

晚震旦世高家山生物群化石新材料^{*}

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提要 对张录易等(1992)所建立的管状骨骼化石 *Qinella* 属进行重新修订, 根据基本宏观特征、壳面装饰和壳壁套管式结构等将 *Qinella shaanxiensis* Zhang, Li et Dong, 1992 和 *Qinella lijiaougouensis* Zhang, Li et Dong, 1992 归入 *Sinotubulites cienegensis* Mcmenamin, 1985, 而 *Qinella* 属征限定为管壳外表面光滑的多层壁套管式结构。对 *Chenella* 的属征进行厘定, 建立 *Chenella regularis* Zhang et Hua 一新种。根据口部特征的似吸盘状构造, 建立蠕形动物一新属 *Yudaiella* Zhang et Hua。

关键词 高家山生物群 化石新材料 管状骨骼化石 蠕形动物化石 晚震旦世

当前地学界普遍认为地球上最早出现的后生动物是以 Ediacara 动物群为代表的软躯体裸露动物, 保存为印痕化石; 以小壳化石为先导的骨骼动物化石的大量出现则标志着寒武纪的起始; 前寒武纪出现的骨骼化石也仅是震旦系或相当地层中偶见少量的主要为管状的以及小壳类型的化石(薛耀松等, 1992; Li Guoxiang et al., 1997)。

前寒武纪生物记录是验证地球上生物起源和早期演化理论的依据, 新化石类群的发现和研究是推动生物起源、演化理论发展的基础。值得指出的是, 近年来我国晚震旦世灯影峡期高家山生物群中大量的具矿化骨骼动物化石新类群的发现和研究, 翔实的证据首先打破了上述早期后生动物演化框架, 并且为提出后生动物起源和演化新观念、新理论奠定了基础。

高家山生物群于 1984 年发现, 1986 年命名, 主要由后生动物实体、遗迹化石和宏观藻类化石组成(张录易, 1986)。1987—1990 年在国家自然科学基金资助下, 在该生物群的化石组成上有了新的突破, 1992 年张录易等首次对这一生物群作了系统描述, 建立了许多新的化石门类和属种。近年来笔者等在国家自然科学基金资助下, 又数次对化石点进行了全面发掘, 获得了大量珍贵标本, 并基本查明了高家山生物群的时空分布。对所得化石进行了更为深入的野外和室内研究, 逐步揭示出高家山生物群是一

个以具矿化壁骨骼化石为主, 兼有软躯体蠕形动物和宏观藻类化石的多门类生物组合。高家山生物群化石个体普遍宏大, 与早寒武世梅树村期小壳化石有明显有别, 反映了生物发展史上一个独立的发展阶段, 代表了最早生物矿化事件的全面开始。翔实的材料还证明具矿化骨骼动物已在晚震旦世就显示了系统演化特征, 订正了以往认为早寒武世多门类小壳骨骼动物为起始的传统观念, 为提出生物进化新理论模式提供了依据。本文就是在此基础上, 对一些化石作了重新厘定, 并描述了几个新属种。

化石描述

门、纲、目、科未定 Phylum, Class, Order, Family uncertain

震旦管属 Genus *Sinotubulites* Chen, Chen et Qian, 1981

- 1977 ? *Cloudina*, Chen Menge and Wang Yizhao, p. 219—221, figs. 1, 2.
1981 *Sinotubulites*, Chen Menge, Chen Yiyuan and Qian Yi, p. 119—120, pl. I, figs. 1, 2; pl. II, figs. 1—6.
1985 *Sinotubulites*, McMenamin, M. A. S., p. 1416—1421, figs. 3, 2, 6; 4, 1, 2, 4—7, 5, 2, 5, 6.
1987 *Sinotubulites*, Signor, P. W., Mount, J. F. and Onken, B. R., p. 431—432, fig. 5, 1.
1992 *Qinella*, Zhang Luyi, Li Yong and Dong Junshe, p. 94—96,

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pl. VII, figs. 1-10; pl. IX, figs. 5, 7, 10.

