

# 辽宁本溪上寒武纪——新三叶虫的个体发育

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动物学者和古生物学者对于三叶虫的个体发育一向极为重视。第一,因为三叶虫是地质史上发生最早的高等无脊椎动物,它的个体发育对于其它高等无脊椎动物,特别是甲壳类的发生和演化有重大关系。第二,是三叶虫的个体发育对于三叶虫的自然分类和系统演化都能提供极为宝贵的资料。近十几年来各国研究三叶虫的学者对于个体发育极为注意。中国是产三叶虫最多的国家之一,不但其地理分布极为广泛,整个古生代海相地层中也都有这类动物的出现,尤其是在寒武纪和奥陶纪,其数量之多,种类之繁,实属罕见。同时中国三叶虫动物群并兼有世界各地几个重要类型,因此三叶虫幼虫在中国的发现,应该值得重视。

有关我国三叶虫幼虫发现的报导和描述,五十年来已有论文十余篇,计共约二十种,按照地质年代可分列于下:

## 下 寒 武 纪

- |                                       |                              |
|---------------------------------------|------------------------------|
| 1. <i>Palaeolenus deprati</i> Mansuy  | { 以上两种均产于贵州遵义金鼎山 (卢衍豪, 1942) |
| <i>Pagetia</i> (?) Sp.                |                              |
| 2. <i>Hebediscus orientalis</i> Chang | 产于湖北宜都                       |
| <i>Dipharus spinosus</i> Chang        | 产于湖北长阳                       |
| <i>Lusatiops sinensis</i> Chang       | 产地同上                         |
| <i>Wulingaspis intermedia</i> Lu      | 产于云南武定 (以上四种见张文堂, 1953)      |
| 3. <i>Wutingia tingi</i> Kobayashi    | 产地同上 (小林贞一, 1944)            |

## 中 寒 武 纪

4. 与 *Inouyia divi* (Walcott) 和 *Fuchouia manchuriensis* (Walcott) 共生, 以及可能属 *Amphoton deois* (Walcott) 的一些幼年标本, 产于山东新泰、颜庄等地 (Walcott, 1913)
5. *Amphoton* (*Sunia*) *typica* Kobayashi, 产于山东泰安
- Amphoton* (*Fuchouia*) *manchuriensis* (Walcott) 产地同上 (以上二种见小林贞一, 1942)

## 上 寒 武 纪

6. *Teinestion lansi* Monke,
- Drepanura Ketteleri* Monke (以上二种均产于山东, 蒙阴, 燕子崖 (Monke, 1903))
7. 与 *Shantungia spinifera* Walcott 及 *Stephanocare richthofeni* Monke 等共生的一些幼虫, 产于山东新泰、颜庄等地 (Walcott, 1913)
8. *Hedinaspis regalis* (Troedsson), 产于新疆东天山却尔却克塔克 *Charchagia norini* Troedsson 产于新疆东天山突尔沙格塔格 (以上两种见 Troedsson, 1937)
9. *Hedinaspis kueichouensis* Lu 产于贵州、三都 (卢衍豪 1954)

## 奥 陶 纪

10. *Taihungshania* sp. 产于四川峨嵋山 (小林贞一, 1951)

## 泥 盆 纪

11. *Typhloproetus sinicus* Chang 产于广西、灵川、凤林山 (张文堂, 1955)

以上十多篇报告所描述的幼虫,大多以幼虫发育的后期为主,幼虫发育的早年期极少发现,各个发育阶段亦极不完整,因此只提供了一些个体发育的片断知识。具有幼虫早年期而且幼虫各个发育阶段都比较完整的,据笔者所知,目前在东亚方面有下列四种三叶虫:

1. *Ptychoparia szechuanensis* Sun (卢衍豪, 1939)
2. *Redlichia intermedia* Lu (卢衍豪, 1940)
3. *Redlichia chinensis* Walcott (Kobayashi & Kato, 1951)
4. *Blackwelderia quadrata* Endo<sup>1)</sup> (Endo, 1939)

以上四种中,前两种为云南昆明所产,第三种为辽宁复县三十里铺所产,第四种为辽宁辽阳双庙子所产。

本文记述的为另一个具有幼虫早年期而同时又有许多幼虫后期各个发育阶段的新三叶虫。此新三叶虫定名为 *Parachangshania hsiaoshihensis* Chien (新属,新种),此种系东北太子河队王钰先生等 1950 年采自辽宁本溪小市之南约 15 里的山城子,产于上寒武纪长山统白山层的下部。兹根据太子河队的报告(王钰等, 1954);将山城子白山层剖面摘录于下,以供参考。本文所研究的材料即系本剖面的下部第 3 层所采:

#### 长山统白山层:

7. 灰色薄层状瘤状石灰岩,夹浅红色及浅绿色页岩,上部含三层浅红色竹叶状石灰岩凸镜体,每层厚 10—30 厘米,中部含 *Changshania conica* Sun (BE 939).....2.5 米
6. 浅灰色薄层灰岩夹绿色页岩含 *Chuangia batia* (Walcott) 等 (BE 937-938).....1.5 米
5. 深灰色薄层状石灰岩夹绿色页岩含 *Chuangia batia* (Walcott) 等 (BE 960).....1 米
4. 浅灰色至白色稍带粉红竹叶状石灰岩含 *Chuangia batia* (Walcott) 等 (BE 936).....1 米
3. 深灰色薄层石灰岩夹绿色石灰质页岩由下而上采得化石五层
  - (1) *Chuangia batia* (Walcott) (BE 961)
  - (2) *Obolus* (BE 962)
  - (3) *Pseudagnostus cyclopygeformis* (Sun) 等. (BE 968)
  - (4) *Dikelocephalidae* 科三叶虫 (BE 967)
  - (5) *Parachangshania hsiaoshihensis* Chien (新属,新种)
- Pseudagnostus chinensis* (Dames) (BE 953).....2 米
2. 浅灰色至白色竹叶状石灰岩产 *Pseudagnostus chinensis* (Dames) 等 (BE 955);.....1 米
1. 掩盖

本文所研究的标本均系保存于石灰岩内,其原有的凸度几乎不变,没有被压成扁平,另一方面所有标本似均未受后来岩层被挤压的影响而产生变形。因此不但幼虫各期的背壳保存相当完好,而且由于凸度保存了原来状态,在经过细心修理以后,也可以察见幼虫侧部的许多构造,这一点对于观察许多发育现象,特别如眼脊和眼的移动,活动颊的发生等,有极其重要的意义,这是一般保存在页岩内的标本所难见到的。

从研究 *Parachangshania hsiaoshihensis* 的结果得知,三叶虫眼的发育,根据活动颊迁移的情况,应该是由腹部向背部移动的,这一结论和 Laeicker 氏 (1935) 观察北美中寒武纪三叶虫 *Blainia gregaria* Walcott (?) 的结果完全相反,而与后来 whittington 氏 (1957) 再度观察该种的结果相同。此外,由 *Parachangshania hsiaoshihensis* 发育也可以知道内边

1) 小林貞一认为 *Blackwelderia quadrata* (Resser & Endo) 这个种的头部应该属于 *Anomocarella* 或 *ptychoparia*, 而其尾部则为 *parablackwelderia spectabilis* (Resser & Endo) (Japanese Journ. Geol. Geogr. Vol. XVIII, No. 4, P. 210—212, 1942)

緣是經過許多阶段始行形成的,最后,这个内邊緣并极度发达,成为头鞍之前的主要构造。

近年来,一般对于三叶虫的发育多分为三期,即: (1) 幼年期 (Protaspid Stage), (2) 中年期 (Meraspis Stage) 和 (3) 成年期 (Holaspis Stage)。幼年期又可分为幼年早期和幼年晚期二个亚期。本文材料甚多,共一百四、五十件,按其发育情况大致可分为 18 期,即幼年早期 1 期,幼年晚期 6 期,中年期 8 期和成年期 3 期。

## 系 統 描 述

### 一、成 虫 标 本

超科: *Dikelocephalacea* Richter 1932

科 *Changshaniidae* Hupo 1953

属 *Parachangshania* Chien (新属)

属型 *Parachangshania hsiaoshihensis* Chien (新种)

定义 头盖作亚方形。头鞍明显,中度凸起,細而长,作切錐状,具三对模糊而又向后傾斜的头鞍沟。頸沟浅,橫过头鞍。頸环中等凸起,寬度均匀。内邊緣寬,低凹,向前傾斜。外邊緣狹,升起,向前凸出。邊緣沟既寬且深。固定頰狹,稍寬于头鞍在两眼叶間寬度之半,眼脊前叶清楚,寬而平坦,位于头鞍前端之兩側。眼叶大,作新月形,位于头盖中部相对位置的稍后方。眼沟深,向外弯曲。后側翼狹小,向后側方微微傾斜。面綫前支向前扩大,与前邊緣联成圓弧状。活动頰寬,凸起。邊緣沟深而寬。邊緣狹,寬度均等,向后方延伸成一頰刺。唇板大,中央作长卵形;側脊窄而隆起,后部渾圓;前側叶平坦,作三角状,兩側向下傾斜。尾部作半圓状;中軸狹,具七到九对的軸节;肋叶寬而平坦,約七到八对;肋沟浅;邊緣寬而平坦,較清楚。

比較 驟然一看,此新属与 *Changshania* Sun 很相似,但將两者仔細地加以比較,則可清楚看出前者具有較狹的头鞍,内邊緣較寬,向前急傾斜,外邊緣向上升起,后側翼較短,面綫前支向前強烈扩大,尾軸較狹,尾部前側部較圓。

此新属三叶虫和孙云鑄教授在 1935 年所創立的 *Changshanocephalus* 也有些相似,但前者具有較細长的头鞍,眼叶較大并且具有向前扩大的面綫前支。

此新属与 *Lioparia* Lorenz 也有些相似之处,主要区别为:前者的头鞍細长,固定頰較寬,内邊緣狹,頸环寬度均匀而且不很显著和具有較大的新月形眼叶。

*Parachangshania* 与 *Aphelaspis* Resser 和 *Pedinocephalus* Ivshin 都有些相似,但其区别在于: *Aphelaspis* Resser 具有較短的头鞍,較寬的固定頰及較小的眼叶,面綫前支向前不甚扩大。將 *Parachangshania* 与 *Pedinocephalus* Ivshin 的属型相比时,則可明显看出: *Pedinocephalus* Ivshin 具有較短的切錐形头鞍,較寬的内邊緣和較小的眼叶。

、 地質历程及地理分布 辽宁太子河流域上寒武紀长山統。

*Parachangshanina hsiaoshihensis* (新属, 新种)

(图版Ⅱ图 4, 7—9, 15)

