endocrine disrupting chemicals, pharmaceutical drugs, and biotoxins are noteworthy. Chemical pesticides and pharmaceutical drugs such as diclofenac are in the centre of debate now-a-days for their notorious effect on wildlife, especially on avifauna, across the globe. Whilst the part played by chemical pesticides in wildlife poisoning has been well established, the role of certain non-steroidal anti-inflammatory drugs (NSAID) such as diclofenac in the decline of vulture populations in South Asian countries was a debatable topic. No straight correlation could be established between the level of diclofenac in vulture tissue and the mortality rate. Many reviews attribute the vulture population decline to other factors as well. Hence, a special section critically reviewing all these issues in the next edition of the book would be a welcome step.

Earlier, the issue of increasing dioxin levels in the environment was more concentrated in the developed world, but currently even developing countries are facing the threat of dioxin poisoning in several environmental matrices. Moreover, long range aerial dispersion of this chemical contributes significantly to the increased levels in developing countries in addition to several anthropogenic causes in the developing world itself. The Stockholm Convention on Persistent Organic Pollutants (POPs) during 1995 was a major step forward in world history wherein world leaders came to a single platform to discuss the way out and to reduce the use of dioxins, furans, PCBs and nine different pesticides (aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex, hexachlorobenzene and toxaphene). The authors have fittingly pointed out these matters in specific chapters.

The book also discusses the usage pattern of pesticides and levels of toxic metals in some of the systems such as water; but, this needs to be revised. The next edition of the book must bring out a comparison of usage pattern of chemical pesticides across the globe and not restrict it to one or two countries and/or continents. There is a need for including heavy metal levels in all possible environmental matrices as published in several peer-reviewed journals. Also, several formatting problems exist in the reference sections.

Reading the book evoked nostalgia, a sense of reading a typical text book, as is reinforced by the key facts presented in boxes in each chapter along with acronyms and a glossary which are of great benefit to readers. Overall, the book is a good attempt by the authors to explain the fundamentals and essence of the environmental and biological impacts of climate change and chemicals.

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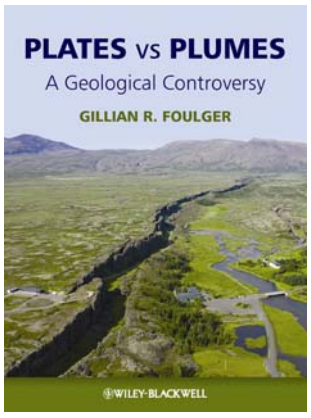

Plates vs Plumes: A Geological Controversy. Gillian R. Foulger. Chichester, West Sussex, UK. 2010. 328 pp. Price: US$ 89.95.

Most of the terrestrial volcanism occurs along divergent and convergent plate boundaries, but intraplate 'hotspot' volcanism has usually been explained with deep mantle plumes. Typical signatures of plumes are thought to include excess temperature, a low seismic velocity region within the mantle, fixity, an age-progressive volcanic track on the plate, a bathymetric swell, high heat flow, non-MORB geochemistry and high $^{3}He/^{4}He$ ratios of the magmas. Recent years have however witnessed a great debate over the existence of mantle plumes, led by Gillian Foulger, the author of this book. The ongoing debate owes itself to a multitude of perplexing observations: Global hotspots do not constitute a fixed reference frame. They do not have the required high heat flow. Most ocean island/seamount chains are not age-progressive and those which are (e.g. Hawaii–Emperor) can no longer be explained by a fixed plume, due to varying palaeolatitudes. The claimed deep mantle plume under Iceland has not been found, despite extensive searching, and the low-velocity seismic anomaly there is confined to the upper mantle. Experimental petrology suggests that primary hotspot magmas are no hotter than primary MORB magmas. Predicted pre-volcanic lithospheric uplift is lacking at even the largest flood basalt provinces (Ontong Java and Siberia).

To discuss and debate the mantle plume model and non-plume mechanisms of intraplate volcanism, Foulger launched a website (www.mantleplumes.org) in March 2003 in collaboration with some colleagues. This ever-growing website, swelled by contributions from over 500 scientists, has become an exhaustive and invaluable resource for thousands of professionals and students worldwide. Since the launch of the website, two major conferences[1,2] have been held, and two massive (telephone directory-size) research volumes[3,4] have been edited by Foulger and her colleagues. This book is her latest contribution to this subject of fundamental importance in the solid earth sciences.

The book begins with an historical account of continental drift, plate tectonics, and plumes. The meteorologist Alfred Wegener, originator of the continental drift hypothesis, is mentioned as a hero with whom the geological community dealt unfairly. This seems somewhat overdone. Foulger states (p. 5): 'The case presented by Wegener was enormously strong and brilliantly cross-disciplinary'. Instead, many readers would accept that

Wegener did not offer plausible mechanisms for the drift (not a shortcoming in itself), mixed bad arguments with good ones, and took liberties with his continents, treating them like rubber sheets in his reconstructions. Continental drift was true in a different sense than Wegener himself conceived (the continents moving across the ocean floors). This reviewer feels that the geologists and geophysicists who attacked that idea for its physical impossibility did their jobs properly – if only geologists and geophysicists of the plume era had been as exacting and as demanding of explanations and mechanisms, we might have been saved four decades of a wrong turning in geodynamics.

