

华南泥盆纪介形类豆石介类 一新族 Sinoleperditiini*

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内 容 提 要

在华南,迄今只在泥盆纪地层中发现豆石介类(leperditiids)。由于它们均具有下垂“V”字型肌痕且此肌痕随时间的推移不断向下延伸,被考虑是豆石介类中一独立的演化支系,并归一新族: Sinoleperditiini。此族,在华南地区含2属和6亚属: *Sinoleperditia* (*Sinoleperditia*) Wang, 1989, *S.* (*Pseudobriartina*) subgen. nov., *S.* (*Yaosuoleperditia*) subgen. nov., *Paramoelleritia* (*Paraleperditia*) Sun, 1978, *P.* (*Paramoelleritia*) Wang, 1976 和 *P.* (*Brevileperditia*) subgen. nov.。重点探讨了此族的起源,演化型式及趋势和绝灭。指出“V”字型或下垂“V”字型肌的功能与闭壳肌可能是异曲同工,起闭壳作用;放射和横向条纹可能是闭壳肌和下垂“V”字型肌频繁收缩所致而不是血管束的痕迹,并可能具有排泄作用; *Dalelina* Sun, 1978 是 *Paraleperditia* Sun, 1978 的同物异名; *Paraoleperditia* Adachi et Igo, 1980 属 Sinoleperditiini 族,其产出时代可能是早泥盆世,而不是奥陶纪;本族可视作划分生物古地理的标志。

关键词 中华豆石介族 泥盆纪 华南

一、前 言

介形类豆石目(Leperditicopida)包括等缘介科(Isochilinidae)和豆石介科(Leperditiidae)。它们的壳体巨大,壳长一般10mm,最大>80mm,三度空间是一般介形类的数百倍,乃至上万倍,并具有大的闭壳肌痕和“V”字型或下垂“V”字型肌痕,是介形类中的一特殊类群。它们的地质历程从奥陶纪到泥盆纪。自70年代中期,随着华南古生代,特别是泥盆纪介形类研究工作的展开,笔者发现,在本区仅泥盆纪地层中产有豆石介类(leperditiids),并均具有不间断向下延伸的下垂“V”字型肌痕,与产自北美、欧洲、西伯利亚等地同期的豆石介类比较,存在着显著的差异,后者均具有非下垂的“V”字型肌痕。系统研究华南泥盆纪豆石介类,特别是下垂“V”字型肌痕的演变规律,不仅有利于生命演化型式的探讨,还可运用于泥盆纪地层,特别是滨海相地层的划分、对比和生物古地理的进一步区划。

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本文研究的材料来源于历年来笔者在野外采集的,野外送来鉴定的和文献记载的。它们分布于中国 11 个省和自治区(插图 6)。另外,在本文成文前,施从广和方宗杰又分别提供了贵州独山尧梭组和云南曲靖西屯组的豆石介类材料。

宋之耀和任玉皋分别为本文摄制标本图影和清绘图件,在此一并致谢。

二、豆石介类“V”字型肌痕等的性质和功能

肌痕是由闭壳肌、“V”字型或下垂“V”字型肌和肢体附着肌在壳侧内表面留下的印痕(并反映在内核上),如插图 1, A 所示。下面就“V”字型或下垂“V”字型肌痕的功能作一探讨。

“V”字型肌痕位于“眼”结节的下方和闭壳肌痕的前上方(插图 1, C; 插图 2), 普遍见于华南以外的奥陶纪至泥盆纪的豆石介类中; 下垂“V”字型肌痕(插图 1, A, B, E), 推测由“V”字型肌痕演变而来, 主要见于华南泥盆纪豆石介类中。关于它们的功能, 通常被认为是大颚肌或触角肌留下的印痕(Berdan, 1984; J11)。本文从下垂“V”字型肌痕及相关特征分析, 推测与闭壳肌痕同功异曲, 是具有闭壳功能的肌束留下的印痕, 理由是(1)据 Anderson(1974)研究揭示, *Cytheridea papillosa* (Bosquet) 的前肌痕是另一组闭壳肌留下的印痕, 称前闭壳肌痕(frontal adductor muscle scar), 与“V”字型肌痕位置一致;(2)放射条纹在下垂“V”字型肌痕后侧中断向前延伸和在前侧出现横向条纹, 可能意味着下垂“V”字型肌(痕)具有闭壳能力;(3)下垂“V”字型肌痕与闭壳肌痕之间常表现出互为消长的关系, 如产自 Givetian 的豆石介类, 其下垂“V”字型肌痕显著增大, 而闭壳肌痕则相对缩小, 意味着闭壳肌的部分闭壳功能由下垂“V”字型肌取代。

在豆石介类标本的内核上, 一般都具有以闭壳肌痕为中心的放射条纹和下垂“V”字型肌痕前侧的横向条纹(插图 1, B; 图版 V, 图 5)。关于放射状条纹的性质、功能, 在有关文献中(如 Berdan, 1984; J12), 趋向一致认为是血管束(blood vessels), 并据此推测豆石介类具有心脏。笔者对此解释颇持异议。闭壳肌在体腔内是从一壳的内表面横穿到另一壳的内表面, 心脏是不可能出现在此位置上的, 因此必须考虑放射状条纹与闭壳肌间的联系。笔者推测, 放射状条纹是闭壳肌频繁收缩的结果。当强大的闭壳肌收缩时, 施加于壳瓣内表面的拉力, 能够引起壳瓣变形, 体腔缩小。在壳瓣内表面积未变的情况下, 通过内表面的褶皱以补偿体腔的缩小。从力学观点来看, 闭壳肌是应力中心, 褶皱则是应变的结果。平行(或横向)条纹形成的原理当与放射状条纹一致, 只不过一个以近圆形的闭壳区为应力中心, 另一个以下垂“V”字型肌区为应力中心, 形状不同, 产生不同排列形式的条纹, 并在内核上留下铸模。当然也不排除由目前尚不清楚的原因形成的, 并可能具有某些功能, 如排泄作用, 即当两壳关闭时, 体腔内的水通过此沟槽(褶皱)系统迅速地被排出体外。

三、豆石介类的古生态

豆石介类的生活方式, 从潜穴到自由游泳的推测都有, 尚无统一看法。从产自华南泥盆纪的豆石介类来看, 其壳体的最大厚度常位于体中线偏下部位(具有较低的重心), 腹面比较宽平, 体笨、壳厚, 据此推测, 它们应以底栖爬行生活方式为主。豆石介类可能与其它介形类

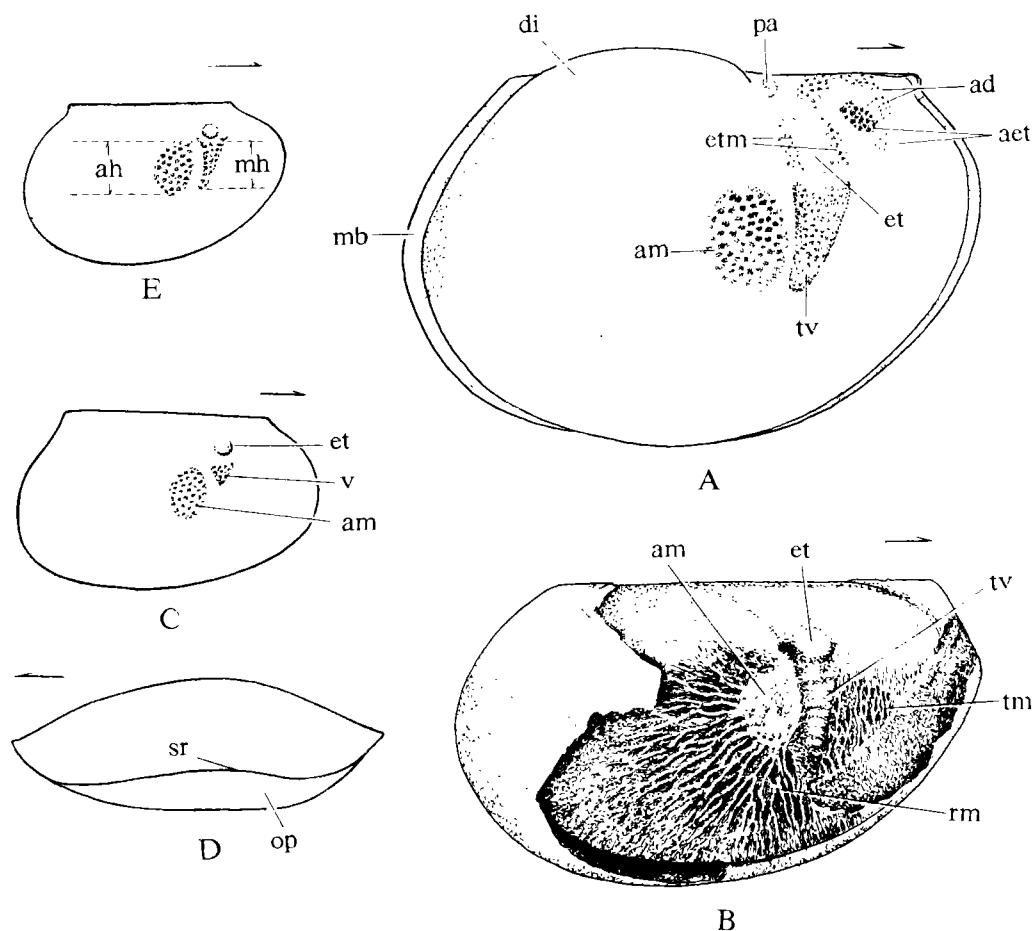


插图 1 豆石介类的构造及其术语

Leperditiiid structures and their terminology

ad; antero-dorsal muscle scar, 前背肌痕; aet; anterior "eye"-tubercle muscle scar, 前“眼”结节肌痕; am; adductor muscle scar, 闭壳肌痕; di; postero-dorsal inflation, 后背膨胀; et; "eye" tubercle, “眼”结节; etm; "eye"-tubercle muscle scar, “眼”结节肌痕; mb; marginal brim, 边缘带; op; overlap platform, 叠覆平台; pa; posterior antero-dorsal muscle scar, 后前背肌痕; rm; radiating markings, 放射条纹; sr; stop ridge, 停脊; tm; transversal markings, 横向条纹; tv; trailing chevron muscle scar, 下垂“V”字型肌痕; v; chevron muscle scar, “V”字型肌痕. ah; vertical height of adductor muscle scar, 闭壳肌痕的垂直高度; mh; vertical height of trailing chevron muscle scar below parallel line through the top of adductor muscle scar to dorsal margin, 通过闭壳肌痕顶端与背边平行的平行线以下的下垂“V”字型肌痕的垂直高度。

一样,是较活跃的生物,它们的转移很可能是通过游泳方式完成的。豆石介类既非等瓣,也非圆盘状(disk),采取自由游泳的生活方式似乎不太可能。至于其潜穴能力,笔者同意 Berdan (1969)的分析,即那些无翼状构造、生活在潮间带的豆石介类,当潮退后沉积物暴露于水面上时钻进泥中。

豆石介类的摄食方法,一般被认为是咀嚼类型,可能是因为将“V”字型肌痕当作大颚肌痕所致。在本文中,对“V”字型肌痕的性质、功能已作过讨论,推测可能是附加闭壳肌痕。目前还缺少证据,尚难确定豆石介类是哪种摄食方法。

按照钟铿等(1992, 10—12 页)沉积相划分及命名方案,中国泥盆纪豆石介类主要产在滨岸碎屑岩相区,如云南曲靖早泥盆世下西山村组,广西苍梧县早泥盆世贺县组(旱圳组);和碳酸盐台地相区,特别是局限海台地相,如广西中泥盆世晚期唐家湾组(东岗岑组);半闭塞潮下带的礁后相或台凹相,如广西象州早泥盆世二塘组,中泥盆世早期应堂组古车段。产豆石介类的岩性为白云岩、白云质灰岩、泥灰岩、亮晶灰岩、细—微晶灰岩、泥晶灰岩、泥岩、粉砂质泥岩、粉砂岩等。其共生化石有介形类的古足目类(*paleocopids*),卡味尔介类(*cavelinids*)和小克罗登介类(*kloedenellids*)等及腕足类、层孔虫、双壳类、块状和枝状珊瑚等。根据上述情况分析,中国泥盆纪豆石介类主要生活在潮上(或潮间带)到潮下浅水区。虽然少量豆石介类标本也曾在碳酸盐台地台槽相(如广西南丹罗富塘丁组和塘乡组下部)和海槽相(如广西玉林樟木早泥盆世北均塘组)中发现过,但推测是外来的。在水动力和盐度方面也具有较强的适应力。泥盆纪期间,中国南方豆石介类可能主要生活于暖水环境,如早泥盆世时候,云南曲靖位于赤道附近(方润森等, 1985, 33 页);晚泥盆世期间,广西桂林地处 $N2.2^{\circ}$ (Ye *et al.*, 1988, p. 104)。

笔者(1988)曾将中国南方晚古生代介形类生态组合划归 5 个集群,豆石介类集群(*Leperditiid Association*)几乎包括由单一豆石介类组成的组合,主要代表潮间带和潟湖环境。

