BOOK REVIEW

***G.R. Foulger*: Plates vs Plumes. A geological controversy**

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Title: Plates vs. Plumes: A Geological Controversy, 328 pp.
Author: Gillian R. Foulger
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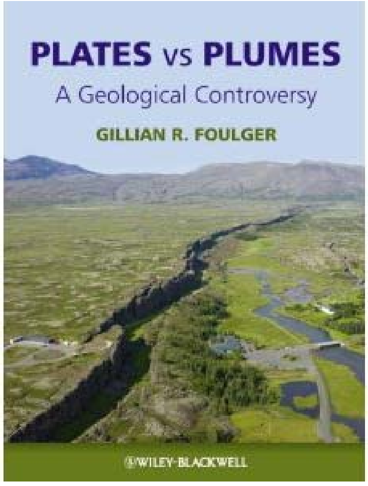

DESCRIPTION OF THE BOOK:

A This book will be very useful to Earth scientists who are interested in the debate between the Plate and Plume hypotheses. It reviews hypotheses, including a clear statement of the former. Thereafter, it follows a methodological approach, drawing widely from many volcanic regions in chapters on vertical motions of Earth's crust, magma volumes, time-progressions of volcanism, seismic imaging, mantle temperature and geochemistry.

B The volume contains eight chapters (1) *From plate tectonics to plumes, and back again*; (2) *Vertical motions*; (3) *Volcanism*; (4) *Time progressions and relative fixity of melting anomalies*; (5) *Seismology*; (6) *Temperature and heat*; (7) *Petrology and geochemistry*; (8) *Synthesis*. Noteworthy, at the end of each chapter, exercises and projects for students are suggested.

C The book is very well written and contains abundant illustrations. It would make an excellent text for courses in petrology and geophysics for scientists and graduate students. It will be suitable as a reference work for those teaching relevant classes, and it is an ideal text for advanced undergraduates and graduate students studying plate tectonics and related topics.

D Reasonably priced at € 45, the book is strongly recommended. Free copies may also be requested by educators from the Wiley website.

REVIEW

Earth magmatism that is not associated with subduction usually occurs at divergent plate boundaries. Volcanism that does not fall into one of these two categories was attributed by Morgan (1971) to deep mantle plumes. Typical signatures of plumes (and "hotspot" magmatism) include high temperatures, low seismic velocity in the mantle, fixity relative to one-another, a volcanic age progression on the surface, high heat flow, and non-MORB geochemistry. For thirty years, the usual reaction to observations that do not fit these predictions has been to adapt the hypothesis in numerous ways. As a result, the multitude of current plume variants now amounts to an unfalsifiable hypothesis.

In the early 21st century, demand became relentless for a theory that can explain melting anomalies in a way that fits the observations naturally and is forward-predictive. This has resulted, in recent years, in a great debate over the existence of mantle plumes (e.g. Ernesto et al., 2002; Anderson and Natland, 2005; Comin-Chiaramonti et al., 2007 and references therein). In particular, there is a substantial mechanical controversy. For example, the centrifugal forces and the different inertial momenta in the shells of our planet is usually ignored.

Experimental petrology and seismic tomography suggest that primary "hotspot" magmas may not be hot after all. For example, Ernesto et al. (2002) show that the Tristan da Cunha and

Trindade "hotspots" in the South Atlantic are cold. In addition, the global "hotspot" constellation does not constitute a fixed reference frame. From these, and many other problems with the Plume hypothesis, the Plate hypothesis emerged. It is the exact inverse of the Plume hypothesis. The Plate hypothesis attributes melting anomalies to shallow effects directly related to plate tectonics. It rejects the hypothesis that surface volcanism is driven by convection in the deep mantle.

To discuss and debate the mantle plume model, and to encourage development of alternative models, Foulger founded the website http://www.mantleplumes.org/ in March 2003. Following this, two research volumes of scholarly papers were produced by Foulger and her colleagues (Foulger et al., 2005; Foulger and Jurdy, 2007).

The present, single-author book begins with an historical account of continental drift, plate tectonics, and plumes. Six following chapters discuss the evidence of vertical motions, volcanism, age progressions, seismology, temperature and heat, and petrology and geochemistry. The whole subject is wrapped up in a final synthesis chapter. Foulger's objective is to present the Plate model for intraplate volcanism, which associates volcanism with processes associated with Plate tectonics, and is founded on geophysical-geochemical evidence, as an alternative to the plume model. In this context, "hotspot" magmas are the expression of surface extension and mantle heterogeneity, both natural consequences of plate tectonics, at normal temperatures. Source fertility and CO_2 are important parameters controlling the mantle solidus. High $^3He/^4He$ ratios do not imply a primordial lower mantle reservoir sampled by deep plumes, but may develop in old olivine-rich cumulates in magma chambers. Olivine crystals trap ^3He and have no U-Th, and therefore experience no ^4He growth. Flood-basalt-sized volumes of magma at volcanic rifted continental margins may be produced simply as a consequence of the rifting process, without hot plumes.

Seismology is not a reliable thermometer. Low-seismic-velocity mantle regions are not necessarily hot, but may contain partial melt, H_2O-CO_2, or simply higher Fe/(Mg+Fe) olivine. A particularly interesting section of Foulger's book contains seismic tomography images (cf. also Ernesto et al., 2002). There, the author exposes how past workers studying Iceland have used inappropriate methods to depict the Iceland melting anomaly as a plume.

In summary, Foulger considers that essentially all Earth's volcanism results, in one way or another, from plate tectonics. She does not consider mantle plumes necessary, nor supported by observational evidence. This provides a single, unifying theory for Earth's magmatism, in place of two, separate, independent causes.

This book is eminently suitable as a global geodynamics text for geology and geophysics researchers and students.

References

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