Six chapters discuss the evidence of vertical motions, volcanism, age progression, seismology, temperature and heat, and petrology and geochemistry, wrapped up by a final synthesis chapter. Foulger describes how the modern plume model is without constraints, and with scores of additional, ad hoc variants erected on a case-by-case basis to explain away anomalies, without considerations of physical plausibility or conflicts with other evidence. Thus the new arguments are that pre-volcanic subsidence is also consistent with plumes, that there are cool plumes, that plumes are not fixed but sway in the 'mantle wind'. . . . The modern plume model is essentially irrefutable and non-testable, and Foulger states that as a result she does not aim to disprove or refute it in the book.

Foulger's objective instead is to present the plate model for intraplate volcanism, which is an umbrella term for the diverse, secondary, shallow-level processes associated with plate tectonics. In the plate model, the stress field in the Pacific plate that results from variable contraction thermal, is such as to encourage a thermo-elastically driven crack in the Hawaii region to propagate. 'Hotspot' magmas are a result of mantle heterogeneity (a natural consequence 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 because olivine crystals trap ^3He and have no U–Th (and therefore no ^4He growth). Flood basalt-sized volumes of magma at the volcanic rifted continental margins may be produced simply as a consequence of the rifting process, without hot plumes. Seismology is not a thermometer: low seismic velocity mantle regions are not necessarily hot, but may contain partial melt, CO_2, or simply higher Fe/(Mg + Fe) olivine.

Foulger, a seismologist and volcanologist, has closely studied Iceland and the surrounding North Atlantic region, as well as the Yellowstone hotspot. Particularly interesting sections of her book are about how tomographic images can be misleading – one wonders whether this is sometimes intentional, to bolster preconceived models. She describes how several past workers studying Iceland used inappropriate methods to depict the Iceland melting anomaly as a plume. In one study, 10% slower seismic wavespeed in the upper mantle and only 0.5% slower wavespeed in the lower mantle were found, but the investigators saturated the colour scale at only 0.5% of the anomaly, which gave the visual impression of a continuous low-velocity conduit extending from the upper into the lower mantle below Iceland. Another study used a vertical exaggeration of 5, which changed a flat low-velocity anomaly into a vertically elongated pipe. These sections do a particularly valuable service in enlightening the reader.

This book, noting its broad scope, contains some minor inaccuracies in topics that are not Foulger's specialty areas. For example (p. 45), 'thick conglomerate beds at the base of the Deccan lavas in peripheral areas' (no reference quoted) simply do not exist. In Ar–Ar dating by step heating not '80% of the steps are within acceptable error limits' (p. 120), but a certain percentage (usually >60%) of total argon released must be from statistically indistinguishable continuous steps. The statement 'Most tholeiites differ from alkali basalts in containing sufficient silica that under equilibrium conditions the mineral quartz can exist' (p. 230), shows apparent confusion between modal and normative quartz. The main aspect of a classification of large igneous provinces is not whether their size is 50,000 km^2 (as suggested by this reviewer), or 100,000 km^2 (as by another team; p. 21), but that large igneous provinces include many provinces that are not flood basalts at all. And, Eclogite is the high-pressure form of basalt, but not 'thus composed almost entirely of the basalt-forming minerals' (p. 230; the adjoining table is correct).

Readers with a curiosity about how the real earth works will find the book a valuable source of information and ideas. It is important to recognize that in the plate model there is no single mechanism that fits all localities as the plume model sought to do (but no longer does, due to abundant anomalies and more abundant ad hoc variants and escape routes). The plate mechanisms involve subduction, lithospheric delamination, edge-driven convection, and several other processes which Foulger describes. These (along with asteroid impacts) can be applied to individual localities. This is a fundamental aspect of the plate model, not a weakness, because all volcanic regions differ inherently in their settings, characteristics and geological histories. A 'one size fits all' model, such as the plume model, cannot explain their vast diversity.

To summarize, Foulger considers intraplate volcanism as a necessary and natural consequence of plate tectonics, and does not consider mantle plumes necessary or viable. This means, plate tectonics is a more powerful theory than usually thought. The plate model is currently being developed, and the message of the book is that this is where much exciting future work remains to be done.

The book is eminently suitable as a global geodynamics text for geology and geophysics students. The book has over 700 references, the most recent from 2009. It is attractively produced and the text is clearly printed on semi-glossy paper throughout. It has a beautiful cover image of the Thingvellir graben in Iceland, the boundary between the North American and the Eurasian Plates. The book is richly illustrated; the many black-and-white illustrations are nicely drawn and printed, and a substantial number of colour illustrations, including tomography images, are sharply and beautifully printed on glossy paper. I have much pleasure in recommending this book, a distillation of global geodynamics information and ideas by a true leader in the field, for the libraries of institutions and individuals.

