
Preface

Scientists have paid attention to studies about palynomorphs in petroleum since the early 1980s. Traverse (1988) in his unique work **Paleopalynology** wrote “A number of studies have turned up the interesting fact that spores/pollen are capable of being swept along with migrating petroleum as it moves through porous sedimentary rocks.” McGregor (1996) reviewed studies of palynomorphs in petroleum and considered that these studies merit wider attention, because the results and interpretations of researchers working on this subject have achieved credibility.

A Chinese monograph **Palynology of Petroleum Source** (in Chinese with English Summary) was published by Science Press in Beijing in 2013. Some palynologists and petroleum geologists suggest that English edition of the monograph should be published. This suggestion is supported by the leadership of Lanzhou Center for Oil and Gas Resources, Institute of Geology and Geophysics, Chinese Academy of Sciences (formerly the Lanzhou Institute of Geology, Chinese Academy of Sciences).

Petrolipalynology is the English version of the Chinese monograph, with additions that advance **Palynology of Petroleum Source**. This book is the first English monograph in this field. The principles and methods for determining petroleum source rocks based on the fossil spores and pollen are explained, and the character and distribution of the petroleum source rocks in the inland petroliferous basins and the coastal shelf petroliferous basins of China are expounded within the monograph. In accordance with the study on palynomorphs in petroleum, the authors discuss how microfissures in source rocks should be the passages for primary migration of petroleum and then expound on the mechanisms of petroleum migration in detail. Based on more than 20 years of palynological data accumulation, the authors have produced a book of use to commercial petroleum exploration and undergraduate and graduate students alike. Just as Prof. Xia Zhu wrote “Research on palynology of petroleum sources has established a bridge of discipline infiltration between palynology and petroleum geology, opening up a new research field.” In a word, Petrolipalynology is a seminal discipline with bright prospects.

This English monograph is written by Prof. Dexin Jiang (Lanzhou Center for Oil and Gas Resources, Institute of Geology and Geophysics, Chinese Academy of Sciences), Dr. Eleanora I. Robbins (San Diego State University),

and Dr. Yongdong Wang (Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences), with plates edited by Prof. Huiqiu Yang.

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Preface (Chinese Edition)

As energy sources, oil and natural gas are very important for the development of national economies, especially China's. Coal of course is the foremost energy source used in China. The world's petroleum industry developed rapidly in the span between 1950 and 2000; it reached the height of development in the 1980s. Owing to the rapid development of petroleum exploration in the inland petroliferous basins of China, many new petroleum fields such as the Kekeya and the Yakela oil fields in the Tarim Basin, and the Huonan and the Beisantai oil fields in the Junggar Basin were discovered since the 1970s. The development of this petroleum industry offered an opportunity for science and technology to blaze new trails.

An apparatus for extraction of spores and pollen from crude oil samples was set up in the palynological laboratory in Lanzhou Institute of Geology, Academia Sinica, in 1965. Since then, abundant fossil spores, pollen, and algae have been extracted from more than 200 crude oil and natural gas samples associated with oil samples from the Jiuquan, Ordos, Junggar, Turpan, Tarim, Qaidam, Liaohe, Beibu Gulf, Sanshui, and Zhujiang Mouth basins. The initial findings of spores and pollen in crude oils were confirmed by renowned scientists, academicians of Chinese Academy of Sciences. The first appointed director of the original Institute of Geology, Academia Sinica, Prof. Defeng Hou said "Fossil spores and pollen found in crude oils can provide reliable information for judging and dating petroleum source beds, which can also offer evidence for the generation and migration of petroleum." The renowned sedimentologist Prof. Lianjun Ye said "Study on spores and pollen in crude oils serve the production of petroleum by means of palynology as a tool. It is a creative work and is proved to be effective." The renowned palynologist Prof. Jen Hsü said "Spores and pollen in crude oils can provide valuable evidence for petroleum origin and petroleum sources." The famous petroleum geologist Prof. Xia Zhu said "Research on palynology of petroleum sources has established a bridge of discipline infiltration between palynology and petroleum geology, opening up a new research field. The academic accomplishments will be possessed of important function of guidance to petroleum exploration." Thus, the study of spores and pollen in crude oils was listed in the National 1986 to 1990 and 1991 to 1995 Science and Technique Major Research Programs.