模式种 *Sinotubulites baimatuensis* Chen,
Chen *et* Qian, 1981

属征 直或弯曲的管状壳体, 中空, 壳面光滑或饰以同心生长线、生长脊槽, 壳壁厚。横切面圆或外缘呈不规则多边形, 内缘近圆或浑圆形, 居中或偏心, 直径变化大。

讨论 与本属特征较近的属有 *Cloudina* Germs, 1972, *Rugatotheca* He, 1980 和 *Coleolella* Missarjhevsky, 1969。 *Cloudina* 管体呈叠锥套合状结构可区别于 *Sinotubulites* 属。 *Coleolella* 属与本属相近, 二者均具有不规则的环状纹饰, 但前者无纵肋。 *Rugatotheca* 属的纹饰在管壁内外基本相同, 且为双层壁(岳昭, 何廷贵, 1989)而 *Sinotubulites* 属管的纹饰是由外层壁的褶皱形成的, 其内层壁近平滑, 且壁的厚度较大, 这些特征可以区别于前两属。

分布及时代 中国湖北宜昌, 灯影组白马沱段; 中国陕西宁强, 灯影组高家山段; 墨西哥 Canora 地区 La Cienega 组和美国内华达 Dunfee 山脉 Deep Spring 组下部。新元古代末期。

***Sinotubulites cienegensis* McMenamin, 1985**

(图版 I, 图 5-8; 图版 II, 图 1-5, 6a, b, 14)

1985 *Sinotubulites cienegensis*, McMenamin, p. 119-120, pl. 1, figs. 1-2; pl. 2, figs. 1-6.

1992 *Qinella shaanxiensis*, Zhang Luyi, Li Yong and Dong Junshe, p. 95-96, pl. VII, figs. 1-5, 8-10; pl. IX, figs. 5, 7, 10.

1992 *Qinella lijiaoguensis*, Zhang Luyi, Li Yong and Dong Junshe, p. 96-98, pl. VII, fig. 7; pl. IX, figs. 6a, c.

材料 数十件保存完好的标本。

描述 壳体近圆柱状管, 中空, 直或微弯曲, 两端开口。直径一般大于 1 mm, 最大直径 3.5-4 mm, 长 25 mm。管壁厚(0.15-0.6 mm), 为多层层状壁, 呈管中套管的套管式结构。有的管壁厚度占管体外径 1/3 以上。管体内壁表面光滑。管体外表面发育有环脊, 环槽, 环纹和纵褶。环脊是由多层壁褶皱尖锐的波峰叠合而成, 往往高突而尖锐; 环槽系多层宽缓的圆滑的波谷叠合而成, 多成宽圆谷状; 纵褶是多层壁平行管体纵向高突的褶皱; 环纹是较细的纹饰。环脊, 环纹变化较大, 可相互平行, 弯曲或斜交, 彼此间距不一。随标本不同纵褶数量各不相同。管体横断面多为多边形。

保存较好的标本, 管壁可见到 7-8 层, 单层厚 0.016 mm, 层间距 0.06-0.12 mm。内层一般平

直, 往外与第二层之间往往间距较大(为 0.12 mm), 之间填充有隐晶质碳酸盐, 局部见似海绵状褐色磷酸盐质相连。再往外各层紧密排列(均由褐色磷酸盐所组成)形成波峰尖锐波谷宽圆的不规则褶皱, 褶皱起伏由内向外逐渐强烈, 形成高突的环脊和宽缓的浑圆波谷。以上管壁的结构特征显然不是后期成岩作用管体溶解分异而形成的, 应是其原生结构。

Sinotubulites cienegensis 管壁成分分析

标本号	Si	Ca	P	Cu	K	Fe
Lj223	7.41	72.54	16.44	3.61		
Lj223	81.16	18.84				
Lj643 内壁表面	14.396	74.855			1.504	9.247
Lj643 外壁表面	70.047	13.401			1.432	14.326
Lj643 壁中间层	84.282	5.977			2.225	7.515
Lj643 外壁表面	80.363	17.489				2.148

管壁成分经电子探针能谱分析, 高硅低钙或低硅高钙, 缺少磷, 显示强硅化的碳酸盐。 只一个探区见磷。据岳昭(1990)* 所测 2 个标本 4 个能谱分析, 平均为高钙(37.66%-53.98%), 低硅(0.17%-13.93%), 高磷(26.31%-41.45%), 为磷酸钙质。即使在同一个样品上, 所测元素成分不尽相同, 可能是受成岩作用交代不同所致, 或者是化石在酸蚀过程中部分元素遭溶蚀。

化石产于灰白色内碎屑灰岩中, 呈零星无序的分布, 一般呈黑色斑点, 易于寻找。岩石薄片化石体多呈褐黄色, 管内充填物与围岩相同, 均由隐藻团粒结构的碳酸盐岩矿物所组成, 局部见黑色胶磷矿碎屑, 说明化石体为异地埋藏, 经过了水动力搬运过程, 因而冰醋酸浸泡出的化石极少是完整标本。

