

陕南末元古代高家山生物群主要化石类群及其特征^{*}

华 洪

(西北大学地质系 西安 710069)

张录易 张子福 王静平

(国土资源部西安地质矿产研究所 西安 710054)

提要 末元古代高家山生物群是以骨骼化石为主, 兼有软躯体后生动物及宏观藻类化石的一个多门类化石组合, 是目前已知最早且最为多样化的骨骼化石生物群。化石主要产于上震旦统灯影组高家山段中上部, 时限约 565—543 Ma。目前虽然尚难对其进行系统的生物学分类, 但根据化石的形态特征可以划分为以下几个类群, 即具矿化壁的骨骼类群, 包括管状化石、锥管状化石、瓶状化石、球状化石、杯状化石和疑难化石等, 以及蠕形动物化石类群, 遗迹化石类群和宏观藻类化石类群等。还选取与其同时代且特征较为相似的峡东西陵峡生物群和南非纳米比亚纳玛生物组合进行比较。

关键词 末元古代 高家山生物群 化石类群 骨骼化石 蠕形动物化石 陕南

1 前言

陕西宁强地区是中国最早发现震旦纪后生动物的产地(陈孟莪等, 1991)。早在本世纪 50 年代末至 60 年代初, 原陕西磷矿队在宁强宽川铺李家沟就发现了“蠕形虫化石”。1964 年, 张录易将其定为 *Chabakovia* sp.; 陈孟莪等(1975)将其定为 cf. *Sabellidites* sp., 并认为是中国首次发现的后生动物化石, 同时根据化石所赋存的层位、岩性组合特征和区域分布, 将宽川铺组厘定为: 其下部命名为高家山组, 并与湖北峡东震旦系灯影组中上部对比; 其上部富含小壳化石的灰岩、硅质岩夹薄层胶磷矿仍称“宽川铺组”。邢裕盛等(1984, 1985)又将该类化石厘定为后生动物遗迹化石, 命名为 *Shaanxilithes ningqiangensis* Xing, Yue et Zhang 1984。1982—1984 年, 陕西省地质矿产局第二地质队在研究宁强宽川铺震旦系—寒武系界限时, 曾在高家山组发现 *Sinotubulites baimatuoensis* Chen, Chen et Qian 1981。1984 年, 张录易、林世敏等在详细分析前人研究成果的基础上, 在宁强胡家坝高家山碑湾, 即陈

孟莪等(1975)建立的上震旦统高家山组的层型剖面上, 发现了极其丰富的后生动物实体化石、遗迹化石和似宏观藻类等化石(林世敏等, 1986)。张录易(1986)将其命名为高家山生物群, 并作了初步描述, 为便于与峡东对比, 又将本区灯影组由下而上划分为 4 段: 即藻白云岩段、高家山段、碑湾段和宽川铺段, 分别与蛤蟆井段、石板滩段、白马沱段和天柱山段对比。高家山生物群就产在上震旦统灯影组高家山段中上部, 顶界为富含早寒武世梅树村阶小壳化石的灯影组宽川铺段底界所限定, 底界暂以高家山段之底为界, 不排除下延至藻白云岩段。1992 年, 张录易等首次对这一生物群作了系统描述, 发现了许多新的化石门类 and 化石产地。近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系统发掘, 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。

高家山生物群的地理分布主要在陕西省宁强县境内, 以胡家坝镇高家山为中心, 西至罗家河小塘子梁—长坡垭—宽川铺选将坪一带, 东至石板沟—竹叶沟, 胡家坝—勉县鹑鸽洞—元墩子一带, 东西长约 40 km 的范围内均可见到, 地理坐标为东经 106°15′

收稿日期: 2000-02-10

^{*} 国家自然科学基金资助课题(No. 49772081)

