

中国东部地壳与 岩石的化学组成

郝明才 迟清华 著

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内 容 简 介

本书是第一部分系统研究中国东部区域地壳和岩石化学组成的专著。

地壳和岩石化学组成作为地学的基本数据和地球化学定量研究的基础而受到广泛重视。本书立足于现代分析技术,以中国东部各区域地层、火成岩和变质岩全面系统的地球化学实测资料为基础,提出了华北地台地壳化学元素丰度、中国东部地壳化学组成估计值、出露地壳平均化学组成、各时代地层平均化学组成以及中国各类火成岩、中国东部各类沉积岩和变质岩的平均化学组成。提供丰度值的元素达 78 种。阐述了我国东部各构造单元地层和岩石的区域地球化学特征,研讨了 60 余种微量元素在岩石中的地球化学分布。其中一些元素如铂族元素的丰度是鲜为人知的,反映了区域地壳和岩石化学组成研究的新水平。

本书可供从事地球化学、岩石学和基础地质研究人员、地质矿产勘查、环境和农业科技人员及有关高等院校师生应用与参考。

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**THE CHEMICAL COMPOSITIONS
OF CRUST AND ROCKS
IN THE EASTERN PART OF CHINA**

Yan Mingcai and Chi Qinghua

Science Press

1997

前 言

本书是在地质矿产部“八五”重点基础地质项目“中国东部上地壳区域元素丰度研究”成果的基础上编写而成的。项目由地质矿产部地球物理地球化学勘查研究所承担,与中国地质大学等单位合作完成。

地壳和岩石化学组成作为地学的重要基础研究内容而受到广泛的重视。地壳化学元素丰度研究从 Clarke (1924)发表了著名的地壳化学元素丰度表至今已 70 多年,其间不同学者以不同方法,对地壳的主要化学元素丰度取得了基本一致的结果,但其内涵并不相同,认识在不断深化,许多微量元素丰度也在不断改进,一些难测元素迄今仍为概略的估计值。近年来通过全球性地壳断面和超深钻的研究,对地壳的组成与结构的认识又有了很大进步,认识到陆壳在横向和纵向上很不均匀,因而 70 年代以来人们将对区域整体地壳的实测研究作为现代了解地壳化学组成的主要方向,并以区域地壳的值近似地代表总陆壳的组成。

本研究立足于中国近年来测试技术的进步及区域地质与区域地球化学的研究成果,在东经 105°以东的中国东部约 $3.3 \times 10^6 \text{ km}^2$ 区域内,系统地采集了 500 余条标准地层剖面、800 余个有代表性的火成岩体和变质杂岩体样品,总计 28 253 个,组合成 2 718 件分析样,取得了除惰性气体和不稳定元素之外所有元素的值。

主要成果有:①华北地台地壳化学元素丰度;②中国东部地壳化学组成估计值;③中国东部及各构造单元出露地壳化学组成;④中国东部及各构造单元地层平均化学组成;⑤中国各类火成岩平均化学组成;⑥中国东部各类沉积岩平均化学组成;⑦中国东部各类变质岩平均化学组成;⑧中国东部地壳与岩石化学元素分布特征。

本研究主要特点:①区域地壳模型具实在性。以现代地壳结构模型为指导、区域地壳断面、地质和地球化学的实际综合资料为基础建立的区域地壳模型,更接近区域地壳的实际情况。②样品有充分的代表性。样品采集全面考虑了时空的代表性,对反映深部组成的变质地体作了系统的综合研究。③采用了准确可靠的配套测试方法技术,实测元素达 77 种。取各分析方法之所长,以我国传统的经典方法与现代的仪器方法相结合,共选用了 15 种可靠的测试技术。采用了最新的测试研究成果,提高了数据的可靠性。④对难测元素如 Pt、Pd、Os、Ru、Rh、Ir 和 Au 等进行了测试方法专题研究,显著提高了其灵敏度和准确度。⑤对样品分析质量采用国家一级地球化学标准物质进行严格的质量监控(包括铂族元素),显著提高了丰度值的可靠性。⑥填补了多种岩石(特别是变质岩)微量元素丰度的空白,显著改进了岩石化学元素丰度值。⑦区域地壳模型、选取的样品和测试数据之间具有同一性,与外国学者的汇编资料相比,减少了地壳化学元素丰度值的不确定度,显著提高了不同岩石和元素之间的可比性,为地球化学定量研究奠定了更坚实的基础。

总之,本研究在区域地壳模型设计与其实际依据、岩石分类、样品代表性、实测元素数和区域地壳与岩石化学元素丰度值的可靠性等方面均优于国外现有资料,反映了区域地壳和岩石化学元素丰度研究的新水平。所提供的一套全面系统的基础地球化学数据,可供国内外地学界广泛应用。作为重要自然物质化学组成的基本背景亦可供环境、农业等部门参考应用。区域地壳、区域岩石的元素分布与演化的系统资料对中国大陆块及地球动力学的宏观研究也提供了重要信息。