化石度量(mm)

登记号	管长	外径	内径	壁厚	单层壁厚
86Lj109	14	1.9-2.4	1.6-2.0	0.15-0.2	
86Lj1a	5	1.4	0.6	0.4	
86Lj1b	25	3.5	2.8	0.2-0.6	0.04
86Lj82	1.94	1-1.4	0.66	0.2-0.4	
Lj1	18	1.48	1.4		0.03-0.06
Lj2	6	2.32	1.52	0.42	0.016
86Lj86	1.5	2.32	1.52	0.42	0.08
9226	3.54	2.27	1.25	0.29	

比较 岳昭(1990)曾命名 *Sinotubulites shaanxiensis* Yue, 并做过描述。张录易等(1992)考虑到模式标本壳壁保存较差, 全被硅化, 丁启秀等

* 岳昭, 1990, 扬子地台前寒武系-寒武系过渡层骨骼微生物生物地层学及古生物, 中国地质科学院攻读博士研究生学位论文。
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(1993)进一步工作也未查明其壳壁微结构,虽然管体外部纹饰形态有相似之处,也不易归入其中,故建立 *Qinella* 属以示区别。经近年来复查,其中的 *Qinella shaanxiensis* Zhang, Li et Dong 1992 和 *Qinella lijiagouensis* Zhang, Li et Dong 1992 的基本宏观特征,壳壁套管式结构与 *Sinotubulites ciene-*
gensis McMenamin 1985 基本一致,故将上述两种作了修订,归入其中。

产地和层位 陕西宁强宽川铺李家沟、胡家坝高家山;上震旦统灯影组高家山段。

秦氏虫属 Genus *Qinella* (Zhang, Li et Dong, 1992) emend. nov.

1992 *Qinella*, Zhang Luyi, Li Yong and Dong Junshe, p. 94, pl. VII, figs. 1—10; pl. IX, figs. 5, 7, 10.

模式种 *Qinella levis* Zhang, Li et Dong, 1992

属征 壳体呈圆筒状磁管,直或微弯曲,稍具锥度,横断面次圆形,管壳内外表面光滑,具稀疏的纵褶线,局部见斜交管体轴线。管体两端开口,尚未见始端和末端。管壁为多层状壁套管式结构,由磷酸钙质成分组成。

讨论 修订后的 *Qinella* 属征,与 *Sinotubulites* 属均为多层层状壁套管式结构的管体,其主要区别在于管体外部纹饰:前者壳表面光滑,仅见稀疏的纵褶;后者壳表面具清晰的环脊,环槽,环纹,二者区别显著。

分布及时代 中国陕西宁强;晚震旦世晚期。

平滑秦氏虫 *Qinella levis* Zhang, Li et Dong, 1992

(图版 I, 图 1, 3, 4, 9—12)

1992 *Qinella levis*, Zhang Luyi, Li Yong and Dong Junshe, p. 96, pl. VII, fig. 6.

正模 9238, 陕西宁强宽川铺李家沟, 灯影组高家山段。

材料 8 枚较完好的标本。

描述 壳体呈圆筒状套管,中空,直或微弯曲,稍具锥度。管表面光滑,具稀疏的纵褶。管内壁光滑。管体两端开口,尚未见始端和末端。保存长度 3—9.73 mm, 外径 0.8—2.08 mm, 内径 0.38—0.8 mm, 壳壁厚 0.1—0.35 mm, 单层厚 0.04—0.08 mm, 管壁为多层状壁套管式结构,可见 6—7 层或 10 层以上,层间常有间隙,在不同横断面上间隙有所不同。如正模标本一端层间隙可占管体直径的

1/3。内层好似隔板构造,管体内腔呈圆-椭圆。壳壁常见石内藻类钻孔。化石呈灰黑色保存到灰白色内碎屑灰岩中。壳质成分经能谱分析为磷酸钙质。

产地及层位 陕西宁强宽川铺李家沟;上震旦统灯影组高家山段。

壳质成分能谱分析

标本编号	Ca	Si	P	Ti	K	S
599 外层内壁	68.810	2.418	30.772			
内层内壁	64.462	3.645	26.690	3.951		1.253
内层内壁	69.839	3.331	20.881		5.649	0.301
604 中层表面	69.677	1.529	28.658			
中层表面	68.904	1.757	29.339			0.136
外层表面	8.889	83.452	7.659			
外层表面	56.562	18.258	25.180			
外层表面	57.000	5.468	27.532			
中层断面	63.479	4.533	30.071		1.917	
内层	9.552	78.064	10.899		1.485	
平均	53.2714	20.2455	23.7681			

陈氏虫属 Genus *Chenella* (Zhang, Li et Dong 1992) emend. nov.

