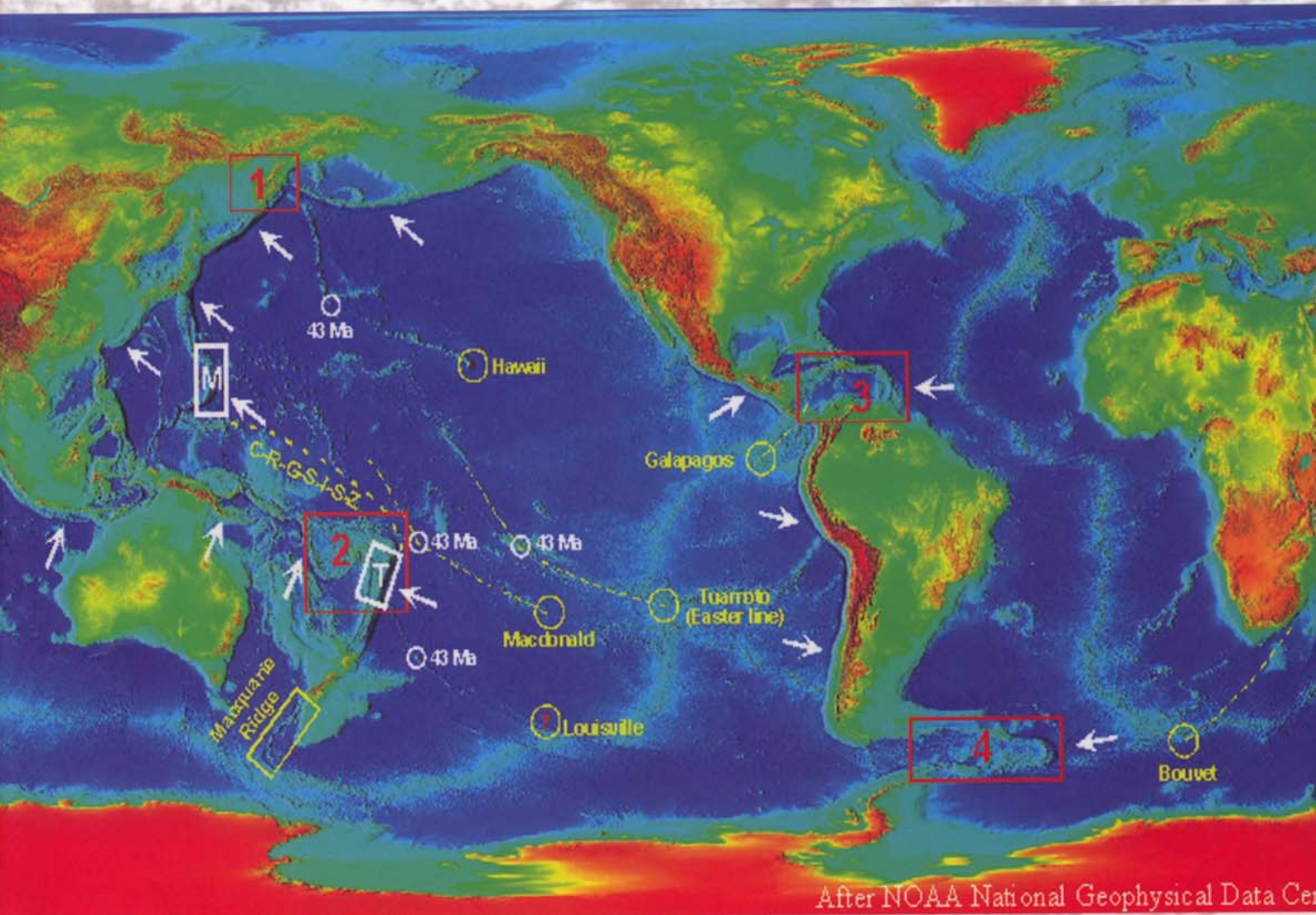


火成岩构造环境和成矿作用

Symposium on Igneous Rocks Tectonics and Mineralization



天津地质矿产研究所

Tianjin Institute of Geology and Mineral Resources

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“Perce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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Interactions between mantle plumes and mid-ocean ridges: Observations, concepts and mechanisms

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Abstract. Plate tectonics and mantle plumes are genetically independent, but when the ascending mantle plumes approach lithospheric plates, interactions between the two occur. Such interactions are most prominent near ocean ridges where the lithosphere is thin and the effect of mantle plumes is best revealed. While ocean ridges are mostly passive features in terms of plate tectonics, they play an active role in the context of plume-ridge interactions. This active role is in practice a ridge suction force that drives asthenospheric mantle flow towards ridges as the result of material needs to form the ocean crust and lithospheric mantle in the broad zone of mantle upwelling beneath ocean ridges. Because the LVZ has the lowest viscosity that increases exponentially with depth, the ridge-ward asthenospheric mass flow is largely horizontal in the direction against the motion of the overlying lithospheric plate. It follows that the spreading lithospheric plates must necessarily be decoupled from the sublithospheric flow, particular in the ocean basins with fast-spreading ridges such as the Pacific because of the spreading-rate dependent material demand/flow towards the ridge. The ridge suction force or ridge-ward mass flux is linearly proportional to plate spreading rate. The above concepts and postulated mechanisms of asthenospheric mantle flows and plume-ridge interactions are supported by geological, geophysical, and geochemical observations illustrated in this paper.

1. Introduction

Geological processes are consequences of Earth's thermal evolution. Plate tectonics, which explain geological phenomena along plate boundaries, elegantly illustrate this concept. For example, the origin of oceanic plates at ocean ridges, the movement and growth of these plates, and their ultimate consumption back into the Earth's interior through subduction zones provide an efficient mechanism to cool the earth's mantle, leading to large-scale mantle convection. Mantle plumes, which explain another set of global geological phenomena, cool the earth's deep interior (probably the Earth's core) and represent another mode of Earth's thermal convection [e.g., *Davies & Richards*, 1992]. Plate tectonics and plume tectonics are thus genetically independent of each other. However, when the rising plumes approach the lithospheric plates, interactions between the two inevitably result. Such interactions are most prominent near ocean ridges where the lithosphere is thin and the effect of mantle plumes is best revealed. "Plume-ridge interaction" has been a hot topic in recent years, and much effort has been expended in this area aimed at understanding the geological, geochemical, and geodynamic consequences [e.g., *Schilling et al.*, 1983, 1994, 1995, 1996, 1999; *Schilling*, 1991; *Feighner & Richards*, 1995; *Ito & Lin*, 1995a,b; *Ito et al.*, 1996; *Kincaid et al.*, 1995, 1996; *Ribe*, 1996; *Sleep*, 1996; *Haase & Devey*, 1996; *Hékinian et al.*, 1996, 1997, 1999; *Pan & Batiza*, 1998; *Niu et al.*, 1999; *Graham et al.*, 1999; *Georgen et al.*, 2001; *Haase*, 2002].

In this paper, instead of reviewing details of existing models, I present some new perspectives on the geochemical and geological consequences of plume-ridge interactions in the form of schematic models. These models differ from most common perceptions, but are consistent with observations and comply with simple physics. I focus on first-order observations and stress the importance of several fundamental concepts and variables required to fully understand the "expression" and "intensity" of plume-ridge interactions. These include: (1) what mantle plumes are; (2) the nature and composition of plume sources; (3)