

山東淄博煤田本溪統 G 層 鋁土礦的植物化石*

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(附 2 圖版, 1 插圖)

中國北部 G 層鋁土礦的地質時代一直是東亞地質界一個懸而未決的問題。近年, 張文堂同志^[1]曾建議將其分為上下兩部分: 上部即狹義的 G 層鋁土礦。其時代為下石炭紀; 下部為通稱的山西式鐵礦, 可能屬於上泥盆紀。對於張同志的這種意見, 筆者及盛金章同志^[2]過去已表示過不同的看法。最近, 周祖助^[3]、真允慶^[4]兩同志在“地質知識”上又分別從多方面提出了反對張文堂同志那種建議的論據, 並一致認為 G 層鋁礦與山西式鐵礦的層位是不能分開的, 兩者為同一時代的產物, 都應該視為中石炭紀本溪統底部的沉積。無疑的, 周、真兩同志的意見已引起了地質界更為廣泛的注意。但是過去有關此一問題的爭論, 大都是本於理論性的推測, 或只是根據野外地質剖面的觀察, 對於鑑定地層時代最依重的古生物證據, 則不是完全沒有, 就是僅僅提及而已。本文就是針對這種需要, 特來介紹一些新近從 G 層鋁土礦中所發現的植物化石, 並從古植物學方面來討論 G 層鋁土礦的地質時代。

本文描述的材料, 主要是冶金工業部鋼鐵管理局 501 地質勘探隊的陳小炳、李振揚

時代	層厚(米)	岩石符号	岩 性 簡 述
中 石 炭 紀 (本 溪 統)	6.5		徐家庄灰岩含燧石結核厚 5-12 米, 含動物化石 <i>Fusulinella bocki</i> , <i>Choristites mosquensis</i> 等。
	8.5		灰黃色砂頁岩互層夾粘土厚 7-10 米。
	3.5		草率灰岩, 0-7 米, 含動物化石 <i>Marginifera</i> sp., <i>Fusulinella</i> sp., <i>Chonetes cf. latesinnata</i> 等。
	6.5		戴黃維色砂頁岩厚 3-10 米, 含植物化石 <i>Sigillaria</i> (?) <i>shantungensis</i> 動物化石 <i>Schellwienella</i> sp.
	1.2		灰黃褐色鋁土頁岩厚約 1.2 米, 含植物化石 <i>Bergeria</i> sp.
	1.5		灰至灰綠鋁土頁岩厚 0.2-1 米。
6.0	2.2		灰白紫黃細粒鋁土頁岩厚 1.5-3 米, 含植物化石 <i>Leptopteris brongniartii</i> , <i>Neuropteris</i> sp.
	2.3		灰白鋁土頁岩厚 0.6-4 米。
	1.5		黃綠鋁土頁岩厚 1-2 米, 含植物化石 <i>Bergeria</i> sp.
	6.0		紅色高鉄頁岩 (山西式鉄礦), 厚 2-10 米底部凹陷所夾頁岩中含植物化石 <i>Bergeria</i> sp.
中陶 奧紀	濟南 統		兰灰石灰岩。

圖 1. 山東淄博煤田本溪統綜合柱狀剖面

(比例尺 1:400 主要根據冶金工業部 1955 年 501 隊)

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等同志於 1956 年秋在山東淄川、博山煤田的湖田礦區從事於本溪統底部的 G 層鋁土礦的勘查與鑽探時所採集的標本。與這些植物化石一起採得的還有少許本溪統中、上部的腕足類化石,這些化石經王鈺、劉第塘同志鑑定後,也一併列入插圖 1 的剖面*中。另一塊鱗木化石是鋼鐵管理局的劉天命等同志於 1954 年採自山西陽泉煤田本溪統底部的 G 層鋁土礦中的,以其頗具特徵,也附帶記述於此。該標本的層位,據劉同志等所附的地層剖面約相當於本文插圖 1 G 層鋁土礦的中、上部。

對於上列採集化石標本及提供地質資料的諸位同志,筆者於此均致以衷心的感謝。又本文在寫作過程中,斯行健教授曾提示許多寶貴意見,亦謹此深表謝意。

屬 種 的 描 述

Linopteris brongniarti (Gutbier) Potonie

(圖版 1, 1a—b, 2)

歸於這一個種的標本是含於 G 層鋁土礦中部一個岩蕊的破面上,它們都是一些脫落的零星小羽片的印痕,其中保存最好的如圖版 1, 圖 1, 1a—1c 所示。小羽片為卵圓形至長卵圓形,微彎作鐮刀狀,頂部鈍圓,基部收縮成心形,兩側邊略略平行。中脈作“分裂”(Cleft)形態,不很明顯或僅僅在靠近基部的 $\frac{1}{4}$ 處勉強可見,並和其餘聯結成狹窄的 4—6 邊形網格的側脈接合在一起。一般情況為臨近中脈的網格較長,向上作很強的彎曲,其餘的漸次變短,並逐漸外移而彎向側邊。

當前的標本雖頗零碎,但其特徵與 Stockmans 和 Mathieu^[5]所描述於同一種名之下的兩塊產自河北開平唐山層的標本完全相同。同時, Daber^[6]最近所發表產自本種模式標本(type-specimen)所在地區 Zwickau-Lagau 的一塊 *L. brongniarti* 的小羽片,也和我們的非常相似。因此,中國的這些標本應該歸於這一種名之內是沒有問題的。

此外,我們的標本與產於歐洲上西利西亞維斯發、最初為 Potonie^[7](1904, 29 號, 圖 2)和 Gothan^[8](1921, 頁 100, 圖 94)定名為 *L. brongniarti* 的一塊標本也很相似。值得注意的是,在 Gothan 以後的著作^[9]及其不久前和 Weyland^[10]合著的“古植物學教程”(1954, 頁 148, 圖 131)中,這一標本都被改歸之於 *L. neuropteroides* (Gutbier) 之內。但是,上西利西亞這一標本和 Seward^[11](1910, 頁 573, 圖 374)所刊載屬於 *L. neuropteroides* (Gutbier) 的模式標本,以及許多古植物學家^{[6] [12] [13]}通常歸為 *L. neuropteroides* 種名之下的一些標本是頗不相同的。這兩種植物的最重要不同點之一,正如 Potonie^[7]所首先指出,並且後來為許多古植物學家所承認的那樣,其小羽

* 其中的蠟科化石係根據筆者與關士聰等同志於 1952 年在該煤田工作時所採、經盛金章同志的鑑定而增補於此者。

片的寬度與長度的比率(1:3—3.5)是較 *L. brongniarti* 的這種比率(1:2—2.5)要小些。這種互相區別的特徵,在剛才引證的這些文獻有關這兩個種標本的圖片上,也都很好的表現了出來。所以,筆者仍傾向於將上西利西亞的這一標本維持 Potonie 所原定的種名。

本種與本屬“有兩個頂端小羽片”(Paripinnate group of *Linopterids*)的另幾種,即 *L. subbrongniarti* (Grand'Eury) Zeiller, *L. obliqua* (Bunbury) Zeiller 等的關係,也還是不很明確的。

