Shaanxi qinba diqu Nipenxi yanjiu

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陕西秦巴地区

陕西秦巴地区泥盆系研究

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内容简介

《陕西秦巴地区泥盆系研究》一书,是在野外实地调查的基础上,经室内系统研究编写而成。本书由绪言、地层特征与划分、生物地层、地层对比及界线讨论、岩相古地理、沉积矿产、化石描述及图版等部分组成。重点采用了生物地层研究法,对不同沉积小区泥盆系重新健全或建立了新的地层系统,初步统一了长期混乱的地层名称,进行了新的划分和对比。首次建立了十一个生物组合带,对主要地层界线进行了专门论述和讨论。采用现代沉积学观点,对早、中、晚泥盆世分别编制了岩相古地理图。将铁、铜、铅、锌、汞、锑等层位矿产划分为十个成矿层位,并一一对其沉积环境和分布规律进行了探讨。书中对珊瑚、腕足类、牙形刺等八个门类中共一百八十五个化石属种进行了系统描述,附化石图版三十四个,全文三十八万余字,图表七十五份。本书是本省泥盆系研究最新成果的系统总结,可供数学、科研和生产单位参考利用。

陕西秦巴地区泥盆系研究

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前言

《陕西秦巴地区泥盆系研究》,系陕西省地质矿产局计发(80)30号文和科发(81)08 号文下达的一项科研项目,并列入地质矿产部一九八二和一九八三年地质科学技术发展计划 (编号:82122号)。该项工作由陕西地矿局区域地质调查队承担,从一九八一年开始,至 一九八三年结束。本成果是在《陕南的泥盆系专题总结报告》和《陕西的泥盆系》断代总结 基础上,要求测制并建立、健全各小区泥盆系典型剖面或代表性剖面,通过进一步划分、对 比工作之后,进行的又一次较深入的研究和系统总结。

《陕西秦巴地区泥盆系研究》科研成果报告,经陕西地矿局于一九八四年十二月初在西安组织了评审会,由地矿部地质科学院侯鸿飞副研究员和西安地质矿产研究所曹宣铎工程师主审,其他评审员有尚瑞钧、成汉钧、郑延力、方永安、陆岩、叶茂泉、刘忠孝、杨志华等,同志审阅,提出了宝贵的意见。其后,陕西地矿局又于一九八四年十二月中旬发给了评审证书,并据评审会决议,要求认真修改,尽快组织公开出版。一九八五年春,由杜定汉负责修改、编纂成书。

全书由八部份组成。绪言由王武原执笔;地层特征与划分由杜定汉、周之军、王武原执笔;生物地层特征,地层对比及界线讨论,主要层位矿产,结束语由杜定汉执笔;岩相古地理特征由徐怀艾执笔;化石描述执笔人:珊瑚谢仕发,腕足类周恺,牙形刺郭洪祥,腹足类、双壳类史秉德,介形虫、鱼类、植物赵健。

参加野外调研的除笔者外,还有李稳柱、崔永泉、岳康茂、罗彤、安彬祥、郝俊武、张晓林、王升勤、李宝祥、袁松喜、陈友仓、于庆怀、刘秦国、苏保怀等。在书稿编写过程中,冯俊河承担了各类化石名称的校对与编排;雍兴辉、耿世芳、杨俊安、任怀成、王逢新、徐志成等转绘了各类基础图表。孢粉由伊鹃英鉴定,岩石薄片由田兴禄鉴定,鲜于开梅为矿产部分提供了有关文字资料及插图,最终图表由出版分队清绘。

各门类重要化石,系经西安地矿所曹宣锋、张研,南古所许汉奎、王成源、王尚启,中国地质博物馆潘江,煤炭部地勘分院地质所张弘、何德长、韩同和等同志指导、审核,有的并亲自鉴定、描述。

全书由陈家义主审, 英文由孟庆任翻译。

从一九七六年进行陕南的泥盆系研究以来,直到《陕西秦巴地区泥盆系研究》一书的出版,尚有队内、外不少单位为此研究付出过辛勤的劳动,因此它是集体研究的劳动成果。

在研究和编写过程中,省地质矿产局高级工程师尚瑞钧,工程师郑延力、王友文、方永安、姚鸥春、弥建勇、方德生以及区调队高级工程师卢一伦,工程师张二朋,陈家义、陈书铭、马润华、陈榕、黄建坤、唐世济、高洪学等给予了具体指导。

在此, 谨向上述各位致以衷心感谢!