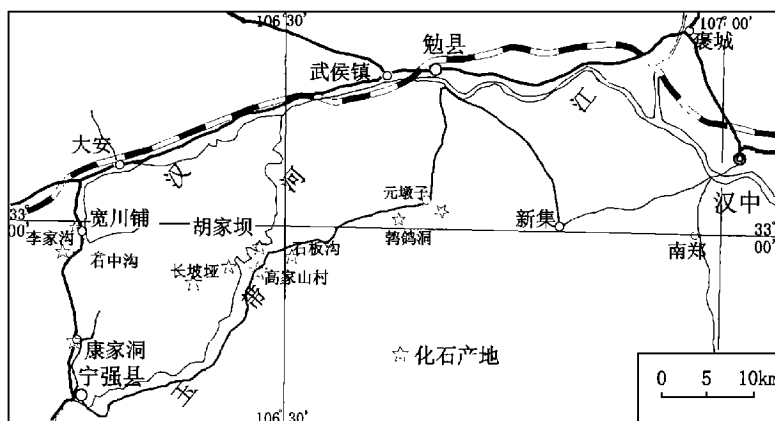


插图 1 高家山生物群化石产地分布图
Location map showing occurrence of Gaojiashan Biota

—106°39′, 北纬 32°53′—33°00′(插图 1)。

本区灯影组尚缺乏同位素年龄依据,考虑到它与峡区灯影组的相似性,其时限据 Knoll 等(1999)对峡东灯影组相应层段的推测应在 565—543 Ma。

2 高家山生物群的组成及其主要特征

前寒武纪-寒武纪过渡期是生物演化极为迅速的时期,高家山生物就是晚前寒武纪末期向早寒武世梅树村期生物演化事件的记录,既有软躯体的后生动物,也有具矿化骨骼的动物,还有宏观藻类植物相伴(插图 2)。这些化石可能代表了已绝灭的生物类群,目前尚难对其进行系统的生物分类,现仅据化石的形态特征将其划分为下列几个大类群:

2.1 具矿化壁的骨骼类群

具矿化壁的骨骼生物是该生物群中最具特色的生物类群,目前已命名的有 7 属 26 种,占该生物群中已发现后生动物实体化石属种的 80%。其个体普遍较大,与小壳化石明显有别,代表了最早期生物矿化事件的真实记录。其代表性类型有:

2.1.1 管状化石(tubular fossils)

以 *Sinotubulites* 类为代表,其主要特征为:管体宏大(最大直径 3.5 mm,长 25 mm),多为圆筒状,稍具锥度,管直或微弯曲,两端开口(目前尚未发现一端封闭的标本),管壁有单层(*Chenella*)和多层(*Sinotubulites*, *Qinella*)之分,多层壁者具管套管式结构(图版 I, 图 1a, 1b;图版 II, 图 1, 6, 11)。

2.1.2 锥管状化石(conotubular fossils)

是指以克劳德管类(cloudinids)为代表的末端开口、始端封闭的次圆锥柱状或柱状管,多层壁具有特征的叠锥套合式结构,见萼部藤壶状开口及芽状分枝。高家山生物群中锥管化石类型多样,目前仅对

Cloudina 和 *Conotubus* 作了初步研究(图版 II, 图 3, 4)。

2.1.3 瓶状化石(vase-shaped microfossils)

是产于晚前寒武纪至早寒武世的一类分类位置未定的具瓶状外形的微生物类群,与其他已知化石类群相比,高家山瓶状化石在形态上虽具有一定相似性,但个体最大(是其他已报道化石的 10—100 倍),壳壁成分多由钙质组成,壁厚,有的还具有分层结构,并且常可从围岩中完整剥离出来,与世界其他地区 and 层位的瓶状化石明显有别。目前据壳体形态仅对 *Protolagena* 和 *Sicylagena* 作了初步探讨(图版 II, 图 2, 15)。

2.1.4 球状化石(globular fossils)

数量非常多,球状或椭球状,直径 0.05—1.00mm,一般为 0.2—0.6mm,大多中空,单层壁或多层壁,以孤立个体或串珠状或密集成团分散在灰岩中(图版 II, 图 7, 8)。

2.1.5 杯状化石(cup-like fossils)

