysaccus</i>	+	+	+
<i>Alisporites</i>	+		
<i>Limitisporites</i>	+	+	+
<i>Vestigisporites</i>	+	+	
<i>Gardenasporites</i>	+	+	+
<i>Illinites</i> s. l.	+	(+)	+
<i>Striatomonosaccites</i> - <i>Striomonosaccites</i>	+	+	(+)
<i>Striatolebachites</i>	+	(+)?	(+)?
<i>Protohaploxypinus</i>	+	+	(+)
<i>Striatoabieites</i>	+	+	(+)
<i>Striatopodocarpites</i>	+	+	(+)
<i>Costapollenites</i>	?	+	+
<i>Hamiaipollenites</i>	+	+	+
<i>Vittatina</i>	+	+	+
<i>Cycadopites</i>	+	+	+

由表 I 可见,所列车排子组 29 属花粉中,约 2/3 的属,尤其是几乎全部具肋属,皆出现

于育空和乌拉尔东坡组合,这说明它们之间的共性颇为强烈。车排子组合组成较为丰富,蕨类植物孢子属种较多,表明其古气候背景比其它两地相对更适宜植物生存。

亚安加拉区不但 GSPD 组合出现较早,其中某些地区甚至可能是某些裸子植物的发源地,如北疆阿希列剖面早石炭世晚期的阿勒玛利组上部(维宪晚期—谢尔普霍夫 Serpukhovian 早期)已出现单囊花粉 *Remysporites*, *Florinites*, *Vesicaspora* 和原始两囊无肋花粉;哈萨克维宪期已出现 *Remysporites*, 同期或稍晚有单囊的 *Florinites*(或 *Potonieisporites*, 即 *Walchiozonaletes praecipuus* Lubert, 1955, P1. VIII, fig. 159)。

越来越多的资料表明,裸子植物花粉(主要是具囊者)在亚安加拉区之外某些地区巴什基尔—莫斯科期已出现颇多,但不如本文重点讨论的几个 GSPD 组合中那样占优势。

我国甘肃靖远早石炭世晚期靖远组(Namurian A)已出现少量两囊无肋花粉,至上覆的红土洼组(Namurian A—C)裸子植物花粉更多,有单囊的 *Florinites*, *Potonieisporites*; 两囊无肋的 *Klausipollenites*, *Alisporites*, *Platysaccus*, *Limitisporites*, *Vestigisporites* 和个别可疑的两囊具肋花粉等\*。又如山西朔县本溪组(Westphalian C—D)组合,裸子植物花粉总含量虽低(约 5%),但类型已颇可观,单囊有 *Florinites*, *Potonieisporites*, *Vesicaspora*, 两囊无肋花粉较多,有 *Klausipollenites*, *Piceapollenites* 和 *Pityosporites* 及种子蕨花粉 *Schopfipollenites* 等(Ouyang and Li, 1980)。

加拿大滨海省纳缪尔 A 期已出现 *Schopfipollenites*, 至维期发 A(=巴什基尔晚期)有 *Florinites*, *Schulzospora*, *Schopfipollenites*? (Barss, 1967)。美国早石炭世晚期已出现 *Schulzospora*, *Remysporites*。晚石炭世早期(Morrowan)还见到 *Florinites*, *Potonieisporites*, 稍晚有两囊无肋和具肋(*Illinites*)花粉(Fredereksen, 1972), 上石炭统顶部(Virgilian)还见到 *Striatoabieites* 和 *Hamiapollenites* 等(Jizba, 1962)。

据 Djupina(1979)引述,在西欧,纳缪尔期已出现 *Potonieisporites* (Scott, 1975), 西班牙纳缪尔阶上部已有 *Complexisporites*(= *Illinites*) (Neves, 1964)。

在顿巴斯和顿涅茨克, *Potonieisporites* 在上石炭统底部已出现,莫斯科期已有 *Cordaitina*, *Guthoerisporites*, *Limitisporites*, *Illinites* 和 *Gardenasporites* 等(Inosova et al., 1976; Djupina, 1979)。在波兰 Mseno 盆地维斯发 D 期(大致相当于 Moscovian 阶中部)已出现相当多类型,包括单囊花粉 *Latensina*, *Wilsonites*, *Potonieisporites*, *Florinites*, *Bascanisporites*, *Candidispora*, *Vesicaspora*, 两囊无肋花粉 *Alisporites*, *Limitisporites*, 两囊具肋花粉 *Illinites*, *Protohaploxylinus*?, *Hamiapollenites*, *Tumorisporites* 和 *Vittatina* 等(Kalibova, 1989)。

由此可见,裸子植物在欧美区、华夏区的出现也颇早(至于泥盆纪和早石炭世早期某些前裸子植物或裸子植物的前花粉、即形态与蕨类植物孢子目前尚难区分者,不在本文讨论范围之内)。不过,这两个区在早石炭世末至巴什基尔—莫斯科期非煤炭沼泽环境出现的组合中一般仍是蕨类孢子占优势,裸子植物花粉中主要是高地(upland)生长的古松柏类的花粉(包括原始单囊或具单缝和大部分两囊无肋花粉),种子蕨花粉(*Illinites*, *Schopfipollenites*)分异度不大。北疆、乌拉尔地区、加拿大北极群岛部分地区和育空地区则以种子蕨花粉(主要

\* 朱怀诚, 1991(手稿): 甘肃靖远晚石炭世孢粉。

是两囊多肋和 *Vittatina* 等)为主,种子蕨和其他裸子植物(包括松柏类和科达类)构成植被的主导成分。

人们或许要问,如果没有动物化石佐证,类似北疆上述组合面貌者,有无可能确定是石炭纪抑或二叠纪,我们认为,只要建立了标准组合序列和进行孢粉的细致形态分类研究,这种划分是完全可能的。以北疆为例,巴什基尔—莫斯科期的裸子植物花粉到二叠纪在形态上已发生了若干变化,总趋势是:单囊具肋花粉个体由大到小,二囊具肋花粉近极肋纹和远极条带一般由低平变得较高、间距变宽;二囊花粉囊的分异和内部结构也起了变化,此外,二叠纪还不断出现新的类型;当然还有其他的如孢子组成等的演替。

