

云南曲靖地区早泥盆世无颌类化石*

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云南曲靖地区早泥盆世地层中产无颌类化石早有报导。抗日战争前王曰伦于翠峯山和廖角山(原誤称“妙高山”)两地均曾发现头甲魚(Cephalaspidae)科化石(丁文江、王曰伦 1936—1937; 楊鍾健 1939)。其后, 李广源等于廖角山采得的魚化石經楊鍾健鉴定, 其中无颌类化石定为 *Cephalaspis* sp. (李广源等 1942, 滇东曲靖、沾益地質, 未刊稿)。上述化石可惜均未进行古生物学描述, 标本于抗日战争期間几經輾轉, 今已不知下落。

1962—1963年冬春之际, 张国瑞与著者等在云南进行泥盆紀魚化石調查时, 于曲靖地区采得相当丰富的无颌类化石, 就目前可以鉴定的材料, 其中隶属于骨甲魚类者包括二新属、新种, 其中一属代表一新科一新目。隶属于异甲魚类者計一新属新种, 代表一新科新目。

这篇短文系曲靖地区无颌类化石的初步报告。

綱 Cephalaspides (Osteostraci) Berg 1940

目 Galeaspiformes ord. nov. (新目)

特征: 骨甲魚类。头甲大致呈吻端圓鈍的三角形, 具发育的胸角。头甲背面无背及侧发电区。眼孔彼此相距甚远, 朝向背側方。鼻-垂体孔呈裂隙状、极长, 向后伸延至两眼孔后緣联綫。松果孔极小, 位于两眼孔之后。眶下感觉沟很短。眶上沟(或V字形感觉沟)特别发育。

科 Galeaspidae fam. nov. (新科)

特征: 同目的特征

属 *Galeaspis* gen. nov.

种 *G. changi*¹⁾ sp. nov.

(图版 I, 1—2)

正型标本: 一件近于完整的头甲及其印模, 左后側略变形。中国科学院古脊椎动物与古人类研究所标本登記号 V.2981。

产地及时代: 云南曲靖廖角山王家园采石場南山南坡。早泥盆世。

属及属型种的特征: 中等大小的骨甲魚类。头甲(cephalic shield)基本呈三角形, 背

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1) 种名贈与昆明工学院地質系张欣平先生。

面沿中軸圓滑隆起。头甲吻緣圓鈍，无吻突。側緣略呈弓形外拱。胸角 (pectoral cornu) 較寬而扁平，其末端指向后方。似无明显的胸竇 (pectoral sinus)。头甲的間帶部分 (interzonal part) 很短，其后緣略向后凸出。无背棘。

鼻-垂体孔 (naso-hypophyseal opening) 呈狹长的裂隙状，向后延伸达两眼孔后緣联綫，其长超过头甲眶前部的长度 (由眼孔至头甲吻端的距离)。眼孔較大，彼此离开甚远，朝向背側方。无独立的松果片。松果孔很小，位于两眼孔后緣联綫之后。常見于骨甲魚类的側电区及背电区均缺如。

感觉沟的分布与已知骨甲魚类頗有差別。具发育的眶上沟 (或V字形感觉沟)，該沟由眼孔前上方起始向后伸延，經眼孔內側終止于間帶后緣之前。眶下感觉沟很短，其前端不超过眼孔前緣，向后与側感觉沟連接。每側的縱側感觉沟向側面伸出三条长的側横枝，其中最后一枝最长，伸向胸角。每条縱側感觉沟以一条中横联枝与V字形感觉沟联系。

头甲腹面目前知道的很少，由头甲的腹面邊緣及头甲后緣的横断面观察，头甲腹面似乎扁平的，腹环于后緣可能不封閉。

头甲外骨骼表面由区間沟 (interareal canal) 分割成許多小的多角形区。紋飾由小的粒状突起組成，該种突起每个多角区通常只有一个。

正型标本的測量 (单位: 毫米)

中长 (Length in median line)	37.5
全长 (L. from tip of cornu to rostra end of shield)	45.8
松果孔至吻端长 (L. from pineal opening to rostral end of shield)	23.5
寬 (Maximum breadth)	60
眼間寬 (Breadth between orbital opening)	20
間帶高 (Height of interzonal part)	14.5

比較: 新属 *Galeaspis* 在头甲的一般特征及胸角、鼻-垂体孔的构造方面与骨甲魚类有着共同性質。但是由于电区的缺如，彼此离开的眼孔，特殊长的鼻-垂体孔、显著后移的松果孔以及感觉沟系統的分布等特征与已知骨甲魚类有明显区别，因此它不属于骨甲魚类中任何已知的目。

所有已知骨甲魚类头甲背面均具有成对的側电区及单一的背电区，而这些电区是由紧密鑲嵌的多角形小骨片覆盖。在 *Galeaspis* 的头甲背面我們找不到任何这种多角形骨片覆盖区，因此著者认为 *Galeaspis* 头甲背面不存在电区。

已知骨甲魚类的眼孔位于头甲背面，通常彼此很接近，而 *Galeaspis* 的眼孔則彼此离开甚远，位于头甲的背側面，其眼孔間的距离与通过两眼孔中心处的头甲寬的比率約为 45%。这一比率在骨甲魚类的一般类型中則小的多，如 *Hemicyclops* 只有 13% 左右 (Stensiö 1932, 图 23)，在骨甲魚类眼孔較离开的种类如 *Nectaspis*，也只有 22% 左右 (Wangisö 1952, 图 104)。

