

滇东北昭通附近早泥盆世脊椎 动物化石新知¹⁾

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摘要 本文记述了发现于云南昭通箐门沟箐门水库附近的几件早期脊椎动物化石,其中包括盔甲鱼类一新种,层位是下泥盆统坡松冲组。新种云南龙门山鱼(*Lungmenshanaspis yunnanensis* sp. nov)与属型种江油龙门山鱼在纹饰上存在明显差异。其头甲侧凹应为自然边缘,龙门山鱼侧背孔并不存在。本文描述的骨鳞鱼类为目前所知层位最低的骨鳞鱼类化石,其额筛甲前端向下强烈弯曲,具分离的前上颌骨,具有杨氏鱼的一些特征。其眼眶凹非常大且深,下颌垂直凹线的位置十分靠前, k/m 值在已知的骨鳞鱼目种类中为最大。昭通三歧鱼(*Sanqiaspis zhaotongensis* Liu)新材料补充了正型标本在感觉管系统保存上的不足。文中对有关的生物地层问题也作了讨论。

关键词 云南昭通,早泥盆世,脊椎动物,生物地层

1991年,中国科学院古脊椎动物与古人类研究所泥盆纪专题组赴云南、广西等地进行野外地质考察并采集化石。在滇东北昭通附近考察期间,于箐门水库下泥盆统坡松冲组的粉砂质泥岩中,采到了保存很好的早期脊椎动物化石,计有无颌类、胴甲类、瓣甲类和总鳍类等。

刘玉海(1975),潘江、王世涛(1981),王俊卿、朱敏(1994)曾分别记述过采自该地区相同层位的无颌类化石,但是胴甲类、瓣甲类和总鳍类的化石却从未发现与报道过。因此,胴甲类、瓣甲类和总鳍类化石的采获,以及对部分化石的记述,不仅大大丰富了这一地区早泥盆世动物群的内容,明确了鱼群的性质,而且为滇东北地区含鱼化石地层的详细对比提供了更为详实的脊椎动物方面的证据,并为恢复西南地区早泥盆世的古地理面貌提供了新的资料。

一、含鱼化石层的地质时代

化石产于昭通东北约10公里的箐门水库附近(王俊卿、朱敏,1994,图1)。

昭通箐门泥盆系剖面系滇东北泥盆系的标准剖面。自李承三、叶连俊(1940)记述以来,在不同时期内先后有很多人到这里工作过。我们此次考察重点是含有脊椎动物化

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石的下泥盆统。在方润森¹⁾、鲜思远、周希云(1978)所测制剖面的基础上,进行了详细观察。该区下泥盆统地层大致分为三套:下部为黄绿色泥页岩夹钙质粉砂岩,由于下部被水库淹没,没有见底。在这套地层内产有丰富的早期脊椎动物化石。中部为灰黄色页岩,夹灰岩透镜体,产有丰富的腕足类化石。上部为黄绿色钙质页岩,夹灰黑色层状泥质灰岩,产有腕足类化石。顶部与中泥盆统为整合接触或假整合接触。在1/20万地质图昭通幅中(云南省地质局区域地质调查队,1978),该地区下泥盆统也分为三套,自下而上分别为“翠峰山组”、坡脚组和边箐沟组,与前文中所述的下、中、上三套相对应。

上述三组很难与滇东曲靖地区的下泥盆统地层对比,因为在曲靖地区尽管也曾发现鲨鱼类的下颌和鳞片(王念忠,1986),表明在这里曾经有过海水侵入,但是并未形成一个正常的浅海环境。因此没有大量的腕足类化石被发现,而仅仅是一些海豆芽化石。能与昭通地区这套地层进行直接对比的是滇东南广南、文山一带的下泥盆统地层。在广南一带,下泥盆统分为三个组:自下而上为坡松冲组、坡脚组、和达莲塘组。在坡松冲组内除了盾皮鱼类外,还有无颌类如 *Gantarostrataspis gengi*、*Gumuaspsis rostrata* (王俊卿、王念忠,1992)和 *Macrothyraspis longicornis* (Pan, 1992)等,以及总鳍类。两地的无颌类虽然在种属上不尽相同,但是在较高级的分类阶元上是相同的。此外,两地区下泥盆统含鱼层,其上覆地层均为坡脚组,含典型的坡脚动物群,如腕足类 *Acrospirifer tonkinensis*、*Dicoelostrophia* 等。滇东北与滇东南下泥盆统地层,不论是鱼群内容还是地层层序都完全可以对比。因此滇东北的下泥盆统下部应以坡松冲组代替原来打有“*”号的“翠峰山组”(廖卫华等,1978;朱敏等,1994),这样既可以避免造成典型的翠峰山群与“翠峰山组”在涵义上的混乱,同时也易于掌握和使用。坡松冲组的时代大致相当于济根期或晚济根期,与曲靖地区的徐家冲组相当(朱敏等,1994)。

二、化石描述

无颌类 Agnatha

盔甲鱼亚纲 Galeaspida Tarlo, 1967

华南鱼目 Huananaspiformes Janvier, 1975

三歧鱼科 Sanqiaspididae Liu, 1975

三歧鱼属 *Sanqiaspis* Liu, 1975

属型种 长吻三歧鱼 (*Sanqiaspis rostrata* Liu 1975)。

归入种 昭通三歧鱼 (*Sanqiaspis zhaotongensis* Liu 1975)。

属征 头甲略呈窄三角形;吻突细长;角呈棘状,向后延伸;鼻-垂体孔呈前凸后凹的新月形;鳃穴17对;两对中横管,前面一对退化,相互不连通;纹饰由极其细小的粒状突起组成。

比较与讨论 三歧鱼 (*Sanqiaspis*) 具向后延伸的棘状角,头甲近似窄三角形,这些特征可以同其它华南鱼类明显区别。在盔甲鱼类中,单从头甲形状看,三歧鱼似乎与乌蒙山鱼 (*Wumengshanaspis*) 最为接近,但乌蒙山鱼已有标本中头甲后缘与角残缺,角究

1) 1976: 云南省各时代地层总结,云南的泥盆系。云南省地质科学研究所印(内部)。

竟如华南鱼 (*Huananaspis*) 侧向伸展, 还是似三歧鱼向后延伸, 目前尚无确凿证据。原作者 (王士涛、兰朝华, 1984) 从鳃区后部鳃穴向中背部收缩的趋势, 推测乌蒙山鱼可能为三歧鱼型。若确如此, 则向后延伸的棘状角为这两个属的共同特征。需要说明的是, 这一推测并不十分可靠, 因为鳃区后部收缩普遍存在于无颌类中。从鳃穴数目, 鼻-垂体孔形状以及纹饰等方面综合考虑, 乌蒙山鱼可能还是更接近华南鱼与亚洲鱼 (*Asiaspis*), 而非如 Wang (1991) 所称, 与三歧鱼组成一单系类群。

昭通三歧鱼 *S. zhaotongensis* Liu, 1975

(图 1—2; 图版 I, 1)

1975, *S. zhaotongensis*, 刘玉海, 图 14, 图版 III, 3.

