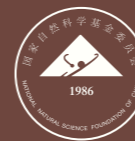




Supported by the National Fund for Academic Publication in Science and Technology



Advances in China's Basic Research

Editor-in-Chief: YANG Wei

Early Permian Tarim Large Igneous Province in Northwest China

Shufeng Yang, Hanlin Chen, Zilong Li, Yinqi Li, Xing Yu

Early Permian Tarim Large Igneous Province in Northwest China systematically presents and summarizes the authors' extensive research carried out over the past two decades. The book covers a variety of unique features of the Early Permian Tarim Large Igneous Province, including its tempo-spatial features, geochemical features and the magma evolution of the igneous rock units, its geodynamics and metallogenesis. It also provides a new geodynamic model for the Large Igneous Provinces, which is different from the models based on the Deccan Large Igneous Province and the Parana Large Igneous Province.

The book is aimed at researchers and graduate students in tectonics, igneous petrology, geochemistry, geophysics, Earth evolution and planetary geology, as well as mining industry professionals. It will also serve as an invaluable reference for the study of Large Igneous Provinces and the geodynamic research of the Central Asian tectonic domain.

Key Features

- Provides tempo-spatial features of the Early Permian Tarim Large Igneous Province by systematic seismic data and borehole data;
- Systemically presents data regarding the petrological and geochemical features as well as the magma evolution of the rock units in the Early Permian Tarim Large Igneous Province;
- Builds up a new model for Large Igneous Provinces, based on the information from the Early Permian Tarim Large Igneous Province.

上架建议：地球科学

ISBN 978-7-308-17664-4



定价：128.00元

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浙江大学出版社
ZHEJIANG UNIVERSITY PRESS



ZHEJIANG UNIVERSITY PRESS
浙江大学出版社



Supported by the National Natural Science Foundation of China (No.40930315)

Supported by the National Fund for Academic Publication in Science and Technology

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图书在版编目(CIP)数据

塔里木早二叠世大火成岩省 = Early Permian Tarim
Large Igneous Province in Northwest China : 英文 /
杨树锋等著. —杭州: 浙江大学出版社, 2017.12
ISBN 978-7-308-17664-4

I. ①塔… II. ①杨… III. ①塔里木盆地—早二叠世
—火成岩—研究—英文 IV. ①P588.1

中国版本图书馆CIP数据核字(2017)第283663号

塔里木早二叠世大火成岩省

杨树锋 陈汉林 厉子龙 励音骐 余 星 著

丛书统筹 国家自然科学基金委员会科学传播中心
策划编辑 徐有智 许佳颖
责任编辑 伍秀芳 (wxftw@zju.edu.cn)
责任校对 魏钊凌 董 唯
封面设计 程 晨
出版发行 浙江大学出版社
(杭州市天目山路148号 邮政编码310007)
(网址: <http://www.zjupress.com>)

排 版 杭州中大图文设计有限公司
印 刷 浙江海虹彩色印务有限公司
开 本 710mm×1000mm 1/16
印 张 13.25
字 数 330
版 次 2017年12月第1版 2017年12月第1次印刷
书 号 ISBN 978-7-308-17664-4
定 价 128.00元

版权所有 翻印必究 印装差错 负责调换

浙江大学出版社发行中心联系方式 (0571) 88925591; <http://zjdxcs.tmall.com>

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Preface to the Series

As Lao Tzu said, “A huge tree grows from a tiny seedling; a nine-storey tower rises up from a mound of earth.” Basic research is the fundamental approach to foster innovation-driven development, and its level becomes an important yardstick for measuring the overall scientific and national strength of a country. Since the beginning of the 21st century, China’s overall strength in basic research has been increasing consistently. With respect to input and output, China’s input in basic research has increased by 14.8 times from 5.22 billion *yuan* in 2001 to 82.29 billion *yuan* in 2016, with an average annual increase of 20.2%. In the same period, the number of China’s scientific papers included in *Science Citation Index* (SCI) increased from less than 40,000 to 324,000; China rose from the 6th place to the 2nd place in global ranking in terms of the number of published papers. In regard to the quality of output, in 2016, China ranked No.2 in the world in terms of citation in 9 disciplines, among which Materials Science ranked No.1; in the past two years, China ranked No.3 in the world both in the number of top 1% most-cited international papers and the number of top 1‰ international hot papers with global share of 25.1%. In talent cultivation, in 2016, 175 scientists from China were included in the Thomson Reuters Highly-Cited Researchers List (136 of which from the Chinese Mainland), which ranked the fourth in the world and the first in Asia.

Meanwhile, we should also be keenly aware that China’s basic research is still subject to great challenges. First, funding for basic research in China is still far less than that in developed countries — only about 5% of the R&D funds in China are used for basic research, a much lower percentage than the 15%–20% in developed countries. Second, competence for original innovation in China is insufficient. The major original science achievements that have global impact are still rare. Most of the scientific research projects are just a follow-up and imitation of the existing researches, rather than brand new novel or pioneering work. Third, the development of disciplines is not balanced, and China’s research level in

some disciplines is noticeably lower than the international level — China's Field-Weighted Citation Impact (FWCI) in disciplines just reached 0.94 in 2016, lower than the world average of 1.0.