四、华南泥盆纪豆石介类 *Sinoleperditiini* 族的起源、演化和绝灭

豆石目类(*leperditicopids*)是地史上出现最早的介形类之一。它们始现于早奥陶世,绝灭于晚泥盆世。例外的是,在华南地区它们却姗姗来迟,泥盆纪时才开始出现,而且只有豆石介类(*leperditiids*)而无等缘介类(*isochilinids*)。孙全英(关绍曾等, 1978)报道自广西象州二塘组的 *Dalelina* Sun, 1978 仅含 1 种和 1 枚保存为内核的正模标本。本文认为它不是等缘介类,而是 *Paraleperditia* Sun, 1978 的同物异名。特别有意义的是,产自华南泥盆纪的豆石介类均具有下垂“V”字型肌痕,这种肌痕随时间的推移不间断地向下伸展,与产自北美、欧洲、西伯利亚等地同期的豆石介类不同,产自后一些地区的均具有非下垂的“V”字型肌痕,与产自奥陶纪和志留纪的祖先相比,变化不大(插图 2, A—E)。下面就华南泥盆纪豆石介类 *Sinoleperditiini* 族的起源、演化和绝灭作一初步探讨。

1. *Sinoleperditiini* 族的起源

根据现有资料,在前泥盆纪地层中尚无可靠的具有下垂“V”字型肌痕的豆石介类的报道。以前记载过的,如西伯利亚志留纪的 *Gibberella* Abushik, 1958, 加拿大志留纪的 *Dihogmochilina latimarginata* (Jones), 确发育有下垂“V”字型肌痕,但不是豆石介类,而是等缘介类。产自日本中部岐阜县 Yoshiki 组的 *Paraeoleperditia* Adachi et Lgo, 1980 也具有下垂“V”字型肌痕,其产出时代被认为是奥陶纪。此属是根据一些保存不佳的材料建立的,可能是豆石介类。就其特征而言,特别是下垂“V”字型肌痕的存在,与产自华南早泥盆世的 *Sinoleperditia* (*Sinoleperditia*) Wang, 1989 十分相似,本文倾向把它归到 *Sinoleperditiini* 族。此属不具有奥陶纪豆石介类的特征,如缺失停坑(stop pits)等,其共生或同组的其它化石,如微体介形类、放射虫等,都是长延限的,有可能是早泥盆世的代表,并可能比产自云南曲靖下西山村组的要新,因其 mh/ah 值相对较大(通过闭壳肌痕顶点划一条与背边平行的

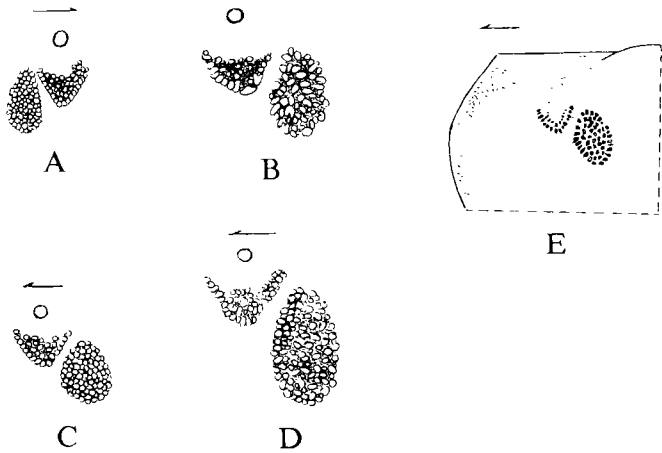


插图 2 产自北美、欧洲和西伯利亚志留系和泥盆系豆石介类的“V”字型肌痕

Silurian and Devonian leperditiid chevron muscle scar from North America, Europe and Siberia

A. *Herrmannina welleri* Swartz, 1949 from Late Silurian of Pennsylvania, USA; B. *Leperditia scalaris* Jones, 1853 from Late Silurian of Pennsylvania, USA; C. *Herrmannina waldschmidtii* Paeckelmann, 1922 from the Givetian of Germany; D. *Leperditia elongata* Peetz, 1901 (Polenova, 1970) from Early Devonian of Siberia, Russia; E. *Moelleritia canadensis* Copeland, 1962 from the Middle Devonian of Canada.

直线, mh 代表此直线以下下垂“V”字型肌痕高度; ah 代表此直线以下闭壳肌痕的高度。插图 1, E)。

就笔者迄今所知, 本族出现的最早代表可能是产自云南曲靖下西山村组下部的 *Sinoleperditia* (*Sinoleperditia*) *brevis* Wang et Liu, 1994 等, 其平均 $mh/ah=0.65\pm$, 比广西玉林樟木北均塘上 lochkovian 和下西山村组上覆西屯组的 *S. (Sinoleperditia) yulinensis* (new name) 等种 mh/ah 值要小, 后者平均 $mh/ah=0.70\pm$ 。并据此推测, 下西山村组可与下 Lochkovian 对比。这就是说, *Sinoleperditia* 族可能始现于早 Lochkovian。其起源机制亦可能在志留纪最晚期或泥盆纪最早期, 经过某次成种事件, 以边域成种的点断型式, 本族由具有“V”字型肌痕的豆石介类的某个属种突然演化而来。

在志留纪豆石介类中, 与 *Sinoleperditia* 最为接近的莫过于 *Herrmannina* Kegel, 1933 (此属还产于泥盆纪地层且分布广泛), 除具有非下垂“V”字型肌痕外, 其余特征, 如锯齿状铰合 (prionodont), 无后背膨胀, 与 *Sinoleperditia* 一致, 可能是后者的祖先。下垂“V”字型肌痕, 像前面已分析的那样, 可能与闭壳肌痕功能相同, 都是具有闭壳作用的肌束留下的印痕, 与“V”字型肌痕相比, 闭壳能力增强, 有利于抗御环境压力, 故能在华南这一新开拓的领域得以生存并迅速适应辐射, 形成比其它地区更为丰富且绝灭时间更晚的豆石介类群落。

华南泥盆纪 *Sinoleperditia* 族的祖先可能存在于本区前泥盆纪地层中, 只是目前尚未找到; 另一种可能是外来的, 即在志留纪最晚期或泥盆纪最早期通过相邻板块散布而来。

2. *Sinoleperditia* 族的系统演化及其趋势

华南泥盆纪豆石介类不仅具有下垂“V”字型肌痕, 而且此肌痕从早泥盆世早期到晚泥盆世末一直不间断地向下伸展, 推测与世界其它地区同期的具有“V”字型肌痕的豆石介类

发生了生殖隔离,当时的华南,对整个豆石介类的分布范围而言可能是一个大的边缘隔离体,发生的是单系演化,意味着 Sinoleperditiini 族是一单系群(monophyletic group)。本族的系统演化最可能自早 Lochkovian 的 Sinoleperditia 开始,通过不断演化、发展,现已初步识别出 2 属,6 亚属和 80 种以上,其间的演化关系如插图 3 所示。这个族除具有豆石目类的共同特征外,其不等的两瓣和腹边的弯曲接触(叠覆),则是豆石介类的共同特征,而非等缘介类的性状,把此族归入豆石介科当属无疑。肌痕是豆石介类软体部分留下的印记。从“V”字型肌痕演变到下垂“V”字型肌痕不仅是功能的加强,而且还涉及到软体部分的变化和重新配位问题,因此具有较高分类阶元的意义。本文暂作族级(tribe)标志。

Sinoleperditia 属壳体较小(一般 <10mm),后背不膨胀和铰合构造为锯齿型(prionodont)(图版 I,图 3); Paramoelleritia 属壳体大到巨大(一般 >10mm,最大 >80mm),后背强烈膨胀和铰合构造为似锯齿型(holomerodont)(图版 II,图 3)。推测,在早 Emsian 或与 Pragian 之交由前者衍生出后者。Sinoleperditia (Sinoleperditia), S. (Pseudobriartina) 和 S. (Yaosuoleperditia) 亚属之间,除壳体大小有变化[S. (Sinoleperditia) 长一般为 6—7.5mm; S. (Pseudobriartina) 常见为 7—12mm; S. (Yaosuoleperditia) 普遍 <8mm]外,其余外形特征变化较小,但 mh/ah 值则有显著变化:S. (Sinoleperditia) mh/ah 值不超过 1; S. (Pseudobriartina) mh/ah 值一般 >1.1 但普遍 <1.15; S. (Yaosuoleperditia) mh/ah >1.2。推测,大约在晚 Emsian 晚期,通过壳体,特别 mh/ah 值的增大,由 S. (Sinoleperditia) 演化到 S. (Pseudobriartina); 在 Givetian 与 Frasnian 之交或此前后,通过 mh/ah 值的增大和壳体变小,由 S. (Pseudobriartina) 演化到 S. (Yaosuoleperditia)。

Paramoelleritia 属也已初步区分出 3 亚属:P. (Paraleperditia), P. (Paramoelleritia) 和 P. (Brevileperditia)。P. (Paraleperditia) 壳体大(>10mm, 但 <40mm), 后背膨胀发育但突起几乎不超过背边, 两侧凸起大和两端边缘带宽; P. (Paramoelleritia) 壳体巨大(一般 30mm 土, 最大 >80mm), 后背强烈膨胀且向上突起显著超过背边, 呈“驼峰”状和两端边缘带宽。推测, 在早、晚 Emsian 之交, 通过后背部膨胀进一步增强和壳体增大, 由前者衍生出后者。P. (Brevileperditia) 壳体相对较小(<20mm), 后背膨胀发育但突起一般不超过背边,

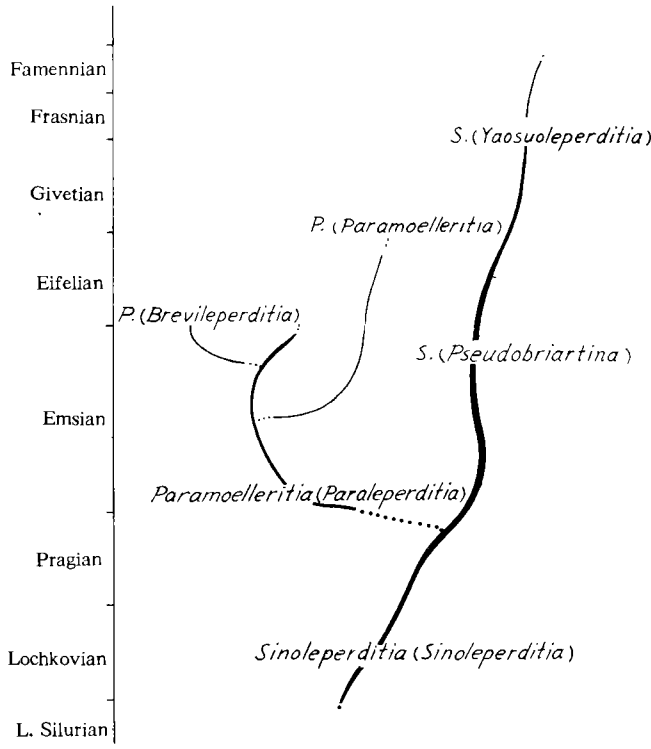


插图 3 Sinoleperditiini 的系统演化
Phylogenetic relationship of Sinoleperditiini

壳体较胖和缺失两端边缘带。大约在晚 Emsian 晚期,通过壳体变小,特别是两端边缘带的失落,由 *P. (Paraleperditia)* 衍生出 *P. (Brevileperditia)*。

在外型特征上,*P. (Paraleperditia)* 和 *P. (Paramoelleritia)* 分别与同期的 *Eomoelleritia* Abushik, 1972 和 *Moelleritia* Abushik, 1958 相似(但前两者具有下垂“V”字型肌痕,而后两者则发育“V”字型肌痕),推测是趋同演化(convergent evolution)现象。

上面已述及,*Paramoelleritia* 属与 *Sinoleperditia* 属间具有显著差异且无过渡类型或中间环节存在。从已报道的 Pragian(关绍曾等, 1978)和早 Emsian 的 *Sinoleperditia* 的种来看,其壳体也较早 Emsian 的 *Paramoelleritia* 的分子小得多(前者 $<10\text{mm}$,而后者通常在 20mm 以上,最大近 40mm)。推测在早 Emsian 或与 Pragian 之交,通过点断型式,瞬间由 *Sinoleperditia* 演化分枝出 *Paramoelleritia*。各亚属间的演化机制,也多半以点断型式为主。