**描述** 头盖作亚方形。头鞍细长, 切锥状, 前端浑圆, 中等凸起, 具三对头鞍沟: 第一对很短, 很模糊, 仅在头鞍两侧才有一些轻微的痕迹, 第二对浅, 向后倾斜, 轻微显出, 第三对较清楚, 在头鞍两侧较宽, 向后倾斜逐渐变浅变细, 互不相通。颈沟浅而宽, 隐约显出, 成水平方向横穿头鞍。颈环轻微显出, 凸度中等, 宽度均等。后部边缘平直, 几成直线状。头鞍中央具一轻微凸起的纵脊, 该纵脊自头鞍前端向后延伸至颈沟。背沟清楚, 宽而深, 向前逐渐变浅至眼脊前方急剧变浅变宽, 至头鞍前端显然变得更浅。内边缘低凹, 向前急倾斜, 微微向前弯曲, 其宽度与外边缘之最宽处相仿。边缘沟既深且宽, 其中部向前弯曲, 两侧向后微倾。外边缘向上翘起, 中部较宽, 向两侧渐次变狭。固定颊狭, 稍宽于头鞍在眼叶处宽度之半, 外侧较高, 向内轻微倾斜, 眼叶大, 成新月形, 约为头鞍长度的三分之二, 位于头盖中线的稍后方, 眼沟深而清楚, 中部向外弯曲, 几成直角。眼脊微弱, 自眼叶前端向内前方斜伸, 达头鞍之前侧角。眼脊前叶宽而平坦, 表面光滑作梯形, 位于头鞍前部两侧。后侧翼狭小, 略作三角状, 向后外侧微微倾斜伸展。

面线前支相当长, 向前扩大, 自前端向前侧方倾斜延伸, 切外边缘成浑圆状之切角。面线后支向后侧伸展, 切后边缘之长约等于头鞍基底部的宽度。

活动颊甚宽, 凸起, 边缘沟深而宽。边缘明显, 宽度均匀, 向后延伸成一细长的颊刺。

唇板大, 后端浑圆, 前侧接近平直。中部强烈凸起, 两侧接近平行, 作长卵形。侧沟明显, 中部较浅, 至两端急剧变深。侧脊清楚, 狭而高起。前侧叶狭而平坦, 具一对宽而向下急倾斜的前侧角。

尾部作半圆形, 具一相当宽而平坦的边缘。尾轴细长, 中等凸起, 向后渐次收缩, 至三分之二处, 显著向内收缩, 而后再复扩大, 使尾轴末端微微肿起。轴浅六对, 浅而宽, 横分尾部为六个环节及一个末节。肋叶宽而平坦, 肋沟 6—7 对, 浅而宽, 微微显出。

## 二、幼虫标本

这一种三叶虫的幼虫发育史可分为三个时期: 即幼年期 (Protospid period), 中年期 (Meraspid period) 和成年期 (Holaspid period)。而幼年期同样也分为两个亚期: 即幼年早期 (Anaprotospid stage) 和幼年晚期 (Metoprotaspid stage)。头部和尾部还没有分开的幼虫, 我们把它作为幼年早期, 头部和尾部开始分开的作为幼年晚期。

### (一) 幼年期 (Protaspid period)

#### (1) 幼年早期 (Anaprotaspid stage)

#### 第 一 期

(图版 1 图 1, 1a—1c, 图版Ⅲ图 1, 1a—1b)

这是这一种幼虫标本中最小的一块标本, 长不超过 0.31 毫米, 宽约 0.34 毫米, 壳体作亚圆形, 宽度稍大于长度。前边缘稍平直, 后边缘较浑圆。壳体凸起, 但前半部稍平坦, 后半部凸起较强烈。头鞍或中轴微微分出, 表面光滑, 从前边缘伸至后边缘, 前端宽而平坦,

約占壳体总寬度的三分之一, 向后緩慢收縮, 呈倒錐狀。近末端輕微隆起, 稍高于后側頰部, 其位置相当于頸环。背沟輕微显出, 前后两端較深, 向中部漸次变浅, 只能在側視或斜光下才比較显著。頰部光滑, 前部較寬, 向后逐漸变狹, 中部近头鞍处較平坦, 外側向四週輕微傾斜, 而在后側部傾斜最为显著。

## (2) 幼年晚期 (Metaprotaspid stage)

### 第 二 期

(图版 I 图 2, 2a—2c; 图版 III 图 2, 2a—2b)

这是 Metaprotaspid stage 中的第一期标本, 作圓形, 長約 0.37 毫米, 寬約 0.36 毫米, 它比前一时期有了很大程度的增长; 在壳体后部約五分之四处有一輕微而又稍稍向后弯曲的橫沟, 分壳体为前后两部, 前部(即头部)甚大, 后部(尾部)很小, 約占头部的五分之一。

头部略作橘狀, 兩側渾圓, 向外凸出, 后部向內微微凹进。头鞍明显分出, 稍高于側部, 前端寬而平坦, 向前輕微伸出, 略凸出于前边緣, 向后漸漸收縮变狹。成一倒切錐形。具二对头鞍沟及一对頸沟, 橫分头部中軸成四节。第一对鞍沟最长, 仅兩側稍清楚, 中部很浅, 只能在适当的斜光下才能隱約显出。第二对較短, 兩側較深, 向中部逐漸变浅, 在头鞍中部相互沟通。頸沟平直, 既深且寬, 但很短。头鞍前叶长, 略相当于后兩对头鞍叶的总和, 略作方柱形状, 較平坦, 兩側界限清楚, 前端与向左右兩側延伸的一对錐脊 (Strand, 1927, 頁 321, Störem, 1941, 頁 81) 相联; 第二对头鞍叶輕微凸起, 前部稍寬后部較狹, 与前一对头鞍叶的分界不很清楚。在这兩对头鞍叶之联接处具一縱向的凹坑, 此凹坑, 形似鏈狀, 在第一对头鞍沟处显得很浅, 向前后两端漸次变深。第三对头鞍叶較凸起, 界綫分明, 略作四方形状。頸环明显凸起, 成短柱狀, 中央較高, 向四週漸次傾斜。背沟清楚, 在第一对头鞍叶之前側方較深, 漸次向中部递浅, 至第二对头鞍沟之稍后方又复变深, 在頸环兩側显著地向下凹陷。頰部光滑, 較寬, 約兩倍于头鞍在背壳中部的寬度, 前后部輕微隆起, 中部靠背沟处較平坦, 約在頰部外側三分之一处开始向兩側下方傾斜, 后側部傾斜較前側部显著。如图 I 图 2b, 2c, 图版 III 图 2a, 2b, 所示。錐脊輕微隆起, 略似眉毛狀, 位在頰部之前方。与头鞍前端相联接, 成鉄錨狀, 內側粗狀, 向外平伸而后漸次变細变狹, 隐没于頰部之前側方。前沟介于錐脊与頰部之間, 內側較深, 与背沟相联, 輕微弯曲, 向后側方漸次变浅, 約在頰部外側的三分之二处消失。

尾部很小, 仅及头部的五分之一, 作半圓狀, 为一橫沟分开, 向下傾斜与头部略成垂直狀。如图版 I 图 2b, 2c 及图版 III 图 2b 所示。尾軸短小, 光滑, 強烈凸起, 急剧向后尖出, 略成三角狀。

### 第 三 期

(图版 I 图 3, 3a—c; 图版 III 图 3, 3a—3b)

这是属于 Metaprotaspid stage 期早期的幼虫, 特点与第二期相似, 但比前一期有着稍大程度的成长。体長約 0.42 毫米, 寬約 0.40 毫米, 前部較后部稍寬, 作亞圓形。

头鞍清楚,前端平坦,向前輕微扩大,中部接近平行,后部緩慢收縮,隆起。具两对头鞍沟及一对頸沟;第一对浅而寬,橫穿头鞍。第二对平直,一如第一对,但較浅。第一对头鞍叶較长而平坦,微微向下方傾斜。第二对稍隆起,成四方形状。第三对較短,成短柱形。頸环明显凸起,成四方形状,大小与第三对头鞍叶相似。頸沟清楚,深而寬。背沟明显,前部較深,向中部逐漸变浅。頰部光滑,強烈凸起,兩側向下急剧弯曲。前沟明显,微微向后側方弯曲,內側較深,向外側漸浅,伸抵頰部最寬处才隱約消失。錐脊明显,細而长,向后側部延伸至腹部前側緣。

尾部作半圓状,強烈向后下方弯曲。尾軸明显凸起,光滑不分节,向后剧烈收縮成圓錐状。肋部低,光滑平坦。

#### 第 四 期

(图版 I 图 4, 4a—4c; 图版 III 图 4, 4a—4b)

壳体成亚圓形,強烈凸起,后側部最为显著。全长約 0.46 毫米,寬約 0.44 毫米。背沟清楚,自始至終均极深而寬。头鞍清楚显出,中等凸起,伸至前边緣,前部近于平行,从第二对鞍沟的稍后方开始向后部逐漸收縮。头鞍沟增至三对,第一对較模糊,仅兩側清楚,向中部漸浅。第二、第三对較明显,平直,浅而寬,穿越整个头鞍。头鞍前叶中等凸起,成矩形,向前輕微扩大,稍寬于第二、第三对头鞍叶仍与錐脊相联。第二、第三对的大小相似,均呈四方形状,稍高于头鞍前叶,而显著地高于兩頰。第四对头鞍叶明显分出,中等凸起,长稍大于寬。頸环呈橢圓状,中央較寬,兩端渾圓,显著凸起,明显地高于兩側。頸沟深而狹,水平伸展。前沟清楚,內側寬而深,向外側漸次变浅变狹。頰部光滑,甚寬,約为头鞍中部的兩倍,內側近背沟处稍平坦,前后部輕微隆起,后側部較其他各处弯曲。錐脊与前一期相似,但稍短而弯曲。

尾部明显分出,略作亚紡錘状,急剧向后下方傾斜,中軸凸起,略成三角状,靠前端三分之一处隱約分出一軸节,末端延伸至后边緣。肋叶光滑,不分节,明显地低于中軸。

#### 第 五 期

(图版 I 图 5, 5a—5c; 图版 III 图 5, 5a—5b)

壳体成亚橢圓形,強烈凸起,中部較寬,前后兩端漸狹。呈渾圓状。体長約 0.48 毫米,寬約 0.46 毫米。头鞍明显,中等凸起,向前輕微扩大,中軸具三对橫沟,分头鞍成四节。頸环清楚,強烈凸起,呈亚卵形,中部較寬,兩端較狹,前后左右分別为較深的背沟及頸沟所限。錐脊明显,較前期平坦,稍短,向左右延伸不远即隱匿不見。前沟浅而寬,唯內側較外側为深。輕微向后側方弯曲斜伸。眼脊位于前沟之中部,呈輕微凸起之細脊状,其位置大致与前沟相平行,自头鞍之前側方附近向后側延伸。頰部凸起,后側部強烈向下腹部弯曲,当背視时,部分外側隱匿不見。当側視时,頰部之外側边因埋于岩石中而不能察見。后側叶明显,寬度均匀无变化,为浅而明显的后側沟分开,內側約二分之一較平坦,而外側則剧烈向下方卷曲。

