

新疆伊犁晚二叠世Ophiomorpha的环境意义

崔智林

摘要 新疆伊犁盆地上二叠统主要为一套湖相碎屑岩夹碳酸盐沉积,厚约2 700 m,在晓山萨依组下部灰岩夹层中产丰富的Ophiomorpha cf.nodosa遗迹化石。标本由一系列代表不同阶段个体所留下的粗细不同的潜穴组成。潜穴具一个明显的加厚的、由内外两层粪瘤构成的衬壁构造。潜穴呈简单直管状或盲肠状,不分叉,以水平和斜伸类型为主;内部充填具粒序性,说明沉积速度较快,且可作为良好的地层示顶构造。这些特征说明沉积基地的沉积速度较快,松软。

Ophiomorpha分布特征表明这种造迹生物的掘穴主要与水体的含氧性和沉积基地的性质有关,而与基地成分、水体含盐度、水深等无明显的关系。

关键词 遗迹化石 上二叠统 天山

中图分类号 P534.46; Q911.33 **文献标识码** A

The Environmental Implication of the Trace Fossil Ophiomorpha from the Upper Permian of the Yily Basin, Xinjiang

CUI Zhi-lin

(Department of Geology, Northwest University, Xi'an 710069)

Abstract

The Yily Basin, developed in the central Tianshan orogenic belt, accommodates a huge thickness (about 5 000 ~ 9 000 m) of continental Permian strata. The Upper Permian is chiefly composed of lacustrine clastic sedimentary rocks interbedded with limestone 2 700 m in total thickness, including units Xiaoshansayi Formation, Hamist Formation, Tiemulike Formation and Bakaluesayi Formation in ascending order. Ophiomorpha is abundantly produced in the Lower part of Xiaoshansayi Formation which consists of thin-bedded limestones interbedded with massive sandstones. Graded pebble-bearing sandstones, cross-bedded sandstones and rippled fine sandstones often constitute cyclic fining-upward deposits in section, showing mountain river fan deposits. The limestone usually contains sands, bioclastics and mud with few plant and freshwater bivalve fossils in them revealing shallow lacustrine deposits. It is absent in black laminar limestone and shales of Tiemulike Formation and Bakaluesayi Formation because this lithology represents an anaerobic condition.

Ophiomorpha exists in limestone beds without laminae in them, preserved as a set of

different burrows in diameter from 0.6 to 1.6 cm, probably representing developing stages of

pellets ovoid, or irregular in shape, but it is conspicuously double-layered. Their maximum length observed in the section can reach 35 cm. They are tube-like or caecum-like, predominantly horizontal and oblique in level, neither showing divergent branching pattern of typical *Ophiomorpha*. So, they are similar to *Ophiomorpha nodosa* Lundgren in size and pellet wall, but different in wall texture and branching pattern. Infill is passive and its composition is like country rocks.

Ophiomorpha was once accepted as a marine indicator (Kennedy and Sellwood, 1970), and afterwards documented in continental strata (Stewart, 1978; Bown, 1982; Merrill, 1984). But Goldering and Pollard (1995) thought that the continental appearance of *Ophiomorpha* is questionable. Samples in this study are collected in absolutely lacustrine sedimentary rocks. This supports the point of view that *Ophiomorpha* can occur in nonmarine environments. Some samples possess upward grading fill (Plate I-E), reflecting a rapid depositional condition. It could be also used as top-indicating structure. Above characteristics demonstrate that the burrow-maker is inclined to penetrate soft sedimentary floor where there are relatively a high rate of deposition and a high level of oxygen content, and they are scarcely controlled by composition of the substrate, water-depth and salinity.

Key words trace fossil Late Permian Tianshan

1 概述

Ophiomorpha 是一个十分重要的遗迹化石，前人已有许多报道，过去一般认为它的分布主要受含盐度、沉积基地性质、水深等环境因素的控制。Kennedy 和 Sellwood 将此化石作为海相指示化石^[1]。以后在陆相地层中的一些发现对这种化石的指相性提出了异议^[2~5]。但 Hasiotis 和 Bown 指出 *Jabel Quetrani* 组为海湾环境，而非陆地环境^[6]。Pollard 等认为南部英格兰下白垩统 *Wealden* 沉积中的遗迹不该归属 *Ophiomorpha*^[2]。Goldering 和 Pollard 把南英格兰下白垩统的 *Ophiomorpha* 修订为 *Beaconites*，并对其出现在非海相地层中的 *Ophiomorpha* 提出了质疑^[6]。本文标本采自新疆伊犁盆地上二叠统浅湖相灰岩中，全部归属于 *Ophiomorpha*。标本保存主要受到水体的含氧性和沉积基底性质的影响，与基底成分、水体含盐度、水深等无明显的关系。