The Chinese government attaches great importance to basic research. In the “13th Five-Year Plan”, China has confirmed scientific and technological innovation as a priority in all-round innovation, and has made strategic arrangements to strengthen basic research. General Secretary Xi Jinping put forward a grand blueprint of making China into a strong power in science and technology in his speech delivered at the National Conference on Scientific and Technological Innovation, and placed emphases on “targeting the world's advanced scientific and technological frontier, consolidating basic research to achieve major breakthroughs in forward-looking basic research and steering original achievements” at the 19th CPC National Congress on Oct.18, 2017. With more than 30 years of unremitting exploration, the National Natural Science Foundation of China (NSFC), one of the main channels for supporting basic research in China, has gradually shaped a funding pattern covering research, talents, tools and convergence, and has taken actions to vigorously promote basic frontier research and the growth of scientific research talents, reinforce the building of innovative research teams, deepen regional cooperation and exchanges, and push forward multidisciplinary convergence. As of 2016, nearly 70% of China's published scientific papers were funded by NSFC — accounted for 1/9 of the total number of published papers all over the world. Facing the new strategic target of building China into a strong country in science and technology, NSFC will conscientiously reinforce forward-looking planning, and enhance the efficiency of evaluation, so as to achieve the strategic goal of making China progressively share the same level with major innovative countries in research output, impact and original contribution by 2050.

The series of *Advances in China's Basic Research* and the series of *Reports of China's Basic Research* proposed and planned by NSFC emerge under such a background. Featuring of science, basics and advances, the two series are aimed to share innovative achievements, diffuse performances of basic research, and lead breakthroughs in key fields. They will closely follow the frontiers of basic research developments in China, and publish excellent innovation achievements funded by NSFC. The series of *Advances in China's Basic Research* will mainly present the important original achievements of the programs funded by NSFC

and display the breakthroughs and forward guidance of the key research fields, while the series of *Reports of China's Basic Research* will show the core contents of the final reports of the Major Programs and the Major Research Plans funded by NSFC to make a systematical summarization and strategic outlook of the achievements in the fields preferred to be funded by NSFC. We not only hope to comprehensively and systematically display the backgrounds, scientific significances, discipline layouts, frontier breakthroughs of the programs, as well as strategic outlooks of the subsequent research, but also expect to summarize the innovative ideas, enhance multidisciplinary convergence and promote the continuity of research in the fields concerned as well as original discoveries.

As an old saying in *Hsun Tzu* goes, “Where accumulated earth becomes a mountain, there prevails wind and rain. Where running waters gather widely and deeply, there gives birth to dragons.” The series of *Advances in China's Basic Research* and the series of *Reports of China's Basic Research* are hoped to become the “historical records” of China's basic research, which will provide researchers with abundant scientific research materials and sources for innovation. It's believed that the series will certainly play an active role in making China's basic research prosper and in building China into a powerful nation of science and technology.



President of NSFC

Academician of Chinese Academy of Sciences

Dec. 2017, Beijing

Preface

Tarim Plate is one of the three major plates in China, surrounded by the Tianshan, Kunlun and Altyn–Tagh orogenic belts. It is also an important connection to the tectonic domains between Central Asia and the Tethys. One notable feature of the Tarim Plate is the wide occurrence of Early Permian intraplate magmatism in which the magmatic rocks were made up mainly of basaltic rocks including basalts, diabase, basaltic andesite, ultramafic rocks, etc. The area of residual distribution of the magmatic rocks can reach about 2.5×10^5 km², and the largest residual thickness is more than 700 m. As a new Large Igneous Province (LIP), it has attracted the attention of many scientists.

Based on more than 20 years of study, this book will systematically introduce the tempo-spatial features of the Early Permian Tarim Large Igneous Province (Tarim LIP), the geochemical features and the magma evolution of the rock units, as well as the geodynamics and metallogenesis of the Early Permian Tarim LIP. This book will also provide a new geodynamic model for the LIPs, which is different from the model based on the Deccan LIP and the Parana LIP. This book is the first book to introduce the Early Permian Tarim LIP, and it is an ideal book for researchers and graduate students in tectonics, igneous petrology, geochemistry, geophysics, Earth evolution and planetary geology, as well as for professionals working in the mining industry. This book will also play a very important role in the study of the LIPs and geodynamic research within the tectonic domain of Central Asia. By taking this opportunity, we would like to express our sincere appreciation of the assistance from other teachers and students at the School of Earth Sciences at Zhejiang University. The research work in this book was supported jointly by the National Natural Science Foundation of China (Nos. 41603029 and 40930315), the National Science and Technology Major Project of China (No. 2017ZX005008-001), the National Key R&D Program of China (No. 2016YFC0601004), and the National Basic Research Program of China (Nos. 2007CB411303 and 2011CB808902).

The Authors
October 2017, Hangzhou

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