Sinoleperditia 族的演化趋势,通过分析本族的各种特征,可以看出下垂“V”字型肌痕在演化趋势中起主导作用。本族自早泥盆世早期出现后,下垂“V”字型肌痕一直不停地向下伸展(插图 4, 5),如下西山村组的 *S. (Sinoleperditia) brevis* Wang et Liu, 1994 等种,其平均 $\text{mh/ah}=0.65\pm$, 西屯组和广西玉林樟木北均塘晚 Lochkovian 的 *S. (Sinoleperditia) yulinensis* (new name) 等种,其平均 $\text{mh/ah}=0.7\pm$; 广西罗富早 Emsian 塘丁组和象州二塘组的 *S. (Sinoleperditia) sp.*, *P. (Paraleperditia) guangxiensis* (Sun), 1978, $\text{mh/ah}=0.94\pm$, 象州晚 Emsian 四排组石朋段和塘乡组下部的 *P. (Paramoelleritia) xiangzhouensis* Wang, 1976 等种,其平均 $\text{mh/ah}=0.99\pm$; 四排组丁山岭段(相当于上 Emsian 上部)的 *P. (Brevileperditia) subcircularis* subgen. et sp. nov. 等种,其平均 $\text{mh/ah}=1.1\pm$ 。中泥盆世期间,如广西象州应堂组古车段(可与 Eifelian 对比)的 *S. (Pseudobriartina) suboblonga* subgen. et sp. nov. 等种,其平均 $\text{mh/ah}=1.128\pm$, 而产自桂林等地东岗岭组或唐家湾组(一般划归 Givetian)的 *S. (Pseudobriartina) yangshuoensis* subgen. et sp. nov. 等种,平均 $\text{mh/ah}=1.13\pm$ 。晚泥盆世,如广西桂林附近桂林组(一般与 Frasnian 对比)的 *S. (Yaosuoleperditia) guilinensis* subgen. et sp. nov. 等种,平均 $\text{mh/ah}=1.22\pm$, 而产自桂林东村组上部和额头村组、贵州独山尧梭组、宁夏卫宁盆地中宁组下段(这些组段推测可与 Famennian 对比)的 *S. (Yaosuoleperditia) mansueta* (Shi), 1964 等种,平均 $\text{mh/ah}=1.239\pm$ 。但下垂“V”字型肌痕下延也不总是缓慢、有条不紊地进行的,从插图 4, 5 能够看出,下垂“V”字型肌痕下延既有相对稳定或缓慢进行阶段,也有突变阶段。其中之一发生在四排组丁山岭段下部, mh/ah 值由 <1 突然增加到 1.1 , 增加幅度超过 0.1 , 而在其余漫长 Emsian 期间, mh/ah 值增加仅 0.06 或更小,毫无疑问这是一次演化突变。在这次突变中,演化出 2 新亚属: *P. (Brevileperditia)* 和 *S. (Pseudobriartina)*。 *P. (Brevileperditia)* 可能通过壳体变小和两端边缘带的失落,由 *P. (Paraleperditia)* 演化而来。这个亚属可能未获得环境适应的应有位置,便昙花一现,随丁山岭段沉积的结束而消声匿迹。 *S. (Pseudobriartina)* 可能通过 mh/ah 值的突然增大而由 *S. (Sinoleperditia)* 演化而来。这个亚属一直延续到东岗岭组或相应层组的上部或顶部。另一次突变发生在东岗岭组与桂林组(可大致分别与 Givetian 和 Frasnian 对比)之交或此前后, mh/ah 值由 <1.15 猛增到 1.2 以上,增幅超过 0.05 , 而在晚 Emsian 晚期和整个中泥盆世期间, mh/ah 值只增加了 $0.04\pm$ 。在这次突变中,通过 mh/ah 值的突然增大和壳体的减小,由 *S. (Pseudobriartina)* 演化成 *S. (Yaosuoleperditia)*。这个亚属存在直到 Fa-

mennian 末期,整个豆石介类在世界上消失。根据现有资料分析(插图 4,5),产自 Lochkovian 的 *S. (Sinoleperditia)* 的种, mh/ah 值从 $0.65 \pm$ 到 $0.7 \pm$,而产自早 Emsian 的 *S. (Sinoleperditia)* sp. 等种, $mh/ah = 0.94 \pm$,Pragian 期间 mh/ah 值的跨幅达 0.2 以上。鉴于在一个阶中 mh/ah 值变化如此之大,笔者推测,在 Lochkovian 与 Pragian 或 Pragian 与 Emsian 之交,或在此前后,也可能发生过 mh/ah 值的突变,并通过后一个突变,由 *Sinoleperditia* 属衍生出 *Paramoelleritia* 属。在 mh/ah 值相对稳定和变化不大期间,下垂“V”字型肌痕发生形状歧异和次级肌痕个体变大、数量减少(插图 4)。下垂“V”字型肌痕一般为弯锥形,据现有资料,在晚 Emsian 开始出现几近垂直的类型(插图 4:8),直到 Givetian;下垂“V”字型肌痕明显增大(插图 4:18—24),主要发生在 Givetian,直到 Famennian;下垂“V”字型肌痕末端增大(插图 4:27—29),主要发生在 Famennian。下垂“V”字型肌痕主要由许多细小的次级肌痕组成,但自 Givetian 开始,次级肌痕发生合并,单个变大,数量减少,直到 Famennian 末期,如插图 4:19,20,23,28,29,32,33 所示。

3. *Sinoleperditiini* 族的绝灭

Coen (1989, p. 312)指出,产自贵州独山尧梭组顶部的 *Leperditia* [= *Sinoleperditia* (*Yaosuoleperditi*)],可能是世界上豆石介类的最晚代表。近来,笔者又在桂林附近东村组顶部及其上覆的额头村组找到了豆石介类。额头村组除产豆石介类的外,还产其它化石,如腕足类、珊瑚、有孔虫等,其中包括有孔虫 *Septaurayella* 组合带(钟铿,1992,279 页)。由于此组合带还产在尧梭组上覆的者王组中,因此两组可进行对比。这样,产自额头村组的豆石介类在层位上比产自尧梭组的高。据钟铿等(1992)推测,额头村组可与牙形刺 *S. praesulcata* 带对比。由于迄未在石炭纪地层中发现过豆石介类,因此推测,在华南泥盆纪结束前或结束时,*Sinoleperditiini* 乃至整个豆石目在华南及整个世界上全部绝灭。其绝灭原因可能与泥盆纪末的地质事件相关,不过尚需进一步调查研究以期证实。

五、泥盆纪豆石介类 *Sinoleperditiini* 族的地理分布

Sinoleperditiini 族的地理分布如插图 6 所示。由于中国泥盆纪豆石介类的研究起步较晚,特别是在地层划分、对比上的价值鲜为人知,未能引起广大地质工作者们的注意,因此这张地理分布图肯定是不够完善的,更多的产地还有待进一步发现。它不仅包括中国泥盆系华南区(王钰等,1982),还包括泥盆系西北区宁夏卫宁盆地、新疆若羌茫崖镇环形山(阿尔金山地区)、昆仑山阿其克库勒湖卡拉楚卡山和泥盆系青藏区甘肃迭部。在宁夏卫宁盆地,*Sinoleperditiini* 族的分子被发现自中宁组下段,其下垂“V”字型肌痕末端增大,平均 $mh/ah > 1.2$,与贵州独山尧梭组上部的一致,如 *S. (Yaosuoleperditia) zhongweiensis* subgen. et. sp. nov. (图版 VI,图 15),并据此推测,中宁组下段的时代应为 Famennian。在生物地理区系上,与鱼化石(潘江等,1987)的研究结果一致,属华南泥盆纪生物地理区系。甘肃迭部泥盆纪豆石介类,已由施从广和王东华(1987)作过报道,计 2 种:*Moelleritia* sp. 和 *M. elongata* Shi et Wang,1987。由于它们均具下垂“V”字型肌痕,当归 *Sinoleperditiini*,分别为 *Paramoelleritia* (*Paramoelleritia*) sp. 和 *P. (Paramoelleritia) elongata* (Shi et Wang),1987。这 2 种产自尕拉组,根据下垂“V”字型肌痕特征,可能代表晚 Emsian 时代。在卡拉楚卡山区,

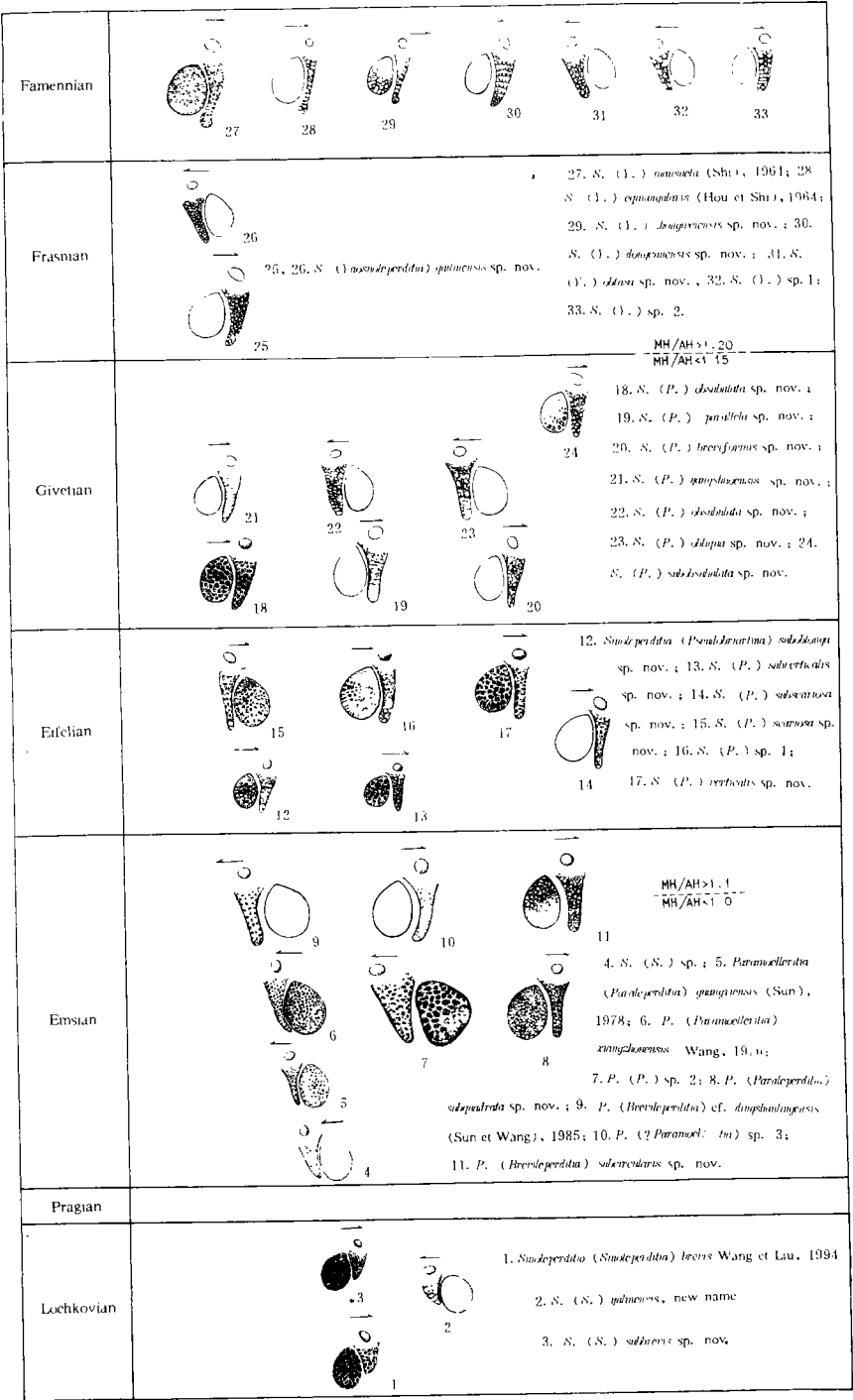


插图 4 Sinoleperditini 下垂“V”字型肌痕的演变趋势
Evolutionary trends of Sinoleperditini trailing chevron muscle scar

Sinoleperditini 族的分子被发现自卡拉楚卡山组上段(相当于上 Emsian 阶),经笔者鉴定为

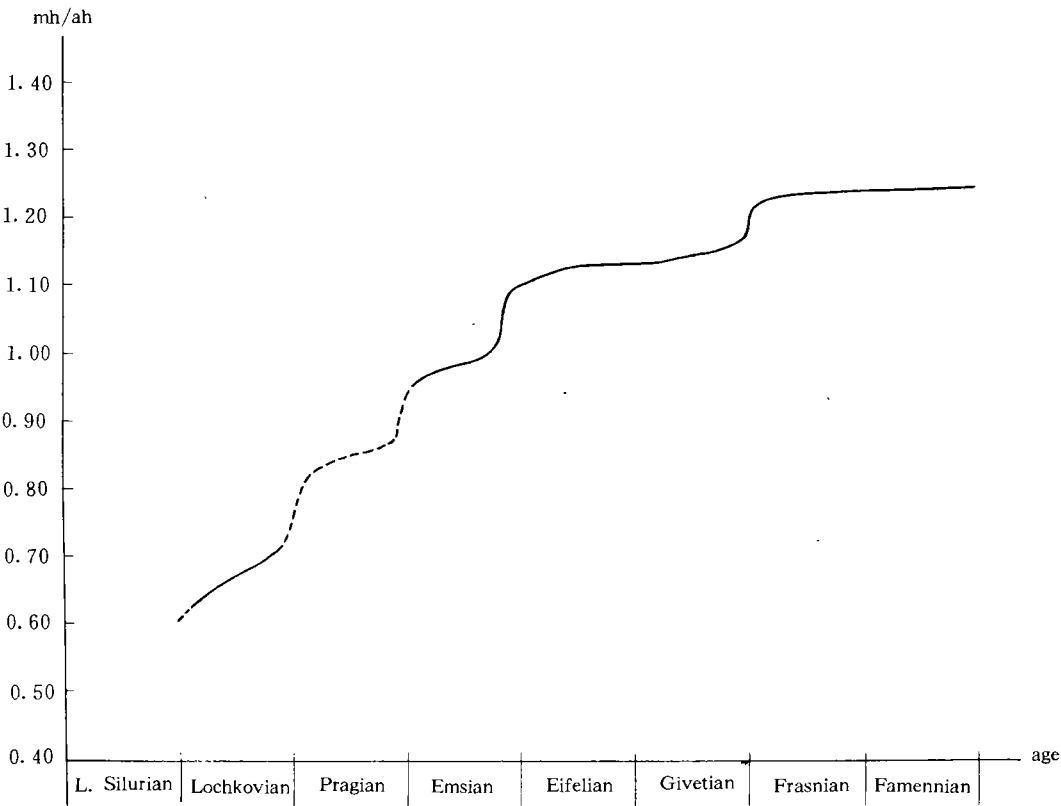


插图 5 *Sinoleperditini* 的平均 mh/ah 值的变化曲线, 随时间推移不断增大
Curve showing mean mh/ah values of *Sinoleperditini*, increasingly with age