Galeaspis 的鼻-垂体孔特殊的长是在骨甲魚类中从未見过的。由于鼻-垂体孔显著向后延伸，*Galeaspis* 的松果孔向后移至眼孔之后。而在已知骨甲魚类中，松果孔通常是在两眼之間。

由于电区的不存在及眼孔彼此离开使得 *Galeaspis* 的感觉沟系統的分布也很不同于已知骨甲魚类。首先是具有特別发育的V字形感觉沟，該感觉沟在骨甲魚类一般是不存

在的,只有 *Hoelaspis*, *Benneviaspis* 和 *Tremataspis* 的上松果沟(Pc, Stensiö 1927, 图 76, 77, 83)可能与之相当,但是在这三个属中 PC 只不过是分布在眼孔后内侧的很短的沟。其次在骨甲鱼类中通常极为发育的眶下沟,在 *Galeaspis* 中却很短,这与其具有发育的 V 字形沟有关。Stensiö (1927, 306 頁)认为骨甲鱼类的眶下沟的眶前部分是与一般鱼类的眶上沟相当。换言之,一般骨甲鱼类的眶下沟,相当鱼类的眶下沟和眶上沟。而 *Galeaspis* 的 V 字沟至少眼孔以前的部分应当与鱼类的眶上沟相当。其眶下沟则与一般骨甲鱼不同,不包括眶上沟。再则 *Galeaspis* 的纵侧感觉沟的外侧具有三条发育的侧横枝,而在骨甲鱼类除 *cmm*₂, *cmm*₃ 外横枝通常只分布在纵侧感觉沟内侧。*Galeaspis* 的这一特征似乎是其侧电区缺如有关。与骨甲鱼类的 *Tremataspis* 和异甲鱼类比较, *Galeaspis* 的纵侧感觉沟相当前二者的中背沟,而一般骨甲鱼类的侧沟相当前二者的侧背沟。

尽管 *Galeaspis* 不见电区,著者以为这并不妨碍将 *Galeaspis* 归属骨甲鱼类。近代鱼类学的研究说明,鱼类发电器官只不过是局部神经和柔软组织特化的结果。而在现生鱼的分类中鳐超目就包括普通鳐目和具发电器官的电鳐目。

綱 Cephalaspides (Osteostraci) Berg 1940

属 *Nanpanaspis* gen. nov.

种 *N. microculus* sp. nov.

(图版 II, 1)

正型标本: 一件后部残缺的头甲及其印模,标本登记号 V.3030。

产地及层位: 同 *G. changi*。

属及属型种的特征: 中等大小的骨甲鱼类。头甲长度不确定,头甲于间带两前侧角间的宽度约 73 毫米,头甲长度大于宽度。头甲吻端具细长的吻突。头甲侧缘略弯曲,向前中凑合,两侧的侧缘延线向吻端约成直角相交。胸角宽而短,指向侧方。胸角与间带的前侧角间具一缺刻状的胸窗。间带(后部缺失)很长,其侧缘略弯曲,由前向后中方向倾斜,间带侧缘前端与胸窗间形成短而宽的前侧角,该角顶端指向侧方。鼻-垂体孔大、呈卵圆形。眼孔甚小,彼此离开,眼孔位于头甲前部,头甲眼前部分不超过头甲中长的三分之一。松果孔不详。侧电区不详,可能不存在,眼孔之后前窄后宽的四边形凹陷可能为背电区。

感觉沟系统保存不甚清楚,可见一对纵行侧沟,起始于眼孔侧下方,向后伸延,终止于眼后凹陷区的后侧方。每侧的纵侧沟外侧具 3 条侧横枝,第一条最长,伸向胸角的前方。第二条伸向胸窗,第三条似乎很短。

外骨骼没有保存,纹饰不详。

比较: 新属 *Nanpanaspis* 的头甲一般特征与已知骨甲鱼类有着共同性质,但是又有一些特征不同于所有已知骨甲鱼类各属。

与已知骨甲鱼类各属比较,虽然 *Nanpanaspis* 具有显著长的间带与 *Nectaspis*, *Acrotomaspis* 及 *Axinaspis* 相似,但是后三属不具真正的胸角及发育的胸窗和吻突而与新属不同。新属的头甲形状及长的吻突等特征与 *Boreaspis* 近似,两属间的区别在于新属的鼻-垂体孔大,呈卵圆形, *Boreaspis* 的鼻-垂体孔呈狭长形,新属眼孔极小, *Boreaspis* 的眼

孔較大,新属的胸竇向着側方, *Boreaspis* 的胸竇向着側后方。

由于一些分类上的重要特征如电区, 口孔形状, 鰓的排列形式等目前尚不了解, 因此关于新属 *Nanpanaspis* 与已知骨甲鱼类各目的关系現在还不清楚。

綱 *Pteraspides* (Heterostraci) Berg 1940

目 *Polybranchiaspiformes* ord. nov. (新目)

特征: 异甲鱼类。头及軀干前部背面由单一的背甲覆盖。背甲沿吻緣及側緣折向腹面, 形成半环形的腹环。腹面除中央具一片腹甲外, 腹环与腹甲間由众多的小骨片組成鑲嵌帶。口孔、眼孔、洞穿背甲。口孔背位, 靠近吻端。眼孔位于背甲前側, 彼此远离。松果孔甚小, 位于眼孔后方。沒有开向外界的外鼻孔。鰓囊通过各自独立的外鰓孔开向外界, 而不形成总的外鰓孔, 每側的外鰓孔沿腹环內側排列。感觉沟系統位于表面齿質层之下, 其分布呈异甲魚型, 但側背感觉沟缺如。甲片被以星状疣突。

科 *Polybranchiaspidae* fam. nov. (新科)

特征: 見目的特征。

属 *Polybranchiaspis*. gen. nov.