正型标本 一件头甲, V4422。

新增材料 一件保存较好的头甲, 残缺右后部及部分吻突。V9762。

产地与层位 云南昭通边箐沟; 早泥盆世, 坡松冲组。

种征 (修订) 头甲后部明显宽于前部; 内角较发育, 呈棘状; 感觉管系统较发育; 眶上感觉管呈漏斗状, 前面分叉; 主侧线管不连续; 前三对侧横管排列较紧密, 与中横管位置对应, 最后一对靠近头甲后缘, 并分叉。

比较与讨论 三歧鱼 (*Sanqiaspis*) 现描述有三个种, 它们是长吻三歧鱼 (*S. rostrata*), 昭通三歧鱼 (*S. zhaotongensis*) 和四川三歧鱼 (*S. sichuanensis*)。属型种长吻三歧鱼 (刘玉海, 1975) 与四川三歧鱼 (潘江、王士涛, 1978) 发现于同一地点与层位, 即四川江油雁门坝早泥盆世平驿铺组中部。刘玉海 (1986) 对此曾作评论, 认为其间在感觉管系统上所表现出的差别, 可能是保存方面的原因所致, 四川三歧鱼应是长吻三歧鱼的次异名。另一个种昭通三歧鱼 (刘玉海, 1975) 产于云南昭通边箐沟早泥盆世坡松冲组中, 唯一的一块标本 V4422, 感觉管系统保存不佳, 且描述十分简略。新增材料与正型标本来自同一地点与层位, 其感觉管系统保存相当好, 它的描述将使昭通三歧鱼的特征更加全面与准确。刘玉海 (1975) 曾将感觉管系统退化作为三歧鱼科的一个重要特征, 从本文所描述的材料来看, 情况并非如此。当时刘玉海之所以有此看法实因材料所限。三歧鱼科的感觉管系统可归入多鳃鱼型 (刘玉海, 1986)。

昭通三歧鱼与长吻三歧鱼间的区别主要有以下几点: 1) 前者头甲后部明显宽于前部, 整个头甲也显得较宽, 后者头甲相当狭窄; 2) *S. zhaotongensis* 内角呈棘状, 而 *S. rostrata* 内角不甚发育; 3) *S. zhaotongensis* 感觉管系统较 *S. rostrata* 发育; 4) *S. zhaotongensis* 眶上感觉管呈漏斗状, 并在前面分叉, 而 *S. rostrata* 则为常见的 V 形。

本文新增标本与正型标本有一点细微差别, 即后者内角基部两侧各具一短棘, 而新标本仅在内角基部内侧有一短棘。但这完全可以是个体差异。

描述 头甲保存较全, 仅残缺右后部及部分吻突。保存长度约 4 cm, 再加上残缺的吻突, 估计长达 5—6 cm。头甲大致呈三角形, 后部明显宽于前部, 最宽处位于两角末端之间, 大约为 3.5 cm。侧缘前部具一圆形缺刻 (orb), 为眶孔位置。后缘明显前凹, 中间具一背棘。角 (c) 较发育, 长棘状, 向侧后方向延伸, 其侧缘与头甲侧缘呈一自然连线。角内侧为发育的棘状内角 (ic), 且在其基部内侧有一次一级的短棘。角末端

