

中国岩相古地理丛书

华北地台早古生代 岩相古地理

冯增昭 等 著



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序

我国的古地理研究已有相当长的历史，有许多丰硕的成果。它可分三个主要的学派。第一个学派主要以古生物地层学的理论为指导，其图件可称之为古生物地层学的古地理图，刘鸿允（1955）的著作可作为这一学派的代表。这种古地理图基本是海陆分布图，在古陆和古海洋中，尤其是在古海洋中，并未分出次一级的古地理单元。第二个学派主要以大地构造学的理论为指导，其图件可称之为大地构造学的古地理图，王鸿祯等（1985）的著作可作为这一学派的代表。在这一学派的古地理图中，根据大地构造学的观点和有关的资料，主要是地层学的资料，把古海洋划分出了次一级单元，内容相当丰富；这就使我国的古地理学向前发展了一大步。第三个学派主要以沉积学的理论为指导，其图件可称之为沉积学的古地理图或沉积相古地理图，即岩相古地理图，也只有这一学派的古地理图才称得上岩相古地理图。此外，一些地理学家也在从事古地理学研究，但它已不属地质学的范畴了。

岩相古地理图又可大体分为两类。70年代以前，它基本上以旧的沉积岩石学理论为指导，可称之为旧型的岩相古地理图。70年代以后，随着沉积学尤其是碳酸盐沉积学的新理论、新观点和新方法的引进、传播和应用，开始出现了新型的岩相古地理图，关士聪等（1984）的图件属此范畴。而新型的岩相古地理图亦可大体分为两种类型，即定性的和定量的。笔者的岩相古地理图，例如本书中的岩相古地理图以及以前业已发表的一些岩相古地理图，属定量的岩相古地理图的范畴。

从古生物地层学及大地构造学的古地理图到岩相古地理图，从定性的岩相古地理图到定量的岩相古地理图，这是我国古地理学发展的主要历史过程和总趋势。

笔者从事岩相古地理学研究的原则如下：

1. 以沉积学尤其是以碳酸盐沉积学的新理论为指导。以此有别于以古生物地层学或大地构造学理论为指导的学派；因此笔者编制出来的图件是岩相古地理图，有别于古生物地层学的或大地构造学的古地理图。

2. 以自己实测的基干剖面所取得的第一手的定量资料和定性资料，尤其是定量资料为立足点。按照统一的规范和严格的要求，实测相当数量的基干剖面，对它进行深入的岩石学研究及沉积环境分析，取得各种第一手的定量及定性资料，尤其是定量资料，这就是笔者能够在前人的工作基础上有所前进和有所创见的立足点。当然，这是要花费相当大的人力、物力和精力的。但舍此也难有捷径。

3. 以“单因素分析综合作图法”为方法论。谚云：不以规矩不能成方圆。要想编制出新型的岩相古地理图，没有新的理论指导不行，没有新的资料不行，没有新的方法论也不行。而笔者在实践过程中探索出来、并付诸实践而且业已证明是行之有效的“单因素分析综合作图法”，就是与笔者采用的新理论和新资料相适应的新方法论。理论、实际资料和方法论，三者一体，密不可分。这就是笔者岩相古地理研究的技术路线的核心。关于“单因素分析综合作图法”，请参看本书第一部分的第四章。

4. 以定量的图件为主。这就是说,在笔者编制的岩相古地理图中,各古地理单元的确定,基本上都有确切的定量资料为依据。这就使古地理图和岩相古地理图基本上摆脱了定性的或示意性的初级阶段,从而发展到了定量化的高级阶段。从示意性或定性的图件到定量化的图件,这是科学发展的必然趋势,这是质的变化。这是笔者的图件有别于前人的最根本的一点。而自己实测基干剖面取得第一手的齐全可信的定量资料,并采用单因素分析综合作图法这一新的方法论,则是使岩相古地理图走向定量化的关键。