见于灰岩的岩石薄片,与 *Gaojiashania* 和 *Conotubus* 共生,形似杯状、钵状体,始部收敛闭合并有横向似脊的底座,由始部向末端逐渐扩散,具不规则齿状花边(图版 I, 图 7b;图版 II, 图 14)。

2.1.6 疑难化石(problematic fossils)

类型十分多样,主要有饼形,圆盘状及分枝管状化石等(图版 II, 图 5, 9, 10, 13)。

2.2 软躯体蠕虫状化石类群

保存在粉砂岩中者多已黄铁矿化,铸型标本可修出完整的个体,为不规则弯曲的管状,中空,外表面具环脊和环纹,有的具圆环状口部构造。保存在灰岩内的化石均被晶质方解石充填,局部保存了体壁、环脊齿状边缘。高家山化石群中蠕形动物化石与已报道的其他前寒武纪软躯体动物化石截然不

类小壳动物群所限定,下界不超过陡山沱组的顶界,两地生物群主要盛产于高家山段及其相当层位石板滩段。

3) 软躯体化石均以蠕形动物为主,均含有矿化初期阶段的骨骼化石,如 *Sinotubulites* 和 *Cloudina* 等。

4) 两生物群均含有以文德带藻为代表的宏观藻类化石。

5) 遗迹化石以水平管状潜穴为主,垂直潜穴小而短。

高家山生物群与西陵峡生物群相比较,其差异性主要有:两生物群均具有地方性色彩,宁强地区的蠕形动物化石个体大,峡东地区相对较小,属种也各不相同;宁强地区骨骼化石的分异度高,产出层位多,可划分两个组合带,而峡东地区仅见保存不好的 *Sinotubulites* 和 *Cloudina*;峡东地区发现了依迪卡拉生物群分子 *Paracharnia dengyingensis* (Ding *et al.*, 1981) emend. Sun 1986, 而宁强地区目前尚未见到;遗迹化石序列和组合面貌两地相差较大。以上差异可能是由不同的古地理环境因素所致,反映了不同生态环境下地方性生物群特征。

根据以上特征,高家山生物群产出剖面可作为建系的重要参考剖面(殷继成等, 1993)。

3.2 与南非纳玛群中生物组合的对比

纳米比亚的纳玛群中含有得到广泛认同的文德纪至寒武纪的软躯体化石、微体化石和遗迹化石。以 *Cloudina* 为代表的最早骨骼化石组合最初就在这里发现的 (Germs, 1972a, b), 后来又发现了一类高脚杯状骨骼化石 (goblet-shaped shelly fossil) (Grotzinger *et al.*, 1995), 它们与依迪卡拉软躯体化石共生, 其分布时代略长于后者。据 Grotzinger 等 (1995) 的推算, 纳玛群中依迪卡拉生物群的分布时限为 549—543 Ma (U-Pb 锆石年龄)。

高家山生物群与纳玛群生物组合对比, 它们的相同点有: 具有相同的骨骼生物化石 *Cloudina*, 骨骼化石虽未在其中占主导, 也没有高家山生物群中类型多样, 但纳玛群中钙化的生物如海绵、刺细胞生物和两侧对称动物可能都是其中代表 (Knoll and Carroll, 1999); 虽然对纳玛群的时代归属仍存在争议, Grotzinger 等 (1995) 也认为 *Cloudina* 的分布可能延续到寒武系底部, 但由于缺乏明确的小壳化石证据, 一直难以定论, 从高家山生物群产出情形分析, *Cloudina* 的分布层位应低于小壳化石产出层位, 纳玛群生物组合与高家山生物群的分布时代也

是基本一致的。

纳玛群碎屑岩中产有全球分布的依迪卡拉生物群的典型分子, 其面貌与高家山生物群以蠕形动物为主的特征截然不同。

4 结 论

1) 高家山生物群产于震旦系灯影组中上部, 震旦系-寒武系连续沉积层序的寒武-震旦系界线之下, 推测其时限约为 565—543 Ma。

2) 高家山生物群除含大量后生动物遗迹化石和宏观藻类化石外, 软躯体蠕虫类和骨骼化带壳动物化石占绝对优势。其总体面貌与著名的依迪卡拉生物群明显不同, 也与早寒武世小壳动物群有显著的区别, 因此它具有指示早期动物演化新方向的潜在信息。