1992 *Chenella*, Zhang Luyi, Li Yong and Dong Junshe, p. 99, pl. XIV, figs. 3, 5—10.

模式种 *Chenella laevis* Zhang, Li et Dong, 1992

属征 化石呈圆筒状管,稍弯曲和微具锥度,始端闭合尚不清楚。管壁薄,为单层层状壁,管内、外表面光滑无纹饰,管径 1.5—3.8 mm,保存长 9—25 mm,管壁成分为钙质或磷酸钙质。

讨论 *Chenella* 常与 *Sinotubulites*, *Cloudina* 共生在一起,但后二者均为多层层状壁,一为套管式结构,一为叠锥套合式结构,与 *Chenella* 区别显著。它与体壁像指状胶套特征的 *Lockportia* Howell 1959 属颇为相似,表面光滑。但后者管体粗大,直径达 20 mm,且产于中志留统;而前者个体微小,时代更老,二者不便比较。

分布及时代 中国陕西宁强;晚震旦世晚期。

光滑陈氏虫 *Chenella laevis* Zhang, Li et Dong, 1992

(图版 II, 图 6c, 7, 8)

正模 GHF9-2G。

材料 5 件。

描述 化石产于黑灰色硅质灰岩和粉砂质灰岩中。化石体呈圆筒柱状,近等粗,直径 1.5—3.8 mm,保存长度 9—25 mm,横断面呈扁圆形,管壁厚

0.01—0.015 mm, 由钙质组成。管壁颜色比围岩和充填物稍暗, 内外表均光滑, 常见管壁被压裂的现象, 说明管壁是矿化的壳壁, 虽然很薄, 但已有一定的硬度, 质较脆, 化石在成岩作用下受上覆沉积物压应力作用而原地破裂。手标本所见管体两端开口, 尚未见封闭端。张录易等(1992)曾描述“岩石薄片见始端呈半球形, 稍具锥度”, 可能不是该种的对应物。

产地及层位 陕西北强高家山, 上震旦统灯影组高家山段。

纵槽陈氏虫 *Chenella canaliculata* Zhang, Li et Dong, 1992

(图版 II, 图 9)

1992 *Chenella canaliculata*, Zhang Luyi, Li Yong and Dong Junshe, p. 99, pl. XIV, fig. 10.

正模 GHF9-2E。

材料 1 件。

描述 化石产于灰黑色灰岩中, 为圆筒状, 一端开口, 另一端埋在灰岩中形态不明。管体近等粗, 横断面哑铃形, 长径为 3.2 mm, 短径 2 mm, 保存长度 13 mm。管壁为层状壁, 厚 0.015 mm, 外表面光滑, 有一条平行管体很深的纵沟, 从管体横断面判断背面也有纵沟。管壁成分为钙质。

比较 本种与本属其它种的区别在于横断面呈哑铃形, 管体上有相对平行管体很深的沟。

产地及层位 陕西北强高家山, 上震旦统灯影组高家山段。

纵褶陈氏虫 *Chenella costata* Zhang, Li et Dong, 1992

(图版 II, 图 10)

1992 *Chenella costata*, Zhang Luyi, Li Yong and Dong Junshe, p. 100, pl. VI, fig. 3.

正模 GHF11-1-2。

材料 1 件。

描述 化石产于灰黑色泥砂质灰岩中, 化石体圆筒状, 两端特征不明。管体近等粗, 横断面哑铃形, 保存长度 6 mm, 直径 2 mm, 管壁厚 0.01 mm, 外表面光滑, 具有近平行管体的纵褶, 褶宽 0.1 mm, 间距 0.1—0.8 mm。管壁经能谱分析成分为: Ca 91.36%, Fe 2.7%, Si 2.6%, S 1.34%, Mg 0.98%, 证明管壁成分为钙质。

比较 本种以管壁表面具纵褶与本属其他种相区别。

产地及层位 陕西北强高家山, 上震旦统灯影组高家山段。

规则陈氏虫 (新种) *Chenella regularis* Zhang et Hua (sp. nov.)

