OROGENESIS: THE MAKING OF MOUNTAINS²

Orogenesis: The Making of Mountains is an ambitious but only partly successful effort to provide "an up-to-date overview of orogenic research" that integrates the approaches of structural and metamorphic geology. The intended audience includes senior undergraduates and graduate students or professionals in related fields seeking an overview of the topic.

The authors have made a serious effort to review the history of thought from classic early papers on the Alps to the current debate on channel flow in the Himalayas. Relatively new fields—for example, interactions among climate, surface processes, and tectonics—are given significant coverage. Examples from a wide variety of orogenic belts of different age, style, scale, and geographic setting are used to illustrate many of the key concepts, with particular emphasis on the Alps and the Himalayan-Tibetan system. The text is well written and should be accessible to anyone with a good geological background. The illustrations are sufficient although highly variable in quality, with grey-scale diagrams through most of the text and colour plates at the back. The reference list is representative and reasonably up-to-date, and students will find that certain sections are good places to "start digging" for background material on specific topics.

My main concern with the book is that, with some exceptions, little effort has been made to present the range of modern ideas on orogenic tectonics within a coherent conceptual or quantitative framework. In some cases, competing or contradictory hypotheses are presented as if they were equally valid, including some that may have been abandoned or superseded as better data or methods became available. Not much guidance is given on how to choose between conflicting interpretations, how to distinguish model assumptions from robust results, or how the choice of model design limits the range of orogenic processes that can be considered.

The treatment of fundamental concepts, particularly quantitative approaches, is uneven. The target audience should be capable of understanding the basic equations used in structural geology (e.g. flow laws, Darcy's law), but in many cases these are described in words rather than shown as equations. A welcome exception is the section on heat transfer (chapter 3), which is quantitative at a level that should be readily accessible to senior undergraduates. Chapter 4 on large-scale features starts by describing individual structures that may have regional significance but are really part of larger systems—it isn't clear why particular faults or folds have been singled out for special treatment. In a book focusing on processes, it would seem to make more sense to introduce critical wedge mechanics at the beginning of this chapter rather than at the end, in order to provide the quantitative framework within which individual structures can be understood. In contrast, chapter 7 (metamorphism in orogeny) starts by developing a clear conceptual framework for students. The historical development of ideas is reviewed and various approaches compared and contrasted; the current state of the art is clearly explained and current problems discussed in that context.

The book as a whole suffers from haphazard organisation, which probably also makes it a little longer than necessary. Some fundamental concepts appear only in the second half of the text—for example, metamorphism is not discussed until chapter 7, although metamorphic data are referred to throughout chapters 5 and 6. The treatment of lithospheric rheology and strength does not appear until chapter 10 (deep structure...), even though these topics are key to understanding the ideas presented in chapter 6. The discussion of surface processes is spread through three chapters (chapter 8, erosion and exhumation; chapter 9, sedimentary history of foredeeps; chapter 11, mountains and Michael R. W. Johnson and Simon L. Harley

Orogenesis The Making of Mountains



climate), which are separated by unrelated material on deep orogenic structure (chapter 10). The channel flow hypothesis is mainly discussed in chapter 6, but reappears at the end of chapter 7 where it seems out of context. Exhumation is discussed in both chapters 8 and 9 with reference to different examples, but problems in estimating exhumation rates from thermochronological data (e.g. the need to assume a geothermal gradient) are not discussed at all.

The treatment of the Tibetan plateau illustrates some of the strengths and weaknesses of this volume. In chapter 5, possible plateau-forming mechanisms are summarised, including convective removal of lowermantle lithosphere and underthrusting by Indian crust, and a range of data bearing on competing hypotheses are presented. Models invoking both lateral extrusion and lower-crustal flow are also mentioned. While this covers the ground, it would have been helpful to point out how assumptions (e.g. whole-lithosphere thickening versus subduction), methods (e.g. advances in numerical modelling), and data (e.g. seismic imaging of the lower crust) have changed in the 30 years since this problem began to be tackled seriously. In addition, the relevant material is distributed through several chapters-geophysical data bearing on this issue are not discussed until chapter 10, plateau dynamics and climate are presented in chapter 11, channel flow is discussed in chapters 6 and 7, and the timing of uplift is discussed in both chapters 5 and 11. Putting all the relevant material into one section on the origin of the Tibetan plateau, with a summary of observations, model predictions, and constraints, would have offered a better synthesis of the topic for students.

Overall, this book offers plenty of food for thought, but its uneven treatment of key topics and organisational problems are likely to limit its value for teaching. Despite its reasonable cost (hardcover £45 or US \$75; e-book \$60), I would not recommend this book as a required text for an advanced undergraduate or graduate class. However, the book would be a useful addition to the library of a geologist desiring an overview of the diverse array of topics associated with modern approaches to mountain building and orogenic tectonics.

Rebecca A. Jamieson Dalhousie University

² Johnson MRW, Harley SL (2012) Orogenesis: The Making of Mountains. Cambridge University Press, Cambridge, UK, 398 pp