种 *P. liaojaoshanensis* sp. nov.

(图版 II, 2—4, 图版 III, 1—3, 图版 IV, 1)

正型标本: 一件近于完整的背甲, 长约 58 毫米, 寬約 52 毫米。标本登記号 V.3027。

副型标本: 一件腹壁保存的背甲, V.3027.1。一件右后側部殘缺的背甲, V.3027.2。

其他材料: 約 40 件保存完整程度不同的背甲及 7 件腹甲。

产地及时代: 曲靖廖角山新寺南, 曲靖翠峯山西山村附近。早泥盆世。

属及属型种的特征: 背甲略呈前端窄后端寬的心脏形。吻緣圓鈍。側緣呈弓形凸出。后緣向內凹, 其兩側端与側緣相遇构成明显的側叶 (lateral lobe)。后緣中央具一伸向后背方的背棘, 該棘不与背甲分离。口孔(图版 III, 3)背位靠近背甲前緣, 呈前緣較直的半圓形。眼孔中等大小, 位于背甲的前側方。松果孔較小呈橢圓形, 位于两眼孔中間略后。

背甲沿吻及側緣折向腹面, 形成半环形的腹环(图版 II, 2), 腹环呈狹窄的条带状。腹甲較之背甲甚小, 略呈四边形。前緣和后緣凹进, 前緣略寬于后緣, 側緣稍拱出。腹环与腹甲間的空隙由数目众多的五角和六角形的小骨片填充(图版 IV, 1)。各自独立开向外界的外鰓孔沿腹环內側排列同上, 每側各 11 个, 外鰓孔呈半圓形。

感觉沟系統在齿質层下通过(图版所示标本齿質层表面已风化掉), 分布大致呈异甲魚型, 但側背感觉沟及位于眼孔后方聯絡眶上沟和眶下沟的联合枝均缺如。中背沟移向外側, 其前部呈規律的弯曲, 后部弯曲不明显。每側的中背沟外側具 4—6 条側橫枝, 其中前四条自側背沟的前部分出, 向側方伸延甚远。后两条发自側背沟的后部, 甚短或缺如。兩側的中背沟間由一条中橫枝联合。下眶沟由四段不連續的短沟組成, 圍繞眼的下方及前方。V 形沟起始于松果孔后方, 向前側方伸延至背甲吻緣。V 形沟的每枝被下眶沟分割为前后两段, 两段間留一空隙, 前段短于后段。

甲片的紋飾由星狀突起組成, 通常這些突起的基部彼此不癒合。突起的頂端或多或少指向后背方。背甲的突起大於腹甲及腹環的突起(圖版 II, 3—4)。

脏骨(圖版 II, 2)位於背甲腹壁下的部分骨化。口腔頂部寬闊而平滑, 略呈半圓形。鰓區每側具 11 個鰓穴, 彼此以鰓間嵴隔開, 所有鰓穴與鰓間嵴大致與中軸垂直, 而略向前側方傾斜。鰓區後部不具存在於骨甲魚類的後鰓壁。

比較: 1958 年 Stensiö 將異甲魚類分成 10 個目, 其中除 Turiniida 目是否當歸屬異甲魚類目前尚有爭論外 (Westoll, 1960; Tarlo, 1962), 其餘各目之間在甲片數目與形狀方面有著很大的差異。與異甲類各目比較, *Polybranchiaspis* 似乎與 *Drepanaspida* 目最為相近。在寬而扁平的體形、腹面具有小骨片組成的鑲嵌帶、開向背面的口孔及紋飾等特征方面二者均很近似。所不同的是在 *Drepanaspida* 目包圍身體背面和側面的甲冑是由中央的中背片、吻片及側部成對的眶片、後眶片、鰓片、角片和一系列口片組成, 並且中央的甲片與側部甲片間被由多角形小骨片組成的鑲嵌帶分開。而 *Polybranchiaspis* 則不具上述鑲嵌帶, 同時上述骨片在 *Polybranchiaspis* 癒合成單一的背甲及腹環。二者之間更大的不同, 還在於 *Polybranchiaspis* 的每個鰓囊通過各自獨立的外鰓孔直接開向外界。而 *Drepanaspida* 目者同所有已知異甲魚類一樣, 每側的各個鰓囊是開向每側的一條總的外鰓管, 然後由一個總的外鰓孔開向下界。*Polybranchiaspis* 這一特征似乎是从迄今我們還不知道的異甲魚的共同祖先那里直接繼承來的。

以上比較說明 *Polybranchiaspis* 是異甲魚類中一特殊種類, 它不屬於異甲魚類中任何已知的目, 而應代表異甲魚綱中一新目。

另外, 很有意義的是 *Polybranchiaspis* 具有骨化的脏骨, 這種情況在無頰類中以前僅見之於骨甲魚類, 而在異甲類通常是骨化的, 因此對其脏骨的了解只是依據脏骨留在背腹甲片內壁上的印痕。在 *Polybranchiaspis* 發現骨化脏骨, 對於進一步了解和研究異甲魚類的脏骨和內部構造, 提供了可能性。