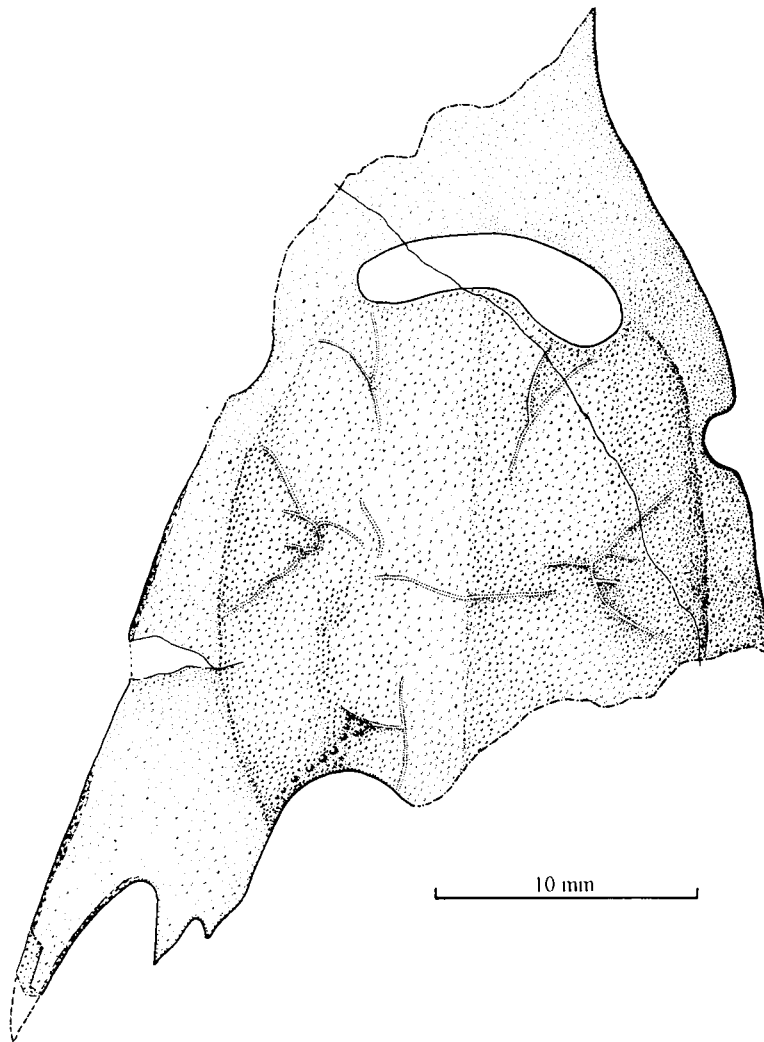


图1 昭通三歧鱼(V9762)头甲背视

Fig. 1 Cephalic shield of *S. zhaotongensis* Liu, 1975 (V9762) in dorsal view

明显超出内角末端。

鼻-垂体孔(nhp.o)呈前凸后凹的肾脏形,长10mm,宽3mm,位于眶前突连线的紧前方。眶孔较小,孔径约为2mm,两眶孔相距约17mm。未见松果孔痕迹。头甲由三部分组成,即中央区、侧区和吻部,前二者的分界线与鳃区外缘相吻合。头甲背部较平,而中央区与侧区之间具一明显界线,侧区较低。头甲沿吻缘和侧缘折向腹面形成腹环,腹环较宽。

感觉管系统在标本上保存良好。由于新标本主要以内模形式保存,而盔甲鱼类感觉管通常穿行于外骨骼的底层,因此这里可以观察到感觉管型式。总体来说,昭通三歧鱼的感觉管系统可归入多鳃鱼型(刘玉海,1986),由中背纵管、侧背干管、侧横管和中横管组成。眶上管(中背纵管的一部分,soc)呈漏斗状,前面分叉,外枝伸向外侧,但不

超过鼻-垂体孔后缘, 内枝近平行, 向前延伸, 接近鼻-垂体孔的后缘。在左侧眶上管后方, 有一条略呈纵向延伸的短管, 可能是中背纵管的退化残迹(v.mdc)。侧背干管由眶下管与主侧线管(即侧背管, lc)组成。眶下感觉管(ioc)较长, 几乎达眶后突。主侧线管不连续, 分成前后两段。前段位于眶上管后侧方, 两侧相距较远。后段靠近头甲中线, 两侧近平行, 向后延伸达于头甲后缘。侧横管在标本上可见四对。前三对由主侧线管前段发出, 相互排列较紧密。其中第一、第二侧横管较短, 第三侧横管(ltc₃)较长, 向外后侧延伸达中央区边缘。第四侧横管(ltc₄)由主侧线管后段发出, 末端分叉, 靠近头甲后缘。中横管有二对, 前面一对(mtc)较短, 由主侧线管向内发出, 与第一侧横管相对应; 后一对两侧相接, 相接处略后凹, 这应相当于背联络管(dcm)。

由于标本主要以内模保存, 其上非常细小且密的粒状突起实际上并非纹饰, 而是由外骨骼基面小腔被充填而形成。但同时由于这种小腔与处骨骼表面突起有某种对应关系, 可以认为昭通三歧鱼头甲纹饰由非常细小的粒状突起组成。这也可以由腹环外模得到印证。此外, 在头甲侧缘及角上保存了少许骨骼。侧缘具有较大的疣突。角上的纹饰与头甲表面上的有所不同, 为长的疣突, 其长轴与角方向一致, 且互相叠压。在内角内侧棘内侧与第四侧模管分叉之间, 内模标本上有一列弧形排列的瘤, 它与感觉管系统是否有某种联系现在还不清楚。

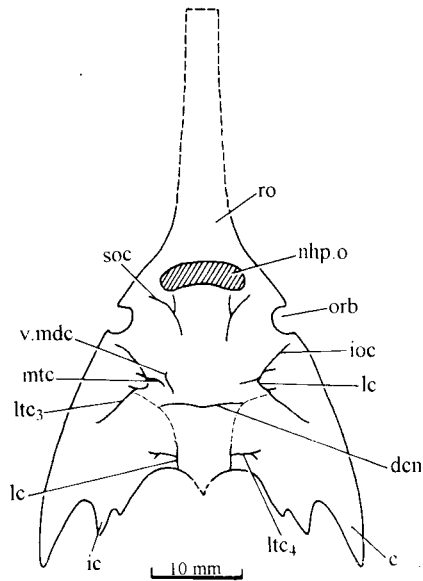


图2 昭通三歧鱼头甲复原图, 背视
Fig. 2 Restoration of the cephalic shield of *Sanqiaspis zhaotongensis* Liu, 1975 in dorsal view

华南鱼科 Huananaspidae Liu 1973

龙门山鱼属 *Lungmenshanaspis* P'an et Wang 1975

属型种 江油龙门山鱼 (*Lungmenshanaspis kangyouensis* P'an et Wang 1975)。

归入种 云南龙门山鱼 (新种) *L. yunnanensis* sp. nov.。

属征 (修订) 头甲侧缘在眶孔的外侧, 有一很发育的侧突, 略呈三角形, 与角之间形成一内凹的侧缘; 角横向伸展, 非常狭长; 内角较小或不发育; 眶孔背位, 位于鼻-垂体孔后侧方。

比较与讨论 龙门山鱼属 (潘江等, 1975) 属于华南鱼科的特征有: 头甲略呈前窄后宽的三角形, 吻突细长, 角侧向伸展, 以及近圆形鼻-垂体孔等。华南鱼科其它两个属是华南鱼属 (*Huananaspis*) 和亚洲鱼属 (*Asiaspis*)。华南鱼眶孔侧位, 可以同龙门山鱼明显区别。亚洲鱼虽然眶孔如龙门山鱼, 为背位, 但眶孔非常之小。此外, 亚洲鱼头甲侧缘缺少侧突, 与角前缘形成圆滑的曲线。中华四川鱼属 (*Sinoszechuanaspis*) 曾被归入华南鱼科, 但由于其头甲背面有一对窗或侧区 (Pan, 1992; 刘玉海, 1993), 后被划出, 归入大窗鱼科 (Macrothyraspididae, Pan, 1992)。

关于龙门山鱼的系统位置,目前仍存在一些争议,主要涉及其头甲侧缘内凹的解释。潘江等(1975)建立该属时,将其归入华南鱼科。Pan(1984)将盔甲鱼类划分为七大类群,包括华南鱼类群(Huananaspids,基本相当于华南鱼目)和龙门山鱼类群(Lungmenshanaspids)。后者包括有龙门山鱼、中华四川鱼和箐门鱼(*Qingmenaspis*)。具体理由原作者未作解释。Wang(1991)在作盔甲鱼类分支图时,将龙门山鱼与箐门鱼组成一个单系类群,离征是头甲背面的侧背孔。这里,Wang(1991, fig. 14)将龙门山鱼的侧凹解释成侧背孔,与箐门鱼的“侧背孔”(潘江、王士涛,1981)相提并论。Pan(1992)又重新回到他最初的观点,即龙门山鱼归入华南鱼科。从我们的新材料来看,龙门山鱼头甲侧凹仍是其侧缘的一部分,与其余部分是自然、连续的,也即否定了它作为侧背孔的可能性。

云南龙门山鱼(新种) *L. yunnanensis* sp. nov.