尾部成半圓形,向后外方傾斜,与头部之分界綫明显,占背壳的四分之一。尾軸輕微凸起,略呈圓錐状,直伸抵后边緣,約为后部最寬处的四分之一,为一浅沟橫分为两节。肋

部为一短而浅并略平行于尾部前緣的肋沟分为两叶。

## 第 六 期

(图版 I 图 6, 6a—6c; 图版 III 图 6, 6a—6b)

壳体长约 0.35 毫米, 寬約 0.50 毫米, 中等凸起, 亚圓形, 明显地由头尾两部組成。头部与尾部长度的比例約为 3:1。头部各主要特点与前期相似, 但这一期幼虫的眼脊較為水平。后側沟也更为明显。

尾部作亚卵形, 向两侧尖出, 中軸中等凸起, 隱約分为三节, 第一节稍大, 呈倒梯形, 第二节稍小, 前部寬, 后部狹。最后一节最小, 作三角状。肋部隱約分为三叶, 第一叶較长, 第二叶較短, 第三叶最小, 第一对肋沟較明显, 內側較深, 向外逐漸变浅, 使第 1、第 2 对肋叶之分界綫很模糊。第二对肋沟短而浅, 仅在內側近尾軸处較显著。

## 第 七 期

(图版 I 图 7, 7a—7d 图版 IV 图 1, 1a—1c)

这一期可能为幼年晚期 (Metaprotaspis stage) 的最后一期。体长约 0.55 毫米, 寬約 0.51 毫米, 背壳呈半圓形, 两侧接近平行, 清楚地由头尾两部組成, 头部約为尾部的三倍。背沟清楚, 后部較深, 向前逐漸变浅。头鞍清楚显出, 直伸至前边緣, 明显地高出两頰。前端稍寬, 极其緩地向后收縮。头鞍沟三对, 第一对不很明显, 但两侧很清楚, 呈凹坑状, 中部甚浅, 只能在側視下才較显出, 第二对明显, 平直, 橫穿整个头鞍, 第三对稍短, 深而清楚。第一对头鞍叶寬, 略作短矩形。第二对, 作四方状, 两侧近于平行。第三对較短小。第四对最狹, 呈矩形。頸环清楚分出, 相当凸起, 略作长方形。后側緣狹, 寬度均等, 其寬度与頸环相仿。錐脊較前一期为短而粗壮, 略呈三角状, 內側較寬, 与头鞍前側端相联, 向后側方漸次傾斜尖出, 約在頰部內側的三分之一处即隱沒。此錐脊在这一期中是最后一次存在, 至下一期此錐脊, 在眼脊的前方、第一对头鞍叶的外側, 即形成了一块狹长的平面, 此即所謂眼脊前叶 (Preocular lobe)。頰部光滑, 向外側卷曲, 当背視时內側約四分之三的地区成中等凸起, 而其外側的四分之一的地区则急剧向腹部弯曲。当側視时 (图版 I 图 7b—7d, 图版 IV 图 1a—1c) 在頰部的外側有一狹长表面光滑微微下陷的三角带, 此三角带前端稍寬, 自第一对头鞍沟之延長綫的稍后方, 向后急剧变狹, 此即为活动頰。面綫隱約出現, 自眼叶向后并微向外側伸展, 切于头部后側緣的稍前方; 前沟清楚, 輕微低洼, 約成三角状, 向外漸次扩大, 約在眼脊之外端附近与活动頰相邻。眼脊清楚, 明显凸起, 微微向后弯曲, 位在前沟的中部, 在第一对头鞍沟之稍前方向后側傾斜延伸, 內側較細向外逐漸变粗变壮。末端与輕微肿起成小瘤状的眼叶相邻。后側緣狹, 寬度均等。尾部清楚, 略作半圓形, 中等凸起。急剧向后傾斜。中軸显著凸起, 略作三角状, 向后逐漸收縮, 伸至后边緣, 为二对深而寬的軸沟分为三节。第一对清楚作长方形状; 第二对較第一对狹而短; 第三对作圓錐状, 稍短于第一与第二对之和。肋部略作三角形, 稍大于尾軸前端的两倍, 具两对向后傾斜的肋沟: 第一对肋叶較闊而长, 平行于后側緣; 第二对狹而短; 第三对作三角状。

## (二) 中 年 期 (Meraspid period)

## 第 八 期

(图版 I 图 8, 8a—8b; 图版 IV 图 2, 2a,)

从这一期开始,只找到头部或尾部,而没有整体的幼虫标本,这也許是因出现了胸节而使头尾易于断裂,由此中年期 (Meraspid period) 可能即从这期开始。

壳体作梯形,前侧缘平直,中央凸起,向前方及两侧倾斜。长约 0.50 毫米,宽约 0.63 毫米。背沟清楚,但在第一对头鞍沟两侧较浅而宽,往后逐渐变深变宽。头鞍清楚,两侧平行,作方柱状,伸抵前边缘,明显地凸出两颊。具三对头鞍沟及一对颈沟:第一对两侧较深,中部渐浅,水平地横贯头鞍;第二对较深,中部轻微向后弯曲;第三对宽,并且清楚显出,向后显著弯曲。第一对头鞍叶两侧不很明显,作长方形。第二对清楚显出,作短柱形。第三、第四对甚清楚,外形相似,均较短,后侧均向后轻微弯曲。颈环最小,但很清楚,作半椭圆状,两端向前微微弯曲,后侧明显向后凸出。其宽约为整个头鞍长度的七分之一。颈沟明显,深而宽,中部向后弯曲。固定颊凸起,表面光滑,其宽约为头鞍底部的一倍半。眼脊前叶平坦,前侧平直,后侧微向内弯,眼脊清楚,轻微凸起,自第一对头鞍之前侧方伸出,开始为水平方向,而后渐次向后外侧倾斜延伸,其末端与一椭圆状的眼叶相接。活动颊狭,光滑,其前端开始于头部的前侧角,向后急剧变宽,至眼叶后方不远处又复缓慢收缩变狭。在背视下仅为 0.004 毫米 (如图版 I, 图 8; 图版 IV 图 2), 但在侧视下,即约为 0.005 毫米 (如图版 I 图 8b; 图版 IV 图 2a)。面线在背视下呈前颊类的形式,但在侧视下面线后支切于头部后侧角成颊角类的形式。

## 第 九 期

(图版 I 图 9, 9a; 图版 IV 图 3, 3a)

为一头蓄标本,长约 0.54 毫米,宽约 0.65 毫米。这一期标本与前期相似,所不同的有这几方面: (1) 头盖具一比较狭的头鞍和较宽的固定颊, (2) 具较短而宽的眼脊前叶, (3) 眼脊较短,眼叶较大, (4) 面线后支切于后侧缘,与背沟间的宽度,稍小于头鞍底部的两倍,而前支切于头盖的前侧缘,约成  $45^\circ$  之切角。活动颊不明。

## 第 十 期

(图版 I 图 10, 10a; 图版 IV 图 4, 4a)

头盖长约 0.59 毫米,宽约 0.76 毫米,作梯形,后部的宽度约为前部的两倍,头鞍作长方形,其长稍大于宽度的两倍,不论从前方到后方,或是从左侧到右侧,均较凸起,延伸至前边缘。

头鞍沟三对,两侧甚深,中部甚浅,分头鞍为四叶。背沟深而宽,略作平行状。固定颊光滑,中等凸起,稍狭于头鞍在两眼叶间的宽度。眼脊清楚,狭,成轻微凸起的细脊状,自头鞍前叶的中部向外横伸,而后向后侧方倾斜伸展。眼叶大而长,约为头鞍长度的三分之二。后侧叶小,较前期为狭。面线前支短,向前轻微扩大,切于头盖的前侧缘;后支较短,切于后侧叶,略成圆形的切角。

## 第 十 一 期

(图版 I 图 11; 图版 IV 图 5)

头盖中等凸起,长约 0.7 毫米,宽约 1.08 毫米。头鞍中等凸起,为深而宽的背沟所限,前端平直,两侧接近平行,作圆筒状,不到前边缘。头鞍沟三对:第一对模糊,仅头鞍两侧有一对凹坑;第二第三对很浅,隐约显出,两侧较深,向后部倾斜变浅,在头鞍中部相互沟通。颈沟深而狭,中部向后弯曲,头鞍前叶较大,略作四方形,轻微向前下方倾斜。其余三对均较短,外形相似,均作短柱状。颈沟深而狭,中部向后微微弯曲。颈环清楚,中部宽,向两侧变狭,明显凸起,作亚卵形。固定颊宽,光滑,中等凸起,稍狭于头鞍在两眼叶后端间之宽。眼沟宽而清楚,后部较深向前渐浅。眼脊轻微凸起,向后倾斜,两侧靠头鞍处较细,向后外侧渐粗。眼叶大而长,明显凸起,向后外侧斜伸,而后急剧变为向后伸展,其末端接近于后侧沟,而与背沟间之宽约相等于头鞍之底部。后侧缘清楚,近头鞍处甚狭,向外急剧变宽。凸起,外边缘清楚,轻微凸起,横向接近水平,宽度均匀,但狭于以后各期。内边缘深而狭,似沟状,横贯水平。眼脊前叶小,自头鞍前侧方,向外伸展渐次扩大。

## 第 十 二 期

(图版 I 图 12; 图版 IV 图 6)

头盖长 0.76 毫米,宽约 1.15 毫米,略作梯形。头鞍强烈凸起,前端稍圆,作圆筒状,具三对短而倾斜的头鞍沟。颈环明显,中等凸起,中部较宽,向后凸出。固定颊光滑,向前缓慢倾斜,稍宽于头鞍在眼间之宽度。内边缘轻微低陷,较前一期为宽,但仍成沟状,外边缘明显凸起,狭而长。眼脊明显凸起,自头鞍前侧向后倾斜伸出。眼叶狭,显著凸出两颊,其长约为头鞍的三分之二,自眼脊向外伸展而后向内弯曲成弧状,眼沟深而宽,外侧靠眼叶处较深,向内侧渐变浅。面线前支向前微微收缩,而后强烈向内弯曲切于前边缘:后支向外几成水平伸展,而后急剧转为向后伸出,切后边缘几成直角状。

## 第 十 三 期

(图版 I 图 13; 图版 IV 图 7)