3) 高家山生物群中管状骨骼化石类型多样, 管壁结构保存普遍完美, 是目前公认最早并且最为多样化的一个骨骼化石组合, 对于研究早期动物骨骼化类型及其成因机制具有极为重要的意义。

4) 高家山生物群化石矿化方式多样, 有磷酸盐化、钙化、黄铁矿化、海绿石化等, 为化石埋藏研究提供了极好素材。

参 考 文 献

- 丁莲芳, 李 勇, 胡夏嵩等, 1996. 震旦纪庙河生物. 北京: 地质出版社, 1—221.
- 邢裕盛, 丁启秀, 罗惠麟等, 1984. 中国震旦系-寒武系界线. 中国地质科学院地质研究所所刊, **10**, 182—183.
- 邢裕盛, 段承华, 梁玉左等, 1985. 中国晚前寒武纪古生物. 北京: 地质出版社, 1—184.
- 罗惠麟, 蒋志文, 武希彻等, 1984. 中国云南晋宁梅树村震旦系-寒武系界线层型剖面. 昆明: 云南人民出版社, 24—36.
- 孙卫国, 1994. 末元古系地层学. 地球科学进展, **9**(1), 62—65.
- 陈孟莪, 1999. 震旦纪生命大爆炸! ——浅论地史早期动物的演化. 前寒武纪研究进展, **22**(3), 36—47.
- 陈孟莪, 王义昭, 1977. 峡东区上震旦统灯影组中段的管状动物化石. 科学通报, **22**(4, 5), 219—221.
- 陈孟莪, 陈祥高, 劳秋元, 1975. 陕南震旦系上部地层中的后生动物化石. 地质科学, (2), 181—190.
- 陈孟莪, 陈忆元, 钱 逸, 1981. 峡东区震旦系寒武系底部的管状动物化石. 中国地质科学院天津地质矿产研究所所刊, **3**, 117—124.
- 陈孟莪, 萧宗正, 1991. 峡东区上震旦统发现宏体化石. 地质科学, **4**, 317—324.
- 陈孟莪, 萧宗正, 1992. 峡东震旦系陡山沱组宏体生物群. 古生物学报, **31**(5), 513—529.
- 陈孟莪, 1994. 皖南上震旦统蓝田组的宏体藻类化石——蓝田植物群的初步研究. 中国科学院地质研究所集刊, **7**, 252—267.