由于作者经验和水平所限,书中存在问题一定难免,不妥之处敬希读者批评指正。

陕西秦巴地区泥盆系研究

摘 要

本书由绪言, 地层特征与划分, 生物地层特征, 地层对比及界线讨论, 岩相 古地 理特征, 主要层位矿产, 化石描述等主要部分组成, 要点如下:

给宫:陕西秦巴地区泥盆纪地层分布广泛,是国内泥盆系发育良好地区之一。根据岩相特征、生物面貌、地层层序、构造关系及变质作用、沉积矿产和厚度变化等基本原则,共划分出两个沉积区,四个沉积分区和四个沉积小区。经过综合研究,重新建立或健全了各沉积小区的地层系统,对长期以来在使用中比较混乱的地层名称和涵义进行了补充、修正,或重新命名,并赋予了新的涵义。

地层特征与划分,在略阳小区、白云-柞水小区、下高川小区和凤县-旬阳小区这四个沉积小区的泥盆纪地层中,前三个小区都因生物较少、或发育不完整、或构造较复杂而对深入研究带来很多不便,致使不少问题一时较难解决,惟凤县-旬阳小区泥盆系不但发育较完整、化石较丰富,且各地层单元构造清楚,剖面连续,界线明确,是进行全面研究的理想地区;目前在该地层小区共划分出下、中、上泥盆统共九个组,它不仅是全区泥盆系划分、对比的标准,也是能和中国典型泥盆系进行较好对比的惟一地区。

下泥盆统由下至上共分三个组,这一时期相对生物较少,沉积物以粗碎屑岩开始,到镁质碳酸盐岩夹泥质岩结束,为一正常海侵序列沉积。

下部西盆河组:下段为含铜砂砾岩、砂岩;上段为板岩夹白云质灰岩,总厚140-18g米。主要化石于顶部白云质灰岩中,如双壳类 Glossites cf. concentricus, Grammysiasp., Cypricardinia sp., Edmondia sp.等。

中部公馆组;下段为厚层白云岩,偶夹绢云母板岩,白云岩含层 孔 虫 Amphipora;上段为中薄层白云岩夹白云质板岩,白云岩含介 形 虫 Paramoelleritia subtrapezoidalis;腹足类 Murchisonia cf. loxonemoides等,总厚 550—688米。

上部龙家河组: 为中厚层泥质灰岩及白云质灰岩 夹 板 岩, 总厚 27—181 米。含腕足 类 Eurys pirfer sp., Athyrisina striata; 珊瑚 Lyrielasma shaanxiensis, Sulcor phyllum long jia heense 等。

中泥盆统由碳酸盐岩夹碎屑岩组成,由下到上分为石家沟组、大枫沟组和古道岭组,各组顶底界线均为整合接触。

石家沟组下段为中薄层泥质生物灰岩夹板岩,上段为厚层白云岩和灰岩及粉砂岩、板岩、总厚 153米。含腕足类 Athyrisina heimi, A.ovata, Acros pirifer houershanensis, 珊瑚Utaratuia qinlingensis, Sociophyllum orientale, Brevise pto phyllum kochanense 等。本组各类生物千百成群,竟相繁殖,充分显示了一个新的地质时期开始的崭新面貌。

大枫沟组山含铁砂岩、板岩夹生物泥质灰岩组成,总厚 214—1018 米。含腕足类 Athyrisina minor., A. uni plicata, 瑚珊 Syringo pora eifeliensis, 鱼类 Placodermi.

古道岭组为中厚层生物灰岩夹板岩,或由白云质灰岩及板岩组成,厚度 674米。含腕足类Stringocephalus obesus, Undispirifer undiferus, 珊瑚Pseudomicroplasma等。

上泥盆统为碎屑岩、泥质岩及碳酸盐岩组成,由下到上分为星红铺组、冷水河组和**南羊** 山组各组界线均为整合接触,顶部与下石炭统连续过渡。

基红铺组下段为板岩夹灰岩;上段为礁灰岩,厚度 1004 米。含牙形刺Ancyrodella rotundiloba alata, Palmatole pis hassi, Polygnathus webbi, 腕足类 Atrypa richthofeni, Emanuella takwanensis, 珊瑚Sinodis phyllum cf. beichuanensis。

冷水河组由钙质砂岩、 灰岩、 泥灰岩组成, 总厚 642 米。 含腕足类 Cyrtos pirifer sinensis, Tenticos pirifer su pervilis, 珊瑚Dis phyllum kostetskae, D. irregulare, 牙形刺 Palmatole pis proversa。

南羊山纽下部为砂质灰岩、钙质砂岩;上部为厚层白云质灰岩或灰岩,总厚 183 米。含 腕足类 Yunnanella, Yunnanellina, 牙形刺 Palmatolepis gracilis gonioclymeniae, Pugracilis expansa, P. quadrantinodosa inflexa, Polygnathus styriacus, Protognathodus sp. 等。