#### 四、古生态-植物区系意义

上文列举的巴什基尔—莫斯科期或莫斯科期国内外的 GSPD 组合表明,晚石炭世早期植物群的演进和植被的分异在地球上局部地区已进入一个新的阶段,即裸子植物在植被中占主导地位的阶段。一个引人瞩目的现象是,那些 GSPD 组合,从北疆经中央哈萨克斯坦、乌拉尔部分地区至加拿大北极群岛至阿拉斯加-育空地区,似乎构成了一个生态带(ecozone),此带按某些古地理图大体位于典型的安加拉植物区之南和欧美-华夏植物区之北。此带植物群,目前大植物化石材料还不充足,从孢粉资料判断,其特征是兼具安加拉区和欧美区色彩,因而可用 Meyen 的亚安加拉区(Subangara Province)一名。换言之,亚安加拉区的形成比通常认为的主要从二叠纪才开始要早得多。

为了形象地说明此生态带或亚安加拉区的地理分布,本文引用了芮琳等(Rui *et al.*, 1991)的一幅古地理图,原为表示晚莫斯科期藓科化石的分区,但稍作了修改:一是时代略提前;二是安加拉古陆及其相邻的哈萨克斯坦、塔里木诸板块位置向北移动了些,这样就更好解释当时孢粉-植物群的分布是受到纬度-气候条件控制的(插图4)。此期冈瓦纳植物区化石资料贫乏,故未明显表示出来。

尽管此带(区)与安加拉区和欧美区有某些共同分子,反映在孢粉组成上的如安加拉色彩的种子蕨和科达类的花粉(*Remysporites*, *Cordaitina* 等)和某些蕨类孢子,欧美区色彩的以鳞木类孢子为主的少量成分(如 *Lycospora*, *Densosporites*, *Endosporites*, *Rugospora*)和古松柏类花粉(*Potoneisporites* 和 *Florinites* 之大部)及个别种子蕨成分(*Illinites*),但在本区以大量具囊、特别是两囊具肋和 *Vittatina* 的出现而独具特色。这类具肋花粉,如前所述,可能与盾籽目植物相关,在安加拉本部极少,在欧美区出现较晚(Westphalian C—D),且在二叠纪以前分异度不大。从大植物化石资料判断,晚石炭世(→二叠纪)安加拉区以科达类为主体(形态与欧美区不同),欧美区煤炭沼泽盆地则以蕨类植物和某些不同类型的种子蕨的繁盛为特色(孢粉组合中亦以孢子为主)。从沉积特点看,此期安加拉区、欧美区已进入或接近重要成煤期,而亚安加拉区多无煤、或仅见煤线或煤层横向分布很有限,有些地方(如乌拉尔东坡、加拿大北极群岛前述剖面)还伴随膏盐等蒸发岩沉积。

关于古气候,则意见分歧颇大,以准噶尔盆地为例,有的认为从杜内至莫斯科期可能属热带常湿或热带夏湿(Nie Shangyou *et al.*, 1990),有的则认为属温带潮湿气候(赵锡文等, 1988)。古植物学家一般都相信,欧美-华夏区属赤道热带-亚热带,安加拉区属北温带,冈瓦纳区属温带-寒温带气候;这种分带性是本文引用的古地理图一致的。至于亚安加拉区,以

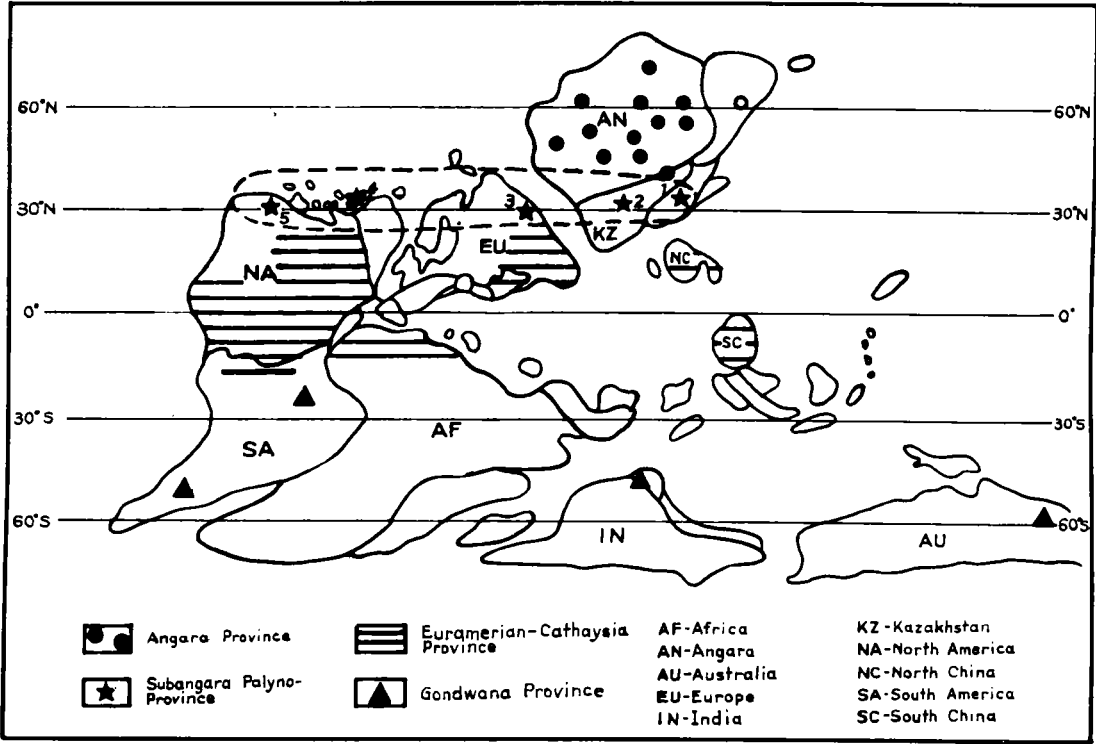


插图 4 示亚安加拉区晚石炭世早期(巴什基尔—莫斯科期或莫斯科期)GSPD 孢粉植物群之分布  
(据 Rui *et al.* , 1991. 略有改动)

Showing the distribution of GSPD palynofloras in Subangara Province during early Late Carboniferous time (Bashkirian—Moscovian or Moscovian)(adapted from Rui *et al.* , 1991)

1. N. Xinjiang. 2. Central Kazakhstan. 3. E. and W. slope of Urals. 4. Ellesmere Island (Arctic Canada). 5. Yukon Territory.

