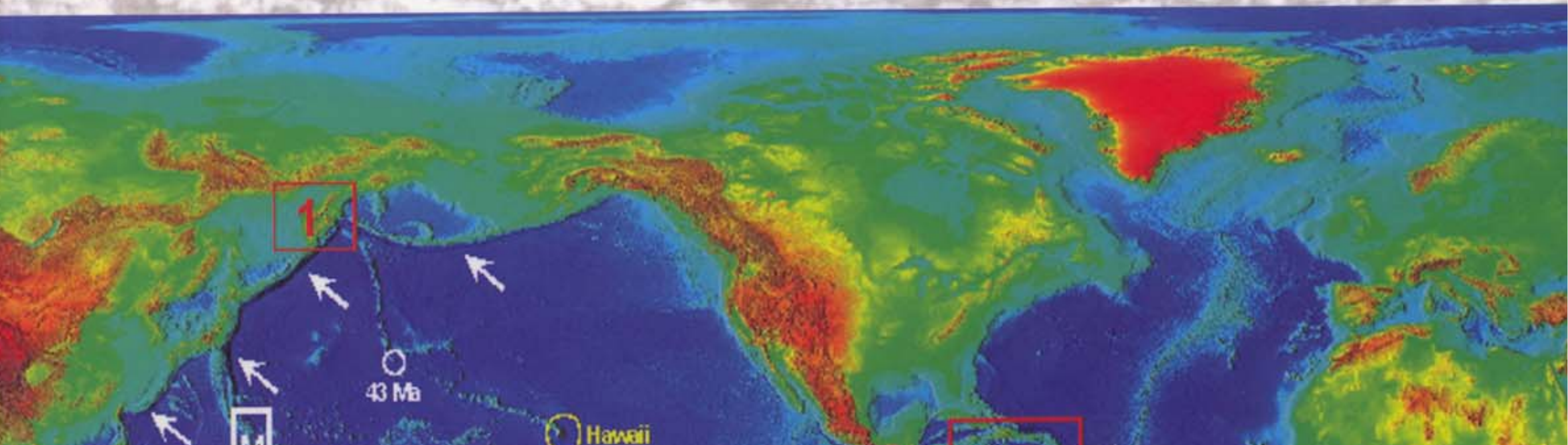
火成岩构造环境和成矿作用

Symposium on Igneous Rocks Tectonics and Mineralization



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Preface

前　言

中国地质调查局"火成岩构造环境和成矿作用"（Igneous Rocks, Tectonics and Mineralization）学术报告会，将于2002年9月24-26日在天津地质矿产研究所召开。会议的主题是"当代火成岩岩石学、地球化学、经济地质学、全球构造和生命起源"。此次活动对于促进我国和国际地学界科技交流、提高我们的科学研究水平和我国新一轮国土资源大调查的成果水平均会起到积极作用。

此次会议是在英国皇家学会、英国自然环境研究委员会（NERC）、中国国家自然科学基金委员会、国土资源部国际合作与科技司和中国地质调查局的支持下开展的。2001年5月中国地质调查局天津地质矿产研究所和英国Cardiff大学签定国际合作研究协议，共同开展"Recycling in Subduction Zones: Evidence from the Eclogites and Blueschists of NW China"（俯冲带再循环：来自中国西北地区榴辉岩和蓝片岩的证据）研究工作，中方成员包括李怀坤研究员、陆松年研究员和王惠初研究员等，英方成员包括Yaoling Niu博士（高级研究员）、Mike O'Hara教授和Julian A. Pearce教授等，合作项目的中、英方负责人分别为李怀坤研究员和Yaoling Niu高级研究员；2001年7月中国地质调查局批示，依托由陆松年研究员和于海峰研究员共同主持的国土资源大调查综合研究项目"中国中西部前寒武纪重大地质事件群研究"开展工作；2002年2月英国皇家学会批准了双方共同申请的国际合作研究项目"Geochemical Consequences of Subduction Zone Metamorphism – Constraints on Mantle Isotopic Heterogeneities"（俯冲带变质作用的地球化学响应——地幔同位素不均一性的制约）（项目批准号：RL/ART/CN/JPO/14092）；2002年5月中方成员依托陆松年研究员主持的中国国家自然科学基金重点项目"我国古陆块对Rodinia全球超级大陆事件的响应"（批准号：40032010）向自然科学基金委员会申请国际合作经费支持，并于2002年7月获得批准（项目批准号：40211130355）。