生物地层特征:加里东运动以后,秦巴地区泥盆系的沉积基底十分复杂,有的沉积区属于较稳定环境,有的沉积区则有相对活动的特征,且表现于整个沉积时期的始终。由于各种因素的控制,所以泥盆系沉积既不同于海西型完整的碳酸盐岩层序,也不同于莱茵型巨厚的火山碎屑岩类型,而多以泥质,砂质及有机质碳酸盐岩沉积为主,或夹有火山碎屑物质。从环境上分析,沉积区总体属于滨-浅海相区,一般在早期沉积阶段,沉积物较粗,具有过渡相或滨海相特征;中晚期沉积物偏细,多属浅海相沉积。岩相的变化,基底的稳定性程度,无疑对各类生物的发育具有明显的控制作用。就生物群总貌而言,本区和我国华南泥盆系一样,均具有南极太平洋古生物地理区划的生物特征,且和广西象州、贵州独山以及四川龙门山地区泥盆系相似,同属近岸浅海、富氧、水动力条件较强的沉积环境,底栖相生物大量发育,浮游相生物次之。另外在这一时期,不但发育了很多具有国际地层对比意义的生物群,且出现了不少地方性种属,这与国内不少地区泥盆系生物面貌的特征也是大体一致的。

在略阳、白云-柞水、风县-旬阳及下高川四个沉积小区中,前两个小区生物发育较次,研究程度较低,后两个小区化石丰富、种类众多,目前已发现的计有珊瑚、腕足类、层孔虫、苔藓虫、海百合、腹足类、介形虫、双壳类、鱼类、三叶虫、牙形刺、菊石、植物等十三个门类,但种属最多、个体最丰富的惟有珊瑚和腕足类,其次应为牙形刺了。据此情况,本文以凤县-旬阳小区为代表,初步划分出十一个生物组合带,由老到新是。

西岔河组(D_1x),生物组合不清**,尚待研**究。 公馆组(D_1g)。

- 1. Paramoelleritia Subtra pezoidalis 组合带; 龙家河细(D.l).
- 2. Lyrielasma shaanxiensis—Euryspirifer 组合带;

- 石家沟组 (D,sh):
- 3. Athyrisina—Utaratuia 组合带,
 - 4. Sociophyllum orientale-Billingsastraea cf. subspeciosa 组合带, 大枫沟组 (D,d).
- : \$5. Syringopora eifeliensis-Caliapora uralica 组合带;
- 古道岭组 $(D_{z}g)$.
- 5. 6. Stringoce phalus obesus-Undispirifer undiferus 组合带;
- 屋红铺组 (D_ax),
- 7. Ancyrodella rotundiloba alata 组合带;
- · 冷水河 (D_sl),
 - 8. Cyrtospirifer Sinensis-Disphyllum kostetskae 组合带; 南羊山组 (Dan):
- * 9. Yunnanella-Yunnanellina 组合带,
 - 10. Polygnathus styriacus-Palmatolepis quadrantinodosa inflexa 组合带;
- 11. Palmatolepis gracilis gonioclymeniae-Palmatolepis gracilis expansa 组合带:

地层对比及界线讨论:在地层对比中,根据剖面完整程度和生物发育状况,本文选择了 风县-旬阳小区泥盆系为代表,用以和广西象州、湖南和甘肃迭部地区泥盆系进行对比。由 于本区微体化石不发育,大多以腕足类和珊瑚化石作为对比依据,惟有晚泥盆世除腕足类、 珊瑚外,还增添有牙形刺作为对比的标准。因区内缺失下泥盆统底部层位,故西岔河组、公 馆组、龙家河组仅分别相当广西象州地区的那高岭组、郁江组、四排组或甘肃迭部地区的上 普通沟组、杂拉组、当多组。中泥盆统的石家沟组、大枫沟组相当象州的应堂组或迭部的鲁 热组,古道岭组则相当象州的东岗岭组或迭部的下吾那组,上泥盆统的星红铺组和冷水河组 可与湖南的佘田桥组或迭部的擦阔合组对比,南羊山组则大致相当湖南的锡矿山组或迭部的 陡石山组。

界线讨论包括泥盆系顶底界线,和下、中泥盆统界线以及中、上泥盆统界线 共 四 种 情况,在讨论中,均以风县-旬阳小区泥盆系界线为代表,其它小区由于资料欠缺,未加论述。

泥盆、志留系界线由于属平行不整合或局部角度不整合接触,缺乏生物,尚不具备讨论的条件。但在局部地区——如旬阳双河水洞沟一带,整合于含珊瑚 Mesofavosites multitabulatus, Stereoxylodes SP., Favosites multiplicatus, Somphopora, Tryplasma 等的中、上志留统之上和西岔河组之下的一套灰绿、紫红色粉砂岩、板岩地层如何归属,还需要进一步研究,实际上也涉及到泥盆、志留系界线问题。

