Book Review

“Plates vs Plumes: A Geological Controversy”, by Gillian R. Foulger, Wiley-Blackwell, 2010;
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This book shows how far we are from a full understanding of thermal and geochemical conditions in the Earth’s interior. The best examples of this are the two apparently difficult to reconcile basic models explaining the origin of melting anomalies in the mantle. The first one, called the plume hypothesis, is based on a paradigm of melting processes occurring in the deep mantle. The second one, called the plate hypothesis, attributes melting anomalies to more shallow effects directly related to plate tectonics. The author, Gillian R. Foulger, Professor of Geophysics at the University of Durham, critically assesses the existing evidence for the plume hypothesis, focusing on real ability of methods involved to discriminate between deep and shallow mantle source for melting anomalies. Although a certain preference for the plate model can be felt throughout the text, Foulger impartially presents pros and cons for both models, discussing methodological aspects and using a firm database selection. The reading of this volume is in fact a fascinating, intellectually inspiring journey through a current ideas on geological processes taking place in the deep Earth.

In Chapter 1, a history of thoughts and ideas on the continental drift and emergence of plate tectonics theory has been outlined, and special stress is given to the idea of plumes as presented by W.J. Morgan, which did not fit the plate tectonics concept. This chapter introduces the reader also to the basics of the

plate concept. Chapter 2 deals with the vertical movements of the crust, expressed as an uplift and subsidence processes. Geological observations are tested in terms of the plate and plumes hypotheses, above all in the context of timing the crust’s vertical movements with melting anomalies. Chapter 3 explains the essence of the concept of melting anomaly, and discusses different aspects of volcanism, attempting to catch up the most characteristic categories that may be helpful in discrimination between different sources and magma origin. Then, like in the previous chapter, observed facts are compared with the predictions of both hypotheses, followed by discussion on strong and weak points of each of them. Time progressions and relative fixity of melting anomalies are critically discussed in Chapter 4, presenting the results of the research done to date, and pointing to difficulties in discrimination which of three compelling scenarios (anomalies fixed to the Earth’s rotation axis vs true polar wander concept vs relative mobility of anomalies) has the most evidence in favor. Problems with modeling of the mantle convection are also discussed, stressing difficulties in application of seismic data in this task. The latter issue is continued in a more comprehensive way in Chapter 5, where seismological technics in imaging the Earth structure are presented. Foulger points to the bareness of seismological database offshore, categorizes melting anomalies according to the seismic data in hand (the best studied being the North Atlantic Igneous Province, the European Cenozoic Volcanic Province, and Yellowstone), critically assesses seismic data obtained for Hawaii, Galapagos, and Azores and compares these results with the seismic structure of the mantle away from currently

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erupting melting anomalies. Then results of global observations are compiled using whole-mantle tomography, data from transition zone and core–mantle boundary, portrayed by an excellent color plates, selected from publications of the last 15 years. Chapter 6 discusses the temperature and heat variations in the crust and mantle, stressing uncertainties in their radial and lateral estimations and discussing different methods (seismology, petrology and geochemistry, ocean floor bathymetry, heat flow measurements, and estimations of heat loss from intrusions and eruptives) to resolve temperature distribution inside the Earth. Particularly contested are application of the seismic method for temperature estimations in the mantle, and the paradigm of the high temperature of the hot spots. Chapter 7 touches on briefly selected aspects of petrology and geochemistry, relevant to the origin of the melting anomalies. Both disciplines are shown to have little ability to reveal the ultimate region of the mantle where rocks parental to surface lavas originated, since the surface lavas will always be contaminated by shallow mantle derivatives. Relationships between the composition of the lava and that of its parent rock are discussed, along with investigations of the role of trace elements and radiogenic isotopes in drawing conclusions on magma sources, and, more comprehensively, on the origin of depleted and enriched basalts. This is followed by a critical assessment of the proposed deep-mantle and core–mantle boundary tracers (He, Ne, Re–Os, Pt–Os, Hf–W isotope

systems). Characteristics of the surface expressions of the melting anomalies (Iceland and Greenland, the Emperor and Hawaiian chains, continental flood basalts, back-arc regions) and plume variants are also discussed. The book ends with Chapter 8, which synthesizes arguments in favor and against the plume and plate hypotheses.

The volume is written and organized in an excellent way. In many chapters the methodological problems, such as dating, establishing hotspot reference frames, and errors and uncertainties in data determination, are discussed at length. A narrative style from introduction through hypothesis predictions confronted with observations, and a final discussion on the pros and cons of each hypothesis is consequently applied from chapter to chapter. Each chapter ends with exercises for students. Many issues and problems do not admit unequivocal solutions and the book does not aspire to answer all questions. Rather, it seeks to assemble a compendium of observations and analytical facts to assist each reader to develop a personal view. As such, it is a valuable work for advanced undergraduate and graduate students, but also for researchers from many specialties in geology, geophysics, geochemistry and geography.

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