

Orthograptus cf. attenuatus Rickards

笔石簇在中国的发现

葛梅钰

(中国科学院南京地质古生物研究所, 南京 210008)

陈淑娥

(西安地质学院, 西安 710054)

内 容 提 要

描述的 *Orthograptus cf. attenuatus* Rickards 笔石簇, 产于我国陕西南郑福成下志留统龙马溪组。这是在我国的首次报道。

关键词 笔石簇 龙马溪组

1985—1986年, 笔者之一(陈淑娥)随西安地质学院成汉钧等在陕西南郑福成工作期间, 在下志留统龙马溪组下部采得笔石簇标本, 经鉴定为 *Orthograptus cf. attenuatus* Rickards 笔石簇, 共生的笔石有 *Oktavites changyangensis* (Sun), *O. sp.*, *Rastrites peregrinus* Barrande, *Monograptus millepeda* (M'Coy), *Petalolithus minor* Elles, *Orthograptus cf. insectiformis* (Nicholson), *Glyptograptus tamariscus* (Nicholson), *Spirograptus minor* Bouček 等, 其层位介于 *Demirastrites triangulatus* 带到 *Oktavites convolutus* 带上部, 与城口志留系双河场组 *Pristiograptus leptotheca* 带—*Petalolithus folium* 带相当。这种笔石簇在我国还是第一次发现。

在国外, 笔石簇很早就有发现(Hall, 1865, p. 146), 其后也陆续有所报道(Ruedemann, 1895, p. 453; Ruedemann, 1908, p. 347, 392, 397, 479; Ruedemann, 1947, p. 400, 404, 406, 432, 434, 454, 461, 463; Jackson *et al.*, 1976, p. 39; Bjerreskov, 1976, p. 41; Leng and Melchin, 1986, p. 1854; Zalasiewicz, 1984, p. 425)。所有这些材料, 除个别产于丹麦 Bornholm(Bjerreskov, 1976)和英国 Wales(Zalasiewicz, 1984)两地外, 皆产于北美地区。从笔石簇产出时期来看, Jackson, Kerr 和 Morrow 报道 Devon 岛 *Monograptus fanicus* Koren 笔石簇产于早泥盆世 Pragian 期地层; Lenz 和 Melchin 报道 Cornwallis 岛的 *Saetograptus fritschi cf. linearis* (Bouček) 笔石簇产于中 Ludlovian 期地层; Bjerreskov 报道丹麦 Bornholm 的 *Rhaphidograptus toernquisti* (Elles et Wood) 笔石簇产于下志留统下 Llandoveryan; Zalasiewicz 报道北 Wales 的 *Didymograptus aff. simulans* Elles et Wood 笔石簇产于早奥陶世 Arenig 期地层外, 其余的双笔石类笔石簇皆产于中一晚奥陶世地层。

本文描述的产于陕西南郑福成笔石簇标本仅有一块。该标本较完好地呈薄膜状保存在黑色粉砂质页岩层面上, 它由 13 个 *Orthograptus cf. attenuatus* Rickards 笔石体组成, 它们

呈稍偏斜的辐射状星状排列,大多数笔石体呈正压保存,个别呈斜叠或近梯形,这些笔石体属同一种。该笔石簇直径约 50mm,各笔石体中轴末端相互紧密叠覆或缠绕,但并未集中形成一个明显的中心,也未见中心囊状膜体。这些笔石体各自长为 8—16mm,宽自始部(横过第一对胞管口部)为 0.8mm,向上增宽,在距胎管口 5mm 处达最大宽度为 1.8mm,此后两侧平行。除个别笔石体的始部保存破碎(或断去)外,皆见胎管,其长 1.6mm,口部宽 0.3mm,它的尖顶伸至 $th\frac{1}{2}$ 的口部,胎管刺细小,中轴显著,似具膜体包裹,中轴伸出笔石体末端之外 2—3mm。胞管直管状,长 1.6mm,口部平,其宽为 0.5mm,腹缘直,倾角 20° — 30° ,相邻胞管间叠覆 $1/2$ 。在 10mm 长度内有 11—12 个胞管。

福成标本的笔石体特征基本上和陈旭等描述黔北龙马溪组的 *Orthograptus attenuatus* Rickards 相同,仅仅有的胞管口缘外斜较为明显,这可能是保存的原因。Rickards 报道英国的 *Orthograptus attenuatus* Rickards 的笔石体窄(宽为 1.7mm)、楔形,胞管密度大(15/10mm)。由此看来,黔北和陕南福成标本均和英国标本稍有差异。从测量情况来看,则陕南福成标本的笔石体宽、胞管倾角、掩盖,以及胞管密度等又和 *Orthograptus angustifolius* Chen et Lin 基本相同,但后者在图像上胞管倾角明显增大,产出的层位也较低。