5. 以中比例尺的图件为主。笔者等编制的岩相古地理图主要是中比例尺的。所谓中比例尺,主要指1:50万到1:400万的比例尺。对于较小的地区,例如一个省或一个油区,可采用1:50万到1:100万的比例尺;对于较大的地区,例如下扬子地区或中下扬子地区,可采用1:100万到1:200万的比例尺;对于更大的地区,例如华北地台或华南地区,可采用1:250万的比例尺;对于全国,可采用1:400万的比例尺。这种中比例尺的岩相古地理图,与小比例尺(如1:1800万或1:1200万的比例尺)的古地理图相比,显然更确切、更深入、更细致了。这种中比例尺的岩相古地理图,对石油、天然气以及其它沉积矿产的预测和勘探,具有重要的理论指导意义。

6. 以海相碳酸盐地层为主要研究对象。这是由当前的主客观条件决定的。主观条件是笔者近十几年来主要从事碳酸盐岩沉积学及岩相古地理学的教学和科研工作,因而从事海相碳酸盐岩地层的岩相古地理研究比较方便和比较熟悉。客观条件是海相碳酸盐岩地层分布面积广,海相碳酸盐岩的油气区和油气田的规模比较大,而我国当前则正迫切需要在这一广阔的大有潜力的新领域中,在其油气勘探工作上,有所突破。当然,有些地区有些层段是以碎屑岩为主的,而从整体考虑,也是应当和必须对它进行研究的。实际上,碳酸盐岩和碎屑岩的关系十分密切,而且是相辅相成的。但是在当前的主客观条件下,有个侧重点也还是必要的。

7. 以地台区为主要研究对象。这也是当前的主客观条件决定的。地台区的海相碳酸盐岩地层比较稳定和有规律,比较好搞些;而地槽区则比较复杂,工作难度较大。另外,地台区海相碳酸盐岩地层的油气潜景也比地槽区为好。因此,先以地台区为主要研究对象,先易后难,先急后缓,是完全恰当的。只要把我国的几个大地台(如华北地台、扬子地台、华南地台、塔里木地台等)的各主要地质时代的岩相古地理特征及其演化规律搞清楚,把它们的岩相古地理图编制出来,则全国范围的岩相古地理研究工作就完成了了一大半,我国海相碳酸盐岩地层的油气预测和勘探工作也就有了最根本的科学依据。到那时再下“槽”,也就天从人愿水到渠成了。

8. 以找油、找气和找其他沉积矿产为主要目的。岩相古地理研究当然要为石油、天然气以及其他沉积矿产的预测和勘探工作服务,为它们提供最根本最基础的科学依据。这是我们的主要目的。有了这一点,我们的研究工作才能“得道多助”,才有旺盛的生命力。

笔者就是以这八项原则为指导,与广大的志同道合者一起,从事并完成“华北地台早古生代岩相古地理研究”这一科研任务的。

从1975年开始,到1988年全部任务完成,历时十有四年!

这是异常艰难的十四年。在本书第一部分《华北地台早古生代岩相古地理研究》的第一章绪论中,笔者已简要地叙述了这一历程的梗概;这里就不再为之感慨了。

在此十四年中,笔者与合作者一起,共实测基干剖面32条,观察其他单位实测的剖面18条,收集井下及露头剖面13条,还收集了大量的区测剖面资料。在这些剖面资料的基础上,采用“单因素分析综合作图法”,基本上以组为单位,编制出了1:250万的华北地台下古生界各组的各种单因素基础图件及其相应的各期的岩相古地理图,共65幅;并以这些图件为基础,撰写出了“华北地台早古生代岩相古地理研究”这一总结性的专论,从而完成了这一历时十四年之久的研究任务。