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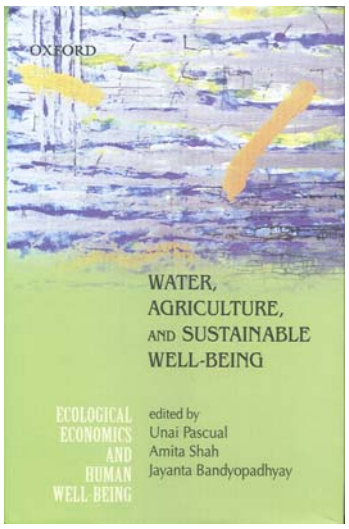

Water, Agriculture and Sustainable Well-Being. Unai Pascual, Amita Saha and Jayanta Bandyopadhyay (eds). Oxford University Press, New Delhi 110 001. 2009. 301 pp. Price: Rs 750.

Agriculture constitutes a key driver of ecosystem change, evident from the wide-scale changes in land cover, stream flow and groundwater systems. It is closely linked with the health of surrounding ecosystems and should be considered an agro-ecosystem. Agricultural activities often undermine the processes that support ecosystems and the interconnections of complex ecosystems that make up the landscape. Nevertheless, agriculture depends on ecosystem functions such as pollination. Hence, decision making involving crop production systems needs to adopt strategies to manage agro-ecosystems as part of the large landscape to enhance multiple ecosystem services for more than just crop production. This comprises adaptive management at a variety of levels, valuing agro-ecosystem services and being aware of tradeoffs between services. The key decisive factors for long-term sustainability involve the agro-ecosystems resilience to change through beneficial feedback, the protection of species diversity, the use of crop-complementary resources and alternative income options. Critical thresholds exist in these systems which, once crossed, can quickly lead to degradation. Once a parcel of land crosses this productivity threshold, soil degradation becomes irreversible in economic terms even though the degradation may be technically reversible. Global surveys suggest that 9% of agricultural land is already so badly degraded that it cannot be reclaimed for productive use by farm-level measures, while 40% of agricultural land is degraded to the point that crop yields are reduced[1,2]. Hence, management of agro-ecosystems has to incorporate innovations, deal with uncertainty and facilitate multi-scale linkages by striking tradeoffs while recognizing the role of local factors. This entails the management of ecosystems on a catchment scale that helps in the implementation of integrated and holistic approaches in managing all the natural resources[3,4]. Sustainability, efficiency of resource use and livelihood issues are assuming a central stage in policy formulation across natural resources (land, water, vegetation) and sectors (domestic, agriculture, industry, commercial).

Water plays a vital role in ecosystem functioning. The demand, by a burgeoning human population, for food and water for food production would double over the next century. Adequacy and quality of water for meeting the growing basic human needs are the prime issues pertaining to water management, as they have direct and significant impacts on human health. The publication under review is a collection of twelve papers focusing on sustainable social well-being and addressing two interconnected themes, namely, the water ecosystem and agriculture. It makes a noteworthy contribution to the methodologies for assessing ecological and economic costs, and identification of appropriate policy frameworks to integrate the issues of suitability of water use for human consumption and for agricultural production, based on the case studies from Asian and European countries. The chapters are grouped under three broad categories – water pollution and health risk, sustainable agriculture and adoption of soil water conservation measures to enhance sustainability. The authors of these chapters attempt to address wide-ranging questions in ecological economics about the valuation of natural resources such as water, both the quantity and several dimensions of quality, and access for the poor and the vulnerable sections of society.

Focusing on the issue of arsenic pollution in the Gangetic Delta of Bangladesh and West Bengal, the first three chapters provide an account of the causes of environmental and health damages. Acharya presents a theoretical model for assessing the health cost due to environmental pollution in the first chapter. He explores different methods of estimating the willingness to pay (WTP) for services such as arsenic-free water supply. The model gauges the household demand for quality water from the indirect utility function of model household defensive expenses that are incurred to reduce the chances of illness. Along with a dose-response function that establishes the link between arsenic exposure level and illness probability, this approach provides a way of estimating the value of services from arsenic removal/reducing technologies. Pascual *et al*., in the second chapter concentrating on the tradeoff risk of developing the disease against its latency, argue for the use of hyperbolic discount rates to value arsenic removal technologies/investment – as households exercise very low discount rates for events far away into the future, considering the time taken for a given disease to manifest from the time of exposure to a given perilous contamination in the environment. In the third chapter, Sarkar highlights the causes and impacts of arsenic contamination in India and Bangladesh. The studies estimate significant damages owing to the over-depletion of groundwater in arsenic affected regions. Sarkar explores the possible sustainable solutions appropriate to the local context in the Ganga–Meghna–Brahmaputra basin and advocates an interdisciplinary approach integrating top-level agricultural policy and grassroots reality.

Maile and Collins, in the next chapter, attempt to address the pollution in downstream flows originating from non-point sources due to inappropriate agricultural practices in the upper catchments. They suggest performance-based payment approach to farmers – this would help in attaining the dual objectives of conservation and well-being of the relevant population. It gives an alternative way of