- 张录易, 1986. 陕西宁强晚震旦世晚期高家山生物群的发现和初步研究. 中国地质科学院西安地质矿产研究所所刊, **13**, 67—88.
- 张录易, 董军社, 田淑华等, 1992. 高家山生物群. 见: 丁莲芳等著: 扬子地台北缘晚震旦世-早寒武世生物群研究. 北京: 科学技术文献出版社, 33—63.
- 林世敏等, 1986. 陕南震旦系上统高家组发现的后生动物、遗迹化石和宏观藻类. 陕西地质, **4**(1), 9—17.
- 殷继成, 何廷贵, 李世麟等, 1993. 四川盆地周边及邻区震旦亚代地质演化与成矿作用. 成都: 成都科技大学出版社, 29—35.
- 薛耀松, 唐天福, 俞从流, 1992. 贵州晚震旦世陡山沱具骨骼动物化石的发现及其意义. 古生物学报, **31**(5), 530—539.
- Conway Morris S, Mattes B W, Chen Menge, 1990. The early skeletal organism *Cloudiana*; new occurrences from Oman and possibly China. Amer. Jour. Sci., **290A**, 245—260.
- Fedonkin M A, Runnegar B, 1992. Proterozoic metazoan trace fossils. In: Schopf W J, Klein C (eds.). The Proterozoic Biosphere: A multidisciplinary study. Cambridge: Cambridge Univ. Press. 389—395.
- Germes G J B, 1972a. New shelly fossils from Nama Group, South-West Africa. Amer. Jour. Sci., **272**, 756—761.
- Germes G J B, 1972b. Trace Fossils from the Nama Group South-West Africa. J. Paleont., **46**(6), 864—870.
- Glaessner M F, 1984. The dawn of animal life——A biohistorical study. Cambridge: Cambridge Univ. Press. 1—241.
- Gaucher C, Sprechermann P, 1999. Upper Vendian skeletal fauna of the Arroyo del Sodado Group, Uruguay. Beringeria, **23**, 55—91.
- Grant S W F, 1990. Shell structure and distribution of *Cloudina*, A Potential index fossil for the Terminal Proterozoic. Amer. Jour. Sci., **20-A**, 261—294.
- Grotzinger J P, Bowring S A, Saylor B E *et al.*, 1995. Biostratigraphic and geochronologic constraints on early animal evolution. Science, **270**, 598—604.
- Grotzinger John P, Saylor Bererly Z, Pelechaty S M, Bowring Samuel A, 1996. Calibrating the Terminal Proterozoic Time Scale. 30th International Geological Congress Abstracts. Vol. 2 of 3, Beijing, China. 4—14.
- Hahn G, Pflug H D, 1985. Die Cloudinidae n. fam., Kalkp Rohren aus dem Vendium und Unter-Kambrium. Senckenbergiana Lethaea, **65**, 413—431.
- Knoll A H, Carroll S B, 1999. Early animal evolution: emerging views from comparative biology and Geology. Science, **284** (5423), 2119—2137.
- Knoll A H, Xiao Shuhai, 1999. On the age of the Doushantuo Formation. Acta Micropalaeontologica Sinica, **16**(3), 225—236.
- Li Guoxiang, Xue Yaosong and Zhou Chuanming, 1997. Late Proterozoic tubular fossils from Doushantuo Formation of Weng'an, Guizhou, China. Palaeoworld, **7**, 29—35.
- McMenamin M A S, 1985. Basal Cambrian small shelly fossils from the La Cienega Formation, Northeastern Sonora, Mexico. J. Paleont., **59**, 1414—1425.
- Palacios T, 1989. Microfossiles de pared organica del Proterozoico Superior (Region Central de 1a Peninsula Iberica). Palaeontographica, Abteilung A, **135**, 226—262.
- Signor P W, Mount J F, Onken B R, 1987. A pretrilobite shelly fauna from the White Inyo Region of eastern California and western Nevada. J. Paleont., **61**(3), 425—438.
- Sun Weiguo, 1986. Late Precambrian pennatulids (sea pen) from the eastern Yangtze Gorge, China; *Paracharis* gen. nov. Precambrian Research, **31**, 361—375.
- Taylor M E, 1986. Late Precambrian mollusc-like fossils from Inyo County, California. Science, **153**, 198—201.
- Yochelson E L, Herrera H E, 1974. Un fossil enigmatico del Cambrico Inferior de Argentina. Ameghiniana, **11**, 283—294.
- Yochelson E L, Stump E, 1977. Discovery of early Cambrian fossils at Taylor Nunatak, Antarctica. J. Paleont., **51**, 872—875.
- Zaine M F, Fairchild T R, 1987. Novas consideracoes sobre os fossils da Formacao Tamengo, Grupo Corumba, SW do Brasil. Anais X Congresso Brasileiro de Paleontologia, Rio de Janeiro, **1987**, 797—807.

FOSSIL EVIDENCES OF LATEST NEOPROTEROZOIC GAOJIASHAN BIOTA AND THEIR CHARACTERISTICS

HUA Hong

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

ZHANG Lu-Yi ZHANG Zi-Fu WANG Jing-Ping

(Xi'an Institute of Geology and Mineral Resource, Ministry of Land and Resource, Xi'an 710054)

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

A diverse fossil assemblage from the approximately 550 Ma latest Neoproterozoic Dengying Formation of South Shaanxi, China is described in this paper. It

contains tubular skeletal fossils, conotubular fossils, vase-shaped microfossil, as well as several other forms of problematic microfossils, worm-like struc-

tures, trace fossils and carbonaceous megafossils. The fossil assemblage not only changes conspicuously the picture of soft-bodied animal dominant marine life in Neoproterozoic, but also encourages us to search for skeletal fossils in Vendian and old rocks.