在此十四年的研究工作过程中,下列同志出了大力,他们是:雷明、王增莲、尤孝忠、应博民、管守锐、张万选;杨俊杰、李银德、王锡福、宋国初、周季陶、王光明、彭荣华、赵松青;刘正增、张孝志、王裕民、胡鹤龄、唐开疆、毛全喜;冀树楷、梁凤恕、申宝祥、王国华;林德超、刘印环、杜凤军;郑昭昌;田海芹、金振奎、王建国、朱爱国、白国平、王泽中、田波、何幼斌、陈永红、陈月清、温顺久、蒋盘良;王宜林、龚跃进、宋传春、王力群;李沛龙、赵继承、于建国、范春辉、赵宝和;孙国、冯小球、席胜利;常振恒、张朝富、阎汝军、高艳书、郭汝泰;肖超政、邓爱居、陈雄炎、高怀林等。本研究成果是和他们的辛勤劳动和大力支持分不开的。特此致谢。

同时,我校、我系及研究生部的领导、科学基金委员会、石油工业部及科技司、胜利油田、长庆油田、华北油田、大港油田、辽河油田、华北石油地质局石油地质大队、山西地矿局、山西地质科学研究所、山西区调队、山西临汾地质队、山西长治地质队、山西大同地质队、宁夏地矿局地质科学研究所、内蒙108地质队、江苏徐州地质队、安徽石油勘探局石油地质研究所、安徽区调队、辽宁区调队、辽宁本溪地质队、吉林通化地质研究所、中国矿业学院、山东矿业学院、淮南矿业学院、大庆石油学院、西北大学、北京大学、中国科学院地质研究所等单位的有关领导及有关同志,均给予了大力的支持。没有他们的支持,是很难完成这一长期而又艰巨的研究任务的。亦特此致谢。

1988年6月,石油工业部科技司在我研究生部召开了评审鉴定会,对本项研究成果进行评审鉴定。科技司石宝珩副处长主持会议。评审组由学部委员叶连俊研究员、田在艺高级工程师、张鹏飞教授、范嘉松研究员、沙庆安研究员、刘焕杰教授、刘本培教授、安太庠教授、王德发教授、王锡福高级工程师、杨复兴高级工程师、侯方浩教授、周堃高级工程师、徐志川高级工程师和张万选教授组成,叶连俊任组长,田在艺任副组长。

评审组认为这项研究是一个浩大的工程,这一研究成果具有以下几个主要特色:

① 基础资料十分丰富、扎实。作了大量的岩石学研究工作。从野外到室内,均有统一的技术思想和工作方法作指导。组织严密,工作认真,要求严格。因此,基础资料的质量是可信的。

② 该项成果的基础研究工作是可靠的。在搞清历年地层划分沿革的基础上,严格地按岩石地层单位作了认真的对比;对区内出现的岩石作了系统的研究,分析了它们的成因类型和形成环境。这些工作给岩相古地理研究打下了良好的基础。

③ 作者倡导的“单因素分析综合作图法”,将判断环境的诸个因素解析为单个定量数据,使岩相古地理的研究和岩相古地理单元的划分有了定量的依据。利用这种方法所获得的各项数据,为油气的评价研究和其他矿产的预测研究,提供了基础数据。以这种方法为技术路线的实践,为国内岩相古地理研究开拓了新的思路。从获得的成果图件证明,这一方法对地台区中比例尺岩相古地理研究具有合理性和科学性。

④ 使用“单因素分析综合作图法”所编制的华北地台寒武纪和奥陶纪17幅以组为单位（仅晚寒武世为统）的大区域中比例尺岩相古地理图尚属首次。古地理单元划分详细并有新的见解。详细和合理地解释了本区早古生代的古地理演化，具有较高的学术和应用价值。

⑤ 根据沉积环境特点、油气显示情况和地球化学、岩石物性等资料提出了一些有利的油气生储盖组合。强调了溶蚀带作为储集型式的重要性，所提出的直接淋漓溶蚀带、断裂溶蚀带和顺层溶蚀带的认识具有创见性。根据生储盖组合和保存情况，对华北地台下古生界的油气远景评价，具有重要的参考价值。