正如 Kidston^{[14] [15]} (1886, 頁 103; 1891, 頁 76) 及 Potonie^[7] 很早就注意到的、被定為 *L. obliqua* (Bunb.) 和 *L. subbrongniarti* (Grand'Eury) 的模式標本實在是不容易與 *L. brongniarti* (Gutbier) 的相區別。因而根據命名優先例的原則,他們都曾將前兩種列於 *L. brongniarti* 的同物異名表之內。因為後一種名為 Gutbier 於 1835 年所創立,而前兩種名是後來才由 Bunbury 及 Grand'Eury 分別在 1847 年及 1877 年所提出的。關於這些種的難以劃分,Stockmans 和 Mathieu 在 1939 年及斯行健教授^[16] 在最近的論文中也都提到過。但是, *L. subbrongniarti* 一名現在雖已近於廢去不用, *L. obliqua* 却好像僅僅因為已應用得很廣並且慣於為人引用之故,許多學者仍把它當作一個獨立的種名來看待,有的甚至反而將許多原被歸於 *L. brongniarti* 的很標準的歐洲標本也概括於 *L. obliqua* 之內,但這樣做的理由何在,則很少提及。其實, Bunbury^[17] (1847, 頁 427) 在創立 *Obliqua* 這一種名時就已明白地聲明過:他的這種植物與 Gutbier 的 *L. brongniarti* 很可能是同一植物,只因他手邊既沒有 Gutbier 的原著,也沒有看到過有關 *L. brongniarti* 的描述及其圖片,因而不得不定為一新種。再看 Bunbury 當年所發表 *L. obliqua* 的圖片,其中脈不作分裂狀態,似不同於一般的 *L. brongniarti*; 縱然它和 Gutbier 種的模式標本一樣,那麼應該保留的種名顯然也應該是 *brongniarti*, 而不是 *obliqua*。

我們很希望有人將這幾種植物的模式標本,再作一次確切的校對和研究,以澄清彼此之間的這些不明確的關係。

Neuropteris sp.

(圖版 1, 圖 1, 1c)

這一個屬,在當前的材料中只有一個很破碎的小羽片。它與上述的 *Linopteris brongniarti* 共生於同一岩蕊的破面上。

小羽片呈劍形至綫形,上部略呈鐮刀狀彎曲,基部收縮成心形,頂端未完全保存,可能為凸圓;中脈明顯,側脈甚細,但較鬆,以很小的角度自中脈分出,初離中脈時幾乎平行,分叉 2—3 次,然後逐漸彎向兩側。側脈從無相互聯結的現象。此一標本歸於

Neuropteris 一屬是沒有問題的,但欲進一步確定其種名則不可能。就其一般形態,與 Stockmans 和 Mathieu^[5](1939, 圖版 2, 圖 6)所描寫產於開平唐山層的 *Neuropteris* aff. *kaipingiana* Sze 及斯行健^[16](1956, 圖版 2, 圖 3—4) 最近所介紹甘肅中寧土坡煤系的 *N. kaipingiana* Sze 的兩塊標本,都很相似。但此一小羽片的葉脈與上述標本似稍有不同。

Sigillaria? shantungensis Lee (新種)

(圖版 1, 圖 3, 3a)

圖版 1, 圖 3, 3a 的那一塊標本,很像是屬於 *Sig. brardi* Brongn. 這一類型中的一分子。可惜的是它的保存太壞,並曾略遭擠壓。從它保存得最好的部分,還可以看出:葉痕比較小,或多或少近於雙凸鏡狀或扁圓形,約 3 毫米寬,3.5 毫米高,側角幾乎鈍圓,上下兩邊各自曲凸向上或向下,但它們的界綫常不很明顯。葉痕中有時還可以看見三個小點痕,橫列於稍微高於正中的部位,幾乎在一個平面 (level) 上。小葉舌印痕未能確實看到。葉痕成螺旋狀排列。各個葉痕之間,有相當顯著的縱行皺紋。

從葉痕的外形和排列,以及葉痕之間具有縱行皺紋的特徵來看,當前標本與 *Subsigillaria* 組中的 *Sig. brardi* 非常相似。*Sig. brardi* 這一著名化石的分佈幾廣及全球,其葉痕的形狀與排列的變化是很大的,但將 Seward^[11] (頁 200, 圖 196), Gothan^[9] (圖版 40, 圖 2—3) 及 Hirmer^[18] (1927, 頁 269, 圖 316—317) 所列舉歸於 *Sig. brardi* 那些比較標準的標本和我們的相比時,兩者的確非常相似。不過,當前標本葉痕的體積比所有已知屬於 *Sig. brardi* 的標本的葉痕都小得多。這樣的標本要將它歸入 *Sig. brardi* 種名之內,顯然是不適宜的。

這一標本與屬於 *Bothrodendron* 的某些種(如 Seward^[11], 頁 252, 圖 212F) 也頗可比較。但 *Bothrodendron* 這一屬植物是以具有更小的葉痕為其特徵的,並且其葉痕的排列的緊密程度和恆成梅花五點的形式也有所不同,因而此一標本也不能歸於該屬。

其他的已知化石中,似已無可作比較的種屬。同時,此一標本一般形態是比較接近於 *Sigillaria* 的,因而暫時定名為 *Sigillaria? shantungensis* Lee (新種),以便於今後的引用。

Bergeria spp.

(圖版 1, 圖 1a—1b, 圖 1; 圖版 2, 圖 1, 2, 1, 5)

“*Bergeria*”是用來表示鱗木莖幹外皮層的表皮剝落以後保存為一種特殊狀態的化石名稱。像這種狀態的化石標本,有一些古植物學家雖曾根據其大小與表面飾紋的

不同而給以不同的種名，但那都是沒有什麼重要意義的。同時，這種狀態的化石，在整個石炭紀及二疊紀的沉積中都能找到，所以它們在鑑定地質時代方面也沒有大的價值。因此我們將在淄博煤田 G 層鋁土礦中所發現的幾塊外皮剝離了的鱗木莖幹的印模標本統歸於 *Bergeria* 之名下。當然，它們也可能是代表着幾個不同的種的。

其中最引人注意的是圖版 2，圖 1 的那一塊標本，同一圖版，圖 2 所示的則是它的負面印痕的一部分。該標本為相當緊密的螺旋狀排列的葉墊所組成，葉墊為菱形至紡錘形，側角鈍圓，上下端尖凸。葉痕的形狀，由於其下部邊界不很清楚，難以確定，但很像是高度比寬度稍多的菱形。葉墊及葉痕表面的飾紋一般都不清楚或僅是偶然顯示出的一種特殊化的形相，並且常常在很短距離之內就有相當的變化。如圖版 2，圖 1 所示，每一葉墊中部稍高地方，常有一卵圓形的小點，大約表示着原來中心輸導束經過的位置。在同一圖版，圖 1a—1b 中更顯示出一種比較少見的情形：在某些葉墊的中部或是靠近其頂部的地方，我們常可看到在中心輸導束印痕之外，兩側還伴有兩點所謂 *Parichnos* 的印痕；如果作更仔細的觀察時，我們還可看見，某些葉墊（如圖 1b 中部上下直列的兩個葉墊）的輸導束印痕顯然較其側的兩印痕略高，而其鄰近的另一葉墊中，其三個小印痕却幾乎位於同一平面上。在接近葉墊頂端的部位，有時可以發現有小葉舌的痕跡。