(图3; 图版1, 2)

正型标本 一件保存不完整的头甲。V9763。

产地与层位 云南昭通边箐沟,早泥盆世,坡松冲组。

种征 头甲主体(除去吻突与角)相对较宽;鼻-垂体孔圆形;眶孔距鼻-垂体孔较远;眶间距大;侧突圆钝,侧缘内凹相对较短;内角小,但非常明显;头甲表面具小的粒状纹饰,其侧缘与角的前后缘具小刺。

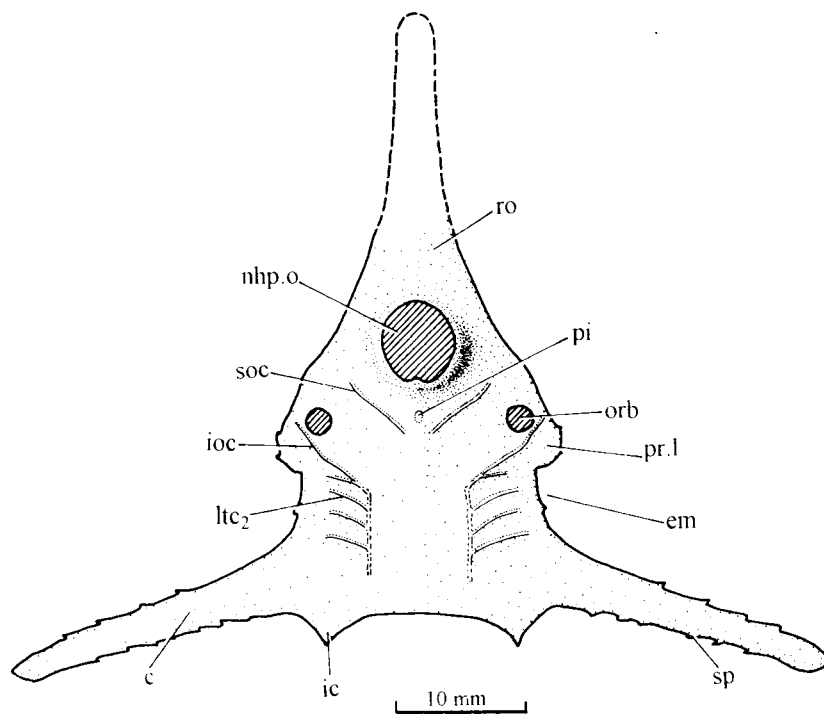


图3 云南龙门山鱼(新种)头甲复原图,背视

Fig. 3 Cephalic shield of *Lungmenshanaspis yunnanensis* sp. nov. in dorsal view

比较与讨论 新种头甲侧缘具明显的侧突, 与侧向延伸的角之间形成一内凹的侧缘, 眶孔背位, 从外形特征上看归入龙门山鱼属似无问题。由于属型种 *Lungmenshanaspis kiangyouensis* (潘江等, 1975) 感觉管系统没有保存, 新种的描述将补充这方面的不足。新种与属型种之间最大的区别在于它们的纹饰, 江油龙门山鱼为稀疏的星状突起, 较大, 而新种则为小且密的粒状突起, 两者外骨骼在组织学上肯定存在较大的差异, 在系统学上的意义目前还不是很清楚。除此之外, 两种间还存在以下主要区别: 1) 属型种头甲主体非常狭窄, 而新种较宽; 2) 属型种鼻-垂体孔为桃形, 而新种基本呈圆形; 3) 属型种两眶孔相距较近, 且靠近鼻-垂体孔, 而新种眶间距较大, 眶孔距鼻-垂体孔也较远; 4) 新种头甲侧缘与角前后缘上有稀少的锯齿状小刺, 而属型种则没有; 5) 相对属型种而言, 新种侧缘内凹较短; 6) 新种头甲后缘具明显内角, 属型种可能不十分发育。

描述 正型标本为一个体较小的头甲, 右侧的角及相邻部分和后缘保存较完整。吻突前半部也缺失。头甲保存长度为 30mm, 宽度为 35mm, 估计其头甲长度约 45mm, 通过两角顶部的宽度约 70mm。

头甲扁平, 略呈三角形, 由鼻-垂体孔前缘向前中轴合并延伸为细长的吻突(ro)。由鼻-垂体孔前缘至吻端长约 22mm, 宽为 4mm。头甲侧缘在眶孔外侧明显向外突出, 形成一个显著的耳状突——侧突(pr.1)。侧突与胸角之间, 头甲侧缘形成一明显的内凹(em), 但相对较短。侧凹略向外后侧倾斜, 并逐渐向外延伸形成胸角的前缘。角(c) 窄长, 其长度为 22mm。角稍向后侧方斜, 末端圆钝, 稍向后弯。内角(ic) 发育, 呈短小的棘状。头甲后缘向前凹入, 没有中背棘。自鼻-垂体孔前缘至背甲后缘的长度约为 23mm。整个头甲比较低平, 唯鼻-垂体孔处明显高出。

鼻-垂体孔(nhp.o) 大, 基本呈圆形, 直径约 5.2mm。后缘微前凹。眶孔(orb) 背位, 位于鼻-垂体孔外后侧、侧突前内侧, 距鼻-垂体孔较远, 眶间距也较大。眶孔圆形, 较小, 直径约 2.5mm。松果体痕迹(pi) 小, 圆形, 位于鼻-垂体孔之后, 两眶孔连线之间。