为一头盖标本,长约 0.90 毫米,头鞍凸起,向前轻微收缩,前端略圆,成圆筒状。具三对短而倾斜的头鞍沟,颈沟很深,横过头鞍,中部平直,两侧向前弯曲。颈环凸起,中部甚宽,两端急剧变狭。内边缘低洼,稍狭于外边缘。外边缘明显凸起,中部微微向前凸出,两侧轻微收缩变狭。固定颊凸起,向前轻微倾斜,与头鞍在眼叶处的宽度相仿。眼脊很清楚,自头鞍之前侧端向后侧方倾斜伸出。眼叶粗大显著,明显凸起,较前期显著缩短,自眼脊相接处缓慢倾斜,约在第二对头鞍沟之延长线处急剧变为向后伸出,成新月状。后侧沟深而宽,靠颈沟处甚狭,向两侧急剧变宽。面线前支切于外边缘,略平行;后支向后侧方斜伸。

## 第 十 四 期

(图版 I 图 14; 图版 III 图 7)

头盖长约 0.95 毫米,宽约 1.24 毫米,这一期标本与前一期很相似,其主要不同点为内

邊緣較寬,面綫前支向前略微擴大,眼葉較短,凸起,眼脊隱約顯出。

### 第 十 五 期

(圖版 II 圖 1)

壳体長約 2 毫米,眼葉間之寬約 3 毫米,可能為中年期的最後一期或成年期的早期。頭鞍成切錐狀,向前輕微收縮。頭鞍溝模糊。頸溝微弱,橫穿頭鞍。固定頰狹,僅為頭鞍中部寬度的一半,內邊緣較前期更寬,平坦向下凹陷。外邊緣甚顯著,相當凸起,中部較寬,向前凸出,稍大於內邊緣寬度之半,兩側變狹。眼葉甚大,明顯顯出,為深而顯著的眼溝所分,作新月狀。面綫前支向前急劇擴大,與頭鞍之中綫約作  $45^\circ$  的交角。

### (三) 成 年 期 (Holaspis Period)

### 第 十 六 期

(圖版 II 圖 2)

這是一塊比以前任何一期更為發育的幼蟲,許多構造已接近成蟲,因而成蟲期可能即已開始。頭蓋長約 3.6 毫米,頭鞍中等凸起,呈切錐狀,前端渾圓,具三對模糊的頭鞍溝,長與底寬的比例約為 8:70 頸溝淺而寬,几成水平狀,橫貫頭鞍。頸環中等凸起,不很顯著,寬度均等,無變化。頭鞍前端具一輕微凸起,平行於邊緣溝的細脊,使頭鞍前區從內邊緣中分出,內邊緣狹,微微彎曲。頭鞍前區稍寬,位於頭鞍前端。外邊緣輕微翹起,中部稍寬,向兩前急劇變狹。固定頰中等凸起,較狹,僅為頭鞍在眼葉處寬度的一半。眼葉大,但較前期為小,明顯凸起,作新月狀,末端向內側移動與背溝之間距約為頭鞍底寬的四分之一。後側緣向外變寬約為頸環寬度的三分之二。

### 第 十 七 期

(圖版 II 圖 3)

頭蓋長約 8.2 毫米,寬約 10.8 毫米,略作梯形,前端向前凸出。頭鞍凸起,後部較寬,向前收縮,前端稍圓,作切錐狀。頭鞍溝三對:第一對甚模糊,第二、第三對較長,隱約顯出,向內傾斜,漸次變淺,互不溝通。頭鞍中央具一輕微凸起的縱脊,該縱脊自頭鞍前端延伸至頸溝。頸溝淺,但清楚。頸環輕微凸起,寬度均等。背溝顯著,兩側較深,至眼脊前方急劇變淺。內邊緣低凹,但較寬,約相等於外邊緣中部之寬度。頭鞍前區低洼,在頭鞍前端較狹,向兩側變寬,與眼脊前葉相聯。邊緣溝寬而深,中部顯著隆起。外邊緣強烈凸起,中部甚寬,向兩側急劇變狹。眼脊前葉清楚,寬而平坦,略成梯形,位於眼脊之前方。固定頰狹,約為頭鞍最寬處之半,外側近眼葉處較高,向內側急劇傾斜。眼葉明顯,頗長,約等於頭鞍長度的三分之二,中部向外彎曲,作弧狀,為深而寬的眼溝分開。後側翼狹,輕微向後側方傾斜,具淺而寬的後側溝。面綫前支向前擴大,與頭蓋前側之延長綫几成垂直伸展,而後向前向內傾斜切外邊緣成渾圓狀的切角;後支自眼脊末端向後側方斜伸,而後急劇向後,切後側葉約成  $70^\circ-80^\circ$  的夾角。

本期與成蟲晚期的頭蓋(圖版 II 圖 4)極為相似,其區別為後者的內邊緣稍寬,頭鞍前部與後部寬度相差稍大,固定頰較狹。

### 个体发育簡述和結論

1. 所有 *Parachangshania hsiaoshihensis* 的幼年期标本都很小, 最大的也不超过 1 毫米, 最早的幼虫尤为微小 (长仅 0.31 毫米)。这时, 壳体作亚圆形; 头尾不分; 中軸隱約显出, 向前輕微扩大; 軸面光滑无沟。从幼年晚期的第一期开始, 壳体就分成头、尾两部分, 中軸与前期相似, 但应指出在这一阶段的前两期中 (即第二期和第三期), 头鞍沟只有三对 (包括頸沟), 从第四期开始, 随着幼虫壳体的发育成长, 头鞍沟也逐渐由三对增至四对, 横分头鞍为五节。其中以第一节为最大, 这种情况在第二期和第三期表現得最为明显。头鞍在幼年期中, 原为向前扩大, 但至中年期 (第八期到第十三期), 成为两侧平行。而在第十四期和十五期, 又变为向前收縮, 以后更逐渐收縮变短。头鞍沟到中年期的晚期中部分开, 向后傾斜。最后至第十七期头鞍的形状发育得与成虫很相似。

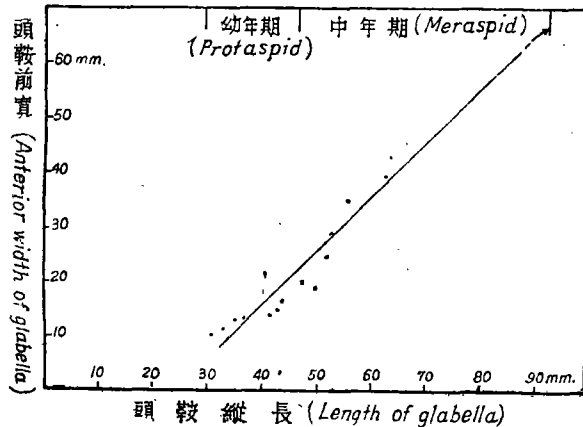


表 1 幼年期和中年期头鞍縱長与头鞍前寬的变化

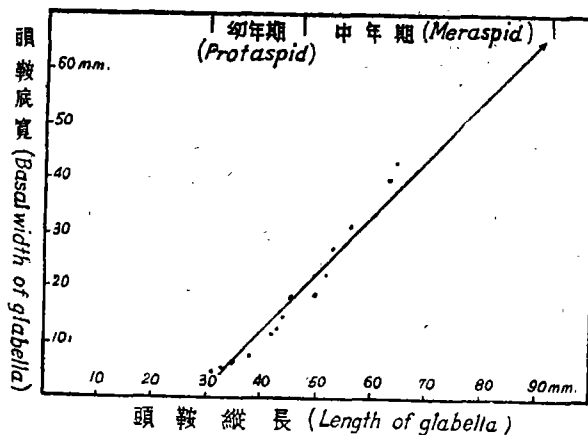


表 2 幼年期和中年期头鞍縱長与头鞍底寬的变化

2. 在幼年早期, 頰部甚寬, 輕微凸起, 至幼年晚期的最后阶段 (即第七期) 則发育成为向下強烈弯曲。而且外侧部被面綫分成内外两部: 内侧部甚寬, 为固定頰; 外侧部甚狹, 略呈三角状, 为活动頰。面綫向后側傾斜, 后支切于头部后側角的稍前方, 形成前頰类的

面綫形式。至第八期(中年期的第一期),面綫后支向后移动切于头部的后侧角,形成颊角类的形式。而活动颊也随着面綫的向后移动而逐渐后伸。至中年期的后期,面綫后支更向轴部移动,移入颊角之内,而活动颊继续发育增大,至成虫时,活动颊长得很宽;而固定颊却变得很狭。面綫前支最初向前轻微收缩,随着幼虫的发育,而逐渐变为向两侧扩张。

3. 在幼年早期中,眼脊前叶无任何痕迹。从幼年晚期的第一期开始,在头鞍前侧有一对轻微凸起的细脊(锥脊),此锥脊在整个幼年晚期中,除更为发育外,无特殊变化。但从中年期起,此锥状即行消失,而在其原来的位置(眼脊的前侧),发育成为一对平坦、以后又渐次增大、成梯形的眼脊前叶。外边缘直至中年期的第三期(即第十一期)才出现,当时仅为一直向、平直、微微凸起的狭脊,直到第十三期还是一条等宽的边缘,但至中年期的后期,两侧迅速变狭,中部轻微凸出,最后至成虫期,才发现成向前凸出,略作三角形的外边缘。与外边缘出现的同时,内边缘也以横沟状出现,以后逐渐变宽,至成虫期的早期(第十六期),又为一平行于边缘沟的细脊分为两部(即内边缘和头鞍前区),随着头壳的长大,最后至成虫时,其宽度逐渐增至头盖全长的七分之一,而头鞍前区却渐次变小,至成虫时,仅为头鞍前端的一个小区域。

4. 眼叶直至幼年晚期的末期(第七期)才在背壳出现,位在离头鞍很远的背壳外侧,当时为很小的椭圆体,至中年期的早期,逐渐变长变宽,发育成一宽广的弧形,随着三叶虫个体的发育而逐渐向头鞍移动,最后至成虫期,其末端已相当接近头鞍,而成新月状。眼脊至第五期在锥脊的后侧,就已出现,是时仅为一向后倾斜、微微凸起的细脊,以后发育长大,与眼叶紧密相联,直至第十五期两者始能区别。从中年期的晚期到成虫期,其长度变化不很大,最后至成虫时才成为一轻微凸起的眼脊。

5. 尾部早在幼年晚期的第一期,就为一直沟与头部分开,以后中轴与肋叶明显分出,两者在幼年晚期的中期,才分出两节,而至末期始增至三对,尾部的整个发育过程,除轴节、肋叶稍有所增加,及形成一平坦的边缘外,没有特殊意义的变化。