往主要指安加拉本部的前缘地区(包括伯绍拉盆地以南的乌拉尔、俄罗斯地台及哈萨克斯坦、中亚部分地区), 根据沉积特点和裸子植物花粉(特别是具肋花粉)在反映干旱气候的含岩盐、石膏地层中的高比例出现, 通常认为是旱生-中生为主植被, 反映干旱-半干旱气候(Hart, 1970; Kremp, 1974, 1977; Meyen, 1982, 1987). Meyen 推测亚安加拉区当在较低纬度(40°N 以南), 为温暖半干旱气候。大多数孢粉学家相信, 花粉具肋是干旱气候的一种形态适应, 果如此, 则本文所述的亚安加拉区自中、晚巴什基尔—莫斯科期已属干旱气候了(例如车排子组此类花粉含量达 44%), 但从有些组合属种组成成分异度颇高情况看, 当时的植被还是相当繁盛的, 决不可能是典型的干旱或沙漠气候, 而很可能是半干旱或半潮湿气候。考虑到北疆、甚至整个亚安加拉区兼具其他区系特点以及某些植物的迁移、混生要求有气候梯度条件, 和本区的古地理位置, 故我们推测有可能属亚热带-暖温带的半干旱(半潮湿)气候, 局部地区为干旱气候。

Meyen(1987)说:“在哈萨克斯坦, 某些典型二叠纪面貌的大化石松柏类是与海相中石炭世动物群共生的, 所以很可能在欧美区西部石炭纪之末—二叠纪之初, 此松柏类为主的植

物群开始取代煤炭沼泽植物群,而在此区之东的植物生态区内则其出现要早得多,并从这里向西迁移。然而,必须记住,欧美区肯定的松柏类是见于 Westphalian B,在那里它们也可能源起于围绕沉积低地的高地环境。”本文认为,伴随着大陆增生、煤炭沼泽植物群的衰落,某些高地裸子植物经历了向原沉积盆地迁移的过程(Fredereksen, 1972)。还有一种可能是,随着欧亚大陆在二叠纪的北移,一些原在亚安加拉区的某些种子蕨植物(和某些松柏类?)向南迁移(Kremp, 1977),因为北美、格陵兰、欧洲之大部到华北,与亚安加拉区晚石炭世面貌类似的组合是在二叠纪甚至晚二叠世才广泛分布开来的。

最后,还有两个问题需要作出解释。一是上述亚安加拉区,既然从巴什基尔—莫斯科期起已发现 GSPD 组合,为何相关大植物化石却很少发现?除了野外采集不足以外,还有几个理由。一是这些孢粉组合大多发现自海相地层,众所周知,海相沉积通常是不利于大植物化石保存的;二是那些花粉的母体植物(种子蕨、松柏类等)多生存于高地,其枝、叶等保存为化石的机会大为减少,特别在氧化环境,在原地或搬运过程中已遭到破坏,而孢粉不仅产量较多,也较易保存;三是某些植物化石亲缘关系及其原位花粉不清楚,不能肯定是否属种子蕨等等。二是海相 GSPD 组合中花粉浓度高的解释问题。孢粉学上有所谓“Neves 效应”,是指 Neves(1958)在研究英国上石炭统组合时发现的一种现象,即 *Cordaites* 的单囊花粉(*Florinites*)易被风力、水流搬运至海相环境(有时比例很高),而沼泽环境的鳞木类的小孢子(*Lycospora*)则很难搬运出沼泽以外到海相沉积中(见 Traverse, 1988),就是说,海相组合中高浓度的 *Florinites* 只反映局部生境(如高地)的植物群落,不能完全代表区域植被面貌。这种现象对解释孢粉组合无疑是有帮助的。但就本文亚安加拉区而言, GSPD 组合分布范围颇广、且包含有陆相或海陆交互相沉积,而北疆广大地区内从晚巴什基尔期至整个二叠纪,除个别层段(如早二叠世塔什库拉组)孢子较多外,皆为 GSPD 组合,亦包括陆相沉积,显然基本上是反映区域性植被面貌的。Barss(1972)在讨论育空地区前述组合时,引证了 Chaloner(1968)与 Neves 效应类似的说法,“在每一种情况下,主要的区域性孢子产生者(生长在远离沼泽的环境)在离三角洲较远的地方沉积下来的地层中最为丰富”,说明育空研究地区的沉积环境影响了具囊花粉的浓度,从而导致了错误的时代鉴定。Chaloner 的观点与孢粉界的通常认识并不矛盾,即泥炭沼泽、湖、河岸边的孢粉组合往往有时出现局部生境成分占优势、区域植被面貌受到歪曲的情形,海相沉积中(通常在浅海、陆棚区孢粉较多,远离陆棚则极少)因多种途径搬运则相对区域性成分较多,尽管主要还是离岸线不太远的区域(北疆上述组合中常伴随不少木质部碎片也可佐证)。其次,花粉浓度(如果不包括分异度)大多情况下不能作为定时代的依据,属种组成、分异度显然更有意义。所以导致 Barss 误定时代的原因,恐怕还是当时类比资料的欠缺和传统观点的束缚。退一步说,即使用 Neves 效应解释,也可说明巴什基尔—莫斯科期以裸子植物为主的植被在“高地”生境分布已颇广泛,并不影响本文在突破传统观点上的重要性。

## 五、结 论

1. 在北疆,单囊(*Florinites*, *Potonieisporites*, *Remysporites*)和原始两囊无肋花粉在早石炭世晚期(Visean)已开始出现;单囊和原始两囊具肋花粉在晚石炭世最早期(Namurian H+R 带或 Bashkirian 早期)已出现,并与具囊无肋花粉(或前花粉)可构成 Pro-GSPD 组

合。

2. 具“二叠纪面貌”的 GSPD 组合(主要是种子蕨、松柏类和科达类等)在晚石炭世早期(中、晚 Bashkirian—Moscovian)已在北半球某些地区存在, 至少反映此等植物在“高地”环境植被中已占主导地位。

3. 亚安加拉区的分异比传统观念所认为的要早得多, 从巴什基尔早期已开始, 至巴什基尔—莫斯科期分布已颇广, 目前已知包括的范围有北疆、哈萨克斯坦、乌拉尔的部分地区至加拿大北极群岛和阿拉斯加—育空地区, 构成一个位于典型的安加拉植物区和欧美区之间的相对独立的生态带。

4. 此带的植被虽兼具安加拉区和欧美区色彩, 但以裸子植物、尤其是种子蕨(可能与盾籽目 *Peltaspermales* 相关)的繁盛和某些古老的松柏类的参与为特色, 可能随着欧亚板块的北移和半干旱气候带的扩张, 它们逐渐向南迁移, 晚石炭世, 特别是早二叠世是亚安加拉区的扩张时期。亚安加拉区在世界中植代的植被发展上, 贡献是巨大的。