总之，本项研究成果在岩相古地理研究的理论和方法上具有新的特色和创造性；所取得的研究成果达到国内同类研究的先进水平，是一份出色的研究成果。这种多单位协作配合和实地调查研究的工作方法，是今后研究工作中值得大力提倡的。评委们一致建议通过部级鉴定。

笔者十分感谢评审鉴定组的这一过高的评价、热情的鼓励以及许多宝贵的指正和建议。

会后，我们对这一研究成果的全部图件和文字总结，进行认真的修正，并完成了出版前的全部定稿工作，并把它作为本书的第一部分《华北地台早古生代岩相古地理研究》。

在本书中，除了其第一部分即其主要内容之外，还有第二部分的5篇基于剖面的岩石学研究及沉积环境分析的论文，主要是笔者的合作者之作。这些论文在此一同发表，仍然是他们对笔者的支持，同时也是我们长期合作共事友谊的留念。

在本书的英文摘要的撰写和修定工作中，金振奎出了大力，陆庆邦教授提出了许多宝贵意见；特此致谢。

本书的姊妹篇《华北地台早古生代岩石学研究》，乃笔者的合作者王英华、杨承运和张秀莲的精心之作，即将由地震出版社出版，读者可先睹为快。这两本书相辅相成，先后问世，可算作我们对我国沉积学和岩相古地理学的一点贡献。

同十四年前相比，笔者现在的日子算是好过的多了。但是，岁月不饶人，吾已年过花甲了。幸者，身体尚佳，斗志尚旺，道路已通，青年学子们之心尚齐，志同道合者日益增多，领导的信任和支持也日益增加。总之，形势和条件还算是好的。这就有可能在不太远的将来，实现我长期以来向往并为之奋斗的目标，即以前述的八项原则为指导，同全国的志同道合者一起，把全国范围的各主要地质时代的岩相古地理图编制出来，并写出相应的文字总结，以《中国岩相古地理图集》的形式问世，促使我国的岩相古地理学和古地理学发展到量化的高级阶段，并为我国的石油、天然气以及其它沉积矿产的预测和勘探提供最根本的和带全局性的科学依据。

这是一个更为艰巨的工程。本书只是这一巨大工程的一部分和开始。但愿天从人助，早日实现这一宏愿。

当本书全部定稿和交付出版之际，谨为此序，以忆往事之坎坷，思成果之不易，怀挚友之支持，言来日之大志。

祝广大读者们好并请指正。

冯增昭

1988年仲秋，于石油大学研究生部，北京

PREFACE

Lithofacies paleogeography study in China has a pretty long history, and many important results have been obtained. It can be classified into three principal schools. The first school takes the theory of paleontological stratigraphy as guidance, and the maps drawn can be called paleogeography maps of paleontological stratigraphy. This school can be represented by the work of Liu Hongyun (1955). This kind of paleogeography map is basically distribution map of lands and seas. In ancient continents and oceans, especially in ancient oceans, the second-order units of paleogeography are not delineated. The second school takes the theory of tectonics as guidance, and the maps drawn can be called paleogeography maps of tectonics. This school can be represented by the work of Wang Hongzheng (1985). In paleogeography maps of this school, the second-order units in ancient oceans are delineated according to the viewpoint of tectonics and relevant data which are mainly stratigraphical data. The contents of these maps are plentiful. This makes the paleogeography study in China progress for a large step. The third school takes the theory of sedimentology as guidance, and the maps drawn can be called paleogeography maps of sedimentology or of sedimentary facies, i. e. lithofacies paleogeography maps. Only paleogeography maps of this school are lithofacies paleogeography maps. In addition, some geographers are also going in for paleogeography study, but this kind of study does not belong to the category of geology.

On the whole, lithofacies paleogeography maps can be grouped into two classes. Before the seventies, the maps were drawn under the guidance of the old theory of sedimentary petrology and can be called old lithofacies paleogeography maps. After the seventies, with the introduction, propagation and application of new theories, new viewpoints and new methods of sedimentology especially carbonate sedimentology, new lithofacies paleogeography maps have began to appear. Maps of Ye Desheng et al. (1983) and Guan Shicong et al. (1984) belong to this category. New lithofacies paleogeography maps can be further divided into two types, i. e. qualitative and quantitative. The lithofacies paleogeography maps of the present writer, such as those in this book and those published previously, are quantitative.