Paramoelleritia (*Paramoelleritia*) 亚属 (孙东立, 罗辉, 1990)。若羌茫崖镇环形山地区的 *Sinoleperditini* 分子, 即 *Paramoelleritia* (*Paramoelleritia*) 亚属等, 由钟端等采集。由于其 $mh/ah > 1$, 故推测产出的地层时代是晚 Emsian 晚期到 Eifelian 期 (其地质时代还可由共生的微体介形类, 如瘤石介类, 予以支持)。张研 (1987), 池永一 (1987), 孙东立和罗辉 (1990) 等通过研究指出, 产自西秦岭和卡拉楚卡山区泥盆纪腕足类和珊瑚动物群与华南生物地理区系密切相关。从产自上述两地区和若羌环形山地区的豆石介类特征来看, 由于它们均具下垂“V”字型肌痕, 属 *Sinoleperditini* 族。此族主要见于华南泥盆纪地层, 因此推测与华南属同一生物地理区系。孙东立、罗辉 (1990) 指出, 阿其克库勒湖地区海相泥盆系的发现, 以及在西昆仑麻扎达南苏里库哇、中昆仑阿羌、木孜塔格区昆仑南坡双陷达板等地海相泥盆系及生物群的发现, 表明昆仑山地区泥盆纪时海域广阔, 形成连通中亚哈萨克斯坦和秦岭、华南海域的通道。倘若这一推测属实, 且又不存在深海障隔, 在泥盆纪, 华南 *Sinoleperditini* 族类可能沿着这一通道向迭部和昆仑山地区传播、扩散。

除华南以外, 具有下垂“V”字型肌痕的豆石介类 *Paraeoleperditia* 还曾报道自日本中部岐阜县。前面已讨论, 这个属可能是 *Sinoleperditini* 族的分子, 产出时代推测为早泥盆世早期, 而不是奥陶纪。在古生代, 从古地理图上 (王鸿桢等, 1989, 插图 25, 27) 看, 日本与扬子地块始终比较靠近, 在早泥盆世早期, 由华南传播去的可能性是存在的。

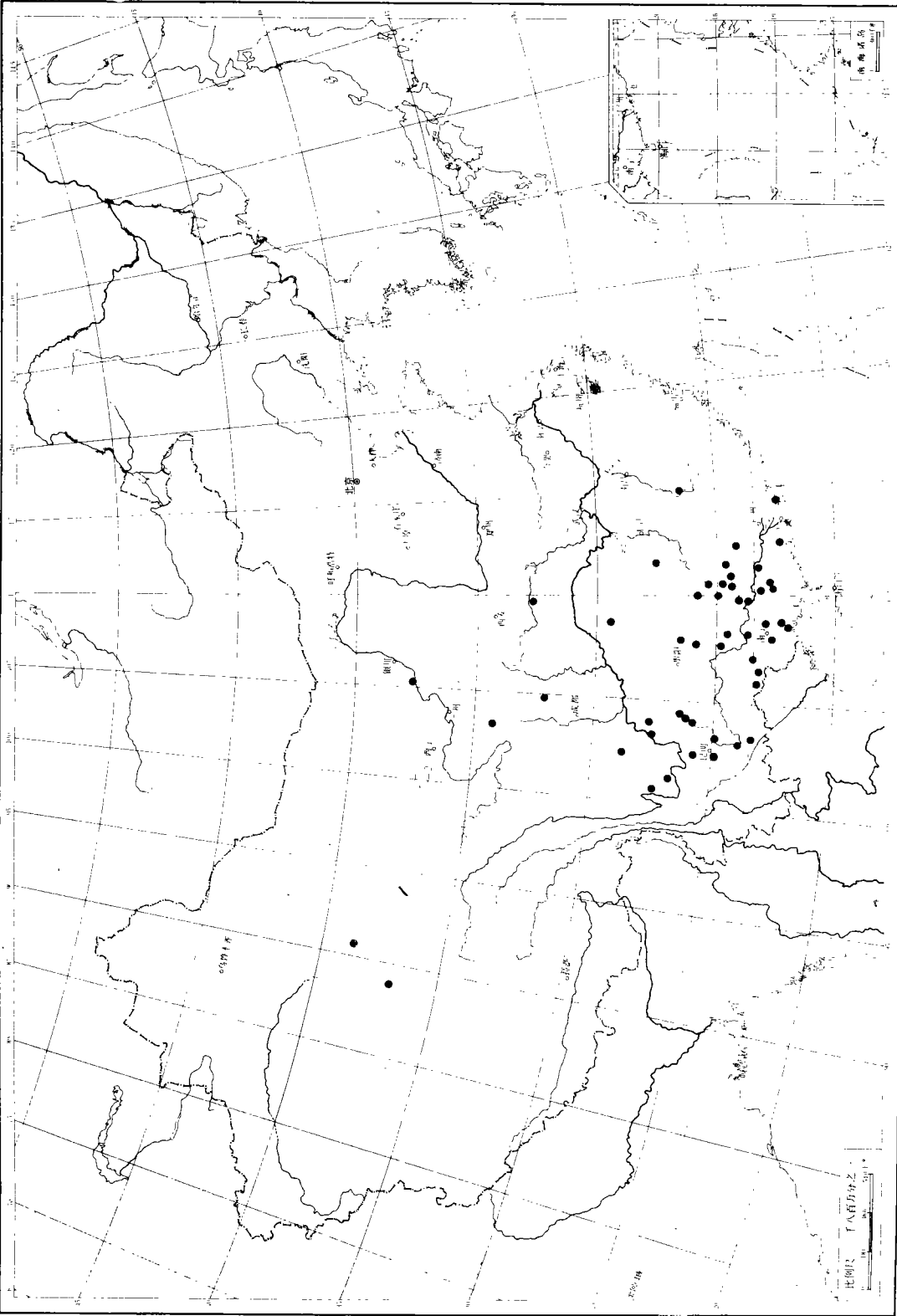


插图 6 泥盆纪 Sinoleperditini 的地理分布 Geographical distribution of Sinoleperditini from the Devonian

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A NEW LEPERDITIID TRIBE SINOLEPERDITIINI (OSTRACODA) FROM DEVONIAN OF SOUTH CHINA

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Key words: Sinoleperditiini, Devonian, South China

Summary

In South China, leperditiid ostracodes are abundant but only known from the Devonian strata up to now. All of them are assigned to a new tribe Sinoleperditiini based on the presence of the trailing chevron muscle scar. The new tribe includes 2 genera and 6 subgenera: *Sinoleperditia* (*Sinoleperditia*) Wang, 1989, *S. (Pseudobriartina)* subgen. nov., *S. (Yao-suleperditia)* subgen. nov., *Paramoelleritia* (*Paraleperditia*) Sun, 1978, *P. (Paramoelleritia)* Wang, 1976 and *P. (Brevileperditia)* subgen. nov., which are regarded as a monophyletic group, with their phylogenetic relationships shown in Text-fig. 3. So far as we know, these subgenera comprise over 80 species, among which 35 species (including 19 new species) are described and illustrated in this paper.

Dalelina Sun, 1978, a monotypic genus, with type species *D. guangxiensis* erected by Sun (1978) on the basis of a steinkern, may be a synonym of *Paraleperditia* Sun, 1978. *Paraoleperditia* Adachi et Igo, 1980 from the Yoshiki Formation of Central Japan may not be an Ordovician representative due to the absence of, for example, stop pits, which are usually present in the Ordovician leperditiids, and the presence of the trailing chevron muscle scar, which has not been found in the Ordovician leperditiids. Other ostracodes associat-

ed with it or from the same formation may not indicate the precise age, either, and radiolarians have a long range from the Ordovician to Devonian. This paper is inclined to refer it to the tribe *Sinoleperditiini* and to the Early Devonian age based on its similarity to *S. (Sinoleperditia)* from the Early Devonian of south China, especially in the trailing chevron muscle scar. The Fukuji Formation overlying the Yoshiki Formation is probably younger than the early Lochkovian proposed by Kuwano (1987) because the determination of the conodont species by its author from the formation is incorrect according to Wang Chenyuan.

The chevron or trailing chevron muscle scar presumably belongs to the adductor system, this is because in the position it is corresponding to the frontal adductor muscle scar named by Anderson (1974); the radiating markings are stopped from the extension behind the trailing chevron muscle scar and the transversal markings are well-developed in front of and parallel to the trailing chevron muscle scar (Text-fig. 1, B; pl. V, fig. 5), which may imply the trailing chevron muscles to perform the function of an adductor; and when the trailing chevron muscle scar is enlarged, it is often accompanied with the smaller adductor muscle scar, i. e., the function of adductor muscles may be undertaken in part by the trailing chevron muscles, such as in *S. (Pseudobriartina) yangshuoensis* sp. nov. (Pl. V, figs. 2, 3). The radiating and transversal markings (Text-fig. 1: rm, tm) are possibly formed by the frequent contraction of adductor and trailing chevron muscles. When closing the carapace, a strong pull from the adductor and trailing chevron muscles probably causes valves metamorphosis and body cavity reduction, for which the wrinkles (transversal and radiating markings) on the inner surface of valves just make compensation. the radiating and transversal markings perhaps perform the functions, for example, as a drainage system, i. e., in the process of closing the carapace, the water is quickly drained away from the body cavity along this system.

A preliminary discussion is made on the paleoecology of *Sinoleperditiini*; their geographical distribution may be considered as a mark indicating the Devonian paleobiogeography (Text-fig. 6). The present paper also roughly probes into the origin, evolution (Text-fig. 3) and extinction of this tribe.

The evolutionary trends of *Sinoleperditiini* are preliminarily recognized as follows (Text-figs. 4, 5): (i) The trailing chevron muscle scar uninterruptedly extends downward from earliest to latest Devonian. (ii) The sudden changes of mh/ah value (mh; vertical height of trailing chevron muscle scar below the parallel line through the top of adductor muscle scar to dorsal margin; ah; vertical height of adductor muscle scar) took place in the intervals between early Late Emsian and late Late Emsian, between the latest Givetian and earliest Frasnian and, probably, between the latest Lochkovian and earliest Pragian or between the latest Pragian and earliest Emsian. (iii) The vertical conic-shaped trailing chevron muscle scar occurred in the late Emsian to Givetian; the large trailing chevron

muscle scar relative to adductor muscle scar is discovered in Givetian to Famennian; the trailing chevron muscle scar with a drop-shaped lower end took place in the Famennian; and the secondary muscle scars of trailing chevron muscle scar were reduced in number, with individual scars enlarged in size in Givetian to Famennian.

In addition, the *Sinoleperditini* extinction might take place by or at the end of Devonian.

SYSTEMATIC PALEONTOLOGY

Class Ostracoda Latreille, 1804

Order Leperditicopida Scott, 1961

Family Leperditidae Jones, 1856

Tribe *Sinoleperditini* trib. nov.

A leperditid group with trailing chevron muscle scar. Carapace generally 6—20mm in length, sometimes attaining or over 80mm. Surface smooth. Right valve larger than and overlapping left one; left valve slightly higher than right one along dorsal margin. Stop ridge and overlap platform well-developed along ventral margin of left valve. Hingement prionodont (Pl. I, fig. 3) and holomerodont (Pl. II, fig. 3).

Genera: *Sinoleperditia* Wang, 1989, *Paramoelleritia* Wang, 1976 and ? *Paraeoleperditia* Adachi et Igo, 1980.

Remarks: The new tribe is assigned to the family Leperditidae Jones, 1856 based on the presence of strongly unequal valves and a sinuous contact margin in ventral view, and the absence of a complete brim along free margin.

The genus *Paraeoleperditia* Adachi et Igo 1980 does not look like the Ordovician representative as aforementioned and tends to be referred to the Devonian *Sinoleperditini*.

Geological and geographical distribution: Devonian; China and ? Japan.

Genus *Sinoleperditia* Wang, 1989

Type species: *Sinoleperditia* (*Sinoleperditia*) *yulinensis* (formerly known as *S. guangxiensis* Wang, 1989)

Diagnosis: Trailing chevron muscle scar well-developed; carapace 6mm to 20mm in length, generally 10mm \pm . Posterodorsal inflation essentially undeveloped on valves; brims narrow on ends. Radiating and transversal markings commonly present. Hingement prionodont (Pl. I, fig. 3).

Subgenera: *Sinoleperditia* (*Sinoleperditia*) Wang, 1989, *S. (Pseudobriartina)* subgen. nov. and *S. (Yaosuoleperditia)* subgen. nov.

Remarks: This genus is subdivided into *S. (Sinoleperditia)*, *S. (Pseudobriartina)* and *S. (Yaosuoleperditia)* mainly based on the mh/ah value, i. e., *S. (Sinoleperditia)* with

$mh/ah < 1$; *S. (Pseudobriartina)* with $mh/ah \geq 1.1$; and *S. (Yaosuoleperditia)* with $mh/ah > 1.2$.

Here *Leperditia guangxiensis* Sun, 1978 is referred to *S. (Sinoleperditia)*. Since the species name *guangxiensis* was preoccupied, *S. (Sinoleperditia) guangxiensis* Wang, 1989 has to be replaced by a new species name, *S. (Sinoleperditia) yulinensis*.

Geological and geographical distribution: Devonian; China.

Subgenus *Sinoleperditia (Sinoleperditia)* Wang, 1989

Type species: *Sinoleperditia (Sinoleperditia) yulinensis*.

Diagnosis: Carapace generally 6—7.5 mm, sometimes attaining or over 9 mm; mh/ah values from > 0.6 to ≤ 1 .

Geological and geographical distribution: Early Devonian; South China.

***Sinoleperditia (Sinoleperditia) brevis* Wang et Liu, 1994**

(Pl. I, figs. 1—3; Text-fig. 4:1)

1994 *Sinoleperditia brevis* Wang et Liu, p. 144, pl. I, figs. 1—8.