上述這種葉墊中三個小點痕變化多端的出現於同一標本之上是比較少的，這標誌着此一標本是介於 *Bergeria-Aspidiaria* 的保存狀態。但這也並不是非常希奇的，Potonie^[19] (1905, 42, 頁 10, 圖 7) 所介紹屬於 *Bergeria* 的一塊歐洲標本，就有這種類似的特徵。

此外，川崎繁太郎^[20] (1931—1934, 圖版 73, 圖 210) 那塊採自淄博煤田並被定為 *Lepidodendron oculus felis* (Abbado) Zeiller 的標本與當前的頗為接近，似乎也只能定為 *Bergeria* sp.。

圖版 1，圖 4 的那塊成 *Bergeria* 狀態的標本，也許是屬於另一種鱗木的。它的保存很破碎，但與印載於 Hirmer^[18] “古植物手冊”的（頁 226, 圖 259）那一 *Bergeria* 狀態的鱗木標本有些相似。

另一塊鱗木莖幹印痕標本，可能也應歸於 *Bergeria* 屬名之內，是夾生於 G 層鋁土礦的最底部，直接位於中奧陶紀石炭岩裂縫中的標本。因岩片的裂面不平，顯示於圖版 II，圖 4 的圖片，是不大清楚的。實際上，這一標本上還明顯的保存着一些螺旋狀排列着的紡錘形的葉墊，其他的構造或飾紋却都已看不見。它的負面印痕附載於同一圖版的圖 5，具有一些截頭小木桿式的突起物，乍然看來，很接近於 *Knorria* 的保存狀態。

Lepidodendron sp. (? 新種)

(圖版 II, 圖3, 3a)

這一小塊鱗木標本是產於山西陽泉煤田本溪統 G 層鋁土礦的上部的。岩塊的背面還有一瓣鰭類的化石, 據顧知微同志意見, 其屬種已不能鑑定, 但因其為中國北部 G 層鋁土礦中已知的唯一的動物化石, 故特將其圖片附列於圖版 II, 圖 6, 以供參考。

此一鱗木標本雖小, 但保存得很好。葉墊為菱形至紡錘形, 起伏中等, 側角寬圓, 頂底角尖凸, 彼此之間為狹窄的邊帶相隔離。葉痕位於葉墊的正中或稍微高於正中的地位, 約佔葉墊寬度的 $\frac{3}{4}$, 菱形, 其上半部比下半部略大, 側角狹窄, 頂底角圓凸。葉痕中的三點小印痕, 差不多大小, 排列近於同一平面, 位於較葉痕水平中綫略低的地方。葉痕的上下部分, 都有一細微、但頗明顯的龍骨 (keel), 一個很小的葉舌坑印痕緊接於葉痕頂端之上。葉痕兩側角有一條向外下方射出的細綫, 但沒有達到葉墊的邊緣。其他的節紋沒有見到。

在已知的各種鱗木中, 可與此一標本相比的為北美 Nova Scotia 上石炭紀的 *L. dichotomum* var. *bretonensis* Bell^[13] (1938, 頁 92, 圖版 95, 圖 5—9 等)。北美的這一變種, 其鱗木的葉墊和葉痕的外形、葉痕中三個小印痕的排列位置以及自葉痕側角指向外下方的細綫, 都與我們這一標本的相似。但是如 Bell 所描述的, 北美這一植物, 在靠近葉墊頂角的地方有一個淺淺的、特別小的三角形印痕, 和在葉墊下半部常具有橫列的皺紋, 却都是我們這一標本所沒有的。所以中國標本還不能歸於 Bell 的變種之內。至於當前標本與 *L. dichotomum* Sternberg 標準種的相似程度是比較少的, 像那些為 Potonie^[19] (1905, 49, 圖 1) 和 Lesquereux^[21] (1880, 圖版 64, 圖 3) 等所引載的屬於 *L. dichotomum* 的比較標準的標本, 其葉墊的形狀和外表飾紋都與我們的大不相同。

另一種分佈很廣的鱗木 *L. obovatum* Sternberg 的某些標本, 如 Hirmer “古植物學手冊” (1927, 頁 198, 圖 231—233) 所示的, 與我們這種植物也有些相似之處。但該種在葉痕之下恆具有 transpiratory scars, 這一點是很容易與我們的這個種相區別的。似乎可以肯定的說, 當前標本應該屬於一未經描寫過的種或變種, 可是這一材料是還不足以為它創立一新的種名的。

結 論 及 討 論

本文介紹的植物羣包括下列幾種:

Linopteris brongniarti (Gutbier) Potonie

Neuropteris sp.

Sigillaria? shantungensis Lee, n. sp.

Lepidodendron sp. (? n. sp.)

Bergeria spp.

這一植物羣已知屬種數目之少是不足以完滿的表示出這一植物羣的特性的，但就其所在層位的地質時代來說，則很明顯的是傾向於不老於中石炭紀或歐洲地質時代表中的維斯發期的。這一材料中最重要的是有 *Linopteris brongniarti* (Gutbier) 的發現。因為 *Linopteris* 這一屬化石是歐洲中石炭紀或維斯發期中部及上部的重要化石，至於 *L. brongniarti* 這一種，則除常出現於中石炭紀外，少數標本也曾發現於上石炭紀及下二疊紀。在中國開平煤田的唐山層中，已經 Stockmans 和 Mathieu 證實其確有存在，根據這兩位比利時學者及中國許多地質古生物學家的意見，開平的唐山層無疑的等於華北他處的本溪統，都應屬於中石炭紀的上部（即後期維斯發或後期莫斯科）。此一植物羣中歸於 *Neuropteris* sp. 的標本，雖因種名未能確定而不能提供其可靠的地質時代，但它與只見於華北本溪統的 *N. kaipingiana* Sze 是頗為近似的。在這裏，*Sigillaria? shantungensis* Lee, n. sp. 的發現也是頗饒意義的。固然這一植物的屬名還沒有肯定，可是與它最為近似的植物化石是中歐斯梯芬期 (Stephanian) 及紅底期 (Rotliegende) 的重要分子 *Sigillaria brardi* Brongn.。值得注意的是，這一個分佈幾達全球的中、上石炭紀以及下二疊紀的重要化石在東亞的同期沉積中却一直缺少可靠的報導。赫勒^[22] 曾記載 (1927, 頁 275), 他曾在湖南醴陵的一個小礦區見到過一塊屬於 *Sig. brardi* 組的封印木標本。在另一著作^[23] 中, 他又認為他所創立的那一產於雲南宣威的 *Sig. acutangula* Halle 也可與 *Sig. brardi* 相比, 特別是接近於 Weiss (1893, 圖版 15, 圖 61 F) 的那一標本。斯行健^[24] 所介紹的江蘇賈汪煤礦的 *Sigillaria* sp. 也有些像 *Sig. brardi*。此外, 川崎^[20] 所描述的朝鮮寺洞統的某些封印木標本, 也頗接近於 *Sig. brardi*。然而, 所有這些標本都是出於較當前標本所在地層為高的沉積之中的, 同時, 它們彼此之間的真正關係也不明確。所以, 任何這種類型化石的新發現, 都還是值得注意的。