2 地层与沉积

新疆伊犁盆地位于中天山构造带。区内二叠系主要出露在阿吾拉勒山。下二叠统为一套巨厚的陆相火山岩和火山碎屑岩，上部夹凝灰质粉砂岩、砂岩、泥岩，厚 2 000 ~ 6 500 m；上二叠统主要为湖相沉积，自下而上包括晓山萨依组、哈米斯组、铁木里克组和巴卡勒河组^[8, 9]。在伊宁县白石墩北约 3.5 km 处的巴卡勒萨依剖面(图 1)晓山萨依组下部产丰富的 *Ophiomorpha cf. nodosa*。过去该遗迹的最早记录是美国犹他州狼营阶^[10]。新疆标本产于上二叠统近底部，其时代早于美国犹他州的标本。

晓山萨依组为灰黄、灰绿色粉砂岩、泥岩和灰岩与块状砂岩、含砾砂岩的旋回性沉积，厚 419.5 m，砾岩和砂岩在剖面上常构成多旋回的向上变细序列叠置而成的巨厚

层，底部具冲刷面和滞留砾岩，向上依次为粒序状含砾砂岩，板状或槽状交错层砂

河道相沉积。浅湖相主要由粉砂质灰岩、生物屑灰岩、粉砂质泥岩构成。泥质灰岩中具纹层，可见变形层理，泥岩和灰岩中化石稀少，仅见少量的植物化石。总体显示了河流控制的浅湖相沉积。哈米斯特组为块状玄武安山岩、流纹斑岩、火山角砾岩和凝灰岩夹砂砾岩，厚365 m，铁木里克组和巴卡勒河组由深湖—半深湖相暗色泥岩、灰岩和块状砾岩组成，厚1900 m，泥岩和灰岩中水平纹层发育，缺乏底栖生物化石。砂砾岩呈透镜状，内具块状层理、平行层理、粒序性，显示出重力流沉积特征。

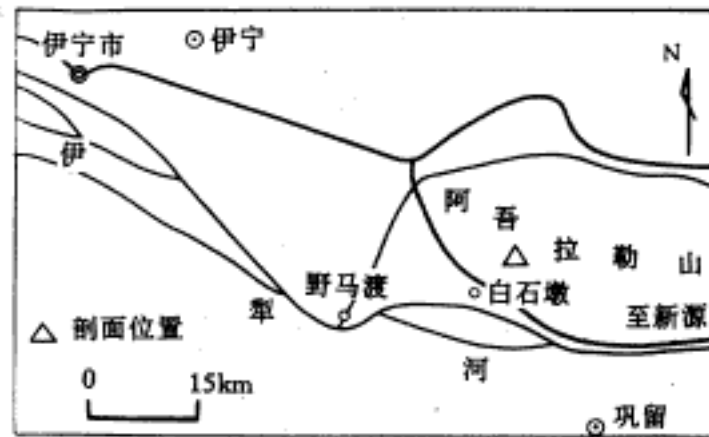


图1 剖面位置

Fig.1 Location of the sampled section

3 化石描述

蛇形迹属 *Ophiomorpha* Lundgren, 1891 瘤状蛇形迹(相似种) *Ophiomorpha* cf. *nodosa* Lundgren, 1891 (图版I-A-G, 图2)