5. 亚安加拉区从晚巴什基尔—莫斯科期起或多或少受到干旱气候的影响, 可能属亚热带—暖温带的半干旱(半潮湿)气候, 但有待更多的证据证明。

6. 传统观念认为 GSPD 组合始于中二叠世有很大的局限性。近几年兴起的生态地层概念引用到古孢粉学上是很有必要的, 因为它可以弥补传统生物地层学上往往忽视空间生态分异的不足。煤炭沼泽以外的生态区, 利用孢粉组合确定地层时代不能与前一种环境下的组合进行机械对比, 应该先建立相应的以海相动物化石为依据确定时代的标准组合层序; 对欧美在某些煤沼植物群以外的以往定为“二叠纪”的 GSPD 组合似有复核的必要。

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## ON OCCURRENCE OF PALYNOLOGICAL ASSEMBLAGES OF GYMNOSPERMOUS, ESPECIALLY STRIATE POLLEN DOMINANCE (GSPD) FROM BASHKIRIAN—MOSCOVIAN SEDIMENTS IN NORTHERN XINJIANG, NW CHINA

Ouyang Shu and Zhou Yu-xing

(*Nanjing Institute of Geology and Palaeontology, Academia Sinica, Nanjing 210008*)

Wang Zhi and Zhan Jia-zheng

(*Academy of Oilfield Prospecting and Development of Xinjiang, Ministry of Oil Industry,  
China, Karamay 834000, Xinjiang*)

**Key words:** Palynological GSPD assemblage, Bashkirian-Moscovian, N. Xinjinag.

### Summary

In palaeobotanic textbooks (e. g. Gothan and Weyland, 1974), the Mesophytic (a period dominated by gymnosperms, particularly conifers) is considered to begin from early Late Permian (roughly corresponding to the base of Zechstein in Europe). In classic palynological monographs (e. g. Hart, 1965; Traverse, 1988), on the other hand, assemblages of gymnospermous, especially striate pollen dominance (called GSPD assemblage for short in this paper) are generally thought to start from early Middle Permian (Kungurian). These two traditional concepts, both related to and different from each other, are widely accepted among palynological circles and often used as clues to age-determination of unknown strata. However, more and more palynological data indicated that GSPD assemblages occurred much earlier than they were traditionally thought. The present study aims at demonstrating with some examples the appearance of GSPD assemblages, under specific ecological conditions, as early as the early Late Carboniferous, i. e., Bashkirian—Moscovian. Description of the relevant taxa will be published in the monograph *A Systematic Study on Carboniferous—Permian Spores and Pollen from N. Xinjiang*.

The material discussed here was collected from four localities in N. Xinjiang (fig. 1, in

Chinese text), including one outcrop profile and three borehole profiles. Stratigraphically they can be differentiated into two units, containing two distinct sporopollen assemblages: (1) The Batamayneishan Formation outcropped at Shengligou near Kelamaili on eastern margin of the Junggar basin. This formation is determined as early Bashkirian in age based on fossil fusulinids in the overlying Shiqiantan Formation and fossil plants in the underlying Dishuiquan Formation (and the ammonites *Goniatites*, *Dombarites*, *Platygoniatites* and *Neogoniatites* in the equivalent Nalinkala Formation of late Visean—Namurian A. i. e. Zone E; see Dou Yawei *et al.*, 1985a, b). This formation yields the *Remysporites varicus*-*Striatolebachiites junggarensis* Assemblage which can be called Pro-GSPD assemblage. Similar assemblages have been found in Wells B-9 and Zh-3 nearby. (2) The Chepaizi Formation from Well Ch-25 on the northwestern margin of the basin. The associated fossil animals in this formation include the brachiopods *Choristites radiculosus* A. et E. Evvanov, *C. mansuyi borochorocusis* Yang, *Buxtonia juresanensis* (Tschern.), *Orbiculoides* sp., *Schizophoria* sp., etc., and ostracods, bivalves, etc.; the age of the formation is dated middle-late Bashkirian—early Moscovian. This formation is approximately equivalent to the Shiqiantan Formation on the eastern margin of the basin, because both formations contain similar brachiopod faunas dominated by *Choristites*. The Chepaizi Formation yields the *Protohaploxypinus verrucosus*-*Hamiapollenites chepaiziensis* Assemblage, a real GSPD assemblage. Recently, such assemblage has also been found in the Shiqiantan Formation. Although it is pending for further studies, this new finding has already shown that it is correct to correlate the Chepaizi Formation with the Shiqiantan Formation.

The relevant stratigraphic sequence on the eastern margin of the basin is listed as follows.

Strata	Age	Associated Fossils
Shiqiantan Fm.	M. —L. Bashkirian— E. Moscovian	<i>Profusulinella</i> , <i>Pseudostaffella</i> , <i>Fusiella</i> , <i>Choristites</i> , etc.
Batamayneishan Fm.	E. Bashkirian	<i>Angaropteridium cardiopteroides</i> , <i>Angaridium potaninii</i> , <i>Mesocalamites cristiformis</i> , <i>Noeggerathiopsis</i> sp., etc.
Dishuiquan Fm.	Visean—Namurian A	<i>Lepidodendropsis</i> , <i>Lepidodendron</i> , <i>Sublepidodendron</i> , <i>Demetria asiatica</i> , etc.

1. The *Remysporites varicus*-*Striatolebachiites junggarensis* Assemblage is obtained from the Batamayneishan Formation in the outcrop profile mentioned above. This formation is composed of nonmarine volcanic rocks, mainly neutral and acidic lava intercalated with carbonaceous mudstone, coal seams and tuffaceous sandstone, more than 340m in thickness (fig. 2). The spores and pollen are recovered from the carbonaceous mudstone in the upper part, with the main taxa illustrated in Plate 1.

This assemblage is not very diverse in composition, including the following genera and

species: *Calamospora* sp., *Cyclogranisporites* sp., *Verrucosisporites* sp., *Retitriteles* sp., *retusotriteles* spp., *Geminospora* sp., *Perotriteles* sp., *Remysporites psilopterus*, *R. multirugulatus*, *R. marginatus*, *R. varicus*, *R. marginella*, *R. rugosus*, *Potonieisporites* sp., *Florinites* sp., *Striatolebachiiites junggarensis*, *S.* sp., *Protohaploxylinus* sp., *Striatolebachiiites* sp. and *Striatopodocarpites* sp.