(图版 I, 图 2)

正模 91NL3-1(0605)。

材料 9 个长短不一的管体。

描述 化石呈白色规则的圆管状, 近等粗, 直或稍弯, 两端开口, 横断面为较规则的圆形管, 内外壁表面光滑无纹饰。管壁为单层结构, 管壁成分为 P 33.24%, Ca 66.751%。

化石保存最长者 3.4 mm, 直径 0.5—0.6 mm, 壁厚。

比较 新种的基本特征与 *Chenella laevis* Zhang, Li et Dong 1992 十分相似, 但此种管体较规则, 上下管径基本一致, 直径比后者小。

产地及层位 陕西北强宽川铺李家沟, 上震旦统灯影组高家山段。

玉带虫 (新属) *Yudaiella* Zhang et Hua (gen. nov.)

模式种 *Yudaiella formosa* Zhang et Hua (gen. et sp. nov.)。

特征 体为压扁的长条状圆形管, 在保存范围内近于等粗, 但有规律性的缢缩现象, 管宽 4—5 mm, 保存长度 50 mm, 平行层面产出。体表具浅灰黑色的膜, 表面可见密集的横向环纹, 不甚规则, 由颜色深浅不同和高低差异而显示, 随管体弯曲而有疏密及形态变化, 1 mm 长度上有 5—7 条环纹。口部可见一圆环形、似吸盘状构造, 高突, 直径约 5 mm, 圆环外缘稍倾斜, 表面光滑, 在生物立体镜下未见纹饰; 环内部为圆形凹陷区, 直径 2 mm 左右。尾部没有保存, 情况不明。未见头部特殊构造, 体表无瘤点等装饰, 也无附肢等保存。

讨论 以口部圆环形, 具似吸盘状构造有别于已知的其它蠕形动物。高家山生物群中蠕形动物虽然极为丰富, 但迄今为止均未发现保存有吸盘状构造者, 故建立一新属, 以待材料进一步积累。

时代与分布 中国陕西北强, 震旦系灯影峡期。

美丽玉带虫 (新属、新种) *Yudaiella formosa* Zhang et Hua (gen. et sp. nov.)

(图版 II, 图 12, 13)

正模 93NH-1a-b。

材料 仅 1 件标本,保存有正体和副体。化石以碳质压膜方式保存在黄绿色粉砂岩层面上。

描述 见属征。

产地及层位 陕西宁强高家山,上震旦统灯影组高家山段。

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NEW FOSSIL EVIDENCES FROM LATEST NEOPROTEROZOIC
GAOJIASHAN BIOTA, SOUTH SHAANXI

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Key words: Gaojiashan Biota, skeletal fossils, worm-like fossils, Latest Neoproterozoic

Summary

The similarites of column-in-column structure of their multiply-layered tube walls as well as their typified wall ornaments make it possible to transfer *Qinella shaanxiensis* and *Q. lijiagouensis* to *Sinotubulites cienegensis*. While the genus *Qinella* is retained, and delimited to the smooth walled multiply-layered tubular fossils, also is of column-in-column structure. *Chenella*, however, can be readily distinguished from any other members of the tubular fossils by its single layered wall.

A worm-like structure with a circular sucker-like structure in its anterior has been described for the first time, and ascribed to a new genus *Yudaiella*.

SYSTEMATIC PALEONTOLOGY

Phylum, Class, Order, Family uncertain
***Sinotubulites* Chen, Chen et Qian, 1981**
1977 ? *Cloudina*, Chen Menge and Wang Yizhao, p. 219—221, figs. 1, 2.
1981 *Sinotubulites*, Chen Menge, Chen Yiyuan and Qian Yi, p. 119—120, pl. I, figs. 1, 2; pl. II, figs. 1—6.
1985 *Sinotubulites*, Mcmenamin, M. A. S., p. 1416—1421, figs. 3.

2, 6; 4, 1, 2, 4—7, 5; 2, 5, 6.

1987 *Sinotubulites*, Signor, P. W., Mount, J. F. and Onken, B. R., p. 431—432, fig. 5; 1.

1992 *Qinella*, Zhang Luyi, Li Yong and Dong Junshe, p. 94—96, pl. VII, figs. 1—10; pl. IX, figs. 5, 7, 10.

Type species: *Sinotubulites baimatuoensis* Chen, Chen *et* Qian, 1981

Diagnosis: Straight or slightly curved tubular shell, with thick wall and circular or irregular polygonal cross-section. Outer surface ornamented with irregular transverse ridges or ribs, annular ornamentation connected and/or cut across by longitudinal ridges parallel or oblique to growth axis.