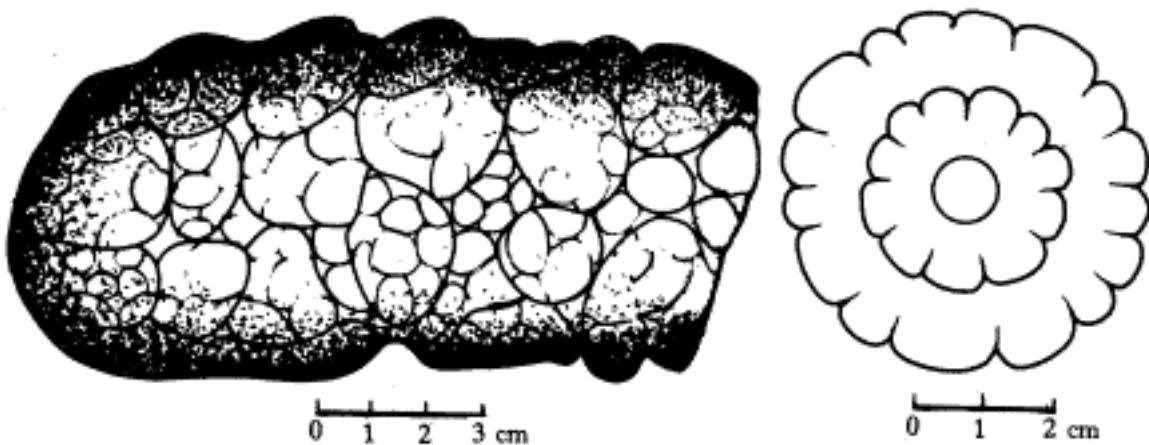


图2 *Ophiomorpha* cf. *nodosa*示意图

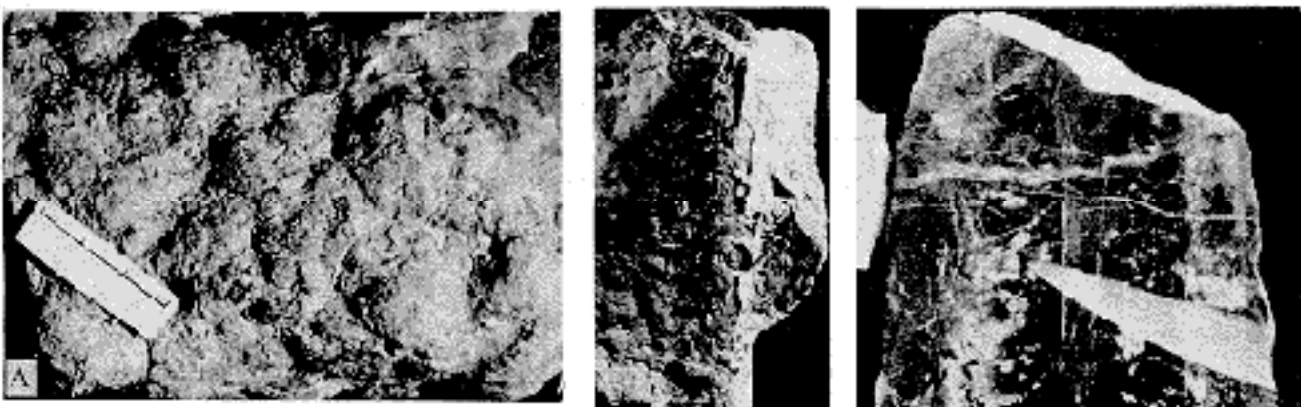
描述 潜穴呈圆柱形或盲肠状，末端不开口，粗细均匀，末端略有收缩，不分叉。管穴有斜伸、垂直和水平，但以斜伸和水平类型为主，直径0.6~1.6 cm，一般较短，可见最大长度12.5~35 cm；衬壁由内、外两层大小不同的卵形或不规则多边形的粪瘤组成，厚0.5~2.5 cm；个体较小者内外层分化不很明显，内层较薄；大者内外层分化明显，内层厚0.9~1.2 cm，外层厚1.0~1.3 cm。粪瘤一般呈交错排列。由粪瘤构成的内外层的颜色呈黑色或灰黑色，明显深于围岩、充填物和内外壁之间的夹层。但小个体的标本内、外层含铁质，呈褐红色，硬度大(图版I-C,D)。在部分标本上可以看到粪瘤由球形或卵形小粪粒组成。管穴内面光滑。充填物与围岩相同，有的标本显示出明显的粒序性(图版I-E)。