In this assemblage, *Remysporites* amounts to 58.5% of the total number of palynomorphs; *Striatolebachiiites* to 18% and *Protohaploxylinus* to 1%. Other monosaccate pollen grains are only found individually, such as *Potonieisporites* and *Florinites* (both in large size). If *Remysporites*, as some palynologists reckoned, actually belongs to Pteridospermae, the gymnospermous pollen in this assemblage may thus reach 80% and pteridophytic spores amount to 19.5%. This is the earliest assemblage ever known so far in the world, which is possibly dominated by gymnospermous pollen. It seems that this assemblage may be correlated with the sudden change in early Bashkirian from Early Carboniferous Angarian Lepidophyte flora to the poorer fossil megaplant assemblage dominated by pteridosperms (see Meyen, 1972, 1987; Dou *et al.*, 1985). Or we can say that at least this is the earliest record of striate pollen (accounting for 20%), representing the relatively original stage in their later divergence and development. Hence the assemblage is called the Pro-GSPD assemblage.

Similar assemblages (*Remysporites* reaching 40—93%) with relatively diverse disaccate striate and non-striate pollen are also encountered in Wells B-9 and Zh-3 which are not far away from the outcrop profile mentioned above. A few representative taxa of the assemblages are given in Plate 1. According to lithostratigraphic and sporopollen assemblage correlation, the strata in question should roughly correspond to, or partly higher than, the Batamayineishan Formation.

2. The *Protohaploxylinus verrucosus*-*Hamiapollenites chepaiziensis* Assemblage is obtained from the dark grey muddy limestone (shallow sea facies) of the Chepaizi Formation (fig. 3). The spores and pollen in the assemblage are abundant, diverse and well-preserved. According to Zhan Jia-zheng *et al.*'s (1991, MS) preliminary study, this assemblage contains about 130 species (types) referred to 50 genera, including 19 genera and 33 species of pteridophytic spores, 9 genera and 23 species of monosaccate non-striate pollen, 3 genera and 10 species of disaccate "laesurate" pollen, 10 genera and 45 species of monosaccate and disaccate Striatiti, 8 genera and 16 species of disaccate non-Striatiti, 1 genus and 3 species of Monocolpates and 1 species of acritarchs.

Listed below are the component genera and the numbers (in bracket) of species:

*Leiotriteles* (3), *Punctatisporites* (2), *Calamospora* (4), *Gulisporites*? (2), *Granulatisporites* (1), *Cyclogranisporites* (3), *Acanthotriteles* (1), *Apiculatisporis* (1), *Convolutispora* (1), *Raistrickia* (2), *Verrucosisporites* (2), *Aneurospora* (1), *Lycospora* (1), *Stenozonotriteles* (1), *Rugospora* (1), *Geminospora* (1), *Endoculiospora* (1), *Endosporites* (3), *Laevigatosporites*

(2).

*Gordaitina* (5), *Parasaccites* (3), *Plicatipollenites* (3), *Virkkipollenites* (2), *Crucisaccites* (1), *Florinites* (3), *Samoilovitchisaccites?* (1), *Potonieisporites* (3), *Vesicaspora* (2).

*Vesitigisporites* (2), *Limitisporites* (3), *Gardenasporites* (5).

*Striatomonosaccites* (2), *Striatolebachiiites* (2), *Chordasporites* (1), *Illinites?* (1), *Lunatisporites?* (5), *Protohaploxyypinus* (13), *Striatoabieites* (5), *Striatopodocarpites* (7), *Hamiapollenites* (7), *Vittatina* (2).

*Klausipollenites* (3), *Voltziaceaesporites* (1), *Falcisporites* (1), *Pityosporites* (3), *Platysaccus* (3), *Alisporites* (2), *Piceapollenites* (2), *Abiespollenites* (1).

*Cycadopites* (3); *Schizosporis* (1).

A few representative genera and species of this assemblage are shown in Plates I and II.

The composition and content of the assemblages in both palyniferous samples are similar, with their average percentage indicated as follows: Pteridophytic spores 21%, gymnospermous pollen 77% (*Monosaccites* 14%, monosaccate *Striatiti* 1%, disaccate *Striatiti* 44%, disaccate non-*Striatiti* 18%, and *Monocolpates* 2%). In the number of species, gymnosperm pollen are also predominant in the assemblages (reaching about two-thirds of the total).

Such an assemblage is quite surprising. According to traditional views and on condition of no various associated marine fossil animals, its age would be determined as Permian. However, the coexisting faunas and regional stratigraphic correlation clearly indicate that the assemblage belongs to middle—late Bashkirian to early Moscovian. The associated fossil animals are by no means reworked, because if they were separated from the matrix and transported, they would not be so well-preserved. For example, *Bouxtonia juresanensis* (Pl. I, fig. 11) bears delicate spines and *Orbiculoides* sp. shown in Pl. II, fig. 16 has a very thin shell. In addition, a similar GSPD assemblage, as mentioned before, has recently been found in the roughly contemporaneous Shiqiantan Formation on the eastern margin of the basin, providing another evidence to support our conclusion that the palynomorphs in the assemblage are mostly indigenous.

This assemblage is probably dominated by pteridospermous pollen, because the Peltaspermaleans of Angaraland have been proved to produce *Protohaploxyypinus* (s. l.) + *Vittatina* pollen (Meyen, 1982) and part of the disaccate non-striate pollen mentioned above may also have derived from pteridosperms. Due to the high diversity and abundance (45%) of striate pollen, this assemblage is a real GSPD assemblage.

Based on correlation of the present assemblage with those similar ones known in the world of roughly the same or slightly younger age, we firmly believe that the GSPD assemblage or vegetation dominated by gymnosperms, especially pteridosperms and conifers, had already existed in Bashkirian—Moscovian or Moscovian in upland environments in some

parts of the world and probably formed a relatively independant ecozone.

Table I Several closely comparable assemblages

Region (Author)	Strata	Assemblage	Striatiti Gymno. pollen %	Age	Associated Fossils
N. Xinjiang (present paper)	Chepaizi Fm.	GSPD	45/78	M. —L. Bashkirian— E. Moscovian	<i>Profusulinella</i> , <i>Pseudostaffela</i> , <i>Fusiella</i> ( Shiqiantan Fm. ); <i>Choristites</i> , etc.
Yukon ( Barss. 1969, 1972)	Ettraint Fm.	GSPD	* 55/85	L. Bashkirian —Moscovian	<i>Profusulinella</i> , <i>Pseudostaffela</i> , <i>Fusulinella</i> .
E. Ural ( Chuvashov et al. , 1979; 1984)	" Second Assemblage"	GSPD	40—46/65—73	Moscovian	<i>Profusulinella</i> , <i>Fusulinella</i> , <i>Fusulina</i> .
W. Ural ( Chuvashov et Djupina, 1973; Djupina, 1979)	unamed	GSPD	40/50	Moscovian	fusulinids with an aspect of Mid. Carboniferous or below the <i>Triticites</i> <i>arcticus</i> zone

\* Barss (1967, and in Bamber and Barss, 1969) regarded the age of the sporopollen assemblage from the Ettraint Formation in Yukon as Early Permian (Wolfcampian). Later (1972), he thought that the original dating was possibly wrong for the associated fossil fusulinids indicated an age of Mid-Pennsylvanian. Besides, 55/85 shown in the table refers to the percentage of striate species number (numeration) versus the percentage of the gymnosperm species in the assemblage. for no percentage of the components was given by Barss.