从已报道的笔石簇材料来看,笔石簇的特点,即:每一个笔石簇皆由一些或许多同种笔石体呈星状辐射排列,这些笔石体由它们的中轴相互缠绕联结,保存后呈叠覆状,或者各中轴与中心囊状膜体相联,有时在中心囊状膜体周围还有一些卵状膜体围绕。在这些笔石簇中,每个笔石体的胎管皆远离中轴缠绕中心或中心囊状膜体。仅有一个例外,就是 Bjerrskov (1976)报道 Bornholm 的 *Rhaphidograptus toernquisti* (Elles et Wood) 笔石簇。它的每个笔石体依靠伸长的胎管刺相互缠绕。因此,它们的胎管就不远离缠绕中心。

穆恩之等曾报道陕西汉中梁山志留统龙马溪组的 *Climacograptus normalis* Lapworth(穆恩之等,1974,第 213 页,图版 99,图 1;陈旭,1984,第 40 页,图版 3,图 1)。经我们重新观察,该标本由许多栅笔石呈星状辐射排列组成,可能是一种栅笔石笔石簇,但该标本有些笔石体排列稍为零乱、胞管性质不太清楚、各中轴末端相互缠绕情况也看不清楚。

关于笔石簇的功能曾有不同的论述。Ruedemann (1895)曾认为中心囊状膜体可能是漂浮器官;笔石体由中轴粘附于中心囊状膜体,营漂浮生活;围绕中心囊状膜体的卵状膜囊可能相当于现代水螅纲的生殖器官(organs of reproduction)。Bulman 不同意笔石用中轴附着海藻漂浮。他认为笔石体自身具备浮力机制(Bulman,1955,1964,1970),虽然它的浮力机制可以表现在许多方面(Bulman,1970,p. V93—V94),但是“说笔石簇主要组成漂浮机制是未必可能的”(Bulman,1970,p. V95)。

Kozlowski 也不同意笔石是用线管(中轴)附着于海藻(可能像现代的马尾藻)在广泛海面上漂浮的意见,他也认为笔石有自己的漂浮机制,使它可以自由地漂浮在海面上,它不需要用线管(中轴)去附着藻类进行漂浮(Kozlowski,1971,p. 335—337)。

Rickards 进一步论证了笔石线管(中轴)的功能及笔石簇特点,他指出:有些笔石簇并没有中心囊状膜体及触手轮状的卵状膜体。他认为 *Monograptus varians* Wood 笔石簇的笔石体中轴(线管)与软组织相连。他支持 Bulman 和 Kozlowski 的“笔石有它自己的浮力系统”以及“用线管附着未必可能是这个器官(线管或中轴)的功能”的意见,并进一步认为“如果每个笔石体皆有它自己的浮力系统,或者每个笔石体皆有同样多而充分的浮力是正确的话,那

么,笔石簇或许首先和有性生殖有关”(Rickards,1975,p.415—416)。

Bjerreskov 支持笔石簇是与有性生殖有关的论述。同时,她进一步设想“在很像外胞管组织那样的附属构造中发育许多胎管的开始部分(可能是原胎管),在笔石簇的早期,它并不附着。软组织由胎管虫自己分泌,接着发生胎管出芽和笔石体的形成,以及胎管、胞管从原始的组织中释放出来。这和末端保留附着的中轴的生长可以同时发生”(Bjerreskov,1976,p.46)。