Remarks: *Cloudina* Germs, 1972, *Rugatotheca* He, 1980, and *Coleolella* Missarjhevsky, 1969 show some similarity to *Sinotubulites*. However, *Cloudina* differs from *Sinotubulites* in having a cone-in-cone structure. *Coleolella* is characterized by regular dense transverse ribs on its outer wall, differing from the usually observable aberrant sculptural elements, such as irregular annulae or longitudinal ridges on that of *Sinotubulites*. While *Rugatotheca* has a two-layered wall, with both outer and inner walls ornamented with same irregularly and densely arranged transverse ribs, *Sinotubulites*, however, its surface ornamentations were formed by the wrinkles of multiply outer walls, with the inner wall still keeping smooth.

Sinotubulites cienegensis McMenemy, 1985

(Pl. I, figs. 5—8; Pl. II, figs. 1—5, 6a, b, 14)

1985 *Sinotubulites cienegensis*, McMenemy, p. 119—120, pl. 1, figs. 1—2; pl. 2, figs. 1—6.

1992 *Qinella shaanxiensis*, Zhang Luyi, Li Yong and Dong Junshe, p. 95—96, pl. VII, figs. 1—5, 8—10; pl. IX, figs. 5, 7, 10.

1992 *Qinella lijiaougouensis*, Zhang Luyi, Li Yong and Dong Junshe, p. 96—98, pl. VII, fig. 7; pl. IX, figs. 6a, c.

Material: Dozens of well-preserved specimens.

Diagnosis: nearly cylindrical tube, straight or slightly curved, with both ends open. Tube walls, multiply-layered and thick, ranges from 0.15 to 1.6 mm, and is characterized by column-in-column structure. 7 or 8 wall-layers may exist in well-preserved specimens, and smooth in the inner wall but wrinkle strongly outwards by degrees. The outer walls may be ornamented with transverse ridges, transverse furrows, annulations as well as longitudinal ridges, which were caused by wrinkle of the multiply walls. The transverse ridges and furrows may correspond to

superimposed crests and troughs of the fold.

In cross-section, the shell walls may be circular, subellipsoidal, or irregular polygonal.

The primary compositions of the tube walls may be calcareous, with varying degree of silicification.

Discussion: The type specimen of *Sinotubulites shaanxiensis* Yue is so poorly persevered and strongly silicified that it can not be assigned readily to this genus and its microstructure is still unknown (Ding *et al.*, 1985). To tell the difference, Zhang *et al.* (1992) set up a new genus *Qinella* and three new species. Of which, *Qinella shaanxiensis* Zhang, Li *et* Dong, 1992 and *Q. lijiaougouensis* Zhang, Li *et* Dong, 1992 are revised here and transferred to *Sinotubulites cienegensis* McMenemy, 1985 based on their similarities in general morphology and column-in-column structure of their tube walls.

Occurrence and horizon: The Gaojiashan member of the Upper Sinian Dengying Formation in Gaojiashan and Lijiagou of Ningqiang county, Shaanxi Province, China.

Qinella (Zhang, Li *et* Dong, 1992) emend. nov.

1992 *Qinella*, Zhang Luyi, Li Yong and Dong Junshe, p. 94, pl. VII, figs. 1—10; pl. IX, figs. 5, 7, 10.

Holotype: *Qinella levis* Zhang, Li *et* Dong, 1992

Diagnosis: Cylindrical to weakly tapering shell, with subcircular cross-section. Conch, straight or slightly curved, with both ends open. Multiply-layered tube walls, phosphate in composition, are typically of column-in-column structure. Both inner and outer wall surfaces are essentially smooth, sparsely ornamented with longitudinal sculptures.

Discussion: The revised *Qinella* shows some similarity to *Sinotubulites* in their multiply walls and column-in-column structure, but differs from the latter in its smooth surface both in inner and outer walls.

Distribution and ages: Ningqiang county, Shaanxi Province, China; latest Neoproterozoic

Qinella levis Zhang, Li *et* Dong, 1992

(Pl. I, figs. 1, 3, 4, 9—12)

1992 *Qinella levis*, Zhang Luyi, Li Yong and Dong Junshe, p. 96, pl. VIII, fig. 6.

Holotype: 9238.

Material: 8 well-preserved specimens.