6. 三叶虫的活动颊及眼的发育,早就引起了许多研究三叶虫学者的讨论。Beecher 在 1895 年首先指出:三叶虫的眼及活动颊都是从幼虫壳体的腹部向侧部移动,而后者再移至背面。但是,当时仅为一种假设。缺乏直接证据。1935 年 Lalicker 研究了 *Blainia gregaria* (Walcott)? 的个体发生后,得出与 Beecher 完全相反的结论,他认为三叶虫眼的出现应迟于面綫、眼叶和活动颊,而且也不是从腹部移到背部的。这一论点以后遭到了许多学者的反对。1957 年 Whittington 重新研究了 Lalicker 的标本后,认为 *Blainia gregaria* (Walcott)(?) 幼年期的眼脊、眼叶及面綫,并不是 Lalicker 所认为的那样。因而 Lalicker 的见解就不能不认为是错误的。虽然我们沒有 *Parachangshania hsiaoshihensis* 的幼年早期 (Anaprotaspid Stage) 及幼年晚期 (Metaprotaspid Stage) 的前期和中期的腹部标本,但仍然可以得出某些结论,因为当幼虫发育至幼年晚期的最后阶段时(第七期),在壳体侧面出现了属前颊类的面綫,而后经过中年早期的颊角类,最后发育成为后颊类,而且眼叶在第七期时位在背壳的侧面,而后逐渐向头鞍逼近,这样就完全可以推测:这一三叶虫的幼虫在早期时,其面綫应在腹部,属前颊类的型式。Palmer (1958) 在研究北美 Nevada 州的 *Crassifimbria walcotti* (Resser) 的幼虫时,也得到同样的结论。

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## ONTOGENY OF A NEW UPPER CAMBRIAN TRILOBITE FROM PENCHI, LIAONING

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The material dealt with in this paper was collected in 1950 by Y. Wang, Y. H. Lu, K. C. Yang, A. T. Mu and C. J. Sheng of our Institute from the lower part of the Peishan Member (Lower Changshan Formation) at Shanchengtze, a village about 7.5 km south to Hsiao-shih, Penchi of Liaoning Province. The faunal succession of the Peishan Member measured by Wang and his party is as follows:

Changshan Formation, Peishan Member:

7. Gray, thin-bedded and nodular limestones interbedded with light red and light green shales, and with three layers of light red lenticular edgewise limestone conglomerates of about 10—30 cm thick, the upper part containing *Changshania conica* Sun (BE939) ..... 2.5 m
6. Pale grey to pink edgewise limestone conglomerates, with ripple marks on its surface, yielding *Chuangia batia* (Walcott) (BE 937—938) ..... 1.5 m
5. Dark grey thin-bedded limestones intercalated with green shales, containing *Chuangia batia* (Walcott), (BE 960) ..... 1 m
4. Pale grey to white or pinkish edgewise limestone conglomerates, yielding *Chuangia batia* (Walcott) and *Lioparia* sp. (BE 936) ..... 1 m
3. Dark grey, thin-bedded limestones interbedded with green calcareous shale, with five fossil horizons in descending order:
  - (a) *Chuangia batia* (Walcott) (BE 961)
  - (b) *Obolus* (BE 962)
  - (c) *Pseudagnostus cyclopygiformis* (Sun) (BE 968)
  - (d) *Dikelocephalidae* (BE 967)
  - (e) *Pseudagnostus chinensis* (Dames)
2. Pale grey to white edgewise limestone conglomerate, containing *Pseudagnostus chinensis* (Dames) (BE 955) ..... 1 m
1. Covered

From bed 3 a new trilobite *Parachangshania hsiaoshihensis* Chien (gen. et sp. nov.) has been found in association with *Pseudagnostus chinensis* (Dames). The bulk of the material consists of more than one hundred excellently preserved larval forms and some detached parts of the carapaces of this species. On careful examination, six developmental stages are recognized: (1) anaprotaspid,

with a subcircular outline, an undivided, conical axial lobe extending the full length of the shield, and smooth, unfurrowed side lobes; (2) early metaprotaspid, with distinct protopygidium, tapering ridges and rudimentary eye ridge; (3) late metaprotaspid, with subelliptical outline, free cheeks, small palpebral lobes and a proparous facial suture; (4) early meraspid, with a subquadrangular glabella, continuous transverse glabellar furrows and a gonatoparian facial suture, and with no anterior border; (5) middle meraspid, with subrectangular glabella, large palpebral lobe, anterior border, anterior limb and an opisthoparian facial suture; (6) late meraspid and holaspid, with truncate-conical glabella, very short and obscure glabellar furrows, distinct brim and preglabella field and bow-shaped eye lobe.

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### Superfamily Dikelocephaloidea Richter 1932

#### Family Changshaniidae Hupé 1953

#### Genus *Parachangshania* Chien (Gen. nov.)

#### Genotype: *Parachangshania hsiaoshihensis* Chien (sp. nov.)

**Diagnosis:** Cranidium roughly subrectangular in outline. Glabella narrow, truncato-conical with three pairs of faintly defined glabellar furrows. Occipital furrow shallow, broad, transverse. Occipital ring uniform in breadth. Brim broad, concave, sloping down forwards. Anterior border comparatively narrow, upturned and arching forwards. Marginal furrow very deep and broad. Fixed cheek narrow, a little wider than one-half the width of the glabella between the palpebral lobes. Preocular lobe flat and broad. Palpebral lobe crescentic, about two-thirds the length of the glabella, and situated at a little behind the middle length of the cranidium. Palpebral furrow deep. Posterior limb slender, as wide as the base of the glabella. Anterior branch of the facial sutures diverging forwards and cutting the anterior margin in a semicircular curve. Free cheek broad, convex; marginal furrow deep and broad; border narrow, uniform in width, and extending into a long genal spine. Hypostoma subelliptical excluding the triangular antero-lateral wings, central portion elongated ovate, separated from the posterior portion by a pair of deep furrows. Posterior and lateral margin bounded by a continuous elevated border.

Pygidium semicircular in outline. Axial lobe narrow, composed of seven to nine axial rings. Pleural lobe broad, divided into seven to eight ribs by shallow furrows. Marginal border broad and flat.

**Comparisons:** At the first glance, the new genus resembles closely *Changshania* Sun 1924, however, the latter may be distinguished chiefly by the narrow and conical glabella, by the wider fixed cheek, by much longer posterior limb, by the less divergent anterior branch of the facial sutures and by the pygidium which is pointed laterally. It is also similar to *Changshanoccephalus* Sun 1935, but it differs in having a narrow and slender glabella, larger palpebral lobe, and in the strongly divergent anterior branch of the facial sutures.

This new genus is also closely related to *Lioparia* Lorenz 1906, but it may be distinguished by the longer glabella, wider fixed cheek, narrower brim and by the large crescentic eye lobe. It is also allied to *Aphelaspis* Resser 1935 and *Pedinocephalus* Ivshin 1956, but *Aphelaspis* has a shorter glabella, wider fixed cheek and frontal limb, smaller eye which is situated at the midway of the glabella and less divergent anterior course of the facial suture. *Pedinocephalus* Ivshin 1956 differs in a short and truncato-conical glabella, a broad brim, small eye lobes and in the large

triangular posterior limb.

**Distributions:** Upper Cambrian, Changshan Formation of Northeastern China.

***Parachangshania hsiaoshihensis* Chien (sp. nov.)**

(Pl. II, figs. 4, 7—9, 15.)

**Description:** Cranium subrectangular in outline. Glabella truncato-conical, slightly rounded in front, longer than wide at the base, moderately convex, sloping laterally to form a low longitudinal ridge extending from the anterior margin of the glabella to the occipital furrow, with three pairs of very shallow glabellar furrows: first pair very short, second pair longer, oblique backwards and inwards, posterior ones long, but narrow, running backwards from the dorsal furrows inwards and backwards and disappearing at a short distance from the middle. Occipital furrow nearly transverse, shallow at the center, gradually deepening laterally. Occipital ring slightly elevated, uniform in width. Dorsal furrows deep and narrow at the sides of glabella, shallowing anteriorly. Brim slightly concave, about same width of the anterior border. Between the posterior part of limb and the ocular ridges there are pair of subtrapezoidal, flat preocular lobes which are connected with each other by a narrow preglabellar field in front of the glabella. Marginal furrow very deep and broad, and slightly curving forwards. Anterior border upturned, broad at the middle and gradually narrowing towards both extremities. Fixed cheek narrow, a little wider than one-half the width of the glabella between the eye lobes, and slightly sloping from eye lobe inwards to the dorsal furrows. Eye lobe large, crescentic, about two-thirds the length of glabella, and situated posterior to the glabella. Palpebral furrow deep and wide, curving outwards. Eye ridge weakly marked, extending obliquely from the anterior extremity of eye lobe slightly forwards to the dorsal furrow at a short distance from the antero-lateral corner of glabella. Posterior limb elongated subtriangular, extending outwards and slightly backwards. Anterior branches of the facial sutures comparatively long, running from anterior ends of the eye lobes divergent forwards to cut the anterior border in a rounded semicircular curve; posterior branches bending outwards and backwards to cut the posterior margin at a distance equal to the basal width of the glabella from the dorsal furrow.

Free cheek broad; cheek body convex; marginal furrow deep and broad; border prominent, uniform in width and extending directly backwards into a long genal spine.

Associated hypostoma elongated, subelliptical in outline excluding the triangular antero-lateral wings; central portion ovate, strongly convex, divided from the posterior lobe by a pair of deep and oblique lateral furrows; Posterior and lateral marginal border very narrow and strongly convex, separated from the central and posterior portions by a sharply defined marginal furrow.

Pygidium roughly semicircular in outline, with a relatively broad and rather flat border. Axial lobe narrow, convex, about one-sixth the width of the pygidium in front, slightly contracted at two-thirds the length from the anterior margin and divided by six transverse furrows into six rings and a terminal section. Pleural lobe broad, gently convex, marked by 6—7 shallow and rather broad pleural-furrows.

THE LARVAL DEVELOPMENT

The terms Protaspid, Metaspid and Holaspid are adapted here for the larval development of *Parachangshania hsiaoshihensis*. The protaspid period of development is subdivided into two stages: the anaprotaspid and the metaprotaspid, of which the anaprotaspid is characterized by lack of any definition of cephalon and protopygidium, and the metaprotaspid has a cephalon and a protopygidium separated by a transverse furrow.

## I. PROTASPID PERIOD

## A. Anaprotaspid stage.

## Stage I.

(Pl. I, figs. 1, 1a—c; Pl. III, figs. 1, 1a—b)

The smallest specimen is measured 0.31 mm in length and 0.34 mm in width. Exoskeleton subcircular in outline, convex from back to front and from side to side, sloping rather rapidly in the posterior portion. Axial lobe weakly defined, only discernible under strong oblique light, tapering gradually posteriorly and extending throughout the entire length, with broad anterior end which is about equal width to the side lobe. No traces of transverse furrows discernible both on the axial portion and on the side lobes. Dorsal furrow feebly marked, rather well developed near the anterior and posterior ends of the axial lobe.