下、中泥盆统界线即龙家河组和石家沟组的分界线。确定主要依据是龙家河组顶部化石带 Eurys pirifer 彻底绝灭,而石家沟组底部 Acros pirifer houer shanensis 和 Athyrisina, Utaratuia 等生物群首次大量发生。这条界线被划分在龙家河组顶部镁质碳酸盐岩和石家沟组底部泥质岩之间。

中、上泥盆统界线被划分在古道岭组生物灰岩和星红铺组板岩之间。因古道岭组一开始

就大量发育的 Stringoce phalus 在此界线之下最后消失, 界线之上大量发育的则是 牙 形 刺 Ancyrodella rotundiloba alata, Palmatole pis hassi, Polygnathus webbi 等生 物 群。但上述两种生物未发现于同一剖面,而是参考稳定的岩石界线作标志而确定的,所以有特进一步验证。

泥盆、石炭系界线在凤县-旬阳地区被确定在上泥盆统南羊山组和下石炭统熊家山组之间。其生物依据是泥盆系顶部大量发育牙形刺 Palmatole pis gracilis expansa, P. gracilis gonioclymeniae, P. gracilis sigmoidalis, P. gracilis gracilis, P. rugosa rugosa, Protognathodus, 熊家山组底部则以牙形刺 Siphonodella sulcata, S. duplicata 和有孔虫 Endothyranopsis? sp.为特点。该界线岩性差异有时不易掌握,划分手段主要是生物标志。下高川小区泥盆、石炭系界线即火焰溪组泥质灰岩之顶界,界线下部以 Yunnanella yunnanellina 组合为特征,界线之上为含炭板岩,以 Caninia sp., Palaeochoristites, Spirifer gielingensis 组合为标志。该界线清楚、稳定、容易识别。

岩相古地理特征,志留纪以后,区内自然地势进一步分异,北为秦岭山地,南为汉南古陆和牛山-平利古陆,中为狭长的泥盆纪海盆,即泥盆纪的主要沉积区。

早泥盆世岩性分异较为明显,按岩比法作图,可分为滨海海湾潮坪相,滨岸相,浅海粉砂泥陆棚相三个相区。公馆汞锑矿和韩城沟铜矿即分布在海湾潮坪相-滨岸相区。

中泥盆世海侵进一步扩大,不同地区沉积物性质和厚度以及生物发育情况各有差别,在 岩相图上显示为具有另一特征的沉积环境。这一时期可分为浅海陆棚边缘斜坡相,浅海粉砂 泥陆棚相,浅海陆棚含礁砂堤相,滨海潮坪相,滨海海滩相。大西沟菱铁-多金属矿床和铅 硐山等地的铅锌铜矿床即分别产于浅海陆棚边缘斜坡相和滨海海滩相或粉砂泥陆棚相区。

晚泥盆世是海侵的全盛时期,海盆内部地形趋于平缓,海岛范围逐渐缩小。沉积物一般厚度较大,韵律层发育。底栖生物从早期到晚期由多到少,末期深水牙形刺生物群较发育。该期可分为滨海海滩相,浅海粉砂泥陆棚相,滨-浅海陆地边缘相(包括砂堤相,砂堤北侧坪地相和砂堤南侧坪地相)等相区。单尚沟、蟠龙山和火焰溪等地的菱铁矿、赤铁矿和黄铁矿即分别形成于滨-浅海陆地边缘斜坡相和滨海海滩相区。

主要层位矿产,区内泥盆纪地层沉积矿产十分丰富,赋存层位主要在中、上泥盆统。目前所发现的主要矿种有铁、铜、硫、铅、锌、银、汞、锑、金、重晶石等计 十 余 种,其 中铁、铅锌、汞在省内工业储量中均占有重要位置。除金矿正在开始研究,其成因类型暂未归属外,对其余矿种一般均认为系正常沉积或沉积-再造类型。 具体可分为三种成因类型,下属六个业类、

海相沉积型,包括浅海相沉积型;滨海相沉积型,

海相变质(或热液改造)沉积型,包括浅海相变质沉积型;滨海相变质沉积型;

沉积-再造型;包括产于碳酸盐岩中的沉积-再造型;产于碎屑岩中的沉积再造型;型;

陕西秦巴地区泥盆系已知有十个主要含矿层位,其中包括正在深入研究的铅硐山、八方 山铅锌矿和公馆汞锑矿。具体含矿层位是。

- 1. 早泥盆世西岔河组铜矿;
- 2. 早泥盆世公馆组汞锑矿;