感觉管系统保存不全, 仅右侧者尚可以观察到。“V”字形眶上感觉管(soc) 较长, 保存长度约 4mm, 起于松果体痕迹外侧, 向前外侧方向延伸, 前端达于鼻-垂体孔的后外侧方; 后端由于没有保存, 两侧是否在松果体痕迹后相遇不得而知。眶下感觉管(ioc) 从眶孔外后侧向后内侧延伸, 稍弯曲, 其前端超过眶孔横中线。由于标本中部没有保存, 因此侧线感觉管观察不到, 推测大致应与中华四川鱼近似。头甲右侧清晰可见四条侧横管(ltc) 的外侧部分, 而与侧线感觉管相接情况, 由于保存原因观察不到。四条侧横管向前微凸, 间距大致相等, 长度也近相等。

纹饰为小的粒状突起, 较密, 排列无规律。

头甲侧缘自相对眶孔位置起, 向后具有小的刺状凸起, 分布无规律。在角的前后缘上也具有稀疏的小刺(sp)。

在标本上可见鳃囊和鳃间嵴的印痕, 它们与头甲中轴近垂直, 彼此排列紧密, 具体数目不清, 但每侧不会超过 11 个鳃囊。

总鳍鱼类 *Crossopterygii*骨鳞鱼目 *Osteolepiformes* Jarvik 1942属种不定 *osteolepid* gen. et sp. indet.

(图4; 图版1, 3, 4, 5)

化石材料 一完整的额筛甲 V10687, 以及二件有破损的下颌 V10688.1, V10688.2.

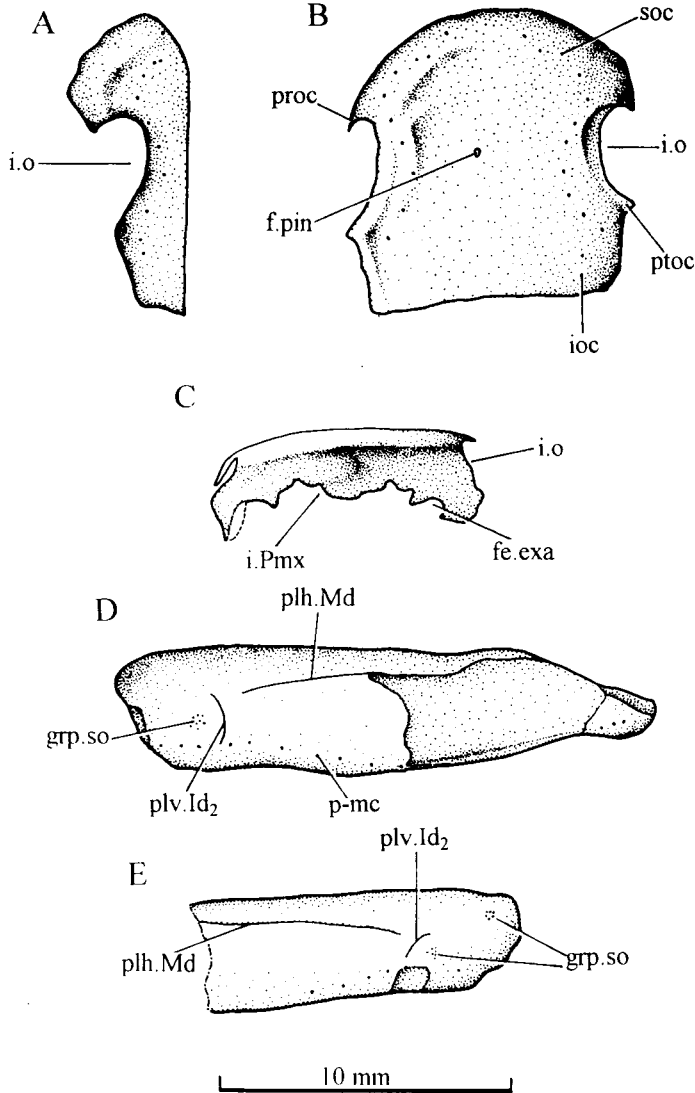


图4 骨鳞鱼类(属种不定)A—C. 额筛甲(V10687)侧视(A), 背视(B)与前视(C);

D. 下颌(V10688.1)侧视; E. 下颌(V10688.2)侧视

Fig. 4 *Osteolepid* gen. et sp. indet. A—C. fronto-ethmoidal shield (V10687) in lateral (A), dorsal (B) and anterior (C) views; D. lower jaw (V10688.1) in lateral view;

E. lower jaw (V10688.2) in lateral view

产地与层位 云南昭通边箐沟, 早泥盆世, 坡松冲组。

比较与讨论 由于化石材料的限制, 仅凭额筛甲以及下颌尚难以确定其分类地位。从表面为整列层覆盖, 以及额筛甲的整体形态应可将其归入骨鳞鱼目。总体特征与其它门类相比较: 分离的前上颌骨在杨氏鱼 (Chang, 1982, 1991), 武定瑟索鱼 (范俊航, 1992) 以及肯氏鱼 (*Kenichthys*) (Chang & Zhu, 1993) 中可以见到; 额筛甲前端向下强烈弯曲, 从上方见不到前外鼻孔, 眶凹较深等特征见于环褶鱼属 (*Gyroptychius*) (Jarvik, 1948); 下颌短高以及垂直凹线的位置相当靠前与肯氏鱼 (Chang & Zhu, 1993) 相似。新材料具有如下独特的特征: 眶凹的长度在整个额筛甲的长度中所占的比例很大, 在已知骨鳞鱼目种类中为最大; 眶凹以及松果孔的位置均相当靠前。

描述 表面为整列层覆盖, 其外表呈深褐色。额筛甲长度为 9.6mm, 在眶前角 (proc) 及眼眶凹 (i.o) 最深处的宽度和长度之比分别为 $c/b=0.96$, $e/b=0.72$, 较为短宽; 前端向下强烈弯曲, 以至指向后下方, 从上方看不见前外鼻孔。从前视图可看出, 分离的前上颌骨缺失, 仅留下两个弓形缺刻 (i.Pmx)。缺刻上缘还有两到三个次一级的小缺刻, 推侧为眶上感觉管 (soc) 的开孔。另外在前上颌骨位置的外侧有另一个缺口应为前外鼻孔 (fe.exa) 的位置所在, 当前上颌骨未缺失时, 它的侧上边缘的一段构成前外鼻孔的下缘。眼眶凹大且深, 眶凹区的长度与额筛甲的长度之比 ($l.i.o./b$) 为 0.64, 该值在已知的 osteolepid 种类中为最大。松果孔 (f.pin) 位于眶区中央, 位置相当靠前, $c/b=0.49$ 。额筛甲顶部两侧可见眶上感觉管的开孔排列成单列。额筛甲表面未见凹线 (pit-line)。