這一材料中的好幾塊外皮剝落的鱗木皮層的印痕標本, 我們都歸之於 *Bergeria* spp.。像 *Bergeria* 這種保存狀態的標本, 通常都認為是沒有什麼確切的地層上的價值的, 因為這種標本是在石炭紀及二疊紀沉積的任何部分都可以找到的。但是, 其中保存最好的一塊 (圖版 2, 圖 1) 所顯示出菱方形的葉墊, 則還是比較接近於某些中石炭紀鱗木葉墊的形狀的。

另一產於山西陽泉煤田 G 層鋁土礦的 *Lepidodendron* sp. (? n. sp.) 對於鑑定 G 層鋁土礦植物羣所代表的時代來說, 和上述淄博煤田所產的各種化石一樣, 也是具有同樣重要的意義的。這一鱗木, 雖因其種名未定而難以視作地層時代的指示物。但其

葉墊的整個輪廓還是顯示出其所在時代是不能老於中石炭紀。因為，正如 Seward^[25] (1941, 頁 187) 在討論早期石炭紀植物羣時就曾指出過，“雖然，就我們所知，晚期石炭紀植物羣中的鱗木類，區別於繁榮於早期石炭紀的那些種類比較少的鱗木是沒有很重要的特點的，有一些特殊現象——最著的是葉墊的形狀和莖部的構造——却是可以很有用地當作地質年代的標誌。下石炭紀鱗木之中有 *L. Veltheimianum*, *L. Rhoddeanum*, *L. Volkmannianum*, *L. Nathorsti** 及其他種類。這些具有長而稍微彎曲、並且向兩端逐漸縮小的尖端的葉墊，如圖 54 所示，就是本屬某些早期種的一種特別現象”。陽泉 G 層鋁土礦的這一 *Lepidodendron* sp. 的葉墊是標準的菱方形，完全不同於那些具有兩端逐漸縮小並成特殊尖端的下石炭紀鱗木的葉墊。同時，陽泉這一鱗木，與僅見於北美 Nova Scotia, Sydney 煤田的 *Linopteris obliqua* 帶中的 *L. dichotomum* var. *bretonensis* Bell 又非常相似。據 Bell^[13] 的研究，Sydney 煤田的 *Linopteris obliqua* 帶的地質時代是大致相當於歐洲的 Westphalian-C。因此，很明顯，陽泉 G 層鋁土礦所含的這一鱗木所顯示的地質時代同山東淄博煤田 G 層鋁土礦植物羣所提供的，完全是一致的。

綜上所述，我們得知，淄博煤田與陽泉煤田 G 層鋁土礦這一小植物羣的組成及其特性，都表示其地質時代不能老於中石炭紀或維斯發期；也就是說：這兩個煤田的 G 層鋁土礦很可能就是緊覆於其上的本溪統的底部，並且也應該是莫斯科期或維斯發期的沉積。因為華北本溪統的時代，無論根據動物化石或者是植物化石，早已證明確切相當於歐洲地質時代表中的上部莫斯科期或上部維斯發期了。

這一結論，與張文堂同志的主張是不相符合的，與周祖勛、真允慶兩同志的看法則基本一致。但是，這一結論，並不排斥將來在個別地區，特別是當本溪統缺失，為太原統或更年輕的地層直接覆蓋的類似於 G 層鋁土礦的沉積中，有找到較中石炭紀更為年輕的標準化石的可能性。

最後還值得討論一下有關華北 G 層鋁土礦生成的方式和環境問題。過去，地質學家大多相信 G 層鋁土礦（包括通稱的山西式鐵礦）是燥熱氣候影響之下，在中奧陶紀石灰岩侵蝕面上長期風化的殘餘堆積。解放以來，雖已有人指出它可能是溫暖氣候下瀉湖相的產物，但是主張其為原地風化殘餘者，仍大有人在。當前研究材料中植物化石的數目甚少，自不足對此問題作一詳細的討論。但是這些化石在岩層中分布的狀況和某些印痕標本的細部也保存得很好的這一情形，根據過去一般的看法，都認為含化石的這種岩層應該是屬於比較平靜的湖水中的沉澱。同時，對於中石炭紀或維斯發期的植物羣，許多古植物學家都曾指出過，在全球所發現的幾乎是一致的，它們是生存於溫帶氣候之中的。因此，我們也可以推測，華北 G 層鋁土礦（至少淄博和陽泉煤田的應如此）可

* 據 Gothan 等 ([10], 頁 209): 此種植物也偶可出現於中石炭紀初期的 Namur-A.

能不是奧陶紀石灰岩風化殼上的殘餘堆積，而是淺水湖或瀉湖中的一般沉積物，當時的氣候並不是熱帶或亞熱帶式的，而是一種溫帶式的濕潤氣候。所有這些，都是支持周祖勛同志等新近提出來的看法的。

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A WESTPHALIAN FLORULA FROM THE G-BAUXITE BED OF THE PENCHI SERIES OF THE TZU-PO COAL FIELD, SHANTUNG

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(With 2 plates and 1 text-figure)

In the autumn of 1956, some borings were made by the 501 party of the Geological Bureau of North China belonging to the Ministry of metallurgical Industry, People's Republic of China, in order to examine the G-bauxite deposits of the Penchi Series in the Hutien area of the Tzu-po (Tzuchuan-Poshan) coal field, Shantung. The cores have yielded a number of fossils which are given in the generalized columnar section (textfig. 1 in the Chinese text, p. 351.) The plants obtained from the G-bauxite bed, though imperfectly preserved, are figured and described here while the animal remains from the overlying rocks of the same series determined by Messrs. Y. Wang, J. C. Sheng, etc. are only listed in the section. In addition, a single specimen of imprint of *Lepidodendron*-stem which was collected by Mr. T. M. Liu in 1954 from the G-bauxite bed of the Penchi Series of the Yangchuan coal field, E. Shansi is also included in this account.

The discovery of plant remains in the G-bauxite bed of the Penchi Series is evidently of some importance to palaeontologists and stratigraphers, because no paleontological results have ever been published and opinions differ considerably among Chinese geologists^{[1][2][3][4]} as to the age of the G-bauxite bed.