Description: Cylindrical tube, straight or slightly curved, with low angle of divergence. Outer surface smooth, sparsely ornamented with longitudinal ridges, locally oblique to the axis. Inner surface smooth. Conch, with both ends open, initial and terminal parts not preserved. The preserved length 3—9.73 mm, cross-section is circular to elliptical with external diameter ranging from 0.8 to 2.08 mm, inside diameter from 0.38—0.8 mm. Tube walls, multiply-layered, about 6—7 layers well distinguishable, sometimes even over 10 layers, with typical column-in-column structure. Thickness of the tube walls about 0.1—0.35 mm, while single layer 0.04—0.08 mm. Interstice between wall layers are variable in different cross-sections. Composition of shells is phosphate by spectral analysis.

Occurrence and horizon: Ningqiang county, Shaanxi Province, China; latest Neoproterozoic

***Chenella* (Zhang *et al.*, 1992) Zhang *et al.* emend. nov.**

1992 *Chenella*, Zhang Luyi, Li Yong and Dong Junshe, p. 99, pl. XIV, figs. 3, 5—10.

Type specimen: *Chenella laevis* Zhang, Li *et al.* Dong, 1992

Diagnosis: Cylindrical to weakly tapering shell, straight or slightly curved. The initial parts are not clear. Wall thin, single layered. Both inner and outer surfaces are smooth. Preserved length 9—25 mm, thickness of the tube walls about 0.1—0.35 mm, composition of shells is calcareous or phosphate.

Discussion: Though *Chenella* generally co-occurs with *Sinotubulites* and *Cloudina*, the latter are all multiply layered, one is of cone-in-cone structure, the other column-in-column structure, quite different from the former single-layered structure. *Chenella* is also somewhat similar to *Lockportia* Howell 1959 in its smooth and leathery tube. The latter, however, is of giant test, with a diameter about 20 mm, and occurs in the Middle Silurian.

Distribution and ages: Ningqiang county, Shaanxi Province, China; Latest Neoproterozoic.

***Chenella laevis* Zhang, Li *et al.* Dong, 1992**

(Pl. II, figs. 6c, 7, 8)

Holotype: GHF 9-2G.

Material: 5 specimens.

Diagnosis: Cylindrical tube, with nearly equal width, and diameter ranging from 1.5 to 3.8 mm. Wall thin, about 0.01—0.015 mm in thickness, with brittle fracture commonly occurred due to the overburden pressure in diagenesis. Both inner and outer surface are smooth. Preserved length is 9—25 mm. Both ends open in hand specimens. Composition of shells is calcareous.

Occurrence and horizon: The Gaojiashan member of the Upper Sinian Dengying Formation in Gaojiashan, Ningqiang county, Shaanxi Province, China.

***Chenella canaliculata* Zhang, Li *et al.* Dong, 1992**

(Pl. II, fig. 9)

1992 *Chenella canaliculata*, Zhang Luyi, Li Yong and Dong Junshe, p. 99, pl. XIV, fig. 10.

Holotype: GHF 9-2E.

Material: only 1 specimen.

Diagnosis: Cylindrical calcareous tube of nearly equal width, with one end open, the other buried in carbonate rocks. Cross-section dumbbell-like, with long and short diameter about 3.2 and 2 mm respectively. Wall thin, about 0.01—0.015 mm in thickness, with brittle fracture commonly occurred due to the overburden pressure in diagenesis. Both inner and outer surfaces are smooth. Preserved length 9—25 mm.

Comparison: Its dumbbell-like cross-section and deep longitudinal furrow differ from other species in the genus.

Occurrence and horizon: The Gaojiashan member of the Upper Sinian Dengying Formation in Gaojiashan, Ningqiang county, Shaanxi Province, China.

***Chenella costata* Zhang, Li *et al.* Dong, 1992**

(Pl. II, fig. 10)

1992 *Chenella costata*, Zhang Luyi, Li Yong and Dong Junshe, p. 100, pl. VI, fig. 3.

Holotype: GHF 11-1-2.

Material: One specimen.

Diagnosis: Cylindrical calcareous shell with dumbbell-like cross-section, nearly equal in size of the tube, with diameter about 2 mm and wall thickness about 0.01 mm. The preserved length 6 mm. Outer surface smooth, and ornamented with longitudinal ridges nearly parallel to the tube, width of the ridges

0.1 mm, with an interval about 0.1 to 0.8 mm.

Comparison: *Chenella costata* is distinct from other species in its longitudinal sculpture.

Occurrence and horizon: The Gaojiashan member of the Upper Sinian Dengying Formation in Gaojiashan, Ningqiang county, Shaanxi Province, China.

Chenella regularis Zhang et Hua (sp. nov.)
(Pl. I, fig. 2)

Holotype: 91NL3-1.

Material: 9 specimens.