下颌标本均仅可见到外侧且有破损或缺失。从破损程度较小的 V10688.2 (图 4D) 可以分辨出下颌的整体形态, 并得到测量数据 (见表 1)。下颌相对比较短高, 长高之比约为 4.3, 与 *Kenichthys* 的情况大致相同 (Chang & Zhu, 1993)。上边缘未见牙齿。前部外侧可见水平凹线 (plh.Md) 及垂直凹线 (plv.Id₂)。垂直凹线的位置十分靠前, $k/m=4.2$, 该比值比 *Kenichthys* 的相同值还大, 而后者被认为在 osteolepids 中为最大 (Chang & Zhu, 1993)。靠近下边缘可见排成单列的感觉管小孔 (p-mc)。在 V10688.2 里, 在垂直凹线前以及靠近前上端的位置可见两组孔群 (grp.so)。

表 1 osteolepid gen. et. sp. indet. 测量数据及有关比值 (测量方法依据 Jarvik 1948, p.34)

Table 1 Measurement and relative proportions of osteolepid gen. et. sp. indet.

(method of measurement according to Jarvik 1948, p.34)

b	l.i.o./b	l.i.o./dp.i.o	r/s+t	t/r+s	d/b	e/b	c/b	l.Lj	l.Lj/ht.Lj	k/m
9.6mm	0.64	1.77 ¹⁾	0.63	0.39	0.96	0.72	0.49	18.8mm	4.3	4.2

1) 两侧平均值。

三、结 论

本文描述的材料为 1991 年在云南昭通边箐沟野外考察所获化石的一部分, 层位是下泥盆统坡松冲组。其它还包括胴甲鱼类和瓣甲鱼类, 目前尚在研究中。通过本文工作, 可以获得以下几点结论。

首先,云南昭通地区下泥盆统坡松冲组中含有较丰富的早期脊椎动物化石,并且以无颌类盔甲鱼类为主。盔甲鱼类目前已描述的有:*Sanqiaspis zhaotongensis* (刘玉海, 1975; 本文), *Qingmenaspis microculus* (潘江、王士涛, 1981), *Zhaotongaspis janvieri* (王俊卿、朱敏, 1994), *Lungmenshanaspis yunnanensis* sp. nov.。

第二,从盔甲鱼类面貌上看,云南昭通下泥盆统坡松冲组与四川江油下泥盆统平驿铺组最为接近。龙门山鱼(*Lungmenshanaspis*)系潘江、王士涛(1975)所建立的一个属,化石采自四川江油平驿铺组。三歧鱼(*Sanqiaspis*)系刘玉海(1975)描述的一个属,属型种材料也采自平驿铺组,两者均属华南鱼目。在昭通所采到的龙门山鱼和三歧鱼虽然与四川江油的属于不同的种,但属确是相同的,说明龙门山鱼和三歧鱼在早泥盆世时的分布不仅仅限于四川北部龙门山区,而且在滇东北也有分布,这说明当时两地之间的水域是相通的(王鸿祯, 1985)。

第三,昭通三歧鱼系刘玉海(1975)建立的一个种,但由于材料保存的原因,没能作详细描述。此次新增材料保存较好,特征明显,因此能对昭通三歧鱼以及三歧鱼属作进一步的修订与补充。

第四,云南龙门山鱼(新种)说明龙门山鱼头甲侧凹应为自然边缘,所谓的“侧背孔”并不存在。龙门山鱼仍隶属华南鱼科。

最后,本文描述的骨鳞鱼类虽然由于材料所限,暂未定属种,但它的有些特征很有意义。比如,其额筛甲前端向下强烈弯曲,具有分离的前上颌骨;其眼眶凹非常大且深,眶凹区的长度与额筛甲的长度之比在已知的 *osteolepid* 种类中为最大;松果孔位于眶区中央,位置亦相当靠前;下颌垂直直线的位置十分靠前, k/m 值在已知的骨鳞鱼目种类中属最大之列。此外,该鱼为目前所知层位最低的骨鳞鱼类化石,同时也表明我国早泥盆世时总鳍鱼类的地理分布较广。以前该类化石曾在云南的曲靖、宜良、武定、文山,广西的六景,四川的龙门山以及甘肃的迭部发现过,但多数没有报道。今后非常有可能在川西南、湘西北和新疆被发现。滇东北总鳍鱼类的新发现,不仅扩大了该类化石的地理分布范围,同时也为探讨滇东中、南部的总鳍鱼类和四川龙门山区总鳍鱼类之间古地理方面的问题提供了中间环节。

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EARLY VERTEBRATE FOSSILS FROM THE EARLY DEVONIAN OF ZHAOTONG DISTRICT, NORTHEASTERN YUNNAN

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Key words Zhaotong, Yunnan, Early Devonian, Early Vertebrates, Stratigraphy

Summary

Three early vertebrates (galeaspids *Sanqiaspis zhaotongensis* Liu 1975, *Lungmenshanaspis yunnanensis* sp. nov., and an undetermined osteolepid), were

described from the Early Devonian of Bianqinggou, Zhaotong District, northeastern Yunnan. It is argued that the fish-bearing formation could be directly correlated with the Posongchong Formation in Guangnan and Wenshan, southeastern Yunnan, and might be named as the Posongchong Formation, rather than the "Cuifengshan Formation". The Posongchong Formation of Bianqinggou yields abundant remains of early vertebrates including galeaspids, antiarchs, petalichthyids and sarcopterygians. Four genera of galeaspids have been described from this formation, i. e., *Sanqiaspis* (Liu, 1975; this paper), *Qingmenaspis* (Pan & Wang, 1981), *Zhaotongaspis* (Wang & Zhu, 1994), *Lungmenshanaspis*.

As to the galeaspids, the Posongchong Formation of Zhaotong District is most similar to the Pingyipao Formation of Jiangyou, Sichuan. Both *Lungmenshanaspis* and *Sanqiaspis* are exclusively found in these two regions, indicating the presence of biogeographic connection.