参加本研究项目的主要成员有:鄢明才、迟清华、顾铁新、李国会、卢荫麻、林玉南、王春书、周丽沂、颜翠萍。项目顾问:谢学锦、张本仁。

在野外地质考察研究中,得到以下单位成员的热情帮助和支持:中国地质大学骆庭川、高山、马振东,长春科技大学戚长谋、迟效国,辽宁省地质矿产局区域地质调查队李星云、刘炳玉,江西省地质矿产局地球物理勘查院薛水根、朱细创,内蒙古自治区地质矿产局第一地球物理地球化学勘查院冷富荣,浙江省地质矿产局地球物理地球化学勘查院吴坤泉,山东省地质矿产局地球物理地球化学勘查院陈运环,河北省地质矿产局地球物理勘查院宫进忠,河北省地质矿产局区域地质调查研究所胡学文,福建省地质勘查技术院蔡以评,吉林省地球物理勘查研究院王立民,山西省地质矿产局区域地质调查队徐朝雷,山西省地质科学研究所田永清,地质矿产部航空遥感中心唐炬。在分析测试工作中,得到以下单位的帮助:地质矿产部郑州综合矿产利用研究所林玉南(铂族元素和金的分析),北京有色金属研究总院周云鹿、陆惠娟、包卫东和中国原子能科学研究院赵砚卿、袁玲(中子活化分析),地质矿产部岩矿测试技术研究所杜安道、阙松娇、韩慧明(稀土元素等离子光谱与质谱分析和Re分析)。研究中还得到涂光炽院士、任纪舜和冯锐研究员、袁学诚和朱梅生教授及地质矿产部科学技术司孙培基、高平同志的热情指导和帮助。张本仁教授、沈其韩院士、邱家骧教授对本书进行了认真的审阅,并提出了宝贵的意见。本书的全部图件由陈丽娟、黄裕芳同志帮助清绘。在此一并致谢!

由于水平所限,疏漏、缺点和错误在所难免,敬请读者批评指正。

Preface

This book is written based on a key project of "Regional Abundance of Elements in the Upper Crust in Eastern China" sponsored by the Ministry of Geology and Mineral Resources (MGMR), China. The project was undertaken by the Institute of Geophysical and Geochemical Exploration (IGGE), MGMR and cooperatively finished with the China University of Geosciences and so on.

Chemical composition of crust and rocks as one of important fundamental geosciences is widely focused on. Research on the crustal abundance of chemical elements has been carried out for 70 years since the publication of the famous table for crustal abundance of chemical elements by Clarke (1924). Since then, crustal abundance of main chemical elements obtained by different researchers with different methods are reliable and consistent. However, the crustal abundance of many trace and ultratrace elements are inconsistent, and the crustal abundance of some elements difficult to determine are still theoretically estimated rather than practically determined due to the lack of effective analytical methods. In recent years, it is practical to more precisely obtain crustal abundance of elements with the development of new analytical techniques, and it is possible for us to have a further understanding of the crustal composition that the crust is uneven vertically and horizontally by the study of global geoscience transect and ultradeep drilling. Therefore, since 1970s, it is likely to precisely estimate the chemical composition of the continental crust through systematic investigation of the regional crust.

This book is benefited from the development of regional geology, regional geochemistry, global geoscience transect and the analytical techniques in China. As many as 28 253 rock samples are systematically collected from about 500 standard stratum profiles, and 800 intrusive and metamorphic rock bodies in the area of about 3.3 million km² of eastern China (east of 105°E). Then these samples are composed 2 718 analytical samples and 150 big analytical samples analyzed by 15 reliable analytical methods. Some elements such as Br, I, N, Te, In, Re, Os, Ru, Rh, Ir, etc. are determined in 150 big composite samples. Abundance of crust and rocks of all elements except inert gas and unstable elements are given.

The main results are as follows: (1) crustal abundance of chemical elements in North China platform; (2) estimates of crustal chemical composition in eastern China; (3) chemical composition of exposed crust in eastern China and its structural units; (4) average chemical composition of strata in eastern China and its structural units; (5) average chemical composition of igneous rocks in China; (6) average chemical composition of sedimentary rocks in eastern China; (7) average chemical composition of metamor-

phic rocks in eastern China; and (8) characteristics of distribution of chemical elements of crust, strata and rocks in eastern China.

The characteristics of this study are: (1) practical regional crustal models. It is relatively reliable because the regional crustal model is established on the integrated data of regional crustal sections, geology and geochemistry. (2) The rock samples are representatively collected from rock bodies and strata with different time and space. Make comprehensive study on metamorphic terrains which can reflect deep crust. (3) use of sensitive analytical methods and technologies. Over 77 elements were analyzed by 15 analytical methods including classical chemical analytical methods and modern instrumental analytical techniques. (4) For some elements such as Pt, Pd, Os, Rh, Ru, Ir and Au, special high-sensitivity and high-accuracy analytical methods are used. (5) National primary geochemical certified reference samples (including PGE and Au) are used to monitor rigidly the analysis quality. (6) remarkable improvement and supplement for elemental abundance of kinds of rocks (especially for metamorphic rocks). (7) identity for regional crustal models, selected samples and analytical results. The data are more reliable and informative compared with those from customary information compiled by researchers. The uncertainties of crustal abundance of chemical elements are reduced. Comparisons with different rocks and different elements are more exact. The data lay a more firmly foundation for quantitative geochemical study.

In a word, design and factual basis of regional crustal models, classification of rocks, representativity of samples, number of analytical elements, reliabilities of abundance of chemical elements of crust and rocks in this study are superior to those of available information. It improves remarkably on abundance of chemical elements of crust and rocks. These basic geochemical data can be widely used in geology, environment and agriculture and so on. The data about elemental distribution and evolution in regional crust and rocks also can provide fundamental information for continental plate of China and geodynamics.

Main participants in the project are Yan Mingcai, Chi Qinghua, Gu Tiexin, Li Guohui, Lu Yinxiu, Lin Yunan, Wang Chunshu, Zhou Liyi and Yan Cuiping. Xie Xuejing and Zhang Benren supervise this project.

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We would be very grateful if readers could give their opinions for the book.

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