附: 關於 *Polybranchiaspis* 的化石, 除上述地點外, 於廖角山勝峯下早泥盆世地層中亦有零碎甲片發現。其層位略低於 *P. liaojaoshanensis*, 標本保存不甚完整, 就所能觀察到的特征而言, 與 *P. liaojaoshanensis* 的不同在於個體較大(寬約 40 毫米), 眼孔似乎也略向前中靠攏些。

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NEW DEVONIAN AGNATHANS OF YUNNAN

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Among the piscine materials collected by Mr. K. J. Chang and the author from the Lower Devonian of Chutsing district, Yunnan in 1962, and 1963, the agnathan fossils are most interesting and represent three new forms. Among them two forms belong to Osteostraci and one to Heterostraci. The present paper is a preliminary note of these fossils.

Class Cephalaspides (Osteostraci) Berg 1940

Order Galeaspiformes nov.

Diagnosis: Head and anterior part of body covered by a solid cephalic shield. Pectoral cornua well developed. Cephalic shield without electric organs. Orbital openings far separated from each other, facing latero-dorsally. Naso-hypophysial opening very long, slit-like in form. Independent pineal plate absent; pineal opening situated behind orbits. Infraorbital sensory canal very short; between orbits there being a strongly developed V-shaped sensory canal. Three long lateral transversal canals issuing from the longitudinal lateral sensory canal of lateral side. External surface of exoskeleton subdivided into small polygonal areas by interareal canals. Ornamentation consisting of grain-like tubercles.

Family Galeaspidae nov.

Diagnosis: As that for the new order.

Genus *Galeaspis* nov.

Species *G. changi* nov.

(Pl. I, 1—2)

Type: A complete cephalic shield and its mould, IVPP Cat. No. V.2981.

Locality and Horizon: Wang-chia-yuan, Liaojaoshan near the city of Chutsing, Yunnan; Lower Devonian.

Diagnosis of genus and type species: Cephalic shield fundamentally triangular with a rounded rostral margin, about $5/8$ of length of main shield in median line to maximum breadth, $6/8$ of length from rostral end to tip of cornua to maximum. Pectoral cornua with pointed end directing backwards, rather broad and flattened in dorso-ventral direction. Interzonal part of shield very short, with a slight convex posterior margin, without dorsal spine. Naso-hypophysial opening slit-like, longer than pre-orbital part of shield. Orbital openings large and separated from each other, facing latero-dorsally. Independent pineal plate absent. Pineal opening small, situated behind orbits. Electric fields absent. Infraorbital canal very short, not extending beyond anterior margin of orbital opening anteriorly. A paired longitudinal lateral canals meeting infraorbital one anteriorly, running backward and ending not far before posterior margin of shield. On the lateral side of longitudinal lateral canal three lateral transversal canals issuing and far extending towards the lateral side of shield. Among them the posterior one running to the cornu of shield. Between orbits the V-shaped canal developed, its apex rounded and situated near the posterior margin of shield. From apex extends anteriorly and somewhat laterally, ending in two thirds of the distance from orbit to rostral end. V-shaped canal communicating with longitudinal lateral canal of proper side by one median transversal commissure.

Surface of exoskeleton subdivided into polygonal areas. These areas are hexagonal in shape, strikingly small, about 120—200 square centimeter. Ornamentation consisting of grain-like tubercles. Each polygonal area generally only with one tubercle.

Remarks: *Galeaspis* is a very peculiar fish among Osteostraci. It differs greatly from the known forms of Osteostraci in the absence of the electric fields, the way of distribution of the sensory canals of the shield, the far separation of orbital openings from each other, the strange long naso-hypophysial opening and the situation of the pineal opening far behind orbits, etc.

All the well known forms of Osteostraci have both the paired lateral and single dorsal electric fields on the dorsal side of cephalic shield, which are covered by numerous small polygonal plates in well-preserved specimen. But in *Galeaspis* the dorsal side of the shield is covered by a continuous exoskeleton, there is no areas covered by polygonal plates at any place; therefore, the author believes that the electric fields are not present in *Galeaspis*.

In *Galeaspis* the orbital openings are far separated from each other, but in the others they are close to each other. The ratio of distance between the openings and the breadth of the shield through the centre of the orbits is about 45% in *Galeaspis*, 13% in average for Osteostraci, as *Hemicyclaspis* (Stensiö, 1932 fig. 23), 22% in *Nectaspis* (Wangjso 1952 fig. 104), in which the orbital openings are most separated among the known Osteostraci.

In *Galeaspis* the naso-hypophysial opening is so long that it is longer than the pre-orbital part of the shield. Since the naso-hypophysial opening extends far backwards; therefore the pineal opening is remote from the orbits in *Galeaspis*; while in other Osteostraci the pineal opening is situated between the orbits.