The occurrences of gymnospermous pollen genera from the three assemblages in N. Xinjiang, Yukon and eastern slope of the Urals are given in table I (in Chinese text). The assemblage from the eastern slope of the Urals includes Assemblages I and II (A+B+C) of Chuvashov et al. . The plus mark in the parentheses indicates that the identification of genus has been changed.

The assemblage of the Chepaizi Formation is very similar to the Ettraint assemblage in Yukon except that the genera and species (including spores) in the former assemblage are much more diverse and include several genera of Gondwana aspect (*Parasaccites*, *Plicatipollenites*, *Virkkipollenites* and *Crucisaccites* in part) and one genus of Angara aspect (*Remysporites*). The common feature of the three assemblages lies in their similar components of striate pollen genera. Considering the similarity of the associated fossil fusulinids in the three examples, the early appearance of GSPD assemblages is not accidental and it could not be simply interpreted by Neves Effect due to their wide distribution in different facies and continuous record through Late Carboniferous to Permian in some areas.

In addition, a similar GSPD assemblage was also found from the Otto Fiord Formation on Ellesmere Island of Arctic Canada (Utting, 1985a) and its age was suggested as not old-

er than Westphalian C on the basis of pollen record. However, according to recent report on fusulinids, gastropods, conodonts, brachiopods, etc., the age of the Otto Fiord Formation has been assigned to Serpukhovian—early Moscovian (Rui *et al.*, 1991). This assemblage is fairly poor in composition and not well-preserved.

As to the Carboniferous—Triassic sporopollen assemblages from the Melville Island of Arctic Canada (Utting, 1985b), it is noteworthy that: (1) The uppermost part (?) of the Canyon Fiord Formation also contains the GSPD assemblage, which was prudently dated Asselian—Sakmarian by Utting. But because no fossil animals have been found in the middle and upper parts of the palyniferous profile, its exact age still remains to be further studied. (2) Almost all the "Permian" formations reported by Utting yield GSPD assemblages. This is quite similar to the case of Late Carboniferous—Permian assemblages in N. Xinjiang.

The Bashkirian GSPD assemblage may also exist in Central Kazakhstan (Chuvashov *et al.*, 1984), although it is not known in detail.

Thus it can be concluded that in Bashkirian—Moscovian or Moscovian deposits with direct or indirect fusulinid and other fossil evidences, the GSPD assemblages had already come into existence in N. Xinjiang—Central Kazakhstan—Urals—part of Arctic Canada—Yukon Territory. Their parent plant communities might have occupied a relatively independent ecozone as sketched in fig. 4 and latitudinally stretched between the northern typical Angara Province and the southern Euramerian Province.

Although GSPD assemblages show the aspects of both Angara Province and Euramerian Province—the Subangara Province in Meyen's sense, it is distinguished by its high content of striate pollen. In Angara Province (s. s.), striate pollen grains are not important components in Carboniferous—Permian assemblages. While in Europe, they generally did not become abundant until Zechstein or a little earlier, and elements under Raristriatiti (e. g. *Lueckisporites* and *Lunatisporites* probably of conifer origin) are often more important; on the other hand, Multistriatiti elements never reached such a high diversity as those in the Subangara assemblages. In northern Nigeria of Africa, the GSPD assemblage was found in the Tarat Formation (palynologically mainly dated Kungurian—Ufimian, Broutin *et al.*, 1990). In the late Autunian—early Thuringian assemblage from SE Spain, gymnospermous pollen grains are generally dominant, while striate pollen grains have a low diversity and relatively low content (occasionally reaching 12% of the total, Broutin, 1986). GSPD assemblage was also reported from Maritime Provinces of Canada in N. America and dated Wolfcampian (Barss, 1967).

Another conclusion arrived at is that the origin and divergence of Subangara Province started much earlier than Permian as generally thought. Although Meyen (1987) correctly pointed out: "The Subangara area was already of incipient formation during the Carboniferous", based on Russian palynological data then available, his claim that the Subangara

conifers (and pteridosperms) had migrated from the Urals westward seems more apparent than real. The actual process, as Kremp (1977) suggested, was most likely that along with the northward drift of Laurasia and the expansion of arid—semiarid belt in Carboniferous—Permian, certain Subangara plants (e. g. the parent plants of some striate pollen) migrated southwards into some areas of Euramerian and N. China because comparable GSPD assemblages did not occur until Middle or Late Permian in those regions. Nevertheless, in order to avoid circular reasoning, it seems necessary to revise the geological ages of some "Permian" GSPD assemblages outside the coal-swamp environments in Euramerian Province. Judging from the palynodata available for the time being, the Late Carboniferous, particularly Early Permian was the expansion period of Subangara Province.

\* \* \* \* \*

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## 图 版 说 明

除注明放大倍数者外,其他图像皆×500。标本分别保存于新疆石油管理局勘探开发研究院地层古生物室和中国科学院南京地质古生物研究所孢粉室。

All figures ×500 unless otherwise indicated. The specimens are curated at Academy of Oilfield Prospecting and Development of Xinjiang, Karamay and Nanjing Institute of Geology and Palaeontology, Academia Sinica, Nanjing.

