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Book review

Godfrey Fitton

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Notes

lines on a pattern without clear linear features may not be a very useful form of artistry. To convince me that this form of interpretation was real would have needed the much higher resolution data of the kind collected in Finland. This may be a case of not seeing the wood for the trees because one of the more significant features of the gravity field in northern Britain, and a 'lineament' not suspected until highlighted by the 1982 IGS Report, does not appear on the maps of gravity lineations at all. What was later called the Cruachan line, and found to correlate with a clear boundary in geochemical anomalies, is the NW-trending truncation of the Grampian Highlands. In fairness, the text refers to this at some point in the later discussion as possibly being a significant change in deep crustal properties.

These quibbles should not distract from the fact that the CD does what its sets out to do. It 'provides a review of the subsurface geological structure of northern Scotland, based primarily on interpretation of the results of potential field (gravity and magnetic) surveys.' It brings this wealth of information to the user in an easily accessible form; indexing and navigation is simple and effective; for those wanting to follow up with their own investigations, the maps can be printed for closer study and a catalogue of measurements of the physical properties of rocks comes as a bonus. The CD is a valuable tool for the Scottish geologist.

Roger Hipkin
University of Edinburgh
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Plates vs. Plumes: A Geological Controversy Gillian R. Foulger. Wiley-Blackwell, Chichester, 2010. 328 pp. ISBN 978-1-4051-6148-0, £37.50, paperback.

The advent of plate tectonics in the 1960s provided a theoretical framework that unified the Earth sciences and made sense of phenomena that had previously defied rational explanation. At a stroke it explained over 90% of volcanism on Earth as being the product of the creation (at mid-ocean ridges) or destruction (at subduction zones) of tectonic plates. But there remained a significant number of volcanic areas, notably Hawaii, that didn't fit into the basic plate tectonic framework. In 1971, W.J. Morgan proposed that J. Tuzo Wilson's relatively fixed mantle hotspots were manifestations of 'convection plumes' rising from the deep mantle, and the mantle plume concept was born. Since then mantle plumes have grown in popularity to the extent that, by the late 1990s, they had become the explanation of choice for any mantle melting anomaly not readily explained by plate tectonics, and even for compositionally anomalous segments of oceanic spreading centres. This is clearly lazy and unscientific, and the very existence of mantle plumes has, over the past decade and a half, been questioned. Lately, the debate has been led by Professor Gillian Foulger, Professor of Geophysics at Durham University, and the purpose of her book is to challenge the assumption that mantle melting anomalies must be caused by mantle plumes.

The title of this book might lead one to expect a balanced review of the current mantle plume controversy, but it isn't and it doesn't claim to be one. Instead it is an eloquent polemic against the plume hypothesis written by someone who genuinely can see no merit in it and is passionate in her opposition to it. The reader should bear this in mind. Professor Foulger starts from the position that the plume concept has been so stretched to accommodate all mantle melting anomalies that it is by now untestable and therefore unfalsifiable, and that the term plume is 'so often used for convenience that the difference between a label and an explanation has become lost'. In this she is undoubtedly correct. Her thesis is that all melting anomalies, intraplate (e.g. Hawaii) or on spreading centres (e.g. Iceland), can be explained by shallow plate tectonic processes without recourse to hot, buoyant plumes rising from the deep mantle. In this she is, in my view, almost certainly wrong. A hypothesis is not invalid simply because it has been misused by some of its supporters.

The book starts with a review of the origins of the mantle plume hypothesis and of the predictions that follow from it. Plumes that have been proposed by several authorities in the field are tabulated and their attributes compared to those expected. The next five chapters concern each of the five main predictions of the plume hypothesis: uplift during the initiation phase, excess volcanism, time-progressive trails of volcanoes leading away from fixed hotspots, seismological observations of mantle plumes, and measurement of mantle temperatures. A seventh chapter then reviews the petrological and geochemical observations that have been used to characterize mantle plumes. In every case the conclusion is the same; the observations don't fit the hypothesis very well. The book ends with a synthesis chapter in which all the various strands are drawn together to conclude, unsurprisingly, that plumes are not needed to explain mantle melting anomalies and that plate tectonic processes can do the job equally well if not better. The book is very well illustrated with both monochrome diagrams and a central section of colour illustrations, and has an impressive 30-page list of references. Most pages have one or more footnotes directing the reader to items in mantleplumes.org, the web site that Professor Foulger manages. This is an easy way to find background information, but the reader should be aware that much of the material on the web site has not been peer reviewed.

One cannot help being impressed by the breadth of material presented in this book. Experts in each of the various disciplines covered will no doubt find things to quibble with or even find things that are simply wrong. But, taken as a whole, Professor Foulger does a skillful job of attacking the plume hypothesis. This isn't to say that she's right, of course. The book is rather like a very clever case presented by a talented counsel for the prosecution in a criminal trial. The jury would almost certainly convict were it not for the equally clever

presentation made by the counsel for defence, followed by the judge's summing up. All we have here is the equivalent of the first of these. The author is masterly in her use of spin and the selective citing of evidence and in places is a little disingenuous. An example from my own field will serve to illustrate this point. In the chapter on volcanism, Professor Foulger argues that large volumes of magma erupted over a short time interval, as in large igneous provinces, could have 'accumulated slowly over tens or even hundreds of millions of years, to then be released on a much shorter time scale by rupturing of the lithosphere'. Very plausible on the face of it, but she omits the important piece of information that the magmas involved have compositions that require very large percentages of melting of normal mantle or even larger percentages if the mantle is enriched, as she proposes, and both of these require the mantle to be much hotter than normal. A large volume of accumulated small-percentage melts doesn't make a large-percentage melt.

In concluding this review I have to admit to being impressed by the book even though my own work comes in for a fair amount of bashing in it. I was struck by the parallels between the plume controversy and the granite controversy, which in various ways dominated igneous petrology in the first half of the twentieth century. Both controversies led to polarized views. In the case of the granite controversy, this was that granites originate through the fractional crystallization of basaltic magma, versus granites are produced through the transformation of sedimentary rocks. The outcome was that both are substantially correct; all granites do go through a magmatic phase; some through fractional crystallisation but many derived largely through the partial melting of sedimentary rocks via migmatites. As H.H. Read (President of the Edinburgh Geological Society, 1929–30, and the leading proponent of the transformation hypothesis) finally observed, there are granites and granites. No doubt the same is true of mantle melting anomalies. They are not all due to mantle plumes, but some almost certainly are.

Godfrey Fitton
School of GeoSciences, Edinburgh University
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