Owing to the absence of the electric fields and the separation of orbital opening in

Galeaspis the distribution of sensory system is much different from that of other known Osteostraci. First, in *Galeaspis* the V-shaped canal is very developed. While in the known Osteostraci, except *Hoelaspis*, *Benneviaspis* and *Tremataspis* (Stensiö, 1927, figs. 76, 77, 83) this canal is absent. Although the Pc of the three genera probably partly corresponds to V-shaped canal of *Galeaspis*, but the Pc is very short. Second, in *Galeaspis* the infraorbital canals are very short, but in other Osteostraci they are strikingly long, extending forwards not very far behind the rostral margin of the shield. Next, on the lateral side of the longitudinal lateral canal there are three long lateral transversal canals, while in other Osteostraci the transversal canals, except $cmm_2 + cmm_3$, generally situated in median side of longitudinal canal, or very short.

Order Incertae Sedis

Genus *Nanpanaspis* nov.

Species *N. microculus* nov.

(Pl. II, 1)

Type: An incomplete cephalic shield and its mould, IVPP Cat. No. V.3030.

Locality and Horizon: As above.

Diagnosis of genus and type species: Osteostraci of median size. Maximum breadth of cephalic shield about 73 mm (between apexes of antero-lateral angle of interzonal part), shorter than length of shield (except rostral process). Rostral process well developed. Rostro-lateral margins of shield curved. Pectoral cornua small, triangular, projecting in lateral direction. Pectoral sinus notch-like, being open to lateral direction. Interzonal part very long and broad, with an antero-lateral angle behind the pectoral sinus on each side. The apex of antero-lateral angle pointing laterally, beyond that of cornu. Orbital openings very small, rather separated from each other, situated so far forwards that the pre-orbital part being shorter than one third the length of shield. Naso-hypophysial opening oval-shaped, large. Pineal opening and lateral electric fields not seen. Behind orbital openings a depressed area, which, probably, representing dorsal electric field. System of sensory canals ill preserved. Infraorbital canals very short. On lateral side of longitudinal lateral canal three latero-transversal canals issuing, among them the anterior one being the longest, extending anteriorly to cornu, the second towards pectoral sinus, posterior one seemingly very short. Ornamentation unknown.

Comparing with the known genera of Osteostraci this genus is similar to *Nectaspis*, *Acrotomaspis* and *Axinaspis* in having long interzonal part, but differs from them in the absence of real cornua, the rostral process and well developed sinus in these three genera.

The new genus is similar to *Boreaspis* in the shape of shield and rostral process, but differs from the latter in having larger, oval-shaped naso-hypophysial opening, smaller orbital openings and the sinus open to lateral direction.

Class Pteraspides (Heterostraci) Berg 1940

Order Polybranchiaspiformes nov.

Diagnosis: Heterostraci of varying size. Anterior portion of body covered by a single dorsal plate from dorsal and lateral sides. Along rostral and lateral margin the dorsal plate bended toward ventral side, forming a hemicyclic ventral rim. Oral opening situated dorsal aspect, as well as orbital and pineal openings perforating the dorsal plate.

Ventral plate much smaller than dorsal one. Ventral rim and ventral plate separated by zones of polygonal tesserae. External branchial openings as that in Osteostraci, being dividual, arranging along median margins of ventral rim on each lateral side of body.

System of sensory canals chiefly of Heterostraci type, but of the two paired longitudinal lateral canals only one paired median dorsal ones present.

Surface of exoskeleton covered with minute stellular tubercles. Visceral endoskeleton on the ventral wall of dorsal plate being ossified.

Family Polybranchiaspidae nov.

Diagnosis: As that for the order.

Genus *Polybranchiaspis* gen. nov.

Species *P. liaojaoshanensis* sp. nov.

(Pl. II, 2—4; Pls. III—IV)

Materials: About 40 dorsal and 7 ventral plates of different individuals (field No. 6239).

Holotype: A nearly complete dorsal plate about 58 mm in length, 52 mm in breadth, IVPP Cat. No. V.3027.

Paratype: A dorsal plate broken off at right lateral posterior part, about 54 mm in length, V.3027.1; an incomplete dorsal plate preserved from ventral side, V.3027.2.

Horizon and Locality: Lower Devonian; Hsinszu, Liaojaoshan and Hsishantsun, Tsuifengshan west of the city Chutsing, Yunnan.

Diagnosis of genus and type species: Dorsal plate subcardio-shaped, flat in front, increasing gradually in vault posteriorly. Rostral margin of this plate rounded, lateral margin comparatively arched. Posterior margin much curved, but in the middle with a dorsal spine, which fused with the dorsal plate.

Oral, orbital and pineal openings perforating dorsal plate. Oral opening situated on dorsal side, hemicyclic form with a arched latero-posterior and a straight anterior margins. Orbital openings mediate in size, near rostro-lateral margin of dorsal plate behind oral opening. Pineal opening very small, situated behind eyes.

Ventral rim comparatively narrow, restricted to marginal zone along rostral and lateral margins of ventral side of body. Ventral plate much smaller than dorsal one, being tetragon in shape, with curved anterior and posterior, arched paired lateral margins. Polygonal tesserae filling the gaps between the ventral plate and ventral rim.

External branchial openings arranged along median sides of ventral rim, each side 11 in number.