## 图 版 I

1. *Cristatisporties* sp.
2. *Remysporites varicus* (Naumova) Wang
3. *Potonieisporites macropterus* (Luber) Wang
4. *Remysporites marginella* (Luber) Wang
5. *Geminospora* cf. *lemurata* Balme, 1962
6. *Tiwariasporis gondwanensis* Srivastava, 1969
7. *Striatomonosaccites stenosaccus* Wang
8. *Striatolebachiites striatus* (Kolchina) Wang
9. *Protohaploxylinus clavus* Zhan
10. *Protohaploxylinus verrucosus* Zhan
11. *Abietinaepollenites* sp.
12. *Striatolebachiites ellipticus* Wang
13. *Striatolebachiites junggarensis* Wang

以上化石中,图 1—4, 6, 7, 9. 产自阜康县北三台井区(北 9)巴塔玛依内山组,标本号: 1. Xsh-J2579, 2, 3, 6, 7. Xsh-

J2577, 4. Xsh-J2580, 9. Xsh-J2557, 5, 13. 产自奇台县双井子巴塔玛依内山组, 标本号: Xsh-J656, 8, 10—12. 产自吉木萨尔县沙帐井区(帐 3)巴塔玛依内山组, 标本号: Xsh-J3167。

图 版 I

- 1. *Calamospora breviradiata* Kosanke, 1950
- 2. *Granulatisporites crenulatus* Playford, 1964
- 3. *Rugospora* sp.
- 4. *Geminospora* cf. *plicata* Owens, 1971
- 5. *Raistrickia* sp.
- 6. *Zonalasporites delicatus* Wang
- 7. *Cordaitina rotata* (Luber) Samoilovich, 1953
- 8. *Cordaitina* cf. *readi* Kirkland et Frederiksen, 1970
- 9. *Samoilovitchisaccites* cf. *sinensis* (Zhang) Hou et Wang, 1990
- 10. *Choristites radiculosus* A. Ivanov et E. Ivanov 腕足类化石。背视,  $\times 1$ 。
- 11. *Buxtonia juresanensis* (Tschernyscher) 腕足类化石。腹视,  $\times 1$ 。
- 12. *Protohaploxylinus* cf. *bharadwajii* Foster, 1979
- 13. *Cycadopites* sp.
- 14. *Platysaccus* sp.
- 15. *Protohaploxylinus verrucosus* Zhan
- 16. *Hamia pollenites chepaiziensis* Zhan
- 17. *Vesicaspora* sp.
- 18. *Pityosporites* sp.
- 19. *Striatopodocarpites sulcatus* Zhan
- 20. *Crucisacites indicus* Srivastava, 1970

以上化石均产自克拉玛依市车排子井区, 车排子组。除 10, 11 外, 1, 7, 8, 12—14, 20. 标本号为 Xsh-J3773, 其他为 Xsh-J3774。

图 版 II

- 1. *Gardenasporites* sp.
- 2. *Lunatisporites?* *debilis* Ouyang
- 3. *Samoilovitchisaccites?* sp.
- 4. *Striatopodocarpites gibbosus* Zhan
- 5. *Lunatisporites?* *adnexus* Ouyang
- 6. *Orbiculoides* sp. 双壳类化石。腹视,  $\times 1$ 。
- 7. *Limitisporites pristinus* Ouyang
- 8. *Hamia pollenites karamayiensis* Zhan
- 9. *Striatoabietes mirabilis* Zhan
- 10. *Striatoabietes silvestritypus* (Samoilovich) Zhan
- 11. *Protohaploxylinus plicatus* Zhan
- 12. *Protohaploxylinus volaticus* (Ischenko) Hart, 1964
- 13. *Vittatina?* (gen. et sp. nov. ?) sp.

以上化石均产自克拉玛依市车排子井区, 车排子组。1, 5. 标本号为 Xsh-J3773; 其他(除图 6 外)为 Xsh-J3774。



# 特马豆克期三叶虫 *Dichelepyge lata* Peng 的个体发育\*

彭 善 池

(中国科学院南京地质古生物研究所, 南京 210008)

## 内 容 提 要

记述了产于湘西泸溪特马豆克期锅塘组的刺尾虫类三叶虫 *Dichelepyge lata* 的个体发育过程。其最显著的变化有头鞍形状和比例的改变, 头鞍沟、颈沟与背沟的分离, 鞍前箍(parafrontal band)的出现与消失, 胸部肋区和轴部比例宽度的改变, 尾部的形状和比例的变更, 尾边缘的出现和肋沟深度的增加, 以及后侧刺的位置逐渐前移。组成成虫期个体的前8个体节(6个胸节和前2个尾节)极有可能在分节0期(measpid Degree 0)便已形成。从分节3期(meraspid Degree 3)起在带后侧刺的体节与轴后区(postaxial field)之间又发育出一个新的体节。过渡期尾部(transitory pygidium)在分节0期或分节1期发育出后侧刺, 在分节4期又同时长出3对侧刺, 其中最后一对侧刺与后侧刺一道形成成年期尾部的尾刺。