From paleogeography maps of paleontological stratigraphy and tectonics to lithofacies paleogeography maps, and from qualitative to quantitative litho-

facies paleogeography maps, are important historic process and the general trend of development of paleogeography in China.

The present writer's principles to study lithofacies paleogeography are following:

1. The guidance is the new theory of sedimentology, especially carbonate sedimentology. This is different from the schools that take the theory of paleontological stratigraphy or tectonics as guidance. Therefore, the maps drawn by the present writer are lithofacies paleogeography maps and are different from paleogeography maps of paleontological stratigraphy or tectonics.

2. The foothold is first-hand quantitative and qualitative data, especially quantitative data, obtained through measuring basic sections by ourselves. According to unified regulations and strict requirements, a number of basic sections are measured. Their petrology and sedimentary environments are studied in depth to obtain first-hand quantitative and qualitative data, especially quantitative data. This is the foothold on which the present writers have made progress.

3. The methodology is "Single Factor Analysis and Comprehensive Mapping Method". It is said: without rulers and compasses it is difficult to draw squares and circles. To make new lithofacies paleogeography maps is not possible without new theory as guidance, without new data, and without new methodology. "Single Factor Analysis and Comprehensive Mapping Method", which was initiated by the present writer and has been proved effectively, is the new methodology which adapts to the new theory and new data. Theory, practical data and methodology are integrated and inseparable. This is the core of the technical line adopted by us in our lithofacies paleogeography study. As to "Single Factor Analysis and Comprehensive Mapping Method", please refer to Chapter IV of the part I of this book.

4. The maps are mainly quantitative. In our lithofacies paleogeography maps, various paleogeographical units are defined on the basis of accurate quantitative data. This makes paleogeography maps and lithofacies paleogeography maps develop from a qualitative or sketchy elementary period to a quantitative advanced period. This is a change in quality. It is quantification that makes our maps different from previous geologists' maps. The key to quantification of lithofacies paleogeography maps is first-hand complete reliable quantitative data obtained through measurement of basic sections by ourselves and the new methodology—"Single Factor Analysis and Comprehensive Mapping Method".

5. The maps are mainly on medium scales. Our lithofacies paleogeography maps are mainly on medium scales. By medium scale, it is meant that

the scale is 1:4 000 000 to 1:500 000. For relatively small areas, such as a province or an oil region, scales of 1:500 000 to 1:1000 000 can be used. For large areas, such as the Lower Yangtze River Region or the Middle-Lower Yangtze River Region, scales of 1:1000 000 to 1:2000 000 can be used. For larger areas, such as North China Platform or South China, the scale of 1:2500 000 can be used. For the whole country, the scale of 1:4 000 000 can be used. In comparison with paleogeography maps on small scales (e. g. 1:18 000 000 or 1:12 000 000), our lithofacies paleogeography maps on medium scales are more accurate and more detailed. This kind of lithofacies paleogeography map is of more important significance in prediction and exploration of oil, natural gas and other sedimentary mineral deposits.

6. The object of study is mainly marine carbonate strata. This is determined by present subjective and objective conditions. The subjective conditions are that for over ten years, the present writer has been pursuing teaching and research of carbonate sedimentology and lithofacies paleogeography, and thus is very familiar with the study of lithofacies paleogeography of marine carbonate strata. The objective conditions are that marine carbonate rocks are widely distributed and have formed large oil and gas fields, and that at present in China it is urgent to make breakthroughs in oil and gas exploration in this broad new potential field of carbonate rocks. Certainly, some stratigraphic intervals in some areas are mainly composed of clastic rocks. However, considered as a whole, these intervals should and have to be studied. In fact, carbonate rocks and clastic rocks are closely related, but under present subjective and objective conditions, it is still necessary to put stress on carbonate rocks.