- 3. 中泥盆世青石垭组铁铜-铅锌银矿;
- 4. 中泥盆世牛耳川组磁铁-黄铁矿;
- 5. 中泥盆世大枫沟组铁矿;
- 6. 中混盆世荷叶坝组铁矿。
- 7. 中泥盆世古道岭组铅锌铜矿,
- 8. 晚泥盆世桐峪寺组铁矿;
- 9. 晚泥盆世火焰溪组铁矿;
- 10。 晚泥盆世三岔沟组黄铁矿。

化石描述, 文中描述珊瑚 104 个种属, 腕足类 51 个种属, 牙形刺 20 个种属, 腹足类 3 个种属, 双壳类 3 个种属, 介形类 1 个种, 鱼类 1 个, 植物 2 个种属, 共 185 个种属。

Research of the Devonian System of Qin-Ba Region within the Territory of Shaanxi

Abstract

This book consists of the following main parts; stratigraphic characteristics and districts, biostratigraphic features, stratigraphic correlation and discussions on the boundaries, features of facies and palaeogeography, mineral deposits in the major layers, and descriptions of the fossils. The highlights in each part are as follows:

Introduction.

The Devonian strata are widely distributed in the Qin-Ba region in the boundaries of Shaanxi province, one of the areas where the Devonian was well-developed. According to some basic principles, such as lithofacies, paleontologic facies, stratigraphic sequences, tectonic processes, sedimentary ore deposits and thickness variation, etc, two depositional provinces, four sub-provinces and four small districts can be identified. Through synthetic studies, the stratigraphic system of each small district is re-established or made perfect, and some stratigraphic names and definitions, which were misused in the past geologic practice, are also supplemented, corrected or renamed with new meanings.

Characteristics and division of the strata

As described above, there exist four small depositional districts, that is,

Lueyang district, Baiyun-Zhashui district, Xiagaochuan district, and Fengxian-Xunyang district, in this region. However, it is not easy to make detailed researches on the Devonian system occurring in the first three districts because of the scarcity of fossils, the imperfect strata and the complex structures involved, so quite a few problems have not been solved for the time being. In contrast, the Devonian of the Fengxian-Xunyang district is not only well developed and fossiliferous but also characterized by its distinctive structures of each stratigraphic unit, its continuous outcrop of the profile and clear stratigraphic bountary surfaces, and the facts make the place become an ideal one where a comprehensive study on the Devonian system can be carried out. The Devonian is now divided into three serieses (the lower, middle, and upper) or nine formations this district, and is the criterion of the stratigraphic division and correlation all over the Qin-Ba region. Furthermore, this district is also a unique area where the Devonian can be better correlated with the typical Devonian strata occurring in other places in China.

The lower Devonian falls into three formations in ascending order. The strata possess relatively fewer fossils, begin with coarse-grianed clastic sediments and end up with magnesium carbonates, reflecting normal transgressive sequence.

Xichahe Formation (lower section): its lower member is dominated by cupreous psepholites, sandstones, the upper member by slates with intercalation of dolomitic limestones. The total thickness is 140-189m. The main fossils are present in the upper dolomitic limestones, such as Glossites of concentricus, Grammysia sp., Cypricardinia sp., Edmondia sp., etc.

Gongguan Formation (middle section), the lower member is thickly-stratified dolomites containing Amphipora, occasionally interbedded with sericite-phyllites, th upper member is thinly-and medium-stratified dolomites with intercalatary dolomitic slate. The fossils present in the dolomites are Ostraco-ds Paramoelleritia subtrapezoidalis, Gasteropods Murchisonia cf. loxonemoides. The total thickness is 550-688 m.

Lnogjiahe Formation (upper section); medium-stratified argillaceous lime-stones and dolomitic limestones, with intercalation of slates. The total thickness is 27-181m. containing Brachiopods Euryspirifer sp, Athyrisina striata, Corals Lyrielasma shaanxiensis, Sulcorphyllum longjiaheense, etc.

The middle Devonian is composed of carbonates interbedded with clastic rocks and subdivided into, in ascending order, three formations, Shijiagou Formation, Dafenggou Formation and Gudaoling Formation. The interface between them is conformable.

Shijiagou Formation, characterized by medium and thin-bedded argillaceous biogenic limestones with interbeds of slates in the lower member, and by
thick-bedded dolomites and limestones as well as siltstones and slates in the
upper member, 153 m thick, containing Brachiopods Athyrisina heimi, A.ovata,
Acros pirifer houer shanensis, Corals Utaratuia qinlingensis, Socio phyllum orientale, Brevise pto phyllum kochanense, etc. The population explosion of living
things of different kinds in this formation shows an entirely new picture
of the beginning of a new geologic period.