Description of Species

Linopteris brongniarti (Gutbier) Potonie

(Pl. I, figs. 1, 1a-b, 2)

The specimens referable to this species occur as detached pinnules in a core from the middle part of the G-bauxite bed. The pinnules are oblong-ovate, slightly falcate, with nearly parallel sides, more or less cordate base and bluntly rounded apex. Midvein, cleft or slit in nature, is very inconspicuous or only traceable for one-fourth the length of a pinnule. The remaining veins form a close mesh of four to six-sided polygons, of which those near the midvein are strongly ascending and elongate and the remain-

der gradually shorter and arched outwards the margin.

The specimens figured here, though fragmentary, agree in all respects with those illustrated and described by Stockmans and Mathieu^[5] (1939, p. 65, Pl. 2, figs. 10-13) under the same designation from the Uppermost Westphalian, i. e., the Tangshan Series (Assise de Tongshan) of Kaiping basin, E. Hopei. The pinnules of a frond from the type-locality (Zwickau-Lugau) of this species figured recently by Daber^[6] (1955, Pl. 21, figs. 2, 2a) under the name *L. brongniarti* Gutbier sp. show also a very close resemblance to the Chinese specimens.

The present material agrees also fairly well with the specimen originally referred to this species by Gothan^[8] in his "Lehrbuch" (1921, p. 100, fig. 94) from the Westphalian of Oberschlesien, which is copied from Potonie's^[7] Abb. u. Besch. foss. pflanzen, Lief. IV. (1904), No. 29, fig. 2. The specimen has subsequently been transferred by Gothan^[9] (1923, p. 77, fig. 69b) and recently by Gothan and Weyland^[10] (1954, p. 148, fig. 131, left-hand one) to *L. neuropteroides* (Gutbier) Potonie. But the Oberschlesien specimen does not agree so well with the type-specimen of *L. neuropteroides* (Gutbier) shown in Seward's^[11] "Plant Fossils", Vol. 2 (1910, p. 573, fig. 374). Furthermore, one of the most important distinctions between these two species first given by Potonie^[7] and later accepted by many authors^{[8][12][13]} is that the common ratio of the width to the length of a pinnule of *L. neuropteroides* (1:3—3.5) is smaller than that of *L. brongniarti* (1:2—2.5); this distinguishable feature is also best shown by all the illustrations of these species just mentioned. The writer is still inclined to support Potonie's original designation of the Oberschlesien specimen.

The relation of the present species to several other species of the paripinnate group of Linopterids is as yet not clear.

Both Kidston^{[14][15]} (1886, p. 103; 1891, p. 76) and Potonie (1904, No. 29, p. 2), has pointed out that the type-specimens ascribed to *Linopteris obliqua* (Bunb.) Zeiller and *L. subbrongniarti* (Grand'Eury) Zeiller are not easily distinguishable from the present species, and they considered *L. obliqua* and *L. subbrongniarti* to be synonyms of *L. brongniarti* on grounds of priority. The last species was proposed by Gutbier in 1835 and the former two by Bunbury in 1847 and by Grand'Eury in 1877 respectively. The difficulties in distinguishing these species were also noted by Stockmans and Mathieu^[5] in 1939 (p. 65) and recently by Sze^[16] (1956, p. 363). The specific name *obliqua* is more familiar and widely employed, and probably because of its popularity that some authors still consider *L. obliqua* as a distinct species, and others have even supposed that some of the European specimens regarded as typical representatives of *L. brongniarti* may be included in *L. obliqua*.

It is hoped that revision of all the type-specimens of these species may clear up the obscure relationships of these plants.

Neuropteris sp.

(Pl. I, figs. 1, 1c)

A small isolated pinnule which apparently belongs to the genus *Neuropteris* was found together with *Linopteris brongniarti* in the same core slab. It may possibly be compared with the specimen figured by Stockmans et Mathieu^[5] as *N. aff. kaipingiana* Sze (1939, Pl. 2, fig. 6) from the Tangshan series of Kaiping basin. The preservation is not sufficiently good for a specific determination.

Sigillaria ? shantungensis n. sp.

(Pl. I, figs. 3, 3a)

The interesting specimen shown here probably belongs to the group of *Sigillaria brardi* Bgt., although it is very badly preserved. On the impression of the best preserved portion, it shows, however, that the leaf scars are more or less double-convex or subcircular in shape, rather small, about 3 mm wide by 3.5 mm high, with narrowly rounded lateral angles and somewhat arched upwards upper and downwards lower borders, but they are usually illy defined. The three cicatricules situated almost in line a little above the middle of the scar can sometimes be observed. The traces of the ligular pits are not visible owing to bad preservation. The leaf scars are evidently spirally arranged and on the interspace between the leaf scars there are distinct vertical undulatory striae or wrinkles.

With regard to the shape of the leaf scars and the decorations of the stem surface the specimen seems to be comparable to the species of *Subsigillaria* group, and recalls somewhat the world-wide spread species *Sig. brardi* Brongn., especially as figured by Seward^[11] (1910, p. 200, fig. 196), by Gothan^[9] (1923, Pl. 40, figs. 2—3) and by Hirmer^[18] (1927, p. 269, figs. 316—317). The size of the leaf scars of our specimen is, however, rather smaller than any of the known specimens of *Sig. brardi*.

In the relatively smaller size and subcircular shape of the scars, the specimen resembles somewhat some species of *Bothrodendron*. But the intervals between the leaf scars of *Bothrodendron* are not so great as the present one; and it is distinguished considerably from our form in having a still smaller size of leaf scars and in having the scars being disposed much more densely and always arranged in quincunx. Hence, the present specimen cannot reasonably be ascribed to the genus *Bothrodendron*.

The present specimen does not resemble closely any other genera; it is rather suggestive of the genus *Sigillaria*, but it is too imperfect for a definite determination. In any case, it probably represents a new species.

***Bergeria* spp.**

(Pl. I, fig. 4; Pl. II, figs. 1, 1a-b, 2, 4, 5)

“*Bergeria*” is a term used for the casts of *Lepidodendron*-stem, of which the superficial layers of outer cortex are deprived. Although attempts have been made by some authors to assign the casts of this type to species, their size and markings are not of importance. And neither do these fossils have any stratigraphic value, because they occur throughout both the Carboniferous and the Permian. Among the material from the Tzu-Po coal field are a few decorticated specimens of *Lepidodendron*-stem, which are all described here under the name *Bergeria* spp., though they may represent different species.