**关键词** 个体发育 刺尾虫类 宽双爪尾虫 特马豆克期 湖南

## ONTOGENY OF *DICHELEPYGE LATA* PENG (TRILOBITA, TREMADOCIAN) FROM LUXI, WESTERN HUNAN

Peng Shan-chi

(Nanjing Institute of Geology and Palaeontology,

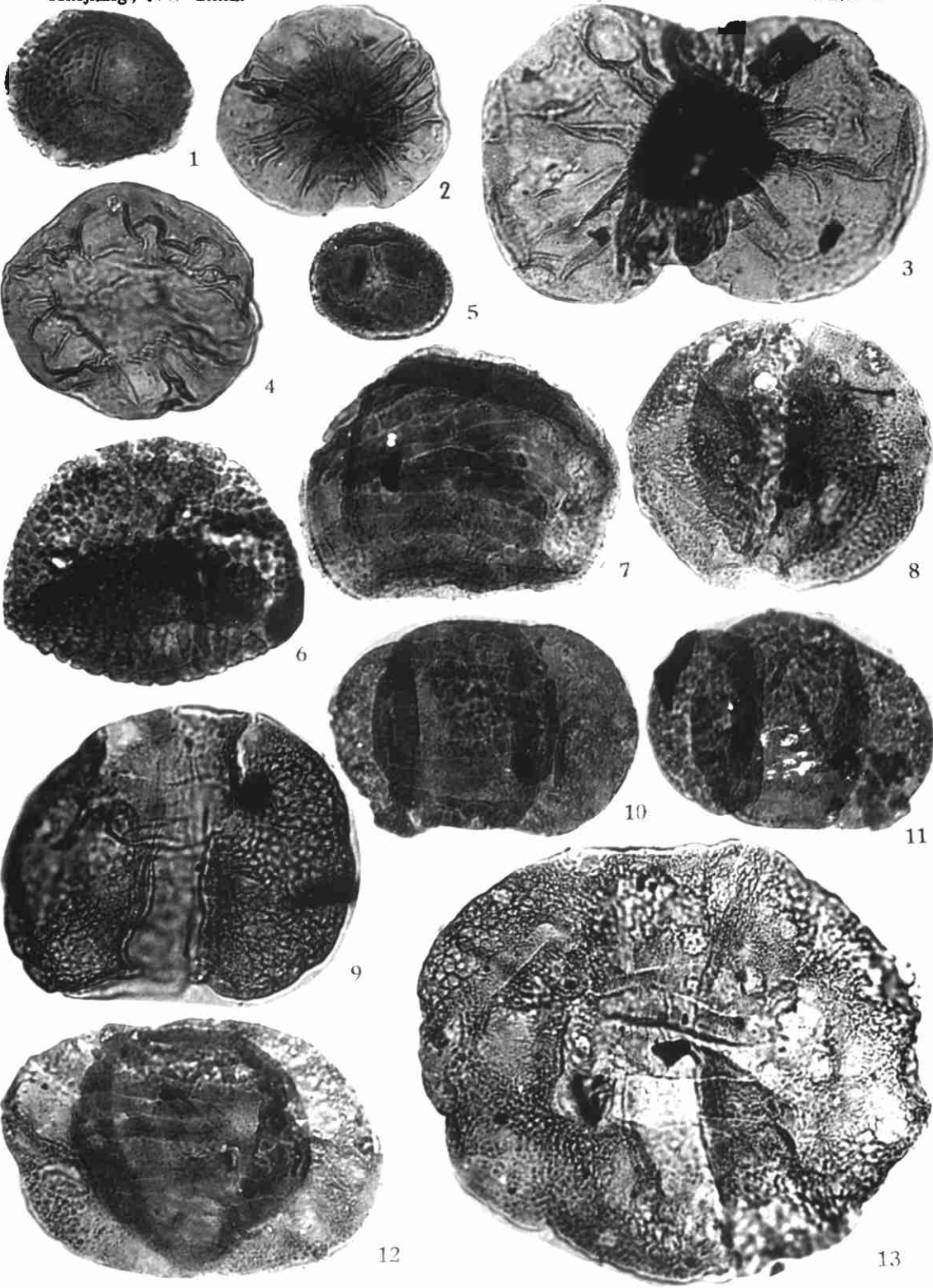
Academia Sinica, Nanjing 210008)

**Key words:** ontogeny, ceratopygid, *Dichelepyge lata*, Tremadoc, Hunan

• 国家自然科学基金资助项目。

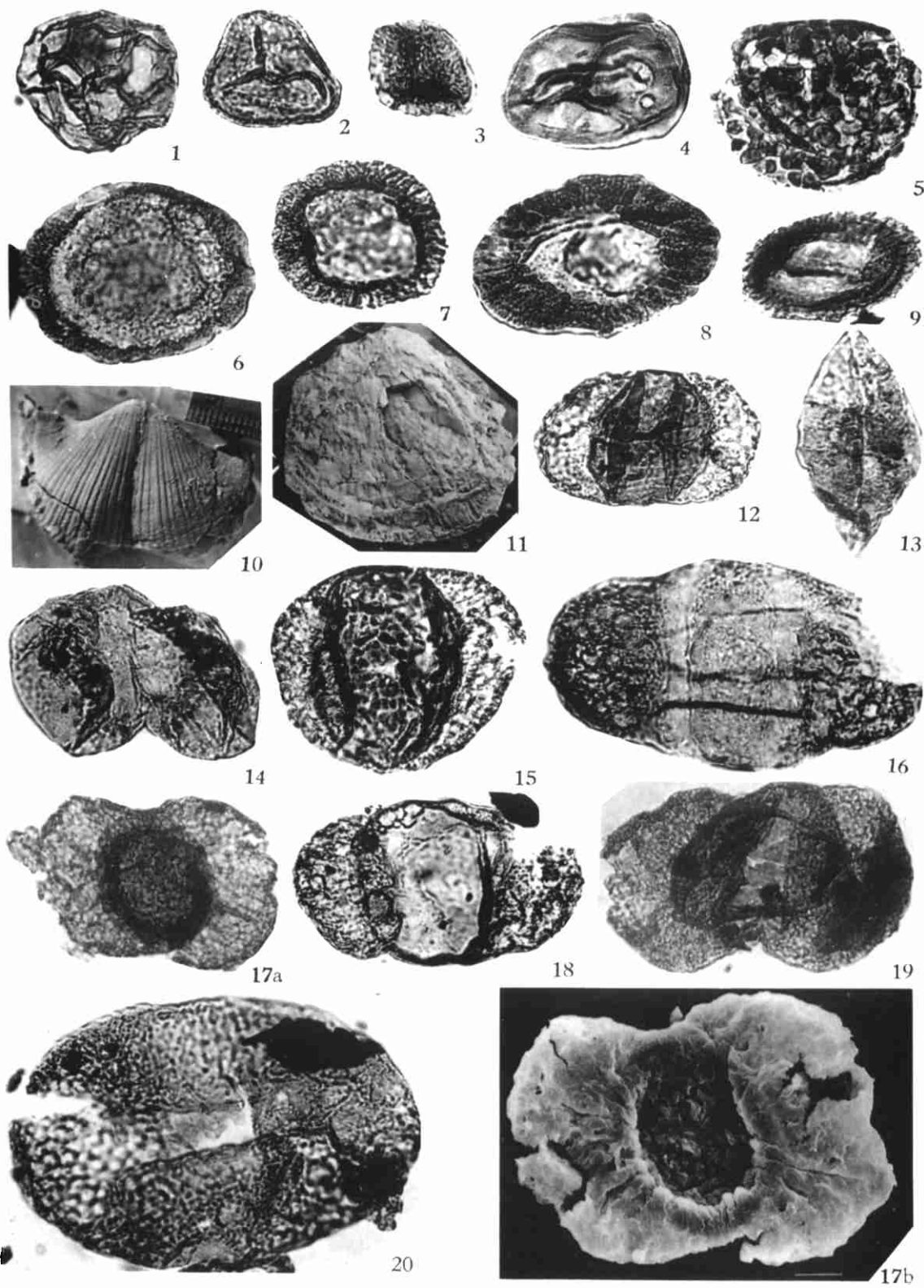
On Occurrence of Palynological Assemblages of Gymnospermous, Especially  
Striate Pollen Dominance from Bashkirian—Moscovian Sediments in Northern  
Xinjiang, NW China

Plate I



On Occurrence of Palynological Assemblages of Gymnospermous, Especially  
Striate Pollen Dominance from Bashkirian—Moscovian Sediments in Northern  
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Plate I



On Occurrence of Palynological Assemblages of Gymnospermous, Especially  
Striate Pollen Dominance from Bashkirian—Moscovian Sediments in Northern  
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Plate III