Dafenggou Formation, made up of iron-bearing sandstones and slates, interbedded with biogenic argillaceous limestones, containing Brachiopods Athyrisina minor, A. uniplicata, Corals Syringopora eifeliensis, Fishes Placodermi. Total thickness is 214-1018m.

Gudaoling Formation: meidum-stratified biogenic limestones with intercalation of slates, or dolomitic limestones and slates, containing Brachiopods Stringocephalus obesus, Undispirifer undiferus; Corals Pseudomicroplasma etc, totally 674 m thick.

The upper Devonian is built up of clastic rocks, mudstones and carbonate rocks and divided into, in ascending order, Xinghongpu Formation, Lengshuihe Formation and Nanyangshan Formation. The interface between the formations is conformable and the contact with the overlying Carboniferous system at the top is continuously transitional.

Xinghongpu Formation: characterized by slates with interbeds of limestones in the lower member and by bioherm limestones in the upper member, 1004 m thick, containing Conodonts Ancyrodelia rotundiloba alata, Palmatole pis hassi, Polygnathus webbi; Brachiopods Atrypa richthofeni, Emanuella takwanensis; Corals Sinodis phyllum cf. beichuanensis.

Lengshuihe Formation: calcareous sandstones, limestones and marls, 642 m thick, containing Brachiopods Cyrtospirifer sinensis, Tenticospirifer supervilis, Corals Disphyllum kostetskae, D.irregulare, Conodonts Palmatolepis proversa.

Nanyangshan Formation, made up of sandy limestones and calcareous sandstones in the lower part, and by thickly-stratified dolomitic limestones or limestones in the upper part, 183 m thick, containing Brachiopods Yunnanella, Yunnanellina, Conodonts Palmatolepis gracilis gonioclymeniae. P. gracilis expansa, P. quadrantinodosa inflexa, Polygnathus styriacus, Protognathodus sp. etc.

Biostratigraphic features

After the Caledonian movement, the sedimentary basement of the Devonian

appeared quite complated in the Qin-Ba region. Some depositional provinces were relatively active whereas others comparatively stable. Such conditions existed througout the Devonian sedimentary history. Controlled by a variety of factors, the Devonian of this region, different not only from the integral succession of Hercynian facies carbonate rocks but the massive pyroclastic rocks of Rhinish facies as well, is dominated by argillaceous, arenaceous, and organic carbonate rocks, interbedded with pyroclastic sediments. The environmental analyses show that the whole sedimentary provinces basically belong to littoralnerrtro facies region. Usually, the coarse-grained sediments characterize the earlier depositional stage, indicating transitronal or beach environments, while the fine-grained sediment is the chaiacteristics of the middle and later stage depositron, pertaining to neritic facies. Both facies changes and the basement stability undoubtedly have control over the evolution of all kinds of ancient living things. Generally speaking, the biota in this region, like that of S. Chin na, possess the biologic natures of Antarctic-Pacific biogeographic sub-region during the Devonian period. The Devonian strata in this region, similar to those of same age in Xiangzhou, Guangxi or in Dushan, Guizhou, or in Longmenshan, Sichuan, were produced in a beach-shallow sea enviornments featured by abundant oxygen, stronger hydrodynamic conditions, flourishing benthonic fauna and a certain amount of planktonic organism. In addition, at this stage, there appeared not only numbers of biologic groups that were of significance to the world-wide stratigraphic correlation but quite a few local species as well. Such biologic feature is coincident with that of many places in China in the Devinian period as a whole.

Among the Lueyang, Baiyun-Zhashui, Fengxian-Xunyang, and Gaochuan districts, the studies on the biostratigraphy in the first two have not been made because of less biologic devlopment in them, by comparison, the last two are marked by their abundant and various kinds of fossils. The fossils, which now have been found, include Corals, Brachiopods, Stromatopora, Hepaliceae, Heterotomous, Gasteropods, Ostracods, Bivalvia, Fishes, Trilobites, Conodonts, Ammonids, plants, etc, totally amounting thirteen kinds. However, Corals and Brachiopods occupy the first place both in sorts and in number, and Conodonts come second. Based on the data, eleven assemblage biozones are tentatively established in Fengxian-Xunyang district. In upward-younging order, they are

Xichahe Formation (D_1x) : further studies are needed because of the obscurity of biologic assemblage.