One of the most interesting examples of *Bergeria* in the present collection is shown in Pl. II, figs. 1, 1a-b and a portion of its counterpart in Pl. II, fig. 2. It consists of rather crowded and spirally arranged leaf cushions which are fusiform, rounded laterally and acuminate at both ends. As the impressions of the lower limit of the leaf scars are always very inconspicuous, the exact outline of the scar cannot be recognised, but it appears most probably to be rhomboidal commonly longer than wide. The surface markings of the leaf cushions as well as the leaf scars are in general not visible or only occasionally preserved in specialized aspect, and when present they may vary somewhat even within a short distance. The leaf cushions enlarged in Pl. II, fig. 1a are each marked with a round-oval punctum more or less near the center of the cushion, which shows approximately the original position of its central vascular cicatrix. Others as given in Pl. II, fig. 1b, which are exceptionally well preserved, show clearly that the central vascular cicatrix is still accompanied with two smaller lateral parichnos cicatricules either close to the upper corner or a little above the middle of the cushion. It is to be noted further that the central cicatrix in the two cushions placed vertically in the midst of this figure lies a little higher than the lateral cicatricules, while in the adjacent left-hand cushion the three cicatricules are almost in line. The traces of ligular pits may sometimes be seen near the upper end of a cushion. The occurrence of all these characteristic features in one specimen, which represent somewhat the *Bergeria*-*Aspidiaria* state of preservation is rather rare, but not unique, as an European example bearing a similar nature of *Lepidodendron*-stem was figured by Potonie^[9] (1905, No. 42, p. 10, fig. 7). Also a specimen from this

coal field determined by Kawasaki^[20] (1931, Pl. 73, fig. 210) as *Lep. oculus felis* (Abbado) Zeiller recalls somewhat the present form.

The fragmentary specimen in Pl. I, fig. 4 probably represents a different species of *Lepidodendron* in the *Bergeria* state of preservation. Though imperfectly preserved, this specimen show in general characters a certain resemblance to that figured by Hirmer in his "Handbuch" (1927, p. 226, fig. 259).

Another imprint of decorticated *Lepidodendron*-stem, shown in Pl. 2, fig. 4 is embedded in a core from the base of the G-bauxite bed lying directly on the uneven erosional surface of the Middle Ordovician limestone. The specimen shows merely some outline of leaf cushions which are fusiform and spirally disposed. The counter part of the specimen is figured in fig. 5 of the same plate, the more or less peg-like projections suggest a superficial likeness to the *Knorria* condition of preservation.

***Lepidodendron* sp. (? n. sp.)**

(Pl. II, figs. 3, 3a)

A small fragment from the Yangchien coal field, given in Pl. II, fig. 3, 3a is the only fossil specimen so far definitely known from the G-bauxite bed of North China, excluding the present material of the Tzu-po coal field. According to its collector Mr. T. M. Liu, the bauxite horizon from which this specimen was found is undoubtedly the equivalent of the upper part of the G-bauxite bed in the Tzu-po coal field. In associated with the *Lepidodendron* species described here, the writer has still found a small piece of indeterminable pelecypod on the other side of the same slab, which is also shown in Pl. II, fig. 6.

The imprint of the *Lepidodendron*-stem is rather well preserved. The leaf cushions are rhomboidal to fusiform, of moderate relief, with laterally rounded angles and somewhat acuminate ends and separated by narrow strips. The leaf scars are situated at the middle or more rarely a little higher than the middle of a leaf cushion, occupying about three-fourths the width of a cushion, rhomboidal with upper borders slightly larger than the lower, lateral angles sharply pointed, upper and lower angles narrowly or obtusely rounded. The three cicatricules are almost in a line and subequal, lying a little lower below the centre-line of a scar. Both fields are marked with a faint keel. A minute, ligular pit appears to occur immediately above the upper apex of a scar. The lines descending from the side-angle of the scar and running laterally downwards are commonly present, but they do not reach the margins of the cushion. Other surface markings are not visible.

Among other known species of *Lepidodendron* which may be compared with the present specimen is *L. dichotomum* var. *bretonensis* Bell from the Upper Carboniferous of Sydney coal field, Nova Scotia^[13] (Bell, 1938, p. 92, Pl. 95, figs. 5—9; Pl. 96, fig. 1; Pl. 97, fig. 4). This form resembles ours in the general shape of the leaf cushions and leaf scars, and particularly in the position of the three cicatricules and in the manner of the laterally descending lines of the leaf scar. The Nova Scotian form as described by Bell is, however, characterized in the upper corner of the cushion by a triangular flattened area, and by the transverse wrinkles generally occurring in the lower part of the cushions which are not found in the Chinese specimen. Our form differs from the typical representatives of *L. dichotomum* Sternberg, such as figured by Potonie (1905, No. 49) and by Lesquereux^[21] (1880, Pl. 64, fig. 3), etc. in the characters of the leaf cushions and their surface decorations. Some specimens of the widespread species *L. obovatum*, as illustrated in Hirmer's "Handbuch" (1927, p. 198, fig. 232) show also a certain resemblance to our form, but the transpiratory scars, an important feature of *L. obovatum*, are absent in ours. It is to be noted finally that our specimen might belong to an undescribed species, but the material is not sufficiently well preserved for creating a new species.

Conclusion

The small florula described in this paper consists of the following species:

***Linopteris brongniarti* (Gutbier) Potonie**

***Neuropteris* sp.**

***Sigillaria* ? *shantungensis* n. sp.**

***Lepidodendron* sp. (? n. sp.)**

***Bergeria* spp.**

Though the number of species is too small to permit of a satisfactory characterization of the florula, its age may be given as not older than the Middle Carboniferous or the Westphalian of the European chronology. The presence of *Linopteris brongniarti* (Gutbier) in our collection is of special importance, since this species is characteristic of the Arcto-Carboniferous province extending from the middle part of Westphalian through Stephanian to the Lower Rotliegendes. Confirmatory evidence of the existence of this species in China has been furnished by Stockmans and Mathieu^[5] from the Tangshan Series (Assise de Tongshan) of Kaiping basin. The Tangshan

Series is regarded by these two authors and by Chinese geologists as well as paleontologists as undoubtedly correlating to the Penchi Series in other parts of N. China—a Middle Carboniferous age (Upper Westphalian or Upper Moscovian). Although the single detached pinnule attributed to *Neuropteris* sp. of the present material cannot serve to determine the character of the florula and its age, it may be more or less compared with *Neuropteris kaipingiana* Sze which is characteristic for the Tangshan Series of Kaiping basin. The discovery of *Sigillaria? shantungensis* n. sp. is also of some interest though the generic identification remains somewhat doubtful. The shape and arrangement of the leaf scars somewhat approach the type of *Sigillaria brardi* Brongniart, but their small size does not agree with the typical representative of this European species. It is interesting to note that this most typical representative of Subsigillariae, a species of world-wide distribution in the Middle and Upper Carboniferous and Lower Permian of Europe, is very little known in the corresponding deposits of Eastern Asia. Halle^[23] (1927a, p. 275) stated that a specimen representing a species of *Sigillaria* of *S. brardi* group had been found in 1917 from a small mine a little more than 20 km. N.N.E. of the Liling district, E. Hunan. In another contribution, he^[23] (1927b, p. 6) has also compared his *Sigillaria acutangula* from Hsüanwei district, E. Yunnan with *Sig. brardi*, particularly the specimen figured by Weiss (1893, Pl. 15, fig. 61f). A small specimen from the Chiawang coal field of N. Kiangsu figured by Sze^[24] (1951, Pl. 1, fig. 5) under the name *Sigillaria* sp. (sp. nov.) bears a certain resemblance to *Sig. brardi*, too. Besides, fragmentary specimens more or less resemble Brongniart's species have been found by Kawasaka^[20] from the Jido Series of Chosen' (Korea). However, all these specimens are discovered from strata much higher than the present one, and their exact relationships still remain imperfectly known. A few specimens of decorticated *Lepidodendron* trunk found in this material are collectively determined as *Bergeria* spp. Forms of *Bergeria* have long known to be of no value for stratigraphical purpose, for they may occur throughout the extent of both the Carboniferous and the Permian system.