The fossils herein described come from two well-exposed sections of the Dengying Formation, namely the Lijiagou section, about 3 km south of the village Kuanchuanpu, and the Gaojiashan section, about 3.5 km southeast the township Hujiaba, Ningqiang County, Shaanxi Province, China respectively. In the former section, the fossils occur in light-gray dolomites of the upper part of the Gaojiashan member, and overlain by about 35 m of interbedded cherts and limestones which contain the first assemblage of Cambrian skeletal fossils in its upper part. In the latter section, however, the fossils are from siltstone and carbonate rocks of the Gaojiashan member, and overlain by over 300 m of dolostones of Beiwan member, which in turn, is covered by about 13 m of calcarenite bearing Cambrian small shelly fossils.

Fossils from the clastic rocks of the Gaojiashan member are generally pyritized, with the richest ones occurred in the siltstone bearing horizontal or rhythmic beddings which represent an undisturbed setting below the wave base. It is well known that pyrite forms, as a result of the activity of sulfate-reducing bacteria, are usually in fine-grained marine sediments, but pyritization of soft tissues is rare. It requires the rapid burial of carcasses to form isolated concentrations of organic matter.

Tubular skeletal fossils from Lijiagou section are well preserved through secondary phosphatization, and can be chemically extracted from the rocks, which made it possible to reconstruction their morphology and fine structures.

FOSSIL EVIDENCE OF DISPARITY

1 Mineralized skeleton fossils

The Gaojiashan Biota comprises the most diversified skeleton fossil assemblage ever known, and consists of tubular fossils, conotubular fossils, vase-shaped microfossils, globular fossils and goblet-shaped fossils as well as several other forms of problematics.

Tubular fossils Tube-like shells, generally straight or slightly curved, cylindrical to weakly tapering. The largest persevered length 25 mm, the diameter is 3.5 mm. Two types can be distinguished in morphology, namely, the single-layered tubular shells, represented by *Chenella*, and multi-layered column-in-column structure, by *Sinotubulites* and *Qinella*.

Conotubular fossils Straight to sinuous conical tubes of possible cone-in-cone structure, with the initial part closed and terminal part opened multiple walls nearly parallel to each other, and somewhat oblique to the long axis intersecting with the inner wall to form a common wall. Conotubular fossils in this biota are quite diversified, and only *Cloudina* and *Conotubus* are discussed in the paper.

Vase-shaped microfossils Though morphologically similar to the vase-shaped microfossils with worldwide distribution, the fossils in the biota are distinct in their large size (1.5–2.5 mm in diameter), thick calcareous wall and rigid deformation.

Globular fossils spherical or elliptical structures, with a diameter range 0.05–1 mm, single or multiplied layer wall, occur in isolation or in string.

Cup-Like fossils only found in thin sections of carbonate rocks, they are of cup-like or bowl-like structures bearing irregular dental wall, with the initial part convergent and closed, forming a base-like structure, and divergent by degrees towards terminal part.

Problematic fossils The problematic fossils in this assemblage are rather varied, comprise interwoven branched tubular fossils of possible calcified algae, hollow and filled spherical structures, and calcified cake-like structure as well as many bizarre structures.

2 Worm-like fossils

The reports of worm-like structures in Precambrian are not uncommon, especially in that of China (Zheng, 1980; Wang, 1982; Sun *et al.*, 1986), but most of them are still awaiting to be rescrutinized. Except for the transverse pattern, elongated macro-carbonaceous films with distinct annulation generally ascribed to worm-like fossils such as *Sabelidites* and *Paleolina* are now tentatively compared

with those of the co-occurred carbonaceous megafossils *Tawuia* due to their similarity both in size and gross morphology.