1994 *S. cf. brevis*, Wang and Liu, pl. II, figs. 1, 2.

Diagnosis: Carapace generally > 6 mm but < 7 mm. Mean $mh/ah = 0.65 \pm$ in adult specimens and ≤ 0.6 in juvenile specimens.

Occurrence: Early Lochkovian Xiaxishancun Formation; Qujing, Yunnan.

Sinoleperditia (Sinoleperditia) yulinensis

(Pl. I, figs. 4, 5; Text-fig. 4:2)

1989 *Sinoleperditia guangxiensis* Wang, p. 252, pl. III, fig. 11.

1994 *S. guangxiensis*, Wang and Liu, pl. I, fig. 13.

Diagnosis: Carapace smaller in size; brims developed on ends but narrow; $mh/ah > 0.69$ to ≤ 0.7 .

Plesiotype: Xitun Formation/122069/119b (Pl. I, fig. 5), with a length of 8 mm and a height of 5 mm.

Occurrence: Late Lochkovian of Zhangmu, Yulin, Guangxi and Xitun Formation of Qujing, Yunnan.

***Sinoleperditia (Sinoleperditia) subbrevis* sp. nov.**

(Pl. I, figs. 6, 7; Text-fig. 4:3)

Material: 11 valves.

Diagnosis: Carapace generally 7—7.5 mm in length and suboval in lateral view. Dorsal margin a little more than half as long as valve; ventral margin strongly convex, with maximum convexity at mid-ventral margin. Ends rounded; anterior end narrower than posterior one, mostly extending slightly above mid-height at anterior end and near mid-height at

posterior end. Sides relatively convex in dorsal view and thickest near center. Stop ridge well-developed along ventral margin of left valve.

Adductor muscle scar large in size, suboval and consisting of many quadrangular and subcircular secondary elements; trailing chevron muscle scar moderately large in size, curved-conic in shape and also composed of many secondary elements; $mh/ah =$ or slightly >0.7 .

Holotype: Xitun Formation/122097/119b (Pl. I, fig. 6), with a length of 7.4mm and a height of 5mm.

Paratype: Xitun Formation/122098/119b (Pl. I, fig. 7), with a length of 7mm and a height of 4.6mm.

Remarks: In the $mh/ah = 0.7 \pm$, the new species is similar to *S. (Sinoleperditia) yuliensis*, but differs from the latter in the more convex ventral margin and the relatively short and high lateral outline.

Occurrence: Late Lochkovian Xitun Formation; Qujing, Yunnan.

Sinoleperditia (Sinoleperditia) delicatis (Jiang), 1983

(Pl. I, figs. 8, 9)

1981 *Leperditia delicatis* Jiang, pl. I, figs. 8, 9.

1983 *L. delicatis*, Jiang, p. 23, pl. V, fig. 5R.

1994 *Sinoleperditia delicatis* (Jiang), Wang and Liu, pl. I, fig. 12.

Leperditia delicatis, which is here assigned to *S. (Sinoleperditia)*, was reported in 1981 and described in 1983 by Jiang. It was collected from the Cuifengshan Formation, including the Xiaxishancun (or Xishancun), Xitun, Guijiatun and Xujiachong Members, which are separately considered as a formation at present. This species might be from the Xitun Formation.

Sinoleperditia (Sinoleperditia) sp.

(Pl. I, fig. 10; Text-fig. 4:4)

1983 "*Leperditia*" sp., Wang and Zhang, p. 554, pl. I, fig. 4.

The specimen is a steinkern bearing relatively clear trailing chevron muscles scars, and adductor muscle scars, which may also be discriminated; $mh/ah = 0.93 \pm$.

Occurrence: Early Devonian Tangding Formation (*Nowakia subtilis* Zone); Luofu of Nandan, Guangxi.

Subgenus *Sinoleperditia (Pseudobriartina)* subgen. nov.

Type species: *Sinoleperditia (Pseudobriartina) suboblonga* sp. nov.

Diagnosis: Carapace generally 8—12mm, sometimes attaining or over 15mm; $mh/ah \geq 1.1$ but generally <1.15 , individually >1.15 .

Geological and geographical distribution: Late late Emsian to Givetian; South China.

***Sinoleperditia (Pseudobriartina) suboblonga* subgen. et sp. nov.**

(P1. Ⅲ, figs. 6—8; Text-fig. 4:12)

Material: Over 16 valves

Diagnosis: Carapace 8—10mm and nearly oblong in lateral view. Dorsal margin about 3/5 as long as valve; ventral margin convex, with maximum convexity near posteroventral angle. Ends rounded with posterior one broader than the anterior; maximum length of carapace near mid-height. Sides moderately convex in dorsal view and thickest slightly below mid-height. Brims narrow on ends and often more conspicuous in steinkern.

Adductor and trailing chevron muscle scars well-preserved; trailing chevron muscle scar consisting of many small secondary elements; mh/ah values from 1.11 to 1.124, with mean mh/ah = 1.12 ±.

Holotype: Yingtang Formation/122099/Zy-1 (P1. Ⅲ, fig. 6), with a length of 8mm and a height of 5.4mm.

Paratypes: Yingtang Formation/122100/Zy-1 (P1. Ⅲ, fig. 7), with a length of 8mm and a height of 5mm; 122101/Zy-1 (P1. Ⅲ, fig. 8), with a length of >4.5mm.

Occurrence: Eifelian Yingtang Formation; Zhongping of Xiangzhou, Guangxi.

***Sinoleperditia (Pseudobriartina) verticalis* subgen. et sp. nov.**

(P1. Ⅲ, figs. 12—14; Text-fig. 4:17)

1994 "*Leperditia*" sp. 2, Wang and Liu, pl. Ⅱ, fig. 12.**Material:** Over 8 valves.

Diagnosis: Carapace medium-sized, subelliptical in lateral view. Dorsal margin about 2/3 as long as valve; ventral margin relatively convex and most convex near mid-ventral or posteroventral margin. Anterior end rounded, but narrower than posterior one and most convex above mid-height; posterior end with a maximum convexity below mid-height.

Adductor muscle scar oval and much larger than trailing chevron muscle scar, which is almost vertical bar-shaped and composed of many fine and small secondary elements; mh/ah values from 1.1 to 1.156, with mean mh/ah = 1.126.

Holotype: Yingtang Formation/122102/Zy-4 (P1. Ⅲ, fig. 14), with a length of 11mm and a height of 6.5mm.

Paratypes: Yingtang Formation/122103/Zy-4 (P1. Ⅲ, fig. 13), with a length of >10mm and a height of 6.68mm; 119420A/Zy-4 (P1. Ⅲ, fig. 12), with a length of 9mm and a height of 5.35mm.

Remarks: In mh/ah value, the new species resembles *S. (Pseudobriartina) suboblonga* sp. nov., but differs from the latter in the vertical bar-shaped trailing chevron muscle scar, the relatively short dorsal margin and the irregularly rounded posterior end with a maximum convexity below mid-height.

Occurrence: Eifelian Yingtang Formation; Zhongping of Xiangzhou, Guangxi.

***Sinoleperditia (Pseudobriartina) scariosa* subgen. et sp. nov.**

(P1. N, figs. 1—3; Text-fig. 4:15)

Material: 4 valves.

Diagnosis: Carapace 8—10mm in length and subelliptical in lateral view. Dorsal margin about $4/7$ as long as valve; ventral margin convex, with a maximum convexity near posteroventral angle. Ends rounded, with posterior end broader than anterior one. Carapace with a maximum length near mid-height and the thickest part behind and below the center.

Adductor muscle scar much larger than trailing chevron muscle scar, which is thin, long and slightly curved-conic and consists of many fine and small secondary elements; mh/ah values from 1.12 to 1.143, with mean mh/ah = 1.125.

Holotype: Yingtang Formation/122104/Zy-4 (P1. N, fig. 1), with a length of 10mm and a height of 6.14mm.

Paratypes: Yingtang Formation/122105/Zy-3 (P1. N, fig. 2), with a length of >8mm and a height of 5mm; 122106/Zy-4 (P1. N, fig. 3), with a length of >8.5mm and a height of >5.5mm.

Remarks: The new species is easily distinguished from *S. (Pseudobriartina) suboblonga* sp. nov. by the thin and long trailing chevron muscle scar and the posterior end which is more strongly extending backward.

Occurrence: Eifelian Yingtang Formation; Zhongping of Xiangzhou, Guangxi.

***Sinoleperditia (Pseudobriartina) subscariosa* subgen. et sp. nov.**

(P1. N, figs. 4, 5; Text-fig. 4:14)

Material: 6 valves.

In the shape of trailing chevron muscle scar, the new species is similar to *S. (Pseudobriartina) scariosa* sp. nov., but the former has a shorter and higher lateral outline and a more broadly rounded posterior end, with mh/ah values ranging from 1.143 to 1.188 (mean mh/ah = 1.162).

Holotype: Yingtang Formation/122107/Ys-132 (P1. N, fig. 5), with a length of 9mm and a height of 6mm.

Paratypes: Yingtang Formation/122108/Zy-3 (P1. N, fig. 4), with a length of 9mm and a height of 6.23mm.

Occurrence: Eifelian Yingtang Formation; Zhongping of Xiangzhou, Guangxi.

***Sinoleperditia (Pseudobriartina) subverticalis* subgen. et sp. nov.**

(P1. N, figs. 9—11; Text-fig. 4:13)

Material: 8 valves.

The new species is characterized by the presence of vertical curved-conic trailing chevron muscle scar, the suboblong outling in lateral view and the most convex ends near mid-height, and may be distinguished from *S. (Pseudobriartina) verticalis* sp. nov.

Holotype: Yingtang Formation/122109. Zy-1 (P1. Ⅲ, fig. 9), with a length of 8mm and height of >4.7 mm.

Paratypes: Yingtang Formation/122110/Zy-4 (P1. Ⅲ, fig. 10), with a length of >6 mm; 122111/Zy-4 (p1. Ⅲ, fig. 11), with a length of >5 mm.

Occurrence: Eifelian Yingtang Formation; Zhongping of Xiangzhou, Guangxi.

Sinoleperditia (Pseudobriartina) sp. 1

(P1. N, fig. 6; Text-fig. 4:16)

Diagnosis: Carapace 9.5mm in length and subelliptical in lateral view. Dorsal margin about $2/3$ of valve length; ventral margin gently convex, with most convexity near posterior or $1/3$ of ventral margin. Ends rounded and posterior one broader than the anterior, with most length of carapace near mid-height.

Brim on ends narrow. Adductor muscle scar large; trailing chevron muscle scar consisting of many fine and small secondary elements and weakly contracted downward like curved-bar shape; $mh/ah = 1.125 \pm$.

Yingtang Formation/122112/Zy-4 (P1. N, fig. 6), with a length of 9.5mm and height of 6.28mm.

Remarks: In the shape, the specimen resembles those of *S. (Pseudobriartina) subscariosa* sp. nov., but the former has the curved-bar shaped trailing chevron muscle scar while the latter the vertical bar-shaped one.

Occurrence: Eifelian Yingtang Formation; Zhongping of Xiangzhou, Guangxi.

Sinoleperditia (Pseudobriartina) obsubulata subgen. et sp. nov.

(P1. N, figs. 7—13; Text-fig. 4:18, 22)

Material: Over 20 carapaces and valves.

Diagnosis: Carapace generally 10mm, some attaining 15mm and suboblong to truncated-circular in lateral view. Dorsal margin slightly shorter than $2/3$ of valve length; ventral margin convex, with most convexity near or slightly behind mid-ventral margin. Ends rounded and posterior one broader than anterior one, with most length of carapace near mid-height. Sides moderately convex in dorsal view and thickest near and slightly below center. Right valve larger than and overlapping left one along free margin; left valve slightly higher than right one along dorsal margin. Stop ridge well-developed along ventral margin of left valve. The "eye" tubercle often poorly developed. Trailing chevron muscle scar slightly smaller than or equal to adductor muscle scar in size, obliquely conic-shaped rapid-

ly contracted downward and consisting of larger and relatively fewer secondary elements; mh/ah values from 1.12 to 1.146, with mean mh/ah=1.13.

Holotype: Tangjiawan Formation/122113/T3-1 (P1. IV, fig. 9), with a length of 11mm and a height of 6.9mm.

Paratypes: Tangjiawan Formation/122114/1218-22 (P1. IV, fig. 7), >8mm in length; 122115/1218-22 (P1. IV, fig. 8), >7.5mm in length; 122116/T3-1 (P1. IV, fig. 10), >4.5mm in length; 122117/T3-1 (P1. IV, fig. 13), >6mm in length; 122118/T3-1 (P1. IV, figs. 11, 12), 15mm in length, 10mm in height and 8.75mm in thickness.

Remarks: The new species resembles *S. (Pseudobriartina) suboblonga* sp. nov. in the shape of the trailing chevron muscle scar, which is relatively larger in size and consisting of relatively fewer and larger secondary elements than the latter, with mh/ah=1.13 (the latter with mh/ah=1.12).

Occurrence: Givetian Tangjiawan Formation, Guilin and Yangshuo, Guangxi.

***Sinoleperditia (Pseudobriartina) yangshuoensis* subgen. et sp. nov.**

(P1. V, figs. 2, 3; Text-fig. 4; 21)

1994 "*Leperditia*" sp. 7, Wang and Liu, pl. III, fig. 8.