## B. Metaprotaspid stages

## Stage II.

(Pl. I, figs. 2, 2a—c; Pl. III, figs. 2, 2a—b)

The first metaprotaspid stage is represented by a carapace measuring 0.37 mm long, and 0.36 mm wide. Shield subcircular, convex transversely and longitudinally, arched downwards near the posterior portion, faintly divided by a weak, transverse furrow into a large cephalon and a small protopygidium. Axial lobe narrow, slightly tapering backwards, well defined by dorsal furrows and moderately vaulted above the cheeks. Axis of cephalon divided by three faint and transverse furrows into four lobes of which the last one is considered as the occipital ring. Anterior furrow very faint, visible only under strong oblique light. Anterior glabellar lobe large, long, with a length equal to the succeeding two lobes, and projecting laterally from the antero-lateral end into a pair of small, slightly elevated tapering ridges (Strand, 1927, p. 321; Störmer, 1941, p. 81). Second and third glabellar lobes somewhat alike, rectangular in outline, and on the connection of these two lobes with one shallow, elongated axial depression. Occipital ring small, quadratic in outline, convex. Dorsal furrow shallow in middle portion, well marked anteriorly and posteriorly. Cheeks smooth, broad, about two times the width of the glabella across the middle part of the dorsal shield, slightly elevated in front to form a transverse ridge and strongly bending down laterally an postero-laterally as illustrated in Pl. I, figs. 2b—c; Pl. III, figs. 2a—b. Between the tapering ridge and the frontal part of the cheeks, a pair of faint frontal furrows present, which extend from anterior portion of dorsal furrows to the antero-lateral margin and merge to the ventral side of the carapace.

Protopygidium small, subsemicircular, less than one-fifth the total length of the carapace, separated from the cephalon by a weakly defined transverse suture and bending down almost vertically as indicated in Pl. I, figs. 2b—c and Pl. III, fig. 2b. Axial lobe elongated triangular, smooth, strongly convex and narrowing rapidly backwards.

## Stage III.

(Pl. I, figs. 3, 3a—c; Pl. III, figs. 3, 3a—b)

The more developed early metaprotaspid stage is represented by a dorsal shield with a length of 0.42 mm and width of 0.40 mm. Shield rather convex, subcircular in outline with comparatively broad anterior portion. Glabella limited by distinct dorsal furrow, slightly expanding forwards, flattened in front and elevated in posterior portion, divided by two weak transverse furrows into

three glabellar lobes of which the anterior one is the largest and longest. Occipital ring distinctly marked, elevated, quadrangular in outline. Cheeks strongly convex, broad, much wider than axial lobe. Tapering ridges distinctly marked by frontal furrows, extending postero-laterally along the antero-lateral margin and merging ventrally at the antero-lateral side of the cephalon. Propygidium larger than the preceding stage, separated from the cephalon by a forwardly arched suture. Axial lobe moderately convex, smooth, without any trace of segmentation. Side lobes subtriangular, flattened, smooth.

#### Stage IV.

(Pl. I, figs. 4, 4a—c; Pl. III, figs. 4, 4a—b)

Shell subcircular in outline, measuring 0.46 mm in length and 0.44 mm in width, strongly convex transversely and longitudinally, bending down postero-laterally. Dorsal furrow deep and broad, expanding gradually forwards. Glabella gently convex, reaching to the anterior border, marked by three transverse glabellar furrows of which the first one is the faintest. Anterior glabellar lobe slightly broader than the succeeding lobes, with a width greater than length. Second and third lobes almost equal in size, rectangular in outline, marked by a shallow longitudinal axial depression; fourth lobe well defined, gently convex, longer than wide. Occipital ring well marked, strongly elevated; occipital furrow deep and straight. Tapering ridge weakly defined by the broad and shallow frontal furrow. Cheek smooth, broad, about twice the width of the glabella in the middle portion of the cephalon, no indication of pleural furrows present.

Propygidium distinctly separated from the cephalon by deep transverse furrow, subfusiform in outline; axial lobe convex, triangular in outline, with a shallow transverse furrow at the anterior third and extending directly to the posterior margin. Pleural lobe apparently smooth.

#### Stage V.

(Pl. I, figs. 5, 5a—c; Pl. III, figs. 5, 5a—b)

Shell subelliptical in outline, with a length of about 0.48 mm and a width of 0.46 mm. Cephalon strongly vaulted. Dorsal furrow broad, deep in posterior portion, shallowing anteriorly. Glabella moderately convex, slightly expanding forwards, weakly divided by three transverse glabellar furrows into four subrectangular glabellar lobes of which the posterior one is more prominent. Occipital ring distinct, semielliptical in outline, strongly elevated. Tapering ridge observable, flattened, slightly elevated above the cheek lobe. Indication of eye ridges present, weakly marked, located immediately behind the tapering ridge, and extending from the anterior end of the dorsal furrow opposite the antero-lateral corner of the glabella outwards and slightly backwards. Cheek like that of the preceding stage but a little narrower, and bending strongly downward around the margin which is concealed in the rock matrix. Posterior marginal border present, narrow, uniform in width, divided from the cheek by a shallow but distinct posterior furrow parallel to the transverse suture.

Propygidium subsemicircular in outline, with frontal margin slightly arched forward, occupying about one-fourth the total length of the dorsal shield. Axial lobe slightly elevated, a little less than one-fourth the greatest width of the pygidium, and faintly marked by a shallow transverse furrow into a short anterior segment and an elongated, narrow terminal lobe. Pleural lobe grooved by a shallow and short pleural furrow subparallel to the anterior margin of the pygidium.

#### Stage VI.

(Pl. I, figs. 6, 6a—c; Pl. III, figs. 6, 6a—b)

Shield gently convex, subcircular in outline, measuring about 0.53 mm long and 0.50 mm in

wide. The length ratio of the cephalon to the protopygidium being about 3:1.

The chief characters of the cephalon are similar to those of the preceding stage, except the eye ridge which extends less oblique from the dorsal furrow and the posterior marginal furrow is much prominent in the present stage. Protopygidium subelliptical, pointed laterally, with a trisegmented axial lobe separated transversely by furrows. Pleural lobes evenly convex, marked by two pairs of faint pleural furrows in inner portion and disappearing near the margin.

#### Stage VII.

(Pl. I, figs. 7, 7a—d; Pl. IV, figs. 1, 1a—c)

The specimen, with a length of 0.55 mm and a width of 0.51 mm, represents probably the last stage of the meteprotaspid in our collection.

Shield vaulted, subcircular in outline, with subparallel lateral sides. Dorsal furrow gradually shallowing from the posterior portion to anterior portion. Glabella convex, very slightly expanded forwards and extending to the anterior margin, separated by three transverse glabellar furrows into four lobes of which the anterior one is the largest; first two glabellar furrows rather weakly marked, posterior one more deep and distinct. Occipital furrow deeply marked. Occipital ring distinctly defined by deep and straight occipital furrow, strongly convex, rectangular in outline. Posterior marginal border as wide as the occipital ring. Tapering ridge shorter but stronger than that of stage VI, and connected with the anterior lobe of the glabella without any interruption, and representing the preocular lobe in later stages. Cheeks gently convex, bending down abruptly in the lateral side.

In lateral view (Pl. I, figs. 7b & 7d; Pl. IV, figs. 1a—c), a narrow, subtriangular depression is present. The depression representing the free cheek is separated from the main cheek body by an oblique suture (the facial suture) which extends from the palpebral lobe rearwards and slightly outwards to cut the lateral margin of the cephalon at a short distance from the posterior marginal border.

Frontal furrows slightly depressed, triangular in outline, and widening laterally. Eye ridge distinctly elevated, extending from the anterior end of the dorsal furrow obliquely outwards and backwards, and continuous posteriorly adjacent to the facial sutures towards the palpebral lobe. Posterior border narrow, uniform in width.

Protopygidium semicircular, moderately convex, separated from the cephalon by a distinct, nearly transverse furrow. Axial lobe prominent, convex, subtriangular, divided by deep and wide furrows into three segments, and extending to the posterior margin of the pygidium. Pleural lobe subtriangular, a little more than twice the width of the axis in front and separated by two incomplete pleural furrows into three ribs.

## II. MERASPID PERIOD.

### Stage VIII.

(Pl. I, figs. 8, 8a—b; Pl. IV, figs. 2, 2a)

A more advanced stage is represented by a nearly complete cephalon, probably belonging to the early meraspid period.

Cephalon trapezoidal in outline, convex from side to side, rather gentle from back to front, measuring ca. 0.50 mm in length (dorsal projection), and 0.63 mm in width at the base. Anterior margin straight. Glabella rectangular, vaulted, distinctly defined by deep and subparallel dorsal furrows, extending to the anterior margin, divided by three continuous glabellar furrows into a large, elongate anterior lobe and three rectangular posterior lobes of about equal size. Anterior

glabellar furrow shallow, weakly defined, second and third furrows rather deep. Occipital ring well limited by deep and broad transverse occipital furrow, semielliptical in outline, about one-seventh the length of glabella in dorsal projection. Fixed cheek strongly convex, broad, about one and half the width of the glabella in dorsal view measuring at the base. Preocular lobe flat, narrow and transverse. Eye ridges slightly elevated, running directly outward then slight backward from the dorsal furrow at a short distance from the frontal margin of the cephalon, and apparently merge into the small elliptical eye lobes. Facial sutures proparian in appearance in dorsal view, gonatoparian in character in side view, with the posterior course cutting the genal angle in a smooth curve.

#### Stage IX.

(Pl. I, figs. 9, 9a; Pl. IV, figs. 3, 3a)

A cranidium probably belonging to the present species has a length of 0.54 mm (dorsal projection), and a width of 0.65 mm. The cranidium bears characteristics somewhat similar to those of the preceding stage, but differs in (1) having a comparatively narrower glabella and a broader fixed cheek; (2) a shorter but wider preocular lobe; (3) a shorter eye ridge and much larger palpebral lobe; (4) Posterior course of facial sutures running in a strongly curve to cut the posterior margin from the dorsal furrow at a distance a little less than twice the basal width of the glabella. Anterior course of facial sutures converging forward to cut the frontal margin at an angle about  $45^{\circ}$ . Free cheeks unknown.

#### Stage X.

(Pl. I, figs. 10, 10a; Pl. IV, figs. 4, 4a)

A cranidium. Length 0.59 mm; width 0.76 mm. Cranidium subtrapezoidal in outline, with a breadth at the base about twice the breadth in front. Glabella rectangular, with a length a little more than twice the breadth, convex from back to front and from side to side, reaching to the frontal margin. Three pairs of discontinuous glabellar furrows present, strongly depressed on sides, separated the glabella into four subequal lobes. Dorsal furrows very deep and wide, subparallel. Fixed cheek smooth, gently convex, and little narrower than the glabella between the palpebral lobe. Eye ridges distinctly marked, running in narrow elevations opposite the middle of the anterior glabellar lobe, then extending obliquely backwards to merge into a large and long eye lobe, which is about two-thirds the length of glabella. Posterior limb a little narrower than that of preceding stage. Anterior branches of facial sutures short, slightly diverging forward, cutting the anterior margin in a rounded curve; posterior branches comparatively longer, cutting the posterior limb in a rounded angle.