Diagnosis: Regular cylindrical tube, straight or slightly curved with two ends open. Cross-section is regularly circular, with a diameter about 0.5–0.6 mm. Both inner and outer surfaces smooth and without ornament. Wall single layered, about 0.02 mm in thickness, and is phosphate in composition. The largest preserved length is 3.4 mm.

Comparison: *Chenella regularis* is somewhat indistinguishable from *Chenella laevis* Zhang, Li et Dong, 1992, but the equal width and small size of the regular tube are diagnostic.

Occurrence and horizon: The Gaojiashan member of the Upper Sinian Dengying Formation in Lijiaogou, Kuanchuanpu, Ningqiang county, Shaanxi Province, China.

Phylum, Class, Order, Family uncertain

Genus *Yudaiella* Zhang et Hua (gen. nov.)

Type species: *Yudaiella formosa* Zhang et Hua (gen. et sp. nov.)

Diagnosis: Long flattened tube, about 4–5 mm in width and 50 mm in persevered length. Though contracting regularly, it is nearly equal in size. The body is marked by annular striae, about 5–7 annulae per 1 mm. A sucker-like structure is quite striking in its anterior part, about 5 mm in diameter, but displays no further structure under high power, the inner of which is a depressed ring, 2 mm in diameter. The body itself is only incompletely persevered on the holotype. The posterior part is missing. No parapodia can be discerned.

Discussion: The circular sucker-like structure in its anterior can tell the difference to other worm-like fossils known, but additional materials are still needed to assess the taxonomy.

Distribution and ages: Ningqiang county, Shaanxi Province, China; Latest Neoproterozoic

Yudaiella formosa Zhang et Hua (gen. et sp. nov.)
(Pl. II, figs. 12, 13)

Holotype: 93NH-1a, b.

Etymology: Name after the river pass through the district.

Material: Only one specimen.

Description: The diagnosis of the species is the same as that of the genus.

Occurrence and horizon: The Gaojiashan member of the Upper Sinian Dengying Formation in Gaojiashan, Ningqiang county, Shaanxi Province, China.

图版说明

所有标本均保存在国土资源部西安地质矿产研究所, 图版 I 及图版 II 之图 1–4, 14 的产地为宽川铺李家沟, 其余为高家山。化石产出层位均为上震旦统灯影组高家山段。

图 版 I

1, 3, 4, 9–12. *Qinella levis* Zhang, Li et Dong, 1992

1. 侧视, $\times 13$; 登记号: 0604。3, 4. 上视, 下视; $\times 8.6$; 登记号: 0599。9. Holotype, $\times 24$; 登记号: 9238。10–12. 系图 1 标本石内藻不同倍数下的特征。

2. *Chenella regularis* Zhang et Hua (sp. nov.)

Holotype, $\times 16$; 登记号: 0605。

5–8. *Sinotubulites cienegensis* McMenamin, 1985

5. 侧视, $\times 4$; 登记号: 86Lj1b。6. 侧视, $\times 8$; 登记号: 86Lj109。7. 侧视, $\times 22$; 登记号: 0591。8. 壳外壁纹饰, $\times 24$; 登记号: 9244。

图 版 II

1–5, 6a, b, 14. *Sinotubulites cienegensis* McMenamin, 1985

1. 图 14 纵断面局部放大, $\times 25$, 登记号: LjL-1。2. 薄片横切面, $\times 10$; 登记号: LjL1-1。3. 薄片横切面, $\times 16$; 登记号: LjL9。4. 薄片纵切面, $\times 6$; 登记号: LjL-2。5. $\times 36$; 为图 6a 的局部放大; 6a, b. 手标本风化表面, $\times 4$; 登记号: GHF9-2G。

6c, 7, 8. *Chenella laevis* Zhang, Li et Dong, 1992

6c. Holotype, $\times 4$; 登记号: GHF9-2G。7. 侧视, $\times 4$; 登记号: GHF10-22-5。8. Paratype, $\times 4$; 登记号: GHF11-2-79。

9. *Chenella canaliculata* Zhang, Li et Dong, 1992

Holotype, $\times 4$; 登记号: GHF9-2E。

10. *Chenella costata* Zhang, Li et Dong, 1992

Holotype, $\times 6$; 登记号: GHF11-1-2。

11. *Chenella* sp.

Holotype, $\times 8$; 登记号: GHF11-2-78。

12, 13. *Yudaiella formosa* Zhang et Hua (gen. et sp. nov.)

Holotype, 正视, 底视, $\times 2$; 登记号: 93NH-1。