The worm-like fossils in Gaojiashan Biota, however, are quite different from other Precambrian ones. They are of body fossils and not mould, some of them are as large as 10mm in diameter and 100mm in length. Those from siltstone are generally pyritized, rarely glauconitized or carbonised, and those from carbonate rock are all calcified. Four main preservation states can be recognized, namely flattened organic or glauconitic structures, and three-dimensionally calcified or pyritized cylinder structures.

3 Trace fossils

12 ichnogenus and 15 ichnospecies have been set up in the biota, which comprise not only grazing traces on the bedding planes of the worm-like animals but also vertical burrows such as *Skolithos* and *Intrites*. It was claimed that Vendian trace fossils were simple and belonged to a single trophic type: deposit feeders grazing along the bedding planes within the sediments, and vertical burrows were absent (Fedonkin and Runnegar, 1992). The new evidence may greatly promote our understanding on the evolution of early animals.

4 Carbonaceous megafossils

Three types have been detected in the grayish brown siltstone in the middle and upper parts of the Gaojiashan member, namely circular or elliptical carbonaceous films without ornamentation, straight or curved ribbon-like structures with tiny branches, foliated structures with longitudinal lines. Though generally strongly carbonized and not so well preserved, they are easy to identify by their distinct morphologies.

图版说明

所有标本保存在国土资源部西安地质矿产研究所。图版 II 图 1, 3—11 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

- 1a. *Chenella laevis* Zhang, Li et Dong
正模, ×4; 登记号: GHF9-2G。
- 1b. *Sinotubulites cienegensis* McMenamin
×4; 登记号: GHF9-2G。
- 2, 3. *Yudaiella formosa* Zhang et Hua (gen. et sp. nov.)
正视, 底视, ×2; 登记号: 93NH1。
- 4a, 6. *Ningqiangella giganteus* Zhang, Li et Dong
4a, 未经风化的黄铁矿化虫体, ×2; 登记号: GNF10-3。
6. 正模, ×1; 登记号: 86W10-2-1。
- 4b, 7b. *Gaojiashania* sp.
4b, 未经风化的黄铁矿化虫体, ×2; 登记号: GNF10-3。
7b, 未经风化的黄铁矿化虫体, ×2; 登记号: 95G-1。
- 5. *Vendotaenia* sp.
风化表面, ×2; 登记号: 98001
- 7a. *Conotubus* sp.
未经风化的黄铁矿化虫体, ×2; 登记号: 95G-1。

图版 II

- 1. *Qinella levis* Zhang, Li et Dong
侧视, ×10; 登记号: 0604。
- 2. *Protolagena gaojiashanensis* Zhang et Li
正模, ×24; 登记号: 8903。
- 3. *Cloudina* sp. A
侧视, ×58; 登记号: 9235。
- 4. *Cloudina lijagouensis* Zhang, Li et Dong
正模, ×45; 登记号: 9235。
- 5. 分枝状疑难化石
×40; 登记号: 0579。
- 6. *Sinotubulites cienegensis* McMenamin
侧视, ×15; 登记号: 99092。
- 7, 8. 串球状疑难化石
7, ×73; 登记号: 9248。
8, ×73; 登记号: 9248。
- 9. 铆钉状疑难化石
×50; 登记号: 99079。
- 10. 枝状分叉的管状化石
×75; 登记号: 99298。
- 11. *Chenella regularis* Zhang et Hua
正模, ×16; 登记号: 0605。
- 12. *Shaanxilithes ningqiangensis* Xing, Yue et Zhang
正模, ×2.6; 登记号: 2B-3。
- 13. 饼状疑难化石
正视, ×10; 登记号: 99GV-3。
- 14. 杯状化石
薄片, ×5.3; 登记号: GHL9-15。
- 15. *Protolagena limbata* Zhang et Li
副模标本, ×23; 登记号: GHF8-8。
- 16. *Skolithos isolatus* Zhang
正模, ×7; 登记号: XG97。
- 17. *Bucerusichnus octoideus* Zhang et Dong
正模, ×1; 登记号: GHF9。