The present monograph is a summary of the palynological achievements in the National 1986 to 1990 Program "Geological theory and exploratory

technique of petroleum fields” and the National 1991 to 1995 Program “Petroleum resources of the Tarim Basin” as well as the Program of National Natural Science Foundation of China “Principles and methods of petroleum source rock identification by means of spores and pollen” (Grant No. R 850879). The character and distribution of petroleum source rocks in the inland petroliferous basins including the Tarim, Junggar, Turpan, Qaidam, and Jiuquan basins and the coastal shelf petroliferous basins including the Liaohe Basin of East China Sea and the Beibu Gulf and Zhujiang Mouth basins of South China Sea are expounded in this monograph. The work is based on the palynological data that have been accumulated for more than 20 years. The main achievements of this monograph are as follows:

1. The definition and classification of petroleum spore-pollen assemblage are provided. An approach based on the oil source rock correlations of fossil spores and pollen species and color for judgment of petroleum source rocks is explained. By way of the application in eight petroliferous basins, the approach is proved to be effective.
2. The authors expound that microfissures in source rocks are the important passages for the primary migration of petroleum, allowing the passage of pollen and spores, and showing that fossil spores and pollen in crude oils are capable of dating petroleum source rocks.
3. The ecological characteristics of the original plants that shed the spores and pollen act as indicators of petroleum source rocks, thereby indicating that the lacustrine and swamp/marsh sedimentary environments under warm/hot and humid/wet climatic conditions are favorable for the formation of nonmarine petroleum source rocks.
4. Fossil spores and pollen in crude oils show reliable information about passages, phases, directions, routes, and distances of petroleum migration. Microfissures in source rocks formed by abnormal high pressure and undercompaction during the process of diagenesis are supported as the passageways for primary migration of petroleum. The passageways for secondary migration include connective pore spaces, bedding voids, joints, fissures, faults, and unconformities in the carrier bed and the reservoir bed. The phase state of primary migration includes the oil phase, gas phase, water-soluble phase, oil-soluble phase, gas-soluble phase, and diffusion phase. The phase state of secondary migration generally inherits the phase state of primary migration. The directions of petroleum migration are from low porosity and permeability rocks to high porosity and permeability rocks, following either vertical migration or lateral migration pathways. The routes of migration are from petroleum source beds to traps. The distances of migration are dependent on the distances between petroleum source beds and traps.
5. Ninety-six species of fossil spores and pollen referred to 52 genera were found in crude oil from an igneous petroleum reservoir in the East Junggar Depression. Igneous rocks cannot yield biological fossils; thus, the spores and pollen in crude oil must have been carried by oil, gas, and water from the surrounding sedimentary petroleum source rocks to the

- igneous reservoir during petroleum migration. This discovery is convincing evidence for the organic petroleum origin theory.
6. One hundred and eighty-three species of fossil spores and pollen referred to 89 genera were found in crude oils from the Tarim Basin. The original plants of the spores and pollen are continental plants, which have their sources from the terrestrial environment. These spores and pollen bear witness to petroleum generation from the continental facies.
 7. The results of the study on fossil spores and pollen in crude oils indicate that in China, the Carboniferous, Permian, Triassic, Jurassic, Cretaceous, and Tertiary Systems of the inland petroliferous basins contain petroleum source rocks, and the Paleogene System of the coastal shelf petroliferous basins contains excellent petroleum source rocks. The spore/pollen exine colors indicate that these petroleum source rocks are mature.

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