我们仔细观察陕西南郑福成的 *Orthograptus cf. attenuatus* Rickards 笔石簇标本,也注意到已报道各类笔石簇的特点,结合对现代浮游生物浮力机制的了解,我们同意和支持 Bulman 和 Kozlowski 等提出的笔石有它自己的浮力系统的意见。显然,他们说的笔石应理解为活的笔石。活的笔石包括具有笔石虫软体以及为软体分泌的外壳(如胎管和胞管)及附属物等。我们也支持“附着或悬挂并不是中轴(线管)这个器官的唯一的”,但我们认为不排除它顺便有支撑或粘附漂浮体或囊胞(膜),如在一些带有轴囊或囊胞(膜)的双笔石类那样的作用。我们不仅赞赏 Rickards 关于笔石簇与有性生殖有关的论述。鉴于笔石簇确是和一些具囊胞(膜)、体壁网格化,以及多刺等特征的笔石一起共生(保存)在黑色炭质页岩中。我们可以设想:在奥陶纪、志留纪,笔石生活在较为温暖、湿润的海洋环境中,那里降水量较大,海水含盐度相对较低,或相当低,但营养盐丰富,某些海藻十分发育,(笔石的)食物十分丰富。由有性生殖产生的笔石生殖细胞生活在同时由笔石分泌的蛋白质类软组织有机物中,它们发育、成长为原胎管虫(原胎管虫的居室保存为化石,就是现在称原胎管,以及其上的线管或中轴)。这个发育过程就和现在了解的蝌蚪孵化过程十分相似。随后,这些原胎管虫离开原来的发育环境——蛋白质类软组织有机物,并随洋(海)流带到其他合适的地方生长、发育。亚胎管的生长标志原胎管虫的发育成熟。与亚胎管生长的同时,或近同时,由胎管上开始芽生繁殖第一个胞管,并由此连续芽生繁殖,形成一个完整的笔石体。如果在原胎管虫孵出、发育过程中,由于海洋环境条件突然变得十分恶劣,如海底火山的突然大量喷发,以及随之发生一系列海洋环境条件的变化,迫使笔石生殖细胞孵出的原胎管虫滞留在与之相伴的蛋白质类软组织有机物中继续生长、发育和成熟,甚至自胎管上进行芽生繁殖第一个胞管,并形成完整笔石体。在这样的环境中,笔石体线管(中轴)不仅自与相伴的蛋白质类软组织相连,而且,线管(中轴)相互缠绕、纽结的机会大大增加,有可能形成笔石簇。从这个意义上讲,各类笔石皆可发育成笔石簇,由于各类笔石原胎管虫的发育阶段(笔石生命周期的重要阶段)及其发育速率的不同。因此,在同样海洋恶劣环境中,也只有某些种类的笔石能形成笔石簇。如果上述设想有一定道理的话,那么,笔石簇的发生可能和特定海洋环境中的笔石的有性生殖有关。

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SYNRHABDOSOME OF *ORTHOGRAPTUS* CF. *ATTENUATUS* RICKARDS FROM NANZHENG, CHINA

Ge Mei-yu

(Nanjing Institute of Geology and Palaeontology, Academia Sinica, Nanjing 210008)

Chen Shu-e

(Xi'an College of Geology, Xi'an 710054)

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Summary

While studying the upper Ordovician to Lower Silurian strata at Fucheng of Nanzheng, Shaanxi, Cheng Han-jun and Chen Shu-e (one of the authors) (1986) found a well-preserved synrhabdosome of *Orthograptus* cf. *attenuatus* Rickards from the lower part

of the lower Silurian Lungmachi Formation, in association with *Oktavites changyangensis* (Sun), *Monograptus millepeds* (M' Coy), *Rastrites peregrinus* Barrande, *Petalolithus minor* Elles, *Orthograptus* cf. *insectiformis* (Nicholson), *Glyptograptus tamariscus* (Nicholson), *Spirograptus minor* Bouček, etc.; the horizon is corresponding to the *Pristiograptus leptotheca* zone to the *Petalolithus folium* zone in the Shuanghechang Formation of Chengkou in age. Such a synrhabdosome is discovered for the first time in China.

The occurrence of a rare synrhabdosome was discovered many years ago (Hall, 1865, p. 46). A few of graptolite synrhabdosomes have been recorded. Ruedemann (1895, 1947) illustrated synrhabdosomes of various taxa, all being diplograptids; Rickards (1975), Jackson and others (1976) and Lenz and others (1986) illustrated some of monograptids; Bjerrreskov (1976) described several of *Rhaphidograptus*, while Zalasiewicz (1984) reported several of *Didymograptus* aff. *simulans* Elles et Wood.

A single synrhabdosome of *Orthograptus* cf. *attenuatus* Rickards was preserved in black silty shale and composed of 13 conspecific rhabdosomes, which are completely developed. These rhabdosomes of synrhabdosome are arranged in stellate aggregations, about 50mm in diameter, apparently twined together at their virgular ends, but not forming a complete center, or possessing a ventral disc of the pneumatocyst or vesicle. These virgulae are sturdy, extending outward for 2—3mm. The sicula is tubular, 1.6mm in length and 0.3mm in width.

These rhabdosomes (individual graptolites) are 8—16mm in length, gradually widening from 0.8mm at the apertural part of the first pair of thecae to 1.8mm at a distance of 5mm from the aperture of sicula, and then both sides become nearly parallel. The thecae are 1.6mm in length and 0.5mm in width in apertural part, with ventral margin straight, inclined 20°—30° and overlapping 1/2, numbering 11—12 in 10mm.