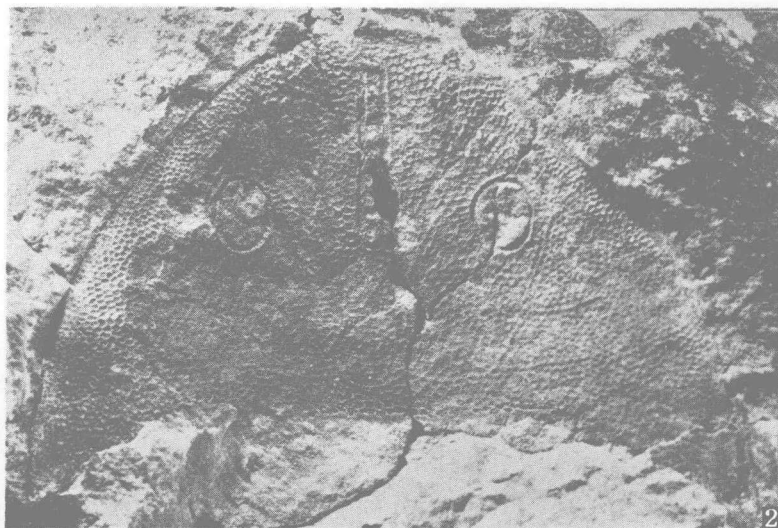
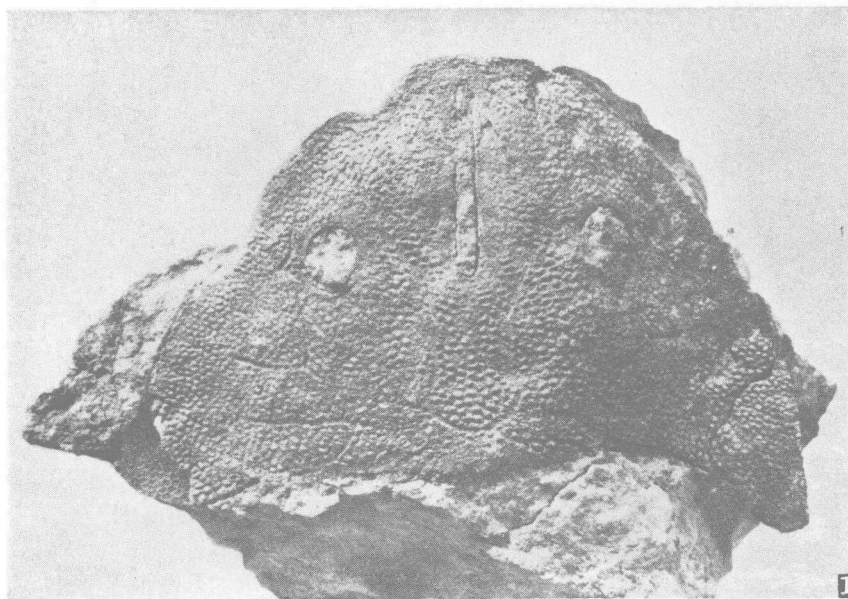
System of sensory canals only known in dorsal plate, running under surface of exoskeleton. Their distribution mainly similar to that of order Heterostraci, but lateral dorsal canals absent. Paired median dorsal canals which interconnected by one median commissure remotely separated from each other. Each median dorsal canal with 4—6 lateral transversal canals, among which last two very short or absent. Infraorbital canal of each side consisting of four pieces, surrounding orbit from ventral to anterior sides. V-shaped canal broken up to two parts by infraorbital, anterior part shorter than posterior one.

Ornamentation of carapace consisting of minute stellar tubercles. Tubercles on dorsal

plate large than that on ventral plate and ventral rim.

Dorsal portion of visceral endoskeleton well ossified. Roof of mouth cavity situated between ventral oral opening and branchial region, broad and smooth. On each side of branchial region there being 11 interbranchial ridges and branchial fossae. All ridges and fossae running laterally and somewhat anteriorly. Postbranchial wall seen in Osteostraci absent.

Remark: The new genus *Polybranchiaspis* has many characteristics in common with known orders of Heterostraci, but does not belong to any one of them. It is most similar to Drepanaspida in having broad and flattened body, position of oral opening, zones of tesserae of ventral side of the body and ornamentation, etc. In Drepanaspida if the median dorsal plates were fused with rostral, oral, orbital and lateral paired ridge plates, forming a single dorsal carapace instead of zones of tesserae of dorsal side, it would be difficult to separate the *Polybranchiaspis* from Drepanaspida. Therefore, at the first glance *Polybranchiaspis* seems skin to Drepanaspida. However, the fact that *Polybranchiaspis* has separate external branchial openings makes it difficult to assign it to Drepanaspida as well as other orders of Heterostraci. *Polybranchiaspis* may derive from an unknown common ancestor of Heterostraci.



1. *Galeaspis changi* gen. et sp. nov. 头甲 (Cephalic shield), V. 2981, 约 $\times 1.5$ 。
2. 同上, V. 2981 的外膜 (external mould of V.2981), 约 $\times 1.5$ 。

图 版 II

1. *Nanpanaspis microculus* gen. et sp. nov. 头甲, 外骨骼风化, 左侧黑线示间带前侧角, 系根据外模复原。(Cephalic shield, exoskeleton weathered away, dark line drawing according to mould of same specimen, showing anterior lateral angle of interzonal part), V.3030, 约 $\times 1$ 。
2. *Polybranchiaspis liaojaoshanensis* gen. et sp. nov. 背甲内视, 示脏骨及腹环 (dorsal plate exposed from ventral side, showing ventral rim and visceral endoskeleton), V.3027.2, 约 $\times 1$ 。
3. 同上, 背甲石膏模型, 示纹饰 (gypseous mould of dorsal plate, showing ornamentation), V.3027.3, 约 $\times 5$ 。
4. 同上, 腹甲石膏模型, 示纹饰 (gypseous mould of ventral plate, showing ornamentation), V.3027.4, 约 $\times 5$ 。