Gongguan Formation (D_1g)

1. Paramoelleritia subtrapezoidalis assemdlage biozone Longjiahe Forma-

tion $(D_1 l)$

- 2. Lyrielasma shaanxiensis-Euryspirifer assemblage biozone Shijiagou Formation (D₂sh)
- 3. Athyrisina-Utaratuia assemblage biozone
- 4. Sociophyllum orientale-Billingsastraea cf. subspeciosa assemblage bio-

Dafenggou Formation (D₂d)

- 5. Syringopora eifeliensis-Caliapora uralica assemblage biozone Gudaoling Formation (D_2g)
- 6. Stringocephalus obesus-Undispirifer undiferus assemblage biozone Xinghongpu Formation (D_8x)
- 7. Ancyrodella rotundiloba alata assemblage biozone

Lengshuihe Formation(D_sl)

- 8. Cyrtos pirifer sinensis-Dis phyllum kostetskae assemblage biozone Nanyangshan Formation (D₂n)
- 9. Yunnanella-Yunnanellina assemblage biozone
- 10. Polygnathus styriacus-Palmatolepis quadrantinodosa inflexa assemblage biozone
- 11. Palmatole pis gracilis gonioclymeniae-Palmatole pis gracilis expansa assemblage biozone

Stratigraphic correlation and discussion on the boundaries

To correlate with the Devonian strata of other regions, such as Xiangzhou in Guangxi, Hunan, and Diebu in Gansu, this paper chooses the Devonian system occurring in Fengxian-Xunyang district as the representive because of its continuous succession and rich fossils. The correlation is mainly based upon Brachiopods and Corals for lack of microfossils except that Conodonts came out and became another correlation standard in the late Devonian epoch. As a result of lacunae of the lower Devonian bottom layers, Xichahe formation, Gongguan Formation and Longjiahe Formation are only equivalent to the Nagaoling Formation, Yujiang Formation and Sipai Formation in Xiangzhou, Guongxi, or the upper part of Putonggou Formation, Gala Formation and Dangduo Formation in Diebu, Gansu, respectively. As far as the middle Devonian is concerned, Shijiagou Formation and Dafenggou Formation correspond to Yingtang Formation in Xiangzhou or Lure Formation in Diebu, Gudaoling Formation to Donggangling Formation in Xiangzhou, or Xiawuna Formation in Diebu. As regards the upper Devonian, Xinghongpu Formation and Lengshuihe Formation to Shetianqiao Formation in Hunan or Cakuohe Formation in Diebu, the Nanyangshan Formation roughly to the Xikuangshan Formation in Hunan province or the Doushishan Formation in Diebu.

The boundary discussion is completely on the basis of the stratigraphicinformation of Fengxian-Xunyang district, dealing with both the bottom and top boundaries of the Devonian and the boundaries between the lower and the middle Devonuan and between the middle and the upper Devonian. The Devonian and boundaries in other districts are not touched upon here for lack of the relevant data.

The discussion on bottom boundary can not go into details on account of the fossil absence and the existence of parallel and local angular unconformities between the Silurian and Devonian systems. On the other hand, though in some local places, such as shuidonggou in Xunyang county, there exists a layer that is made up of gray-greenish, purple siltstones and slates and takes place between the Xichahe Formation and the middle-upper Silurian strata with fossils (Coral) Mesofavosites multitabulatus, Stereoxylodes sp., Favosites multiplicatus, Somphopora, Tryplasma. It needs further study to find where the layer should be placed. As a matter of fact, it is also concerned with the problem of the Silurian-Devonian boundary.

The determination of boundary between the lower and middle Devonian or between the Longjiahe Formation and the Shijiagou Formation is mainly based on the fact that Euryspirifer died out from the top biozone of Longjiahe Formation and that Acrospirifer houershanensis, Athyrisina, Utaratuia fauna, etc, prospered for the first time in the bottom of the Shijiagou Formation. Thus the boundary is set up between the top magnesian carbonates of the Longjiahe Formation and the bottom argillaceous rocks of the Shijiagou Formation.

The middle-upper Devonian boundary occurs between biolithites of the Gudaoling Formation and slates of the Xinghongpu Formation, and its determination lies in the fact that Stringoce phalus disappeared from the Gudaoling Formation in spite of its prosperity in the lower part of the formation and that Conodonts appeared in large quantities above this boundary, such as Ancyrodella rotundiloba alata, Palmatole pis hassi, Polygnathus webbi fauna, etc. The two kinds of fossils, however, are not found in the same section and the recognization of the fossils' appearance and disappearance above the boundary refer to the stable lithostratigraphic surface. For this reason, the result is subject to further examination.