Material: 4 valves

Diagnosis: Carapace 10—13mm in length and suboval or subelliptical in lateral view. Dorsal margin relatively shorter; ventral margin convex, with a maximum convexity near posterior 1/3 of ventral margin. Ends rounded, with anterior end narrower than the posterior; maximum length of carapace near mid-height. Trailing chevron muscle scar equal to or even larger than adductor muscle scar in size and curved-conic shaped, with secondary elements prominently reduced in number through mergence of adjacent ones and arranged in parallel ranks to each other; mh/ah values from 1.133 to 1.152, with mean mh/ah=1.14 ±.

Holotype: Tangjiawan Formation/122119/1218-22 (P1. V, fig. 2), >13mm in length and a height of 8mm.

Paratype: Tangjiawan Formation/119420B/1218-22 (P1. V, fig. 3), with a length of 11mm and a height of 7mm.

Remarks: The holotype and paratype of the new species are steinkerns. In general it is similar to *S. (Pseudobriartina) obsubulata* sp. nov. in lateral outline, but its secondary elements of trailing chevron muscle scar are arranged in parallel ranks to each other and reduced in number through mergence of adjacent ones.

Occurrence: Givetian Tangjiawan (or Tonggangling) Formation, Yangshuo, Guangxi.

***Sinoleperditia (Pseudobriartina) subobsubulata* subgen. et sp. nov.**

(P1. IV, fig. 14; P1. V, fig. 1; Text-fig. 4; 24)

Material: Over 11 valves.

In general shape, the new species resembles *S. (Pseudobriartina) obsubulata* sp. nov., but it has a much more broadly rounded posterior end than anterior one and a vertical, typical conic-shaped trailing chevron muscle scar, with $mh/ah = 1.16$, which is also larger than that of the latter.

Holotype: Tangjiawan or Tonggangling Formation/122120/T9-1 (Pl. V, fig. 1), 10mm in length and 6.4mm in height.

Paratype: Tonggangling Formation/122121/BD188 (Pl. N, fig. 14), 7mm in length and 4.6mm in height.

Occurrence: Givetian Tonggangling or Tangjiawan Formation; Guilin and Xiangzhou, Guangxi.

***Sinoleperditia (Pseudobriartina) breviformis* sp. nov.**

(Pl. V, figs. 8—10; Text-fig. 4:20)

Material: Over 9 valves.

In features of muscle scars, especially the trailing chevron muscle scar, this new species looks like *S. (Pseudobriartina) subobsubulata* sp. nov., but differs from the latter in the lateral outline, with relatively strongly convex posteroventral margin, concave anteroventral margin and broadly obtuse posterior end; the mh/ah values ranges from 1.12 to 1.142, with a mean value of 1.13.

Holotype: Tangjiawan Formation/122122/T9-1 (Pl. V, fig. 9), 9mm in length and 6mm in height.

Paratypes: Tangjiawan Formation/122123/T9-1 (Pl. V, fig. 8), 12mm in length and 8.28mm in height; 122124/T4-1 (Pl. V, fig. 10), 10mm in length and 6.72mm in height.

Occurrence: Givetian Tangjiawan Formation; Guilin, Guangxi.

***Sinoleperditia (Pseudobriartina) parallela* subgen. et sp. nov.**

(Pl. V, figs. 4—7; Text-fig. 4:19, Text-fig. 1:B)

Material: Over 19 valves.

Diagnosis: Carapace 10—15mm in length and truncated-elliptical in lateral view. Dorsal margin a little more than $2/3$ as long as valve; ventral margin convex and most convex near posterior $1/3$ of ventral margin. Anterior end rounded and most convex near mid-height; posterior end rounded and prominently broader than anterior one, mostly extending below mid-height. Sides evenly convex in dorsal view, with thickest part slightly below and behind the center. Brims on ends very narrow; stop ridge developed along ventral margin of left valve.

Trailing chevron muscle scar almost vertical conic-shaped and slightly smaller than or subequal to adductor muscle scar in size, consisting of larger secondary elements in parallel

arrangement to each other; mh/ah values from 1.115 to 1.156, with mean mh/ah = 1.13.

Holotype: Tangjiawan Formation/122125/T4-1 (Pl. V, fig. 5), with a length of 12.6 mm and a height of 7.4 mm.

Paratypes: Tangjiawan Formation/122126/T4-1 (Pl. V, fig. 4), with a length of 12 mm and a height of 7.74 mm; 122127/T4-1 (Pl. V, fig. 6), with a length of >11 mm and a height of 7.23 mm; 122128/T4-1 (Pl. V, fig. 7), with a length of >3.5 mm.

Remarks: In general outline, the new species resembles *S. (Pseudobriartina) subobsubulata* sp. nov., but differs in the more convex posterior end, and in the characteristic trailing chevron muscle scar consisting of larger secondary elements in parallel arrangement to each other.

Occurrence: Givetian Tangjiawan Formation; Guilin and Yangshuo, Guangxi.

***Sinoleperditia (Pseudobriartina) obliqua* subgen. et sp. nov.**

(Pl. V, figs. 11, 12; Text-fig. 4:23)

Material: 7 valves.

The new species is easily distinguished from *S. (Pseudobriartina) parallela* sp. nov. by the suboblong outline in lateral view and the curved-conic shaped trailing chevron muscle scar consisting mainly of 2 rows of large secondary elements; its mh/ah value ranges from >1.1 to <1.125, with mean mh/ah = 1.112.

Holotype: Tangjiawan Formation/122129/1218-22 (Pl. V, fig. 11), 10.5 mm in length and 6.7 mm in height.

Paratype: Tangjiawan Formation/122130/1218-22 (Pl. V, fig. 12), >8 mm in length.

Occurrence: Givetian Tangjiawan (or Tonggangling) Formation; Guilin and Yangshuo, Guangxi.

Subgenus *Sinoleperditia (Yaosuoleperditia)* subgen. nov.

Type species: *Sinoleperditia (Yaosuoleperditia) mansueta* (Shi), 1964

Diagnosis: Carapace generally 7 mm \pm , sometimes attaining or over 8 mm in length; mh/ah value commonly >1.2, sometimes attaining or over 1.3; lower end of trailing chevron muscle scar often enlarged in drop-shape.

Remarks: The new subgenus is different from *S. (Pseudobriartina)* subgen. nov. mainly in the mh/ah value >1.2, the smaller-sized carapaces and the trailing chevron muscle scar usually with an enlarged lower end.

Geological and geographical distribution: Late Devonian; South China.

***Sinoleperditia (Yaosuoleperditia) guilinensis* subgen. et sp. nov.**

(Pl. VI, figs. 1—4; Text-fig. 4:25, 26)

Material: 12 valves.

Diagnosis: Carapace generally $< 6\text{mm}$, individually attaining 8mm and suboblong in lateral view. Dorsal margin about $3/5$ as long as valve; ventral margin gently convex. Ends rounded, with anterior one narrower than posterior one; maximum length of carapace near mid-height. Sides moderately convex in dorsal view, with thickest part located in front of center. Narrow brims on ends present; stop ridge developed along ventral margin of left valve.

Trailing chevron muscle scar slightly smaller than adductor muscle scar, consisting of many fine and small secondary elements; mh/ah values ranging from 1.2 to 1.25 , with a mean value of $1.22 \pm$.

Holotype: Guilin Formation/122131/675-2 (P1. VI, fig. 1), 8mm in length and 5mm in height.

Paratypes: Guilin Formation/122132/T17-2 (P1. VI, fig. 2), with a length of 5.5mm and a height of 3.5mm ; 122133/Gj2192-1 (P1. VI, fig. 3), with a length of 6.5mm and a height of 4mm ; 122134/T30-1 (P1. VI, fig. 4), $> 6\text{mm}$ in length.

Occurrence: Frasnian Guilin Formation; Guilin, Guangxi.

***Sinoleperditia* (*Yaosuoleperditia*) *laorenshanensis* subgen. et sp. nov**

(P1. VI, fig. 5)

Material: 3 valves.

In the shape of the trailing chevron muscle scar, the new species resembles *S. (Yaosuoleperditia) guilinensis* sp. nov., but can be easily distinguished from the latter by the much broader posterior end than the anterior one, the strongly convex posteroventral margin and the weak posterodorsal inflation; its mh/ah value $= 1.24 \pm$.

Holotype: Guilin Formation/122135/675-1 (P1. VI, fig. 5), with a length of 9mm and a height of 6.1mm .

Occurrence: Frasnian Guilin Formation; Guilin, Guangxi.

***Sinoleperditia* (*Yaosuoleperditia*) *mansueta* (Shi), 1964**

(P1. VI, fig. 17; Text-fig. 4:27)

1964 *Leperditia mansueta* Shi, p. 37, pl. 1, figs. 5—9.

Adductor muscle scar attaining or over $1/3$ as high as valve, suboval, composed of many secondary elements including a secondary muscle scar area, which is much larger than the rest of secondary elements in anterior and upper part of the adductor muscle scar. Trailing chevron muscle scar thin and long, curved-conic in shape with a drop-shaped lower end, and consisting of numerous secondary elements; mh/ah values ranging from $1.2 \pm$ to 1.212 , with a mean value > 1.2 .

Plesiotype: Yaosuo Formation/122136/Hs-7 (P1. VI, fig. 17), with a length of $> 8\text{mm}$ and a height of 6.26mm .

Occurrence: Famennian Yaosuo Formation; Dushan, Guizhou.

***Sinoleperditia* (*Yaosuoleperditia*) *zhongweiensis* subgen. et sp. nov.**

(Pl. VI, fig. 15; Text-fig. 4:29)

Material: Over 14 valves.

The new species is similar to *S. (Yaosuoleperditia) mansueta* (Shi), 1964 in the presence of truncated-circular outline in lateral view, the narrow brims on ends and the trailing chevron muscle scar with a drop-shaped lower end, but differs from the latter in the trailing chevron muscle scar mainly consisting of fewer and larger secondary elements; its mh/ah value ranges from 1.22 to 1.24, with a mean value = 1.237.

Holotype: Lower Member of Zhongning Formation/122137/Q91-HB-2 (Pl. VI, fig. 15), with a length of 7mm and a height of 5mm.

Occurrence: Famennian Lower Member of Zhongning Formation; Zhongwei, Ningxia.

***Sinoleperditia* (*Yaosuoleperditia*) *equiangularis* (Hou et Shi), 1964**

(Pl. VI, fig. 16; Text-fig. 4:28)

1964 *Leperditia equiangularis* Hou et Shi, p. 36, pl. I, figs. 1—3.

Trailing chevron muscle scar fine and long, curved-conic in shape, with a drop-shaped lower end, and consisting of fewer and larger secondary elements; mh/ah = 1.27 ±.

Plesiotype: Yaosuo Formation/122138/Hs-4 (Pl. VI, fig. 16), 7mm in length and 4.5mm in height

Occurrence: Famennian Yaosuo Formation; Dushan, Guizhou.

***Sinoleperditia* (*Yaosuoleperditia*) *dongcunensis* subgen. et sp. nov.**

(Pl. VI, figs. 12—14; Text-fig. 4:30)

Material: 8 valves.

Diagnosis: Carapace generally 6mm, individually attaining 7mm and suboblong in lateral view. Dorsal margin about 4/7 as long as valve; ventral margin gently convex. Ends rounded, with posterior end slightly broader than anterior one; maximum length of carapace below mid-height. Sides evenly and gently convex in dorsal view and thickest slightly below mid-height. Brims on ends undeveloped; fine stop ridge present along ventral margin of left valve.

Trailing chevron muscle scar nearly equal to adductor muscle scar in size, curved-conic in shape, with a blunt lower end, and composed of about 8 longitudinal ranks each containing 4 secondary elements in upper part and reduced to 2 secondary elements in lower part; mh/ah = 1.25 ±.

Holotype: Dongcun Formation/122139/T48-1 (Pl. VI, fig. 13), with a length of 6mm and a height of 3.75mm.

Paratypes: Dongcun Formation/122140/T48-1 (P1. VI, fig. 12), >7mm in length; 122141/T48-1 (P1. VI, fig. 14), >6mm in length.

Remarks: The new species may be distinguished from other species of this subgenus by the evenly and gently convex carapace in dorsal view and the trailing chevron muscle scar with blunt lower end, consisting of several ranks of larger secondary elements.

Occurrence: Famennian Dongcun Formation; Guilin, Guangxi.

***Sinoleperditia (Yaosuoleperditia) obtusa* subgen. et sp. nov.**

(P1. VI, figs. 9, 10; Text-fig. 4; 31)

Material: 7 valves.

This new species looks like *S. (Yaosuoleperditia) dongcunensis* sp. nov. in lateral outline, but differs in the middle part of posterior end extending posteriorly at an obtuse angle and the relatively broad and blunt trailing chevron muscle scar; its mh/ah value ranges from 1.195 to 1.255, with a mean value = $1.24 \pm$.

Holotype: Dongcun Formation/122142/T48-1 (P1. VI, fig. 10), with a length of 7mm and a height of 4.31mm.

Paratype: Dongcun Formation/122143/T48-1 (P1. VI, fig. 9), with a length of 6.4mm and a height of 4mm.

Occurrence: Famennian Dongcun and Etoucun Formations; Guilin, Guangxi.

Sinoleperditia (Yaosuoleperditia) sp. 1

(P1. VI, figs. 6—8; Text-fig. 4; 32)

The specimens are preserved as fragments, but with clear muscle scars. The trailing chevron muscle scar is almost equal to the adductor muscle scar in size, curved-conic in shape, with a pointed lower end, consisting of 2 vertical rows of large secondary elements, by which it is distinguished from other species of this subgenus. Its mh/ah value is <1.2 .

Dongcun Formation/122144/T48-1 (P1. VI, fig. 6), >7mm in length; 122145/T48-1 (P1. VI, fig. 7), 6mm in length and 3.7mm in height; 122146/T48-1 (P1. VI, fig. 8), >5mm in length and 3mm in height.