In addition, a single specimen probably representing a new form of *Lepidodendron* from the G-bauxite bed of the Yangchuan coal field serve to prove with considerable weight the age of the florula. The species, owing to its uncertainly specific determination, is not entitled to hold as a stratigraphical index. But judging from the shape of the leaf cushions it is quite probable that an age not older than the Middle Carboniferous may be given. In discussing the floras of the earlier Carboniferous system, Seward^[25] has pointed out that (1941, p. 187) "Though the *Lepidodendraceae* of

the late Carboniferous floras differed, so far as we know, in no very important respects from the smaller number of species which flourished in the earlier days of the period, there are certain distinguishing features—namely the form of the leaf-cushion and the structure of the stem—which can be employed usefully as criteria of geological age. Among the Lower Carboniferous species are *Lepidodendron Veltheimianum*, *L. Rhodeanum*, *L. Volkmannianum*, *L. Nathorsti* and others. The long and slightly sinuous, tapered ends of the leaf-cushions shown in fig. 54 are a distinguishing feature of a few of the older species of the genus". The form of the leaf cushions of the Yangchuan species is typically rhomboidal, differing so much from the leaf cushions characterized by "the long and slightly sinuous, tapered ends" typical for the Lower Carboniferous species of *Lepidodendron*. Besides, the present species stands closely to *Lepidodendron dichotomum* var. *bretonensis* Bell known only in the *Linopteris obliqua* zone of the Sydney coal field, which is considered by Bell to be approximately corresponding to the Westphalian-C of Europe. It is thus clear that the presence of this interesting form, *Lepidodendron* sp. (? n. sp.) in the G-bauxite bed of the Yangchuan coal field is consistent with the evidences on the geological age as furnished by the fossil plants of the G-bauxite bed from the Tzu-Po coal field.

From the foregoing paragraphs it can be seen that the composition and the characters of the small florula of the G-bauxite bed of the Tzu-po coal field as well as the Yangchuan coal field reveal beyond doubt an age not older than the Westphalian or the Middle Carboniferous. Hence, it is highly probable that the G-bauxite bed of these coal fields can be considered as a basal part of the overlying Penchi Series and is also of Westphalian or Moscovian in age, since the age of the Penchi Series of N. China has long been proved by fauna as well as by flora to be equivalent to the Upper Moscovian or Upper Westphalian of the European development.

There is still a divergence of opinion regarding the origin of G-bauxite deposits of North China. It has long been believed by many geologists that these beds (including the so-called Shansi-type iron-ore) are residual products of weathering, probably a chemical weathering on the much eroded surface of the middle Ordovician limestone under a more or less tropical climate. Others, for instance, Messrs. C. C. Chow and Y. C. Tseng, have recently suggested that the G-bauxite may be considered as lake or lagoon deposits under temperate climatic conditions. However, neither of these suggestions has gained general acceptance. Apparently the number of fossil plants described here is too small to admit a full discussion of this subject, but evidence accumulated shows that the rocks which contain the fine impres-

sions of plant remains like the present material were originally deposited under tranquil conditions in water; furthermore, it has been often pointed out that during the middle Carboniferous or Westphalian the floras throughout the world are very uniform and they grew in a temperate climate. There is therefore some reason to suspect that the G-bauxite beds of North China, at least those of Tzu-po and Yangchien coal fields, might not be a weathering product in the residual mantle of the Ordovician limestone, but that they were deposited by ordinary processes in shallow lake or lagoon which reflects wet and temperate conditions, instead of tropical or subtropical. All the evidence provided by the fossil plants confirms the view recently held by Messrs. Chow and Tseng.

圖 版 說 明

下列各圖除特別說明的外,都是表示標本的原大,並且未加任何潤飾,攝影者爲劉雪筠同志;標本均保存於中國科學院古生物研究所。

圖 版 I

圖 1—2. 1a, 1b. *Linopteris brongniarti* (Gutbier) Potonie; 放大 $\times 3$ 。

產地及層位: 山東淄博煤田, 湖田礦區, G 層鋁土礦中部。

登記編號: PB 2609a, 2609b。

1c. *Neuropteris* sp., 圖 1 之一部分, 放大 $\times 3$ 。

圖 3. 3a. *Sigillaria? shantungensis* Lee (sp. nov.) 新種; 3a. 放大 $\times 3$ 。(圖 3 的葉痕曾稍作潤飾)