#### Stage XI.

(Pl. I, fig. 11; Pl. IV, fig. 5)

Cranidium moderately convex, wider than long, measuring 0.7 mm long in dorsal projection and about 1.08 mm wide. Glabella well-defined by deep and broad dorsal furrow, strongly elevated, cylindrical in outline, and marked by three pairs of glabellar furrows; the anterior pair almost obscure, represented only by a pair of shallow pits located at the lateral side of the glabella; second and third pairs very shallow, faintly defined, met at the central part of the glabella. Anterior glabellar lobe large, subsquare, slightly sloping down forwards. Occipital furrow deep, narrow and slightly curving backwards. Occipital ring convex, broad in center, narrowing

laterally. Fixed cheek gently convex, a little narrower than the breadth of the glabella between the posterior end of the eye lobes. Eye ridge slightly elevated. Palpebral lobe large and long, extending slightly oblique outward then directly backwards, and ending at a short distance from the postero-marginal furrow at a distance from the dorsal furrow equal to the basal width of the glabella. Posterior margin border elevated, gradually widening outwards, and marked from the posterior limb by the deep, broad posterior furrow. Anterior border distinctly defined, but much narrower than those of later stages, slightly elevated, transverse and uniform in width. Anterior limb deep and very narrow in front of the glabella. Preocular lobe small, extending from dorsal furrows opposite the antero-lateral sides of glabella and slightly widening outward.

#### Stage XII.

(Pl. I, fig. 12; Pl. IV, fig. 6)

Cranidium with length of 0.76 mm (dorsal projection) and width 1.15 mm. Glabella strongly convex, cylindrical in outline, rounded in front, faintly marked by three pairs of short, oblique glabellar furrows. Occipital ring well defined by deep and broad occipital furrow, moderately convex, slightly arched backward, and broad in middle portion. Fixed cheek gently convex, a little wider than the glabella between the eyes. Anterior limb slightly concave, narrower than the border in front of the glabella. Anterior border elevated, straight, uniform in width. Eye ridges extending slightly oblique backward to unite with the eye lobes, with a length about two-thirds the width of glabella. Eye lobes bow-shaped, distinctly elevated above the cheeks, running from the eye ridge firstly outwards and backwards then turning inwards from the middle portion. Anterior branches of the facial sutures very slightly converging forwards, then curving strongly oblique inwards to cut the anterior border; posterior branches almost transversely outwards, then strongly bending back to cut the posterior marginal border in a right angle.

#### Stage XIII.

(Pl. I, fig. 13; Pl. IV, fig. 7)

Cranidium 0.90 mm in length. Glabella convex, narrowing very gradually forwards, rounded in the front and marked by three pairs of very short and slightly oblique glabellar furrows. Occipital furrow very deep, straight in central portion, bending forward laterally. Occipital ring convex, wide at the middle and rapidly narrowing toward both sides. Anterior limb flat, a little narrower than the anterior border in front of glabella. Anterior border convex, sharply defined by distinct marginal furrow, slightly bending back laterally. Fixed cheek convex, slightly sloping down forwards, as wide as the glabella between the eyes. Eye ridges distinctly elevated and extending laterally into the palpebral lobe without any interruption. Palpebral lobe comparatively shorter than that of the preceding stage. Anterior branches of the facial sutures subparallel and cutting the anterior margin in a strong inwardly curve; posterior branches cutting the posterior marginal border directly backwards and slightly outwards.

#### Stage XIV.

(Pl. I, fig. 14; Pl. III, fig. 7)

A cranidium, measuring 0.95 mm in length and ca. 1.24 mm in width. It is quite similar to the cranidium of the preceding stage. The chief characters in which the present specimen differ from those of the preceding stage are that it has a wider anterior limb, slightly divergent anterior branches of facial sutures, comparatively shorter and elevated palpebral lobe and weakly

defined eye ridges which are differentiated from the palpebral lobe only by their low convexity.

Stage XV.

(Pl. II, fig. 1)

The incomplete cranium which measures about 2 mm long and about 3 mm wide between the eye lobes probably represents the late meraspid or early holaspid stages in the present collection.

Glabella truncato-conical, gradually narrowing forwards, strongly convex, with three pairs of very faint glabellar furrows. Occipital furrow weakly marked, almost transverse. Occipital ring incompletely preserved, uniform in width. Fixed cheek about one-half the width of glabella between the eye lobes, inclined towards the dorsal furrows. Anterior limb much broader than that of preceding stage, slightly concave. Anterior border narrow at sides, elevated, slightly arching forwards, and about one-half the width of the anterior limb in the middle portion. Eye lobes crescentic, very strong, about seven-eighth the length of glabella in lateral projection, sharply defined by deep palpebral furrows. Eye ridge very weak, low. Anterior branches of the facial sutures diverging forwards, made an angle about  $45^{\circ}$  to the axis; posterior branches unknown.

III. HOLASPID PERIOD

Stage XVI.

(Pl. II, fig. 2)

The cranium measuring 3.6 mm in length, has many features similar to those of the adult forms, and it is regarded as the first holaspid stage in the larval development. Glabella truncato-conical, straight in front and rounded anterolaterally, faintly marked by three pairs of very shallow glabellar furrows, and with a length and basal width ratio about 8:7. Occipital ring moderately convex, uniform in width, separated from the glabella by a very shallow and almost straight occipital furrow. Anterior limb nearly flattened, separated from the anterior border by a very deep and broad marginal furrow, and differentiated into a wide preglabellar field and a narrow brim by a low but distinct elevation running parallel to the marginal furrow. Anterior border slightly turning upward, broad at the middle and rapidly narrowing toward the both sides. Fixed cheek gently convex, narrow, about one-half the width of the glabella between the eyes. Palpebral lobe crescentic, a little shorter than that of the preceding stage, with its posterior end extending backwards and inwards at a distance equal to one fourth the basal width of the glabella from the dorsal furrow. Posterior border widening laterally, about two-thirds the width of the occipital ring.

Stage XVII.

(Pl. II, fig. 3)

A cranium, about 8.2 mm in length and 10.8 mm in width, subtrapezoidal in outline, more or less angulate in front. Glabella elevated, truncato-conical, marked by three pairs of short, obscure glabellar furrows; anterior pair almost obsolete, second and third pairs faintly defined, running obliquely inwards and backwards, not reached to the middle portion, with a low longitudinal median ridge extending from the anterior margin of the glabella to the front of occipital furrow. Occipital furrow very shallow but distinct: occipital ring retaining about the same width from side to side. Dorsal furrows deep on side, gradually shallowing forwards around the front of glabella. Brim slightly concave, as wide as the anterior border in front of

glabella, separated from the preglabellar field by a low transverse elevation. Preglabellar field concave, narrow in front of glabella, widening laterally into the perocular lobes which are trapezoidal in outline and are bounded by the low eye ridges in their posterior margin. Anterior border highly upturned, much broad at the middle and rapidly narrowing towards both sides. Marginal furrow broad and deep, slightly elevated at the median portion. Fixed cheek narrow, about one-half the width of glabella, rapidly elevated from the dorsal furrow to the eye lobe. Eye lobe bow-shaped, about two-thirds the length of the glabella, well defined by very deep and broad palpebral furrow. Posterior limb narrow, extending outwards and slightly backwards, separated from the posterior marginal border by a shallow marginal furrow. Facial sutures with the anterior branches diverging forwards almost perpendicular to the anterior margin of the cranidium and cutting the anterior border in a rounded angle; posterior branches running from the palpebral lobe outwards and slightly backwards, then turning obliquely backwards to cut the posterior border in an angle about  $70-80^{\circ}$ .

#### SUMMARY AND CONCLUSION

1. The anaprotaspid and the metaprotaspids of *Parachangshania hsiaoshihensis* are all less than 1 mm in length and are of subcircular to subelliptical in outline. The anaprotaspid measures only 0.31 mm long. It appears to be one of the smallest larval forms in the ontogenetic developments of the trilobites. In the anaprotaspid stage, the axis is weakly outlined, with slightly expanded front and pointed terminal end, and it is characterized by lack of any trace of transverse furrows. In the metaprotaspid period, the axis is somewhat of the same shape as in the anaprotaspid stage, and three transverse furrows on the axis first appear in the earlier two stages (Stages 2 & 3). A protopygidium is then separated by the posterior transverse suture from the cephalon. In the succeeding stages (Stages 4—7), one furrow is added to the cephalon and two are added to the protaspypidium. The frontal lobe is longer than the others in all the metaprotaspid stages, especially in Stages 2 and Stage 3. In the meraspid period, the two sides of axis are nearly parallel with each other in stage 8 to stage 13; in stages 14 and 15, the axis is gradually tapering forwards. From stages 11 to stage 17, the axis grew short, and at the same time, an anterior border and an anterior limb appeared, the furrows on the glabella gradually become oblique, shallow and short. Finally, in stage 17, the glabella and the posterior limb have the same shape as the adult.

2. The cheek in the early stages of protaspid period is very broad and slightly convex. It diminishes its size with the increase of the axial lobe in the succeeding stages. In the last metaprotaspid stage (stage 7), the cheek bends strongly downwards on the sides, and is firstly separated on the dorsal surface by an oblique suture (the facial suture) into two parts: a broad fixed cheek and a narrow free cheek; the latter is elongate, subtriangular in shape in lateral view. Since the facial suture in this stage cuts the margin of the cephalon in front of the genal angle, the proparian character is exhibited. In stage 8 (first meraspid stage), the free cheeks reach the genal angles but not beyond the posterolateral corners of the cranidium. Posterior branch of facial suture shifts now backwards to cut across the genal angle, thus exhibiting the gonatoparous condition. In the later meraspid stages, the suture migrates farther inward behind the genal angle on the dorsal side, and the free cheeks probably take the same form as in the adult. At the same time, with the increase of the size of the larval forms, the anterior branches of facial sutures at first converge forwards to the margin, becoming divergent later through growth.

3. No indication of the preocular lobe has been seen in the anaprotaspid period. The preocular lobe in the metaprotaspid period is represented by a pair of tapering ridges which extend from the antero-lateral corners of the glabella outwards to a narrow band with pointed lateral ends.