Occurrence: Famennian Dongcun and Etoucun Formations; Guilin, Guangxi.

Sinoleperditia (Yaosuoleperditia) sp. 2

(P1. VI, fig. 11; Text-fig. 4; 33)

Trailing chevron muscle scar with 4 ranks of secondary elements, each rank with 2 secondary elements in the upper part, and a large, elongated secondary element in the lower part; mh/ah = $1.25 \pm$.

Dongcun Formation/122147/T48-1 (P1. VI, fig. 11), with a length of 6mm and a height of 3.75mm.

Occurrence: Famennian Dongcun Formation; Guilin, Guangxi.

Genus *Paramoelleritia* Wang, 1976

Type species: *Paramoelleritia* (*Paramoelleritia*) *xiangzhouensis* Wang, 1976

Diagnosis: Carapace ranging from 10 to more than 80mm. Posterodorsal inflation well-developed on both valves. Right valve larger than and overlapping left one; stop ridge and overlap platform present along ventral margin of left valve. Radiating and transversal markings commonly developed. Hingement holomerodont (P1. II, fig. 3). Trailing chevron muscle scar always present.

Subgenera: *Paramoelleritia* (*Paraleperditia*) Sun, 1978, *P.* (*Paramoelleritia*) Wang, 1976 and *P.* (*Brevileperditia*) subgen. nov.

Remarks: This genus is different from *Sinoleperditia* Wang, 1989 in the holomerodont hingement, large-sized carapace and well-developed posterodorsal inflation on each valve.

Dalelina Sun, 1978, a monotype genus, with type species *D. guangxiensis* erected by Sun (1978) on the basis of a steinkern, is considered as a synonym of *Paraleperditia* Sun, 1978.

Specimens with posterodorsal inflation on each valve also have been found from the Frasnian Guilin Formation of Guilin, Guangxi. They may belong to a new subgenus in light of their small-sized carapace ($<8\text{mm}$) and mh/ah value (>1.2). But it can not be erected here due to the lack of sufficient and well-preserved specimens.

Geological and geographical distribution: Emsian to Eifelian; Frasnian; South China.

Subgenus *Paramoelleritia* (*Paraleperditia*) Sun, 1978

Type species: *Paramoelleritia* (*Paraleperditia*) *zhongguoensis* Sun, 1978

Diagnosis: Carapace generally 10—40mm. Sides relatively convex in dorsal view; posterodorsal inflation developed on each valve but hardly to slightly projecting above the dorsal margin. Marginal brims present on both ends; mh/ah values ranging from 0.9 to $1.1 \pm$.

Geological and geographical distribution: Emsian; South China.

***Paramoelleritia* (*Paraleperditia*) *guangxiensis* (Sun), 1978**

(P1. I, figs. 11, 12; Text-fig. 4:5)

1978 *Dalelina guangxiensis* Sun, p. 124, pl. 32, figs. 3a—d.

1994 *D. guangxiensis*, Wang and Liu, p. 154, pl. II, figs. 10, 11.

The holotype of this species is a steinkern with anterior end broken. The adductor muscle scar is large and slightly inclined backward, consisting of a lot of quadrangular secondary elements. The trailing chevron muscle scar is curved-conic in shape, also composed of many small secondary elements; mh/ah = $0.95 \pm$.

Occurrence: Early Emsian Ertang Formation; Xiangzhou, Guangxi.

***Paramoelleritia (Paraleperditia) miaohuangensis* (Sun), 1978**

(Pl. I, figs. 13—15)

1978 *leperditia miaohuangensis* Sun, p. 121, pl. 30, figs. 5a—d.

Except for the larger-sized carapace and relatively gentle convexity in dorsal view, our specimens coincide with those of *P. (Paraleperditia) miaohuangensis* (Sun), 1978 from the early Emsian Ertang Formation in other features.

Plesiotype: Ertang Formation/122148/Ys-152 (Pl. I, figs. 13—15), 32mm in length, 20.8mm in height and 16mm in thickness.

Occurrence: Early Emsian Ertang Formation; Xiangzhou, Guangxi.

***Paramoelleritia (Paraleperditia) subquadrata* sp. nov.**

(Pl. II, figs. 7—9; Text-fig. 4:8)

Material: 10 valves.

Diagnosis: Carapace generally 10—15mm, subsquare to truncated-circular in lateral view. Dorsal margin a little more than 2/3 as long as valve; ventral margin relatively convex. Ends rounded, with posterior end broader than anterior one; maximum length of carapace near or slightly above mid-height. Sides more convex in dorsal view and thickest near the center. posterodorsal inflation on each valve well-developed but hardly projecting above dorsal margin. Brims on ends moderately broad; stop ridge and overlap platform well-developed along ventral margin of left valve. Adductor muscle scar consisting of a lot of secondary elements; trailing chevron muscle scar nearly vertical conic-shaped, also composed of numerous secondary elements; mh/ah values ranging from 0.95 to 1, with a mean value = 0.99.

Holotype: Lower part of Sipai Formation/122149/Zs-0 (Pl. II, fig. 7), with a length of 10mm and a height of 7mm.

Paratypes: Lower part of Sipai Formation/122150/Zs-0 (Pl. II, fig. 8), with a length of 10mm and a height of 7.4mm; 122151/Zs-2 (Pl. II, fig. 9), with a length of >9mm.

Remarks: The new species is distinguished from other species of this subgenus by the vertical bar-shaped trailing chevron muscle scar and the short and high carapace.

Occurrence: Lower part of late Emsian Sipai Formation; Xiangzhou, Guangxi.

Subgenus *Paramoelleritia (Paramoelleritia)* Wang, 1976

Type species: *Paramoelleritia (Paramoelleritia) xiangzhouensis* Wang, 1976

This subgenus is different from *P. (Paraleperditia)* and *P. (Brevileperditia)* subgen. nov. in its very large-sized carapace (commonly 30mm, sometimes attaining or over 80mm) and strongly developed posterodorsal inflation on each valve, which is prominently arched above the dorsal margin like a "hump". In this subgenus, the mh/ah value ranges from slightly smaller than 1 to larger than 1.1, and the margin brim is well-developed on each

end.

Remarks: Among the 5 species and 2 subspecies of this subgenus established by the present writer in 1976, some of them may be in need of a restudy because the change of trailing chevron muscle scar was not taken into consideration at that time.

Geological and geographical distribution: Late Emsian to Eifelian; South China.

***Paramoelleritia (Paramoelleritia) xiangzhouensis* Wang, 1976**

(Pl. I, figs. 1—3; Text-fig. 4: 6)

1976 *Paramoelleritia xiangzhouensis* Wang, p. 233, pl. I, figs. 3—7, 10—12.

1994 *P. xiangzhouensis*, Wang and Liu, pl. I, fig. 9.

The adductor muscle scar is composed of over 100 secondary elements; the trailing chevron muscle scar is curved-conic in shape and comprises 60—80 fine secondary elements; $mh/ah=0.99\pm$.

Occurrence: Late Emsian lower part of Sipai Formation and lower Tangxiang Formation; Xiangzhou and Nandan, Guangxi.

Paramoelleritia (Paramoelleritia) sp. 1

(Pl. I, figs. 5, 6; Text-fig. 1: A)

The specimens are poorly preserved but with clear muscle scars as shown in Text-fig. 1: A and pl. I, fig. 5. The adductor muscle scar is subcircular or subelliptical and composed of many secondary elements. The trailing chevron muscle scar is slightly inclined backward and conic-shaped, consisting of a lot of fine secondary elements; $mh/ah=0.98\pm$.

Lower part of Sipai Formation/Zs-1 (Pl. I, figs. 5, 6), >23mm in length and 16mm in height.

Occurrence: Lower part of Late Emsian Sipai Formation; Xiangzhou, Guangxi.

Paramoelleritia (Paramoelleritia) sp. 2

(Pl. I, fig. 4; Text-fig. 4: 7)

The specimen is preserved as fragments but with very clear muscle scars. The adductor muscle scar is large and inclined posteriorly, consisting of numerous subquadrangular secondary elements. The trailing chevron muscle scar is short and wide, curved-conic in shape, and containing a lot of fine secondary elements; $mh/ah=0.98\pm$.

Lower part of Sipai Formation/122153/Zs-1 (Pl. I, fig. 4), >20mm in length.

Occurrence: Lower part of late Emsian Sipai Formation; Xiangzhou, Guangxi.

Paramoelleritia (Paramoelleritia?) sp. 3

(Pl. I, fig. 10; Text-fig. 4: 10)

Diagnosis: Carapace medium-sized and truncated-circular in lateral view. Ends round-

ed, with posterior end much broader than anterior one; maximum length of valve near mid-height; ventral margin strongly convex, and most convex slightly behind mid-ventral margin. Sides more convex in dorsal view and thickest near center. Postero-dorsal inflation on each valve relatively well-developed. Adductor muscle scar consisting of many secondary elements; trailing chevron muscle scar curved-conic in shape but not closely surrounding the adductor muscle scar (apart from the anterior margin of the adductor muscle scar), consisting of fine secondary elements; $mh/ah=1.1\pm$.

Dingshanling Member (or upper part) of Sipai Formation/122154/Zs-1 (Pl. II, fig. 10), >12mm in length and 9mm in height.

Occurrence: Dingshanling Member of late Emsian Sipai Formation; Xiangzhou, Guangxi.

Subgenus *Paramoelleritia* (*Brevileperditia*) subgen. nov.

Type species: *Paramoelleritia* (*Brevileperditia*) *subcircularis* sp. nov.

Diagnosis: Carapace usually larger than 10mm but smaller than 20mm, relatively high in lateral view and tumid in dorsal view; posterodorsal inflation on each valve developed but hardly to slightly arched above the dorsal margin. Brims on ends undeveloped; a fine ridge visible along the free margin of right valve; $mh/ah=1.1\pm$.

Remarks: This subgenus is similar to *P. (Paraleperditia)* Sun, 1978 in the posterodorsal inflation hardly to slightly arched above the dorsal margin, but differs from the latter in the absence of brims on ends and the relatively small carapace.

Geological and geographical distribution: Late Emsian; South China.

***Paramoelleritia* (*Brevileperditia*) *subcircularis* subgen. et sp. nov.**

(Pl. II, figs. 1—5; Text-fig. 4 : 11)

Material: Over 5 carapaces.

Diagnosis: Carapace $10\text{mm}\pm$ in length and truncated-circular in lateral view. Dorsal margin a little more than half as long as carapace; ventral margin strongly convex, and most convex behind mid-ventral margin. Ends rounded, with posterior end prominently broader than the anterior; anterior end mostly extending above mid-height but posterior end near mid-height. Carapace tumid in dorsal view, with a maximum thickness slightly posterior to middle. Posterodorsal inflation well-developed but hardly arched above dorsal margin. Right valve larger than and overlapping the left one along free margin, most overlap along mid-ventral margin. Brims on ends absent; stop ridge and overlap platform well-developed along ventral margin of left valve; a fine ridge present along free margin of right valve. Adductor muscle scar subelliptical; trailing chevron muscle scar almost vertical conic-shaped, not closely surrounding the anterior margin of adductor muscle scar, consisting of many secondary elements; $mh/ah=1.1\pm$.

Holotype: Dingshanling Member of Sipai Formation/122155/Ys-125 (Pl. Ⅲ, figs. 1—4), 10.5mm in length, 8.2mm in height and 7.2mm in thickness.

Paratype: Dingshanling Member of Sipai Formation/122156/Zt-1 (Pl. Ⅲ, fig. 5), 10mm in length, 7mm in height and 6.2mm in thickness.

Occurrence: Dingshanling Member of late Emsian Sipai Formation; Xiangzhou, Guangxi.

Paramoelleritia (Brevileperditia) cf. dingshanlingensis (Sun et Wang), 1985

(Pl. Ⅰ, figs. 11, 12; Text-fig. 4 + 9)

Except for the relatively short and high carapace and the smooth posterior end, the specimens are coincident with those of *P. (Brevileperditia) dingshanlingensis* established by Sun and Wang (Chen-xian) in 1985 from the Dingshanling Member of the Sipai Formation of Xiangzhou, Guangxi in other features. The trailing chevron muscle scar is curved-conic in shape, not closely surrounding the anterior margin of the adductor muscle scar, with a blunt lower end; the adductor muscle scar is subelliptical and composed of many secondary elements; mh/ah value is about $1.1 \pm$.

Plesiotype: Dingshanling Member of Sipai Formation/122157/Zt-3 (Pl. Ⅱ, fig. 11), with a length of 10mm and a height of 6.8mm; 122158/Zt-3 (Pl. Ⅱ, fig. 12), with a length of 12mm and a height of 8.5mm.

Occurrence: Dingshanling Member of late Emsian Sipai Formation; Xiangzhou, Guangxi.

Explanation of plates

With the exception of those specimens in Pl. Ⅰ, figs. 8, 9, 11, 12, which were reported by Sun in 1978 and Jiang in 1983, the remaining specimens described in this paper are housed in Nanjing Institute of Geology and Palaeontology, Academia Sinica.

Plate I

1—3. *Sinoleperditia (Sinoleperditia) brevis* Wang et Liu, 1994

1. Steinkern, right view ($\times 8$) of *Sinoleperditia brevis* Wang et Liu, 1994, holotype, 119393, YQCH-1; 2. Steinkern, right view ($\times 8$) of *S. brevis*, paratype, 119397, YQCH-1; 3. Steinkern, left view ($\times 14$) of *S. brevis*, paratype, 119398, YQCH-1, showing hingement. All from the early Lochkovian Xiaishancun Formation of Qujing, Yunnan.