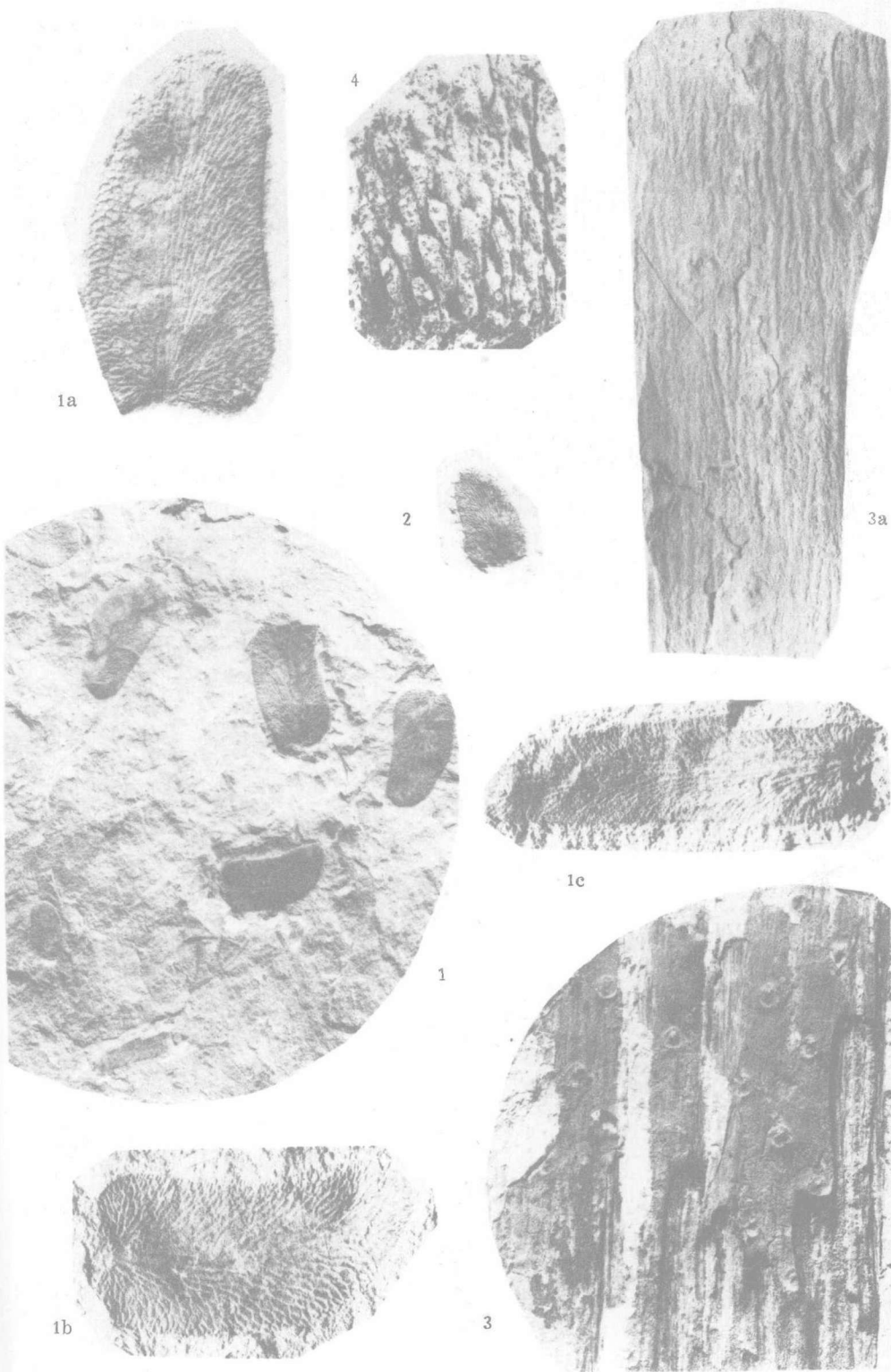
產地及層位: 山東淄博煤田, 湖田礦區, G 層鋁土礦頂板頁岩中。

登記號碼: PB 2610。

圖 4. *Bergeria* sp.

產地及層位: 山東淄博煤田, 湖田礦區, G 層鋁土礦下部。

登記號碼: PB 2611。



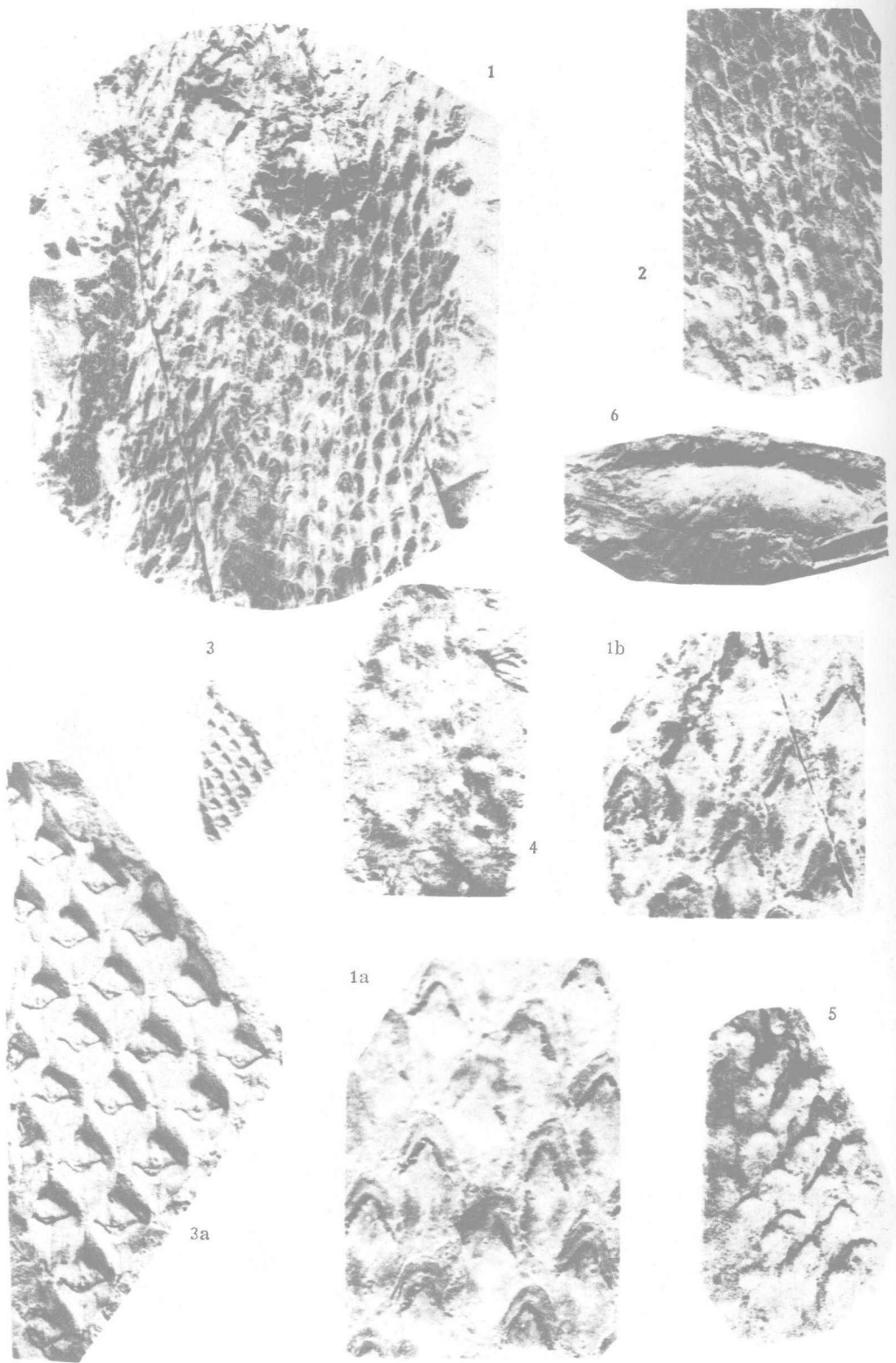


圖 版 II

圖 1. 1a, 1b. *Bergeria* sp.; 1a, 1b 圖 1 之一部分放大 $\times 3$ 。

產地及層位：山東淄博煤田，湖田礦區，G 層鉛土礦上部。

登記號碼：PB 2612。

圖 2. *Bergeria* sp. 圖 1 標本一部分的背面 (A portion of the reverse of the specimen in fig. 1)

產地及層位：同上。

登記編號：PB 2613。

圖 3. 3a. *Lepidodendron* sp. (? n. sp.) 可能為新種；3a，放大 $\times 3$ 。

產地及層位：山西陽泉煤田，桃坡鄉太湖石村，G 層鉛土礦中、上部。

登記號碼：PB 2614。

圖 4—5. *Bergeria* sp.; 圖 5 為圖 4 標本的背面 (reverse)。

產地及層位：山東淄博煤田，湖田礦區，G 層鉛土礦底部。

登記編號：PB 2615。

圖 6. 瓣鰓類的碎片化石；含於圖 3 標本之反面。

產地及層位：與圖 3 的同。