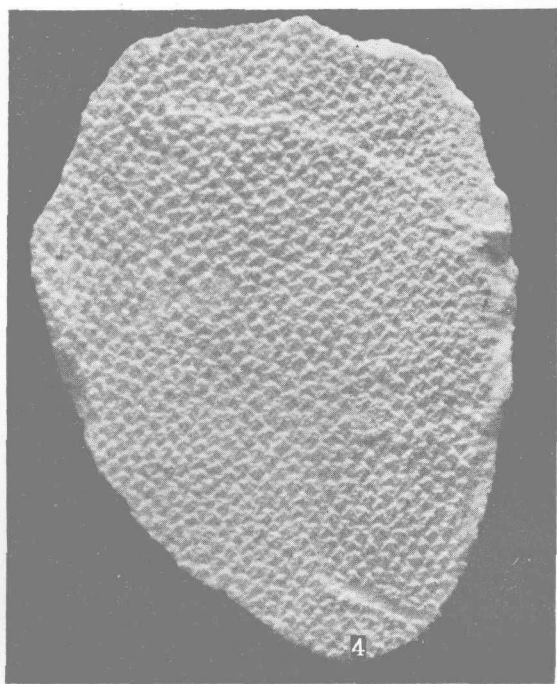
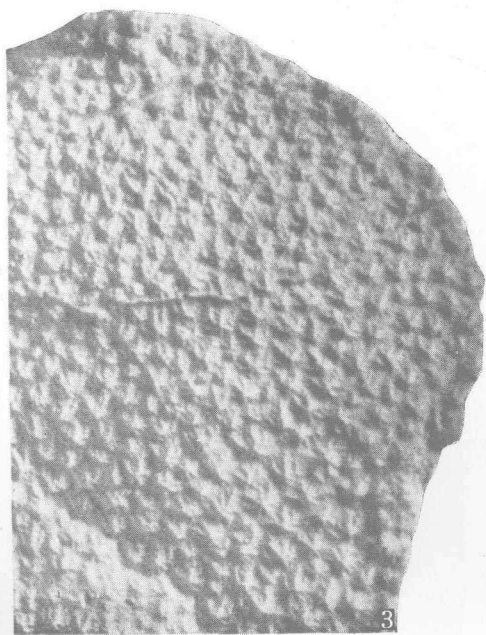
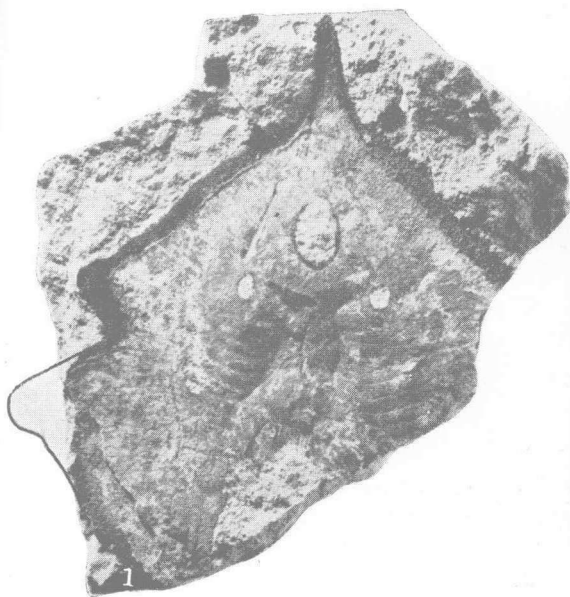
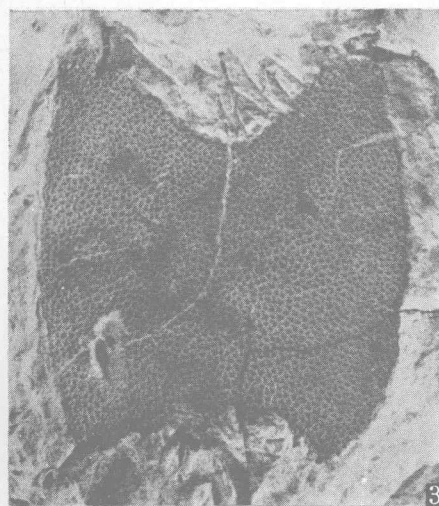
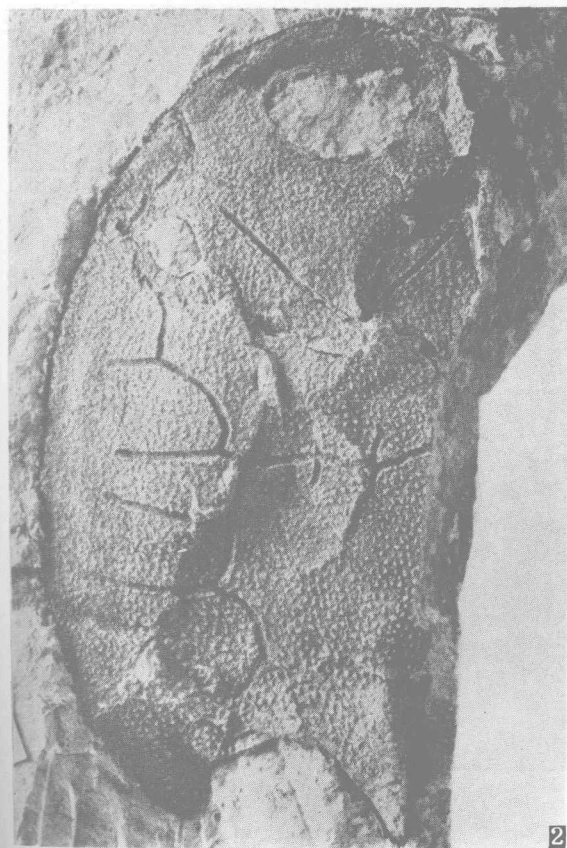
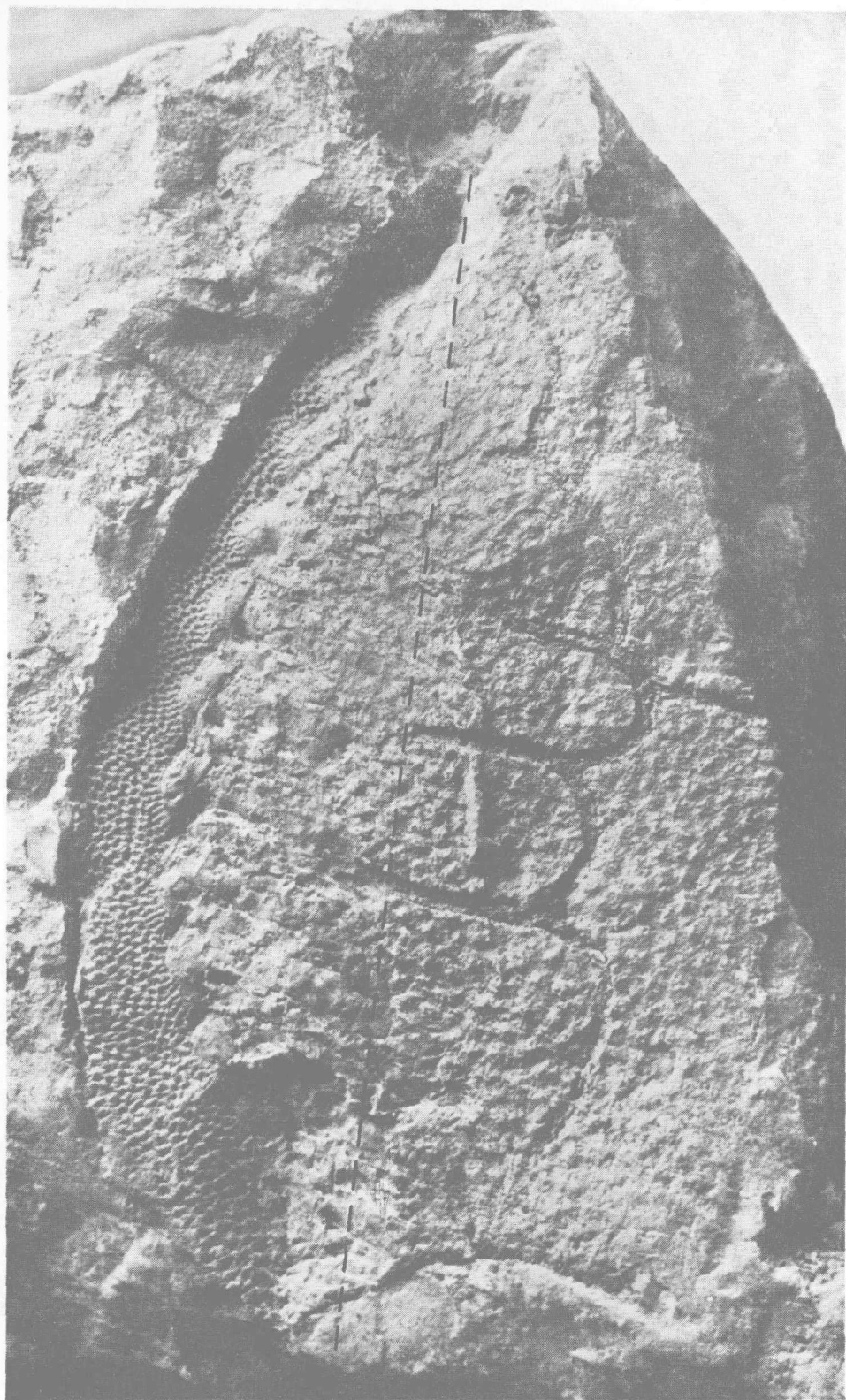


图 版 III

1. *Polybranchiaspis liaojiaoshanensis* gen. et sp. nov. 背甲(dorsal plate), V. 3027 约 $\times 1.5$ 。
2. 同上,背甲 (dorsal plate), V.3027. 1, 约 $\times 1.5$ 。
3. 同上,腹甲 (ventral plate), V.3027. 4, 约 $\times 2$ 。





1. *Polybranchiaspis liaojiaoshanensis* gen. et sp. nov. 背甲左侧缘甲片修去，示腹环、外鳃孔及镶嵌带 (dorsal plate, exoskeleton removed from left lateral margin, showing ventral rim, external branchial openings and zone of polygonal tesserae), V.3027. 5, 约 $\times 4$ 。