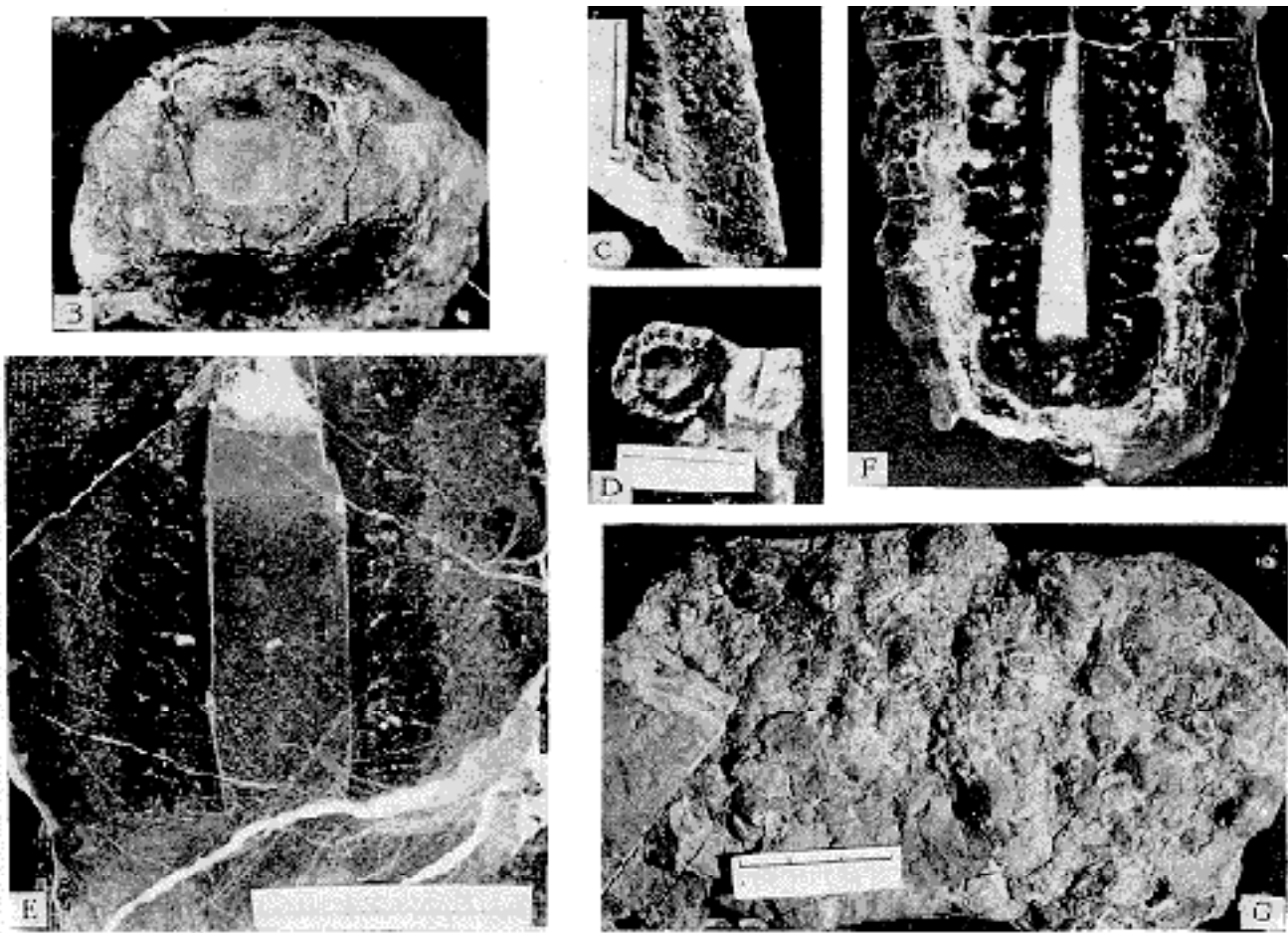
讨论 本属的主要分类依据是衬壁的粪瘤特征，目前包括*O.nodosa*, *O.borneensis*, *O.irregulaire*, *O.annulata*四种^[11]。新疆标本与模式种*O.nodosa*的基本特征相符，衬壁由形态不甚规则、大小不同、排列紧密的粪瘤组成，每一个粪瘤又由小的粪粒组成，但衬壁厚而分层，且无分叉又显示出差别，因此不能确切归入该种，