此次应邀来华讲学的三位学者均是各自研究领域知名的地质学家。**David Rickard 教授**是众多国际知名科学学会的会员，1992-2000任《矿床学杂志》（Mineralium Deposita）编辑，1993-2001为Cardiff大学地球科学系主任，现任欧洲经济地质学家协会副主席，领导"Cardiff硫化物研究工作组"（Cardiff Sulphide Research Group），他的研究兴趣在于地球化学，特别是低温硫化物实验地球化学、地球化学动力学和矿床地质学，公开发表了150多篇论文或专著。**Julian A. Pearce 教授**：历任SCICOM等几个大洋钻探委员会的成员或主席，Bigsby奖章获得者，现为Cardiff大学教授。他的火成岩构造环境判别图解——著名的"Perace图解"，在我国地学界影响极大。**Yaoling Niu 博士**：1992年在美国夏威夷大学获得博士学位；1993-2000在澳大利亚昆士兰大学任讲师、高级讲师；1999年至今为中国地质大学（北京）客座研究员；2001年以来为英国自然环境研究委员会（NERC）高级研究员。三位学者对此次讲学高度重视，撰写了详细的讲座材料。

为了使中国地质工作者更好、更方便地使用报告会材料，天津地质矿产研究所组织有关同志将材料翻译成中文，但是由于时间紧迫、更主要的是由于翻译者的学科所限，中译文中不准确或错误之处在所难免，请不吝批评指正。参加资料翻译和校对的人员包括李怀坤、张翊钧、毛德宝、朱士兴、刘新秒、陈志宏、金文山、曹芳、董玉琴、陆松年、安树清等，在此对上述同志表示感谢。

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2002年9月19日

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Generation and evolution of basaltic magmas: Some fundamental concepts

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Abstract. Some basic concepts and principles of magma generation and evolution are discussed in some detail in the context of global tectonics. These concepts/principles form a basis needed to properly interpret geochemical data such as trace elements and radiogenic isotopes on igneous petrogenesis. The principles discussed are also useful for making good use of field observations and for a better understanding of the petrogenesis of some mafic magmatism associated ore deposits. The principles are primarily based on basaltic systems, but also applicable to other systems provided that some needed caution is taken. Personal views on the petrogenesis of some volumetrically small, but widespread igneous rocks are offered. While these views are based on observations and logical inferences, future tests are needed.

1. Introduction

Magma generation is a consequence of Earth's thermal evolution, and is perhaps the most effective process leading to chemical differentiation of the Earth over Earth's history from a compositionally more or less uniform proto-earth (chondritic?) to the present layered Earth (i.e., the metallic core, and the silicate mantle and crust) with each layer being compositionally heterogeneous on various scales. Furthermore, magma evolution in the course of cooling and perhaps also through wall-rock assimilation at shallow levels is the very process leading to formation of igneous rocks of various composition, mineralogy, textures, and thus different rock series and rock types, recognizing compositionally different primary or parental magmas also playing a governing role in rock diversity. Importantly, igneous petrogenesis-associated mineralization is the by-product of magma evolution/assimilation. Therefore, understanding the fundamental concepts of magma generation and evolution is essential. Unfortunately, current studies of igneous petrogenesis have neglected basic physical principles for petrogenesis, but largely or in certain cases entirely focused on interpretations of trace element and isotopic data. The latter data are important, but the validity of their interpretations becomes highly questionable without having a clear understanding of the fundamentals of magma genesis. The purpose of this contribution is to discuss these basic concepts of magma genesis required to understand the geochemical data and the tectonic settings in which igneous rock bodies of interest may have formed. I concentrate the discussion on basaltic systems, but the principles apply to other igneous systems.

2. The concepts of magma generation

2.1. Partial vs. total melting

Basaltic magmas are melts produced by *partial* melting of mantle peridotites in the upper mantle. The present-day thermal gradient of the Earth's mantle does not allow *total* melting. For reasons of physical melt extraction and heat budget, *total* melting is indeed neither likely in the mantle nor in the crust. As a result, magma generation is the result of *partial*, not *total*, melting regardless of the nature of source rocks or magma types (e.g., komatiites, picrites, basalts, and granitic melts). *Partial* melting has two products, the melt and the residue. The resultant melt represents the easily melted component of the source rock, whereas the residue is the more refractory component of the source rock. The bulk composition of the resultant melts