The Devonian-Carboniferous boundary occurs between the upper Devonian Nanyangshan Formation and the lower Carboniferous Xiongjiashan Formation in the Fengxian-Xunyang district and it is determined according to the fossil data that there appear ample Conodonts at the top of the Devonian system, such as Palmatole pis gracilis expansa, P. gracilis gonioclymeniae, P. gracilis

sigmoidalis, P. gracilis gracilis, P. rugosa rugosa, Protognathodus and that the Conodonts Siphonopella sulcata, S. duplicata and that Stromatopoar Endothyranopsis? sp. characterize the bottom part of the Xiongjiashan Formation. The method of fixing the boundary is dependent upon the fossils because of the irregular lithologic changes above and below the boundary surface. As concerns the Devonian-Carboniferous bountary, in other words, the bottom boundary of Huoyanxi Formation in the Xiagaochuan district, the strata bellow the boundary are characterized by containing Yunnanella-Yunnanellina assemblage biozone wheras the strata above the boundary by slates with Caninia sp., Palaeochoristites, ? Spirifer gielingensis assemblage biozone. This boundary is quite clear, stable, and easily recognizable.

Features of facies and palaeogeography

Since the Silurian period, this investigated region had experienced further topographic differentiation. The narrow Devonian marine basin, the major depositional province, was bounded on the north by the Qinling mountainous areas and on the south by the Hannan and Niushan-Pingli old lands.

The lithologic variation was very obvious during the early Devonian epoch. The mapping by means of lithologic correlation can identify three facies units, that is, estuarine-tidal flat facies, littoral facies and neritic shelf silt-mud facies. The Gongguan Hg-Sh deposits and Hanchenggou Cu deposits are distributed in the first two facies units.

During the middle Devonian, transgression of the sea expanded and sediment properties, thickness and biologic development showed distinct diversity in different places, indicating, as facies map exhibits, that a characteristic sedimentary environment came into being in this epoch. Five facies units can be discriminated; shallow sea shelf-continental slope facies; shallow sea shelf silt-mud facies; neritic shelf biohermbearing sand barries facies; littoral-tidal flat facies and beachy facies. The Daxigou siderite-multimetal deposits and the Qiantongshan Pb-Zn-Cu deposits were formed in the first and the last or the second facies units, respectively.

The late Devonian was the heyday of transgression. The marine basin floor tended to be gentle and the islands dwindled in size. The strata is characterized by its great thickness and well-developed rhythmites. Biologically, bethoses decressed in number in the psocess of time whereas the deep-water conodonts fauna became flourishing at the end of this period. The following facies, neritic shelf silt-mud facies, littoral-neritic terrestrial margin facies (including sand barries and tidal flat facies on both north and south sides of the sand barries). Siderites, haematites and pyrites deposits are produced respectively in the

last and the first facies units in the Danshanggon, Panlongshan, Huoyanxi, etc., places.

Mineral deposits in the major horizons

The sedimentary ore deposits abound in the Devonian strata of this region, especially in the middle and upper Devonian. The major kinds of mineral deposits, which have been found so far, include Fe, Cu, S, Pb, Zn, Ag, Hg, Sb, Au, baryte, etc, among which Fe, Pb, Zn and Hg occupy an important position in the industrial ore reserves of Shaanxi province. Apart from gold ore whose genetic type has not been defined because the studies on it just began, all the other mineral deposits are usually considered to be normal sedimentary or sedimentary-reconstructive types, and can be in detail grouped into three genetic types that are divisible into six sub-types.

Marine sedimentation type; including the neritic sedimentation sub-type and the littoral sedimentation sub-type;

Marine-metamorphic (or thermo-remoulding) sedimentation type, including the neritic metamorphic and the littoral metamorphic sedimentation sub-types,

Sedimentary-reconstructive type, including two sub-types occurring respectively in carbonate rocks and clastic rocks,

It's known that there are ten major mineral-containing horizons in the Qin-Ba region within the territory of Shaanxi, including the Qiantongshan and Bafangshan Pb-Zn deposits and the Gongguan Hg-Sb deposits that are being studied in detail currently. The concrete horizons are as follows:

- 1. the early Devonian Xichahe Formation (Cu)
- 2. the early Devonian Gongguan F. (Hg-Sb)
- 3. the middle Devonian Qingshiya F. (Fe, Cu, Pb, Zn, Ag,)
- 4. the middle Devonian Niuerchuan F. (magnetite-pyrite)
- 5. the middle Devonian Dafenggou F. (Fe)
- 6. the middle Devonian Heyeba F. (Fe)
- 7. the middle Devonian Gudaoling F. (Pb, Zn, Cu)
- 8. the late Devonian Tongyusi F. (Fe)
- 9. the late Devonian Huoyanxi F. (Fe)
- 10. the late Devonian Sanchagou F. (pyrite)

Descriptions of the fossils

The fossils describled in this book amount to 185 species and genera, among which there are 104 species and genera of Corals, 51 species and genera of Brachiopods, 20 species and genera of Conodonts, 3 species and genera of Gastropods, 3 species and genera of Bivalvia, one species of Ostracods, one species of Fish and two species and genera of Plants,

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