7. The object of study is mainly platforms. This is also determined by subjective and objective conditions. Strata of marine carbonate rocks in platforms are relatively stable and regular in distribution, therefore they can be studied relatively easily. But strata in geosynclines are relatively complicated and difficult to study. In addition, the oil and gas potential of marine carbonate strata in platforms is better than in geosynclines. Therefore, platforms are studied first. It is absolutely pertinent to do easy and urgent work first, and difficult and unhurried work later. So long as the characteristics and evolution of lithofacies paleogeography of several large platforms of China (e. g. North China Platform, Yangtze Platform, South China Platform and Tarimu Platform) during every major geological age are understood, and the lithofacies paleogeography maps are worked out, then most work to study nation-wide lithofacies paleogeography is finished. Thereby the most fundamental scientific basis is provided for prediction and exploration

of oil and gas in marine carbonate strata in China. At that time, it will be very easy to work with geosynclines.

8. The principal object is to look for oil, gas and other sedimentary mineral deposits. Certainly, lithofacies paleogeography study should serve prediction and exploration of oil, gas and other sedimentary mineral deposits, and provide the most fundamental and most basic grounds for the prediction and exploration. This is our principal object.

Under the guidance of the above eight principles, together with many comrades, the present writers finished the project "Study of Lithofacies Paleogeography of Early Paleozoic of North China Platform".

This project was started in 1975 and finished in 1988, lasting for 14 years. During this period, together with many comrades, we measured 32 basic sections, observed 18 sections measured by others, collected 13 bore-hole and outcrop sections, and gathered a lot of data of regional geological survey sections. On the basis of the above section data, by the "Single Factor Analysis and Comprehensive Mapping Method", with formation as the mapping unit, 65 fundamental single factor maps of every formation of the Lower Paleozoic of North China Platform and lithofacies paleogeography maps of corresponding ages were drawn. All these maps are on the scale of 1:2 500 000. Based on these maps, the summarizing monography **Study of Lithofacies Paleogeography of Early Paleozoic of North China Platform** has been written out. Thus the fourteen-year project has been finished.

We are indebted to many comrades, friends, and many organizations for their support to this study. Without their support, it would not have been possible to finish this project.

In June 1988, at the Graduate School of Petroleum University, an evaluation conference was called by the Science and Technology Department of the Ministry of Petroleum Industry. The evaluation committee pointed out following important characteristics of this study:

1. The basic data are abundant and solid.
2. The basic study of this project is reliable.
3. The "Single Factor Analysis and Comprehensive Mapping Method" initiated by the first author provided quantitative grounds for the study of lithofacies paleogeography and the determination of lithofacies paleogeography units.
4. The medium-scale lithofacies paleogeography maps of Cambrian and Ordovician of North China Platform, which were drawn with the "Single Factor Analysis and Comprehensive Mapping Method" and whose mapping unit was formation, are the first of their kind.

5. Favourable combinations of generating, reservoiring and capping of oil and gas are suggested on the basis of sedimentary environments, oil and gas shows, geochemical and petrophysical data. The importance of solution zones as a reservoir type is stressed. Recognition of direct eluvial solution zones, fault solution zones and strata-bound solution zones is original. The evaluation of oil and gas potential of Lower Paleozoic of North China Platform, which was made on the basis of combination of generating, reservoiring, capping and preservation conditions, is of important referential value.

In short, this study result is distinguished and original in the theory and method of lithofacies paleogeography study, and reaches the advanced level of similar studies in China. The evaluation committee suggests that this study pass the ministry-level examination.

The present writers are very indebted to the evaluation committee for this high evaluation, enthusiastic encouragement and many precious corrections and suggestions.

After the conference, we made careful correction to the literal summary and all maps of this study, and finished the final version of the manuscript for publication. I hope this book will be useful to the readers.

Prof. Feng Zengzhao
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Beijing, China
September, 1988

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