本种是由一系列粗细不同的标本组成，管穴直径0.6 cm到1.6 cm，衬壁厚由0.5 cm到2.5 cm，可能代表了不同阶段的个体所留下遗迹。

4 古环境与古生态

*Ophiomorpha*是一种居住或居住兼取食的遗迹，由虾或类虾动物形成^[11]。现生代表主要是美人虾和喇咕^[2]。这种潜穴具一个由粪粒粘结成的衬壁，其作用与沉积基底的粘结性有关^[3, 1]，潜穴为被动充填，充填物与围岩成分基本相同。潜穴充填显示出现的粒序性，从下到上碎屑成分逐渐减少，由砂屑灰岩变为泥晶灰岩(图版I-E, 纵切面)。这一管穴的内管底部还没有封闭，就被沉积物所充填，这种现象说明潜穴形成后或形成中被后期沉积物的快速充填。快速充填能由快速沉积作用造成，也反映了沉积环境周期性快速沉积的特征。这种充填类型可作为一种良好的地层示顶构造。





图版说明 A—G. *Ophiomorpha cf. nodosa* Lundgren A.为风化脱落标本，侧面，示大小、形态不同瘤饰构造；B.横断面，示由粪瘤构成的双层衬壁和圆滑的内壁；C，D为同一标本，较细潜穴壁的侧面和断面，示大小较均匀的瘤饰和衬壁结构；E，F纵切面，示具粒序的内部充填，光滑的内壁和深色的衬壁结构；G.为风化脱落标本，侧面，示大小，形态不同瘤饰构造.图中1小格代表1 cm.

潜穴以水平和斜伸类型为主，不分叉，仅见个别假分叉，*O. cf. nodosa* 多呈短粗盲肠状，末端不开口。少数个体较小的标本延伸较长，可达14 cm以上。Pollard等认为这类潜穴可能由于潜穴建造的时间紧张，而没有形成完整的潜穴系统〔7〕。本文标本只限于一层厚度16 cm的单层灰岩中，没有穿到下层砂岩和上层纹层状灰岩；且有的管穴延伸较长，也无分叉。说明时间因素不是主要原因，沉积基底性质是主导因素，在松软的基底上建造具衬壁构造的潜穴要付出更多的劳动。

新疆伊犁的标本仅出现在块状灰岩中，而在上覆的纹层状灰岩中未见及，潜穴瘤状壁发育，较厚，由内外两层组成，这些特征说明沉积基底松软、饱含水分。块状灰岩与纹层状灰岩在成因上的主要区别是前者形成于适度较快的沉积速度和无间断的连续的沉积条件。这类造迹生物喜欢在这种较松软的基底上营造潜穴。从目前发现的标本来看，多数分布在近岸砂岩(包括泻湖、河口湾、潮坪、三角洲相)〔12, 11, 4, 13, 7〕，少数见于近岸灰岩〔12〕，河流相〔5〕，浅海风暴岩〔14, 15〕和深海浊积扇〔16〕。这些环境都容易发生快速的沉积作用，沉积常具周期性，沉积物松软，饱含水分、有机质，且含氧量较高。由此可见，*Ophiomorpha*的造迹生物喜欢在这种沉积基

底上洞穴，基本不受盐度、水深、沉积基底成分的影响。

多期叠置的遗迹组构，基本属于同期的遗迹。沉积相研究表明本组为浅湖相沉积。其中的灰岩夹层为不纯灰色泥晶灰岩，含泥质、砂屑和生物屑，常具纹状构造，显示了滨湖沉积特点。在深湖—半深湖缺氧—贫氧相的铁木里克组和巴卡勒河组中没有出现。因此，在陆相环境下 *Ophiomorpha* 仍可作为充氧环境的标志。在海相环境中主要出现在富氧的滨浅海环境。

Ophiomorpha 虽可出现在陆相地层中，但以海相为主。Frey 等指出美人虾和 *Ophiomorpha* 洞穴出现在那些与真正海水相联系的淡水或半咸水中〔11〕。Maples 和 Archer 用咸水楔或海洋生物回游观点解释了这些海、陆相同时分布的遗迹化石〔17〕。如果是这样，晚二叠世时天山仍与海水有联系。

参加野外工作的还有梅志超，张国伟，滕志宏，金海宏等。

作者简介 崔智林 男 1958年出生 副教授 古生态学

作者单位：崔智林(西北大学地质系 西安 710069)

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