Based on documental record, in general character the synrhabdosome comprises at least a number of conspecific rhabdosomes arranged in stellate aggregations, twined and twisted with each other at the distal end of their virgulae, with or without the disc of pneumatocyst or vesicle-like structures in any of the specimens.

Ruedemann has drawn a number of synrhabdosomes collected from the Ordovician of North America with central discs of pneumatocyst or vesicle-like structures; he considered that the central discs of the pneumatocyst may be a floating organ and the oval vesicles enclosing the central discs of the pneumatocysts are perhaps "organs of reproduction which are to be compared with the gonangia of recent hydrozoa" (Ruedemann, 1895).

Bulman did not agree that the graptolite rhabdosomes attached distally by their nemata (or virgulae) to floating weeds; he considered that they possessed their own buoyancy functions as shown in many aspects, but he states: "It is unlikely that the synrhabdosome association constitutes primarily a buoyancy mechanism" (Bulman, 1970, p. v95). Kozłowski considers that "not only large rhabdosomes could not hang suspended by a thread, but

also neither larvae in the stage of prosicula nor young rhabdosome had any necessity of attaching themselves to the objects floating on the surface," and "the rhabdosomes of the Graptoloidea were provided with floatation organs of various types, which allowed them to float freely near the surface of the sea, the conclusion that most of them lived in the upper layer of water as what is known as neuston, becomes likely to be correct" (Kozłowski, 1971, p. 336). Rickards further confirmed the function of nemata (or virgulae) and the character of synrhabdosomes; he pointed out that some synrhabdosomes possessed no central disc of cupsule and oval vesicles, and the virgulae of the synrhabdosome joined with the soft tissues (Rickards, 1975). He not only supported Bulman (1970) and Kozłowski (1971) in maintaining that the graptolites have their own buoyancy system, but also considered: "The attachment by the nema is unlikely function of this organ" (Rickards, 1975, p. 415) and "If it is correct that every individual graptolite has its own buoyancy system or as many adequate buoyancy systems as every one, then the forming of synrhabdosome perhaps primarily connected with sexual reproduction" (Rickards, 1975, p. 416). Bjerreskov also supported the above-mentioned opinions and further assumed: "A number of siculae develop within an attachment structure, most likely extrathecal tissue, in such a manner that the initial parts of the siculae (? prosiculae) were not attached, as most have been the case in the earlier described synrhabdosomes. The soft tissue may have been secreted by the siculae themselves. In the next stage the budding and formation of the rhabdosome took place, and the siculae and thecae were released from the original tissue. This could have happened simultaneously with a growth of the virgellae in such a way that the extreme distal parts remained attached" (Bjerreskov, 1975, p. 46).

The writers support Bulman (1970) and Kozłowski (1971)'s proposal that every rhabdosome of graptolite has its own buoyancy system. In view of the character and preservation state of the synrhabdosome, the writers consider that the development of synrhabdosome may be connected with sexual reproduction in the specific marine environment. We may conceive that during Ordovician and Silurian, the marine environment was under a warm climate, with more precipitation, lower salinity of the sea water, and rich nutrient salts; the seaweeds might be very well-developed. The genital cells produced by sexual reproduction of some graptolite rhabdosome developed and lived in organic compound of protein soft tissue secreted by the graptolite rhabdosome, and grew up into some primary siculae. This growth course was very similar to the incubation process of the tadpole. Then they formed a prosicula and subsequently a complete rhabdosome. When the marine environment suddenly became very adverse, with a number of volcanic eruptions at the seabottom and a series of changes in condition, the prosiculae were freed to remain in the protein soft tissue secreted by the graptolite rhabdosome, to successively grow up, develop and form a complete rhabdosome therein. Under such a condition, the nemata (or virgulae) of graptolite joined with the protein soft tissue, or the possibility of their connecting and

twining together would greatly increase. In this sense, all graptolites might develop into synrhabdosomes. Since the development stage (the important stage of life cycle) and the rate of growth in prosiculae of various graptolites are different, under a similar adverse marine environment, only some graptolites were capable of forming a synrhabdosome. In case the above-mentioned hypothesis is reasonable to a certain extent, then the occurrence of synrhabdosome may be related to the sexual reproduction of graptolites under a special marine environment.

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图 版 说 明

标本保存在中国科学院南京地质古生物研究所。图影未加润饰。

图 版 I

1. Synrhabdosome of *Orthograptus cf. attenuatus* Rickards

×6, 一个完好的笔石簇, 陕西南郑福成下志留统龙马溪组, 相当四川城口双河场组 *Pristiograptus leptotheca-Petalotithus folium* 带。采集号: FH 86-F-1; 登记号: 117017。

