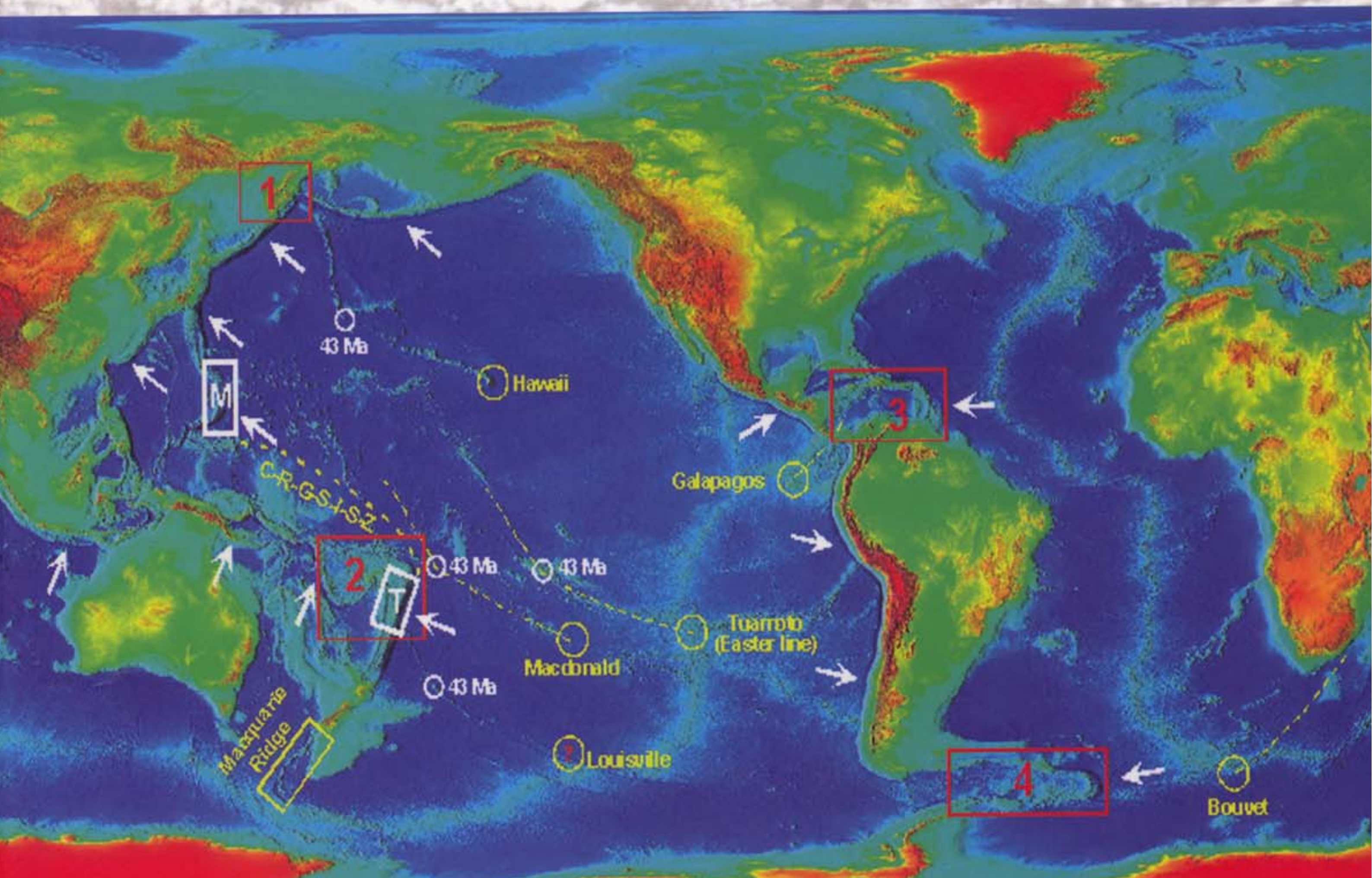
火成岩构造环境和成矿作用

Symposium on Igneous Rocks Tectonics and Mineralization



天 津 地 质 矿 产 研 究 所

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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。

天津地质矿产研究所

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目　　录

The origin of subduction zones: A new perspective and implications for the global tectonics

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Abstract. Tonga and Mariana forearc peridotites representing their respective subarc lithospheres are compositionally highly depleted (low Fe/Mg) and thus physically buoyant relative to abyssal peridotites representing normal oceanic lithospheres (high Fe/Mg) formed at ocean ridges. The observation that the depletion of these forearc lithospheres is unrelated to, and predates, the inception of present-day western Pacific subduction zones demonstrates the pre-existence of compositional buoyancy contrast at the sites of these subduction zones. These observations allow the suggestion that that *lateral compositional buoyancy contrast within the oceanic lithosphere creates the favored and necessary condition for subduction initiation.* Edges of buoyant oceanic plateaus, for example, mark the compositional buoyancy contrast within the oceanic lithosphere. These edges under deviatoric compression (e.g., ridge push) develop reverse faults with combined forces in excess of the oceanic lithosphere strength, allowing the dense normal oceanic lithosphere to sink into the asthenosphere beneath the buoyant overriding oceanic plateaus, i.e., the initiation of subduction zones. This concept may be termed as *Oceanic Plateau Model*. This model explains many other observations and offer testable hypotheses on important geodynamic problems on a global scale as detailed in the text.

1. Introduction

The advent of plate tectonics theory over 30 years ago has revolutionized Earth Science thinking, and provided a solid framework for understanding how the earth works. Many forces may contribute to plate motions [e.g., *Forsyth and Uyeda*, 1975; *Turcotte and Schubert*, 1982; *Cox and Hart*, 1986], but pull by the subducting-slab due to its negative thermal buoyancy, further enhanced by early changes to denser minerals with depth, is widely accepted as the major driving force for plate motion and plate tectonics [e.g., *Forsyth and Uyeda*, 1975; *Turcotte and Schubert*, 1982; *Cox and Hart*, 1986; *Davies and Richards*, 1992; *Stein and Stein*, 1996; *Davies*, 1998; *Richards et al.*, 2000]. It follows that there would be no plate tectonics if there were no subduction zones. Yet how a subduction zone begins is poorly understood despite great efforts [e.g., *Vlaar and Wortel*, 1976; *McKenzie*, 1977; *Cloetingh et al.*, 1982; *Hynes*, 1982; *Karig*, 1982; *Casey and Dewey*, 1984; *Ellis*, 1988; *Mueller and Phillips*, 1991; *Erickson*, 1993; *Kemp and Stevenson*, 1996; *Toth and Gurnis*, 1998]. Here I propose that *initiation of subduction zones is a consequence of lateral compositional buoyancy contrast within the oceanic lithosphere*. This concept differs from models in the literature, but is consistent with observations, and makes testable predictions on important geodynamic problems. It is intended that this contribution will offer a stimulus to the community for a better understanding of fundamental tectonic problems, such as this one, that we should have understood, but we do not yet.

2. The New Concept And A Historical Perspective

The principal vector of motion of a subducting slab is vertical, hence the driving force of the slab is gravitational attraction – i.e. its negative buoyancy with respect to its surroundings. Therefore, it would be physically optimal if one part of the lithosphere experienced a greater gravitational attraction than its adjacent neighbor prior to or during the initiation of a subduction zone. This requires the pre-existence of a density contrast within the lithosphere. If the lithosphere in question is thermally uniform (e.g., for