Paleontologic Studies

Subclass Galeaspida Tarlo, 1967

Order Huananaspiformes Janvier, 1975

Family Sanqiaspididae Liu, 1975

Genus *Sanqiaspis* Liu, 1975

Type species *Sanqiaspis rostrata* Liu 1975.

Referred species *Sanqiaspis zhaotongensis* Liu 1975.

Emended diagnosis Cephalic shield narrow, roughly triangular in shape; rostral process long and narrow; cornu spine-like, posteriorly projecting; naso-hypophysial opening crescent-shaped; 17 pairs of branchial fossae; two pairs of medial transverse canals, the anterior pair less developed and deficient of the commissure; ornamentation composed of the tiny, closely set tubercles.

Remarks *Sanqiaspis* differs from other huananaspiforms by its posteriorly projecting, spine-shaped cornu, and narrow, triangular cephalic shield. Within the Galeaspida, *Sanqiaspis* is most suggestive of *Wumengshanaspis* considering the general shape of the shield. However, since *Wumengshanaspis* did not preserve the cornua and posterior extremity of the cephalic shield, it is uncertain that the cornu of *W.* is similar to that of *Sanqiaspis*. As regard to the number of brachial fossae, the shape of the nasohypophysial opening, and the ornamentation, *Wumengshanaspis* is likely to have close relationship with *Huananaspis* and *Asiaspis*, rather than *Sanqiaspis*.

S. zhaotongensis Liu, 1975

(Fig. 1—2; Pl. I, 1)

1975, *S. zhaotongensis*, Liu, fig. 14, pl. III, 3.**Holotype** A cephalic shield, V4422.**New material** A well-preserved cephalic shield, V9762.**Locality and horizon** Bianqinggou, Zhaotong, Yunnan, Lower Devonian, Posongchong Formation.**Diagnosis (emended)** Posterior portion of the cephalic shield evidently broader than the anterior one; inner cornu fairly developed, spine-shaped; sensory canal system developed; supraorbital canals funnel-like, with anterior end dichotomous; main lateral canal discontinuous; first to third lateral transverse canals closely arranged, corresponding to medial transverse canals in position; fourth lateral transverse canal dichotomous at its end, situated close to the posterior margin of the shield.**Remarks** There have been three species of *Sanqiaspis* described in the literature, i.e., *S. rostrata*, *S. zhaotongensis* (Liu, 1975) and *S. sichuanensis* (P'an & Wang, 1978). Both the type species *S. rostrata* and *S. sichuanensis* were found from the middle part of the Pingyipu Formation (Early Devonian) of Jiangyou, Sichuan. Liu (1986) commented that, the difference of sensory canal system between them is probably due to the preservation of the fossils, and *S. sichuanensis* is the junior synonym of *S. rostrata*. Another species, *S. zhaotongensis*, came from the Posongchong Formation (Early Devonian) of Zhaotong, Yunnan. However, the only specimen was badly preserved as to the sensory canal system, and its description was very simplified. The new material with well-preserved sensory canal system, was collected from the same horizon and locality as the holotype of *S. zhaotongensis*. Its description makes the features of *S. zhaotongensis* more complete and justified. Liu (1975) considered the degeneration of the sensory canal system as one of the important characters defining the family Sanqiaspididae. However, judging from our material, it is not the case. The sensory canal system of the Sanqiaspididae can be included into the polybranchiaspid pattern.At least four differences could be seen between *S. zhaotongensis* and *S. rostrata*: (1) the former has the relatively broad posterior part of the cephalic shield, whereas the shield of the latter is fairly narrow; (2) the inner cornua of the former is spine-shaped, whereas that of the latter is less developed; (3) the sensory canal system of the former is more developed than that of the latter; (4) the supraorbital canals of the former are funnel-like, and have their anterior ends branching, whereas those of the latter are V-shaped.

Family Huananaspidae Liu 1973**Genus *Lungmenshanaspis* P'an et Wang 1975**

Type species *Lungmenshanaspis kiangyouensis* P'an et Wang 1975.

Referred species *L. yunnanensis* sp. nov.

Diagnosis (emended) Cephalic shield with a developed, triangular lateral process at the lateral side of the orbital opening, and forming an embayed lateral margin together with the cornua; cornu laterally projecting, very long and narrow; inner cornu small or less developed; orbital opening dorsal in position, posterolateral to the naso-hypophyseal opening.

Remarks *Lungmenshanaspis* (P'an et al., 1975) is referred to as the Huananaspidae by long and narrow rostral process, laterally extending cornua, and nearly rounded nasohypophysial opening. Other two genera of the Huananaspidae are *Huananaspis* and *Asiaspis*. *H.* is distinguished from *L.* by its laterally situated orbital opening. *A.* has its orbital openings at the dorsal side of the shield, as in *L.*, however, its orbital openings are extremely small. In addition, *A.* is deficient of the lateral process of the lateral margin, which is typical of *Lungmenshanaspis*. *Sinoszechuanaspis* had been assigned to the Huananaspidae, and later was referred to Macrothyraspididae (Pan, 1992) because of its dorsal fenestra.

As to phylogenetic position of *Lungmenshanaspis*, there exist some controversies, which are mainly related with the explanations of the lateral embayment of the lateral margin of the shield. *L.* was originally referred to as the Huananaspidae by Pan et al. (1975). Pan (1984) subdivided the Galeaspida into seven groups including huananaspids (roughly equivalent of the Huananaspiformes) and lungmenshanaspids, and the latter was composed of *Lungmenshanaspis*, *Sinoszechuanaspis* and *Qingmenaspis*. However, the background of the classification was not given by Pan. Wang (1991) considered *Lungmenshanaspis* and *Qingmenaspis* as the sister-group by the laterodorsal opening of the cephalic shield, since the lateral embayment of *L.* was explained as the laterodorsal opening, comparing to that of *Qingmenaspis* (Pan & Wang, 1981). Pan (1992) maintained his primary opinion, i.e., *L.* was originally referred to as the Huananaspidae. According to our new material, the lateral embayment is still part of the lateral margin of the cephalic shield, excluding it from the possibility as the dorsolateral opening.