4, 5. *Sinoleperditia (Sinoleperditia) yulinensis*, new name

4. Steinkern, left view ($\times 9$) of *Sinoleperditia guangxiensis* Wang, 1989, holotype, 103672, G1-023-37, from the late Lochkovian strata of Zhangmu, Yulin, Guangxi; 5. Right view ($\times 8$), plesiotype, 122096, 119b, from Xitun Formation (probably corresponding to the late Lochkovian) of Qujing, Yunnan.

6, 7. *Sinoleperditia (Sinoleperditia) subbrevis* sp. nov.

6. Right view ($\times 8$), holotype, 122097, 119b; 7. Steinkern, right view ($\times 8$), paratype, 122098, 119b. Both from the Xitun Formation of Qujing, Yunnan.

8, 9. *Sinoleperditia (Sinoleperditia) delicatis* (Jiang), 1983

8. Right view ($\times 3$) of *Leperditia delicatis* Jiang, 1983, holotype, YOL-18, from the Cuifengshan Formation of Qujing, Yunnan; 9. Enlarged muscle scars of the same specimen, $\times 16$.
10. *Sinoleperditia* (*Sinoleperditia*) sp.
Steinkern, left view ($\times 7$) of "*Leperditia*" sp. (Wang and Zhang, 1983; Pl. 1, fig. 4), 76073, LF-10, from the early Emsian lower Tangding Formation of Nandan, Guangxi.
- 11,12. *Paramoelleritia* (*Paraleperditia*) *guangxiensis* (Sun), 1978
11. Steinkern, left view ($\times 3$) of *Dalelina guangxiensis* Sun, 1978, holotype, IV65712, from the early Emsian Ertang Formation of Xiangzhou, Guangxi; 12. Enlarged muscle scars of the same specimen, $\times 10$.
- 13—15. *Paramoelleritia* (*Paraleperditia*) *miaohuangensis* (Sun), 1978
Right, dorsal and ventral views ($\times 2$) of plesiotype specimen, 122148, Ys-152, from the early Emsian Ertang Formation of Xiangzhou, Guangxi.

Plate I

- 1—3. *Paramoelleritia* (*Paramoelleritia*) *xiangzhouensis* Wang, 1976
1. Steinkern, left view ($\times 1.6$) of *Paramoelleritia xiangzhouensis* Wang, 1976, holotype, 41113, Ys-175, from the late Emsian lower part of Sipai Formation, Xiangzhou, Guangxi; 2. Partial enlargement ($\times 3$) of the same specimen, showing the muscle scars; 3. Partial enlargement of right valve (steinkern) ($\times 4$) of *P. xiangzhouensis* (Wang and Zhang, 1983; Pl. 1, figs. 1, 2, 76072, NL-39) from the late Emsian lower Tangxiang Formation of nandan, Guangxi, showing the hingement.
4. *Paramoelleritia* (*Paramoelleritia*) sp. 2
Fragment of left valve ($\times 6$), showing the muscle scars, 122153, Zs-1, from the late Emsian lower part of Sipai Formation, Xiangzhou, Guangxi.
- 5,6. *Paramoelleritia* (*Paramoelleritia*) sp. 1
6. Fragment of right valve ($\times 3$), 122152, Zs-1, from the late Emsian lower part of Sipai Formation of Xiangzhou, Guangxi; 5. Partial enlargement ($\times 6$) of the same specimen, showing the muscle scars.
- 7—9. *Paramoelleritia* (*Paraleperditia*) *subquadrata* sp. nov.
7. Right view ($\times 7$) of holotype specimen, 122149, Zs-0; 8. Left view ($\times 5$) of paratype specimen, 122150, Zs-0; 9. Fragment of left valve, paratype, 122151, Zs-2. All from the late Emsian lower part of Sipai Formation, Xiangzhou, Guangxi.
10. *Paramoelleritia* (*Paramoelleritia*?) sp. 3
Right valve, $\times 6$, 122154, Zt-1, from the late Emsian Dingshanling Member (or upper part) of Sipai Formation, Xiangzhou, Guangxi.
- 11,12. *Paramoelleritia* (*Brevileperditia*) cf. *dingshanlingensis* (Sun et Wang), 1985
11. Lateral view ($\times 5$) of right valve, plesiotype, 122157, Zt-3; 12. Partial enlargement ($\times 10$) of left valve, showing the muscle scars, plesiotype, 122158, Zt-3. Both from the late Emsian Dingshanling Member of Sipai Formation, Xiangzhou, Guangxi.

Plate II

- 1—5. *Paramoelleritia* (*Brevileperditia*) *subcircularis* subgen. et sp. nov.
1—4. Right, left, dorsal and ventral views ($\times 5$) of holotype specimen, 122155, Ys-125; 5. Partial enlargement of right valve ($\times 5$) of carapace, showing the muscle scars, paratype, 122156, Zt-1. Both from the late Emsian Dingshanling Member of Sipai Formation, Xiangzhou, Guangxi.
- 6—8. *Sinoleperditia* (*Pseudobriartina*) *suboblonga* subgen. et sp. nov.
6. Steinkern, right view ($\times 6.5$) of holotype specimen, 122099, Zy-1; 7. Steinkern, left view ($\times 7$), paratype, 122100, Zy-1; 8. Latex of right valve in internal view ($\times 8$), showing the muscle scars, 122101, Zy-1. All from

the Eifelian Yingtang Formation of Xiangzhou, Guangxi.

9—11. *Sinoleperditia* (*Pseudobriartina*) *subverticalis* subgen. et sp. nov.

9. Steinkern, right view ($\times 7$), holotype, 122109, Zy-1; 10. Steinkern, fragment, left view ($\times 6$), paratype, 122110, Zy-4; 11. Steinkern, fragment, left view ($\times 6.5$), paratype, 122111, Zy-4. All from the Eifelian Yingtang Formation, Xiangzhou, Guangxi.

12—14. *Sinoleperditia* (*Pseudobriartina*) *verticalis* subgen. et sp. nov.

12. Steinkern, right view ($\times 7$) of "*Leperditia*" sp. 2 (Wang and Liu, 1994: Pl. I, fig. 12), paratype, 119420A, Zy-4; 13. Steinkern, fragment, right view ($\times 6.5$), paratype, 122103, Zy-4; 14. Lateral view ($\times 7$) of left valve, holotype, 122102, Zy-4. All from the Eifelian Yingtang Formation, Xiangzhou, Guangxi.

Plate IV

1—3. *Sinoleperditia* (*Pseudobriartina*) *scariosa* subgen. et sp. nov.

1. Steinkern, left view ($\times 7$) of holotype specimen, 122104, Zy-4; 2. Steinkern, fragment, left view ($\times 8$), paratype, 122105, Zy-3; 3. Steinkern, right view ($\times 8$), paratype, 122106, Zy-4. All from the Eifelian Yingtang Formation of Xiangzhou, Guangxi.

4,5. *Sinoleperditia* (*Pseudobriartina*) *Subscariosa* subgen. et sp. nov.

4. Steinkern, right view ($\times 7$), paratype, 122108, Zy-3; 5. Steinkern, right view ($\times 5$), holotype, 122107, Ys-132. Both from the Eifelian Yingtang Formation of Xiangzhou, Guangxi.

6. *Sinoleperditia* (*Pseudobriartina*) sp. 1

Steinkern, right view ($\times 7$), 122112, Zy-4, from the Eifelian Yingtang Formation of Xiangzhou, Guangxi.

7—13. *Sinoleperditia* (*Pseudobriartina*) *obsulata* subgen. et sp. nov.

7. Steinkern, fragment, left view ($\times 7$), paratype, 122114, 1218-22; 8. Steinkern, fragment, right view ($\times 7$), showing the muscle scars, paratype, 122115, 1218-22. Both from the Givetian Tonggangling Formation. 9. Steinkern, right view ($\times 6$) of holotype specimen, 122113, T3-1; 10. Steinkern, fragment, left view ($\times 7$), showing the muscle scars, paratype, 122116, T3-1; 11,12. Anterior and right views ($\times 3$) of carapace, paratype, 122117, T3-1; 13. Steinkern, fragment, left view ($\times 8$), showing the muscle scars, 122118, T3-1. All from the Givetian Tangjiawan Formation of Guilin, Guangxi.

14. *Sinoleperditia* (*Pseudobriartina*) *subobsulata* subgen. et sp. nov.

Steinkern, right view ($\times 8$), paratype, 122121, BD-188, from the Givetian Tonggangling Formation of Xiangzhou, Guangxi.

Plate V

1. *Sinoleperditia* (*Pseudobriartina*) *subobsulata* subgen. et sp. nov.

Steinkern, right view ($\times 8$), holotype, 122120, T9-1, from the Givetian Tangjiawan Formation of Guilin, Guangxi.

2,3. *Sinoleperditia* (*Pseudobriartina*) *yangshuoensis* subgen. et sp. nov.

2. Steinkern, right view ($\times 5$), holotype, 122119, 1218-22; 3. Steinkern, right view ($\times 5$) of "*Leperditia*" sp. 7 (Wang and Liu, 1994: Pl. III, fig. 8), paratype, 119420B, 1218-22. Both from the Givetian Tonggangling Formation of Yangshuo, Guangxi.

4—7. *Sinoleperditia* (*Pseudobriartina*) *parallela* subgen. et sp. nov.

4. Left view ($\times 5$) of paratype specimen, 122126, T4-1; 5. Steinkern, right view ($\times 5$), holotype, 122125, T4-1; 6. Steinkern, fragment, right view ($\times 6.5$), paratype, 122127; 7. Steinkern, fragment, right view ($\times 8$), showing the muscle scars, paratype, 122128, T4-1. All from the Givetian Tangjiawan Formation of Guilin, Guangxi.

8—10. *Sinoleperditia* (*Pseudobriartina*) *breviformis* subgen. et sp. nov.

8. Lateral view ($\times 5$) of right valve, paratype, 122123, T9-1; 9. Lateral view ($\times 6.5$) of right valve, holo-

type, 122122, T9-1; 10. Steinkern, right view ($\times 5.5$), paratype, 122124, T4-1. All from the Givetian Tangjiawan Formation of Guilin, Guangxi.

11,12. *Sinoleperditia* (*Pseudobriartina*) *obliqua* subgen. et sp. nov.

11. Lateral view ($\times 5$) of right valve, holotype, 122129, 1218-22; 12. Steinkern, fragment, left view, showing the muscle scars, paratype, 122130, 1218-22. Both from the Givetian Tonggangling Formation of Yangshuo, Guangxi.

Plate VI

1—4. *Sinoleperditia* (*Yaosuoleperditia*) *guilinensis* subgen. et sp. nov.

1. Partial enlargement ($\times 11$) of right valve, showing the muscle scars, holotype, 122131, 675-2; 2. Left view ($\times 8$) of juvenile specimen, paratype 122132, T17-2; 3. Steinkern, left view ($\times 7.5$), paratype, 122133, GJ2192-1; 4. Fragment, lateral view ($\times 8$) of left valve, paratype, 122134, T30-1. All from the Frasnian Guilin Formation of Guilin and Yangshuo, Guangxi.

5. *Sinoleperditia* (*Yaosuoleperditia*) *laorenshanensis* subgen. et sp. nov.

Lateral view ($\times 8$) of right valve, holotype, 122135, 675-1, from the Frasnian Guilin Formation of Guilin, Guangxi.

6—8. *Sinoleperditia* (*Yaosuoleperditia*) sp. 1

6. Steinkern, fragment, left view ($\times 8$), 122144, T48-1; 7. Steinkern, left view ($\times 7$), 122145, T48-1; 8. Steinkern, fragment, 122146, T48-1. All from the Famennian Dongcun Formation of Guilin, Guangxi.

9,10. *Sinoleperditia* (*Yaosuoleperditia*) *obtusa* subgen. et sp. nov.

9. Lateral view ($\times 8$) of left valve, paratype, 122143, T48-1; 10. Steinkern, fragment, left view ($\times 8$), holotype, 122142, T48-1. Both from the Famennian Dongcun Formation of Guilin, Guangxi.

11. *Sinoleperditia* (*Yaosuoleperditia*) sp. 2

Steinkern, right view ($\times 8$), 122147, T48-1, from the Famennian Dongcun Formation of Guilin, Guangxi.

12—14. *Sinoleperditia* (*Yaosuoleperditia*) *dongcunensis* subgen. et sp. nov.

12. Steinkern, fragment, left view ($\times 7.5$), paratype, 122140, T48-1; 13. Steinkern, left view ($\times 8$), holotype, 122139, T48-1; 14. Steinkern, fragment, right view ($\times 7.5$), showing the muscle scars, paratype, 122141, T48-1. All from the Famennian Dongcun Formation of Guilin, Guangxi.

15. *Sinoleperditia* (*Yaosuoleperditia*) *zhongweiensis* subgen. et sp. nov.

Steinkern, right view ($\times 8$), holotype, 122137, Q91-HB-2, from the Famennian Lower Member of Zhongning Formation of Zhongwei, Ningxia.

16. *Sinoleperditia* (*Yaosuoleperditia*) *equiangularis* (Hou et Shi), 1964

Steinkern, right view ($\times 8$), plesiotype, 122138, Hs-4, from the Famennian Yaosuo Formation of Dushan, Guizhou.

17. *Sinoleperditia* (*Yaosuoleperditia*) *mansueta* (Shi), 1964

Steinkern, fragment, right view ($\times 7.5$), plesiotype, 122136, HS-7, from the Famennian Yaosuo Formation of Dushan, Guizhou.