The change of these narrow ridges from the early metaprotaspid to the late metaprotaspid stage is very gradual, although the appearance of the palpebral lobe and the eye ridges closely behind these in the transition between the middle to the late metaprotaspid stages is remarkable. In the early meraspid stage, with the disappearance of the tapering ridges, a depressed area in front of the eye ridges is formed, it increases its size longitudinally and finally becomes a subtrapezoidal preocular lobe. The anterior border and anterior limb are entirely absent in the protaspid period and in the first three stages of the meraspid period (Stage 8—Stage 10). The border begins to appear in the middle meraspid stage (Stage 11) as a very narrow, convex band separated from the glabella by a frontal furrow (the rudimentary frontal limb). It is straight and almost uniform in width from stage 11 to stage 13, but tapers rapidly laterally in late meraspid stage and finally attains a broad subtriangular outline in adult. In accompanying with the growth of the anterior border, the anterior limb widens longitudinally from the middle to the late meraspid stages, it is divided in the early holaspid stage by a transverse low ridge into a narrow brim and a broad preglabellar field. As the size of the trilobite increase, the brim grows rapidly, occupying a length (sagittal) about one-seventh the total length of the cranidium in adult, and the preglabellar field diminishes to form a narrow area in front of the glabella.

4. The palpebral lobe first appeared in the last metaprotaspid stage (stage 7) is very small, oval in shape, situated at the lateral side of the cranidium and far from the glabella. It is prolonged and enlarged from an elongate smooth curve in the early meraspid stage to crescentic in the late meraspid with its posterior end gradually migrated inward. In the holaspid stages, the palpebral lobe becomes a bow-shaped are and it moves more and more close to the glabella through growth. The eye ridge issues apparently from the point opposite the anterolateral side of glabella behind the tapering ridge in stage 5. It is undifferentiated from the palpebral lobe until it reaches the late meraspid stage (stage 14). In the holaspid stages, the eye ridge is represented only by a low thin ridge and the change of its relative length from late meraspid stage to the adult is very gradual.

5. The protopygidium appears first in the early metaprotaspid stage, being poorly defined by a transverse furrow from the cephalon. It is distinctly trilobed by dorsal furrows into a narrow axial and two broad pleural lobes. The axis and pleurae are both bisegmented in the middle metaprotaspid stage and tri-segmented in the later metaprotaspid stages. Through successive growth, the form of the pygidium in the meraspid and holaspid stages is not significantly changed from that of the late metaprotaspid, except the addition of new segments and the formation of a flat marginal border.

6. The developments of free cheeks and the eyes has long been a subject discussed by many authors. Beecher points out that the free cheek and the eyes in the larval stages migrate from the ventral side first forwards to margin and then backward over the cephalon to their adult position. The assumption appears to be purely hypothetical, and there is no direct evidence at his time supporting this view. In 1935, based on the descriptions of a series of larval stages probably belonging to the species *Blainia gregaria* Walcott, Lalicker arrives at a conclusion differing from previous writers in the trilobite ontogeny that the eyes appear later than facial suture, palpebral lobes and free cheeks, and that instead of migrating over the margin from the ventral side, they are formed on the free cheeks during some moult. This conclusion has later been met with criticisms. Whittington (1957) on re-examining Lalicker's original specimens claims that the protaspids of *Blainia gregaria* do not have eye ridge, palpebral lobe, and dorsal facial sutures in the position Lalicker portrayed them.

In the anaprotaspid and early and middle metaprotaspid stages of *Parachangshania hsiaoshensis* the course of the facial suture is unknown, but it seems that the facial sutures occur on the ventral side. As soon as the size of the shield increased in the late metaprotaspid stage, a

proparous facial suture was clearly demonstrated and during the further growth stages it passes through from gonatoparous in early meraspid to opisthoparous in the middle meraspids and in the adult. Following the stages backwards it seems quite possible that the early protaspid with its subcircular outline had a proparous facial suture on the ventral side, as it has been recognized by Palmer (1958) in the ventral aspect of the North American Lower Cambrian trilobite *Crassifimbra walcotti* (Resser).

### EXPLANATION OF PLATE

All specimens described in this paper are kept in the Institute of Palaeontology, Academia Sinica. All illustrations on Plates I and II have been whitened and are photographed by Mr. M. F. Pang, while the figure on Plates III and IV are the camer-lucida drawings made by the writer.

#### Explanation of Plate I

##### *Parachangshania hsiaoshihensis* Chien (gen. et sp. nov.)

Figs. 1, 1a—1c: Anaprotaspid,  $\times 35$  (see Pl. III, figs. 1, 1a—1b).

1, dorsal view; 1a, anterior view; 1b, side view; 1c, posterior view. Cat. No. 9662.

Figs. 2, 2a—2c: Early metaprotaspid with tapering ridge, occipital ring and protopygidium  $\times 35$  (see Pl. III, figs. 2, 2a, 2b).

2, dorsal view; 2a, anterior view; 2b, side view; 2c, posterior view. Cat. No. 9663.

Figs. 3, 3a—3c: Early metaprotaspid with distinct tapering ridges (see Pl. III, figs. 3, 3a, 3b).

3, dorsal view; 3a, anterior view; 3b, side view; 3c, posterior view. Cat. No. 9664.

Figs. 4, 4a—4c: Middle metaprotaspid with four faint axial lobes  $\times 35$  (see Pl. III, figs. 4c 4a, 4b).

4, dorsal view; 4a, anterior view; 4b, lateral view; 4c, posterior view. Cat. No. 9665.

Figs. 5, 5a—5c: Middle metaprotaspid with obscure eye ridges and distinct posterior marginal border  $\times 35$ . (see Pl. III, figs. 5, 5a, 5b).

5, dorsal view; 5a, anterior view; 5b, side view; 5c, posterior view. Cat. No. 9666.

Figs. 6, 6a—6c: Middle metaprotaspid with distinct eye ridges and three axial lobes on protopygidium  $\times 35$ . (see Pl. III, figs. 6, 6a, 6b).

6, dorsal view; 6a, anterior view; 6b, side view; 6c, posterior view. Cat. No. 9667.

Figs. 7, 7a—7d: Late metaprotaspid with rudimentary free cheek and facial sutures  $\times 35$ . (see Pl. IV, figs. 1, 1a, 1c).

7, dorsal view; 7a, anterior view; 7b, lateral view of right side; 7c, posterior view; 7d, lateral view of left side. Cat. No. 9668.

Figs. 8, 8a, 8b: Early meraspid with remarkable anterior limb, preocular lobes, free cheeks and facial sutures  $\times 30$ . (see Pl. IV, figs. 2, 2a).

8, dorsal view; 8a, anterior view; 8b, side view. Cat. No. 9669.

Figs. 9, 9a: Early meraspid cranium  $\times 30$  (see Pl. IV, figs. 3, 3a).

9, dorsal view; 9a, side view. Cat. No. 9670.

Figs. 10, 10a: Early meraspid cranium  $\times 30$ . (see Pl. IV, figs. 4, 4a).

10, dorsal view; 10a, side view. Cat. No. 9671.

Fig. 11: Middle meraspid cranium  $\times 30$ . (see Pl. IV, fig. 5). Cat. No. 9672.

Fig. 12: Middle meraspid cranium  $\times 30$ . (see Pl. IV, fig. 6). Cat. No. 9673.

Fig. 13: Middle meraspid cranium  $\times 30$ . (see Pl. IV, fig. 7). Cat. No. 9674.

Fig. 14: Middle meraspid cranium  $\times 30$ . (see Pl. III, fig. 7). Cat. No. 9675.

## 图版 I 说明

本文所描述的标本保存在中国科学院古生物研究所。图版 I, II 之标本曾以镁燻熏成白色薄膜, 然后照相, 摄影者为庞茂芳等同志, 图版 III 及 IV 为笔者用反光繪图仪所繪。

*Parachangshania hsiaoshihensis* Chien (新属, 新种)

- 图 1, 1a—c. 幼年早期,  $\times 35$ 。(参看图版 III 图 1, 1a—1b)  
1. 背視; 1a, 前視; 1b, 側視; 1c, 后視。  
登記号碼: 9662。
2. 2a—2c. 幼年晚期的早期, 具椎脊, 頸环, 及尾脊。  $\times 35$ 。(参看, 图版 III 图 2, 2a—2b)  
2. 背視; 2a, 前視 2b, 側視; 2c, 后視。  
登記号碼: 9663。
3. 3a—3c. 幼年晚期的早期, 具明显的椎脊。  $\times 35$ 。(参看, 图版 III, 图 3, 3a—3b)  
3. 背視; 3a, 前視; 3b, 側視; 3c, 后視。  
登記号碼: 9664。
4. 4a—4c 表示幼年晚期的中期, 具四对模糊的头鞍沟。  $\times 35$ 。(参看, 图版 III, 图 4, 4a—4b)  
4. 背視; 4a, 前視 4b, 側視; 4c, 后視。  
登記号碼: 9665。
5. 5a—5c. 幼年晚期的中期, 具眼脊, 后側緣。  $\times 35$ 。(参看, 图版 III, 图 5, 5a—5b)  
5. 背視; 5a, 前視; 5b, 側視; 5c, 后視。  
登記号碼: 9666。
6. 6a—6c. 幼年晚期的中期, 表示具清楚的眼脊, 尾部分为三节。  $\times 35$ , (参看, 图版 III, 图 6, 6a, 6b)  
6. 背視; 6a, 前視; 6b, 側視; 6c, 后視。  
登記号碼: 9667。
7. 7a—7d. 幼年晚期的后期, 具活动頰及面綫,  $\times 35$ , (参看, 图版 IV, 图 1, 1a—c)  
7. 背視; 7a, 前視; 7b, 右視; 7c, 后視; 7d, 左視。  
登記号碼: 9668。
8. 8a—8b. 中年期的早期, 具外边緣, 眼脊前叶, 活动頰及面綫。  $\times 30$  (参看, 图版 IV, 图 2, 2a)  
8. 背視; 8a, 前視; 8b, 側視。  
登記号碼: 9669。
9. 9a. 中年期的早期, 头盖标本。  $\times 30$  (参看, 图版 IV, 图 3, 3a)  
9. 背視; 9a, 側視。  
登記号碼: 9670。
10. 10a. 中年期的早期, 头盖标本。  $\times 30$  (参看, 图版 IV, 图 4, 4a.)  
10. 背視; 10a, 側視。  
登記号碼: 9671。
11. 中年期的中期, 头盖标本。  $\times 30$  (参看, 图版 IV, 图 5.)  
登記号碼: 9672。
12. 中年期的中期, 头盖标本。  $\times 30$  (参看, 图版 IV, 图 6.)  
登記号碼: 9673。
13. 中年期的中期, 头盖标本。  $\times 30$  (参看, 图版 IV, 图 7.)  
登記号碼: 9674。
14. 中年期的中期, 头盖标本。  $\times 30$  (参看, 图版 III, 图 7.)  
登記号碼: 9675。