***L. yunnanensis* sp. nov.**

(Fig.3; Pl. I, 2)

Holotype An incomplete cephalic shield, V9763.**Locality and horizon** Bianqinggou, Zhaotong, Yunnan, Lower Devonian, Posongchong Formation.**Diagnosis** Portion proper of the cephalic shield (excluding the rostral process and cornua) relatively broad; naso-hypophysial opening rounded, far from orbital openings; distance between the orbital openings large; lateral process arched, and embayment of the lateral margin relatively short; inner cornu small, however obvious; ornamentation consisting of small tubercles; lateral margin of the shield, anterior and posterior margins of cornu equipped with small spines.**Remarks** The new species is assigned as *Lungmenshanaspis* by its dorsally placed orbital openings, the obvious lateral process of the lateral margin of the cephalic shield, which forms an embayment together with laterally extending cornu. The largest difference between the type species *Lungmenshanaspis kiangyouensis* (Pan *et al.*, 1975) and new species is on their ornamentations. *L. kiangyouensis* has the scarcely distributed, large stellite tubercles, whereas *L. yunnanensis* has the small, closely set tubercles, indicating the large difference of the histological structure of the exoskeleton between these two species. The other differences include: 1) the portion proper of the cephalic shield of the type species is very narrow, whereas that of the new species is relatively broad; 2) the naso-hypophysial opening of the type species is peach-shaped, close to the orbital openings, whereas that of the new species is nearly rounded, far from the orbital openings; 3) the distance between the orbital openings in the type species is very small, whereas that in the new species is fairly large; 4) the lateral margin of the shield, the anterior and posterior margins of cornu are equipped with small spines in the new species; 5) relative to the type species, the embayment of the lateral margin in the new species is short; 6) the new species bears the obvious inner cornu, which is probably less developed in the type species.**Crossopterygii****Order Osteolepiformes Jarvik, 1942****osteolepid gen. et sp. indet.**

(Fig.4, Pl.I, 3,4,5)

Material A complete fronto-ethmoidal shield, V10687; two incomplete lower jaw, V10688.1, V10688.2.

Family Huananaspidae Liu 1973**Genus *Lungmenshanaspis* P'an et Wang 1975**

Type species *Lungmenshanaspis kiangyouensis* P'an et Wang 1975.

Referred species *L. yunnanensis* sp. nov.

Diagnosis (emended) Cephalic shield with a developed, triangular lateral process at the lateral side of the orbital opening, and forming an embayed lateral margin together with the cornua; cornu laterally projecting, very long and narrow; inner cornu small or less developed; orbital opening dorsal in position, posterolateral to the naso-hypophyseal opening.

Remarks *Lungmenshanaspis* (P'an et al., 1975) is referred to as the Huananaspidae by long and narrow rostral process, laterally extending cornua, and nearly rounded nasohypophysial opening. Other two genera of the Huananaspidae are *Huananaspis* and *Asiaspis*. *H.* is distinguished from *L.* by its laterally situated orbital opening. *A.* has its orbital openings at the dorsal side of the shield, as in *L.*, however, its orbital openings are extremely small. In addition, *A.* is deficient of the lateral process of the lateral margin, which is typical of *Lungmenshanaspis*. *Sinoszechuanaspis* had been assigned to the Huananaspidae, and later was referred to Macrothyraspididae (Pan, 1992) because of its dorsal fenestra.

As to phylogenetic position of *Lungmenshanaspis*, there exist some controversies, which are mainly related with the explanations of the lateral embayment of the lateral margin of the shield. *L.* was originally referred to as the Huananaspidae by Pan et al. (1975). Pan (1984) subdivided the Galeaspida into seven groups including huananaspids (roughly equivalent of the Huananaspiformes) and lungmenshanaspids, and the latter was composed of *Lungmenshanaspis*, *Sinoszechuanaspis* and *Qingmenaspis*. However, the background of the classification was not given by Pan. Wang (1991) considered *Lungmenshanaspis* and *Qingmenaspis* as the sister-group by the laterodorsal opening of the cephalic shield, since the lateral embayment of *L.* was explained as the laterodorsal opening, comparing to that of *Qingmenaspis* (Pan & Wang, 1981). Pan (1992) maintained his primary opinion, i.e., *L.* was originally referred to as the Huananaspidae. According to our new material, the lateral embayment is still part of the lateral margin of the cephalic shield, excluding it from the possibility as the dorsolateral opening.

indet.

图中简字说明

c	cornu	角
dcm	dorsal commissure	背联络管
em	embayment of lateral margin of cephalic shield	头甲侧缘内凹
fe.exa	fenestra exonaria anterior	前外鼻孔
f.pin	pineal foramen	松果孔
grp.so	group of pores	孔群
ic	inner cornu	内角
i.o	orbital notch	眼眶凹
ioc	infraorbital canal	眶下管
i.Pmx	notch for premaxilla	前上颌骨缺刻
lc	main lateral-line canal	主侧线管
ltc ₁₋₄	first to fourth lateral transverse canals	第一至第四侧横管
mtc	main transverse canal	中横管
nhp.o	naso-hypophysial opening	鼻-垂体孔
orb	orbital opening	眶孔
pi	pineal organ	松果体
plv.Id ₂	verticle pit-line of infradentary 2	第二下齿骨垂直凹线
plh.Md	horizontal part of mandibular pit-line	下颌凹线的水平部分
p-mc	preoperculo-mandibular sensory canal	前鳃盖-下颌感觉管
pr.l	lateral process of cephalic shield	头甲侧突
proc	preorbital corner	眶前突
ptoc	postorbital corner	眶后突
ro	rostral process	吻突
soc	supraorbital canal	眶上管
sp	spinette	小刺
v.mdc	vestige of median dorsal canal	中背管退化残迹

图版 I 说明 (Explanations of Plate I)

1. 昭通三歧鱼 (*Sanqiaspis zhaotongensis*) 头甲 (a cephalic shield), × 3 V9762
2. 云南龙门山鱼 (新种) (*Lungmenshanaspis yunnanensis* sp. nov.) 头甲 (a cephalic shield), × 2 V9763
3. 骨鳞鱼目, 属种未定 (*Osteolepid* gen. et sp. indet.) 一完整的额-筛甲 (a complete fronto-ethmoidal shield) × 5 V10687
4. 骨鳞鱼目, 属种未定 (*Osteolepid* gen. et sp. indet.) 一不完整的下颌 (an incomplete lower jaw), × 5 V10688.1
5. 骨鳞鱼目, 属种未定 (*Osteolepid* gen. et sp. indet.) 一不完整的下颌 (an incomplete lower jaw), × 5 V10688.2

