Book Review

Orogenesis: The Making of Mountains by Michael R. W. Johnson and Simon L. Harley Cambridge University Press, 2012; ISBN: 978-0-521-76556-5 (hardback), USD 75.00

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Mountains were the place where geology was born. Reading the record in the rocks, one by one as they crop out along a mountain slope, the first geologists could uncover the history of sedimentary layers, observe trends of faults, analyze geometry of folds, find out spatial relations between rock facies, discriminate igneous from sedimentary rocks, and learn about the sedimentary basins at the foreland of orogens, all this knowledge completed from surface observations long before scientific drilling came into being. Today, armed with a modern geophysics and geochemistry, and equipped with plate tectonic history, we understand processes leading to formation of mountains much better than our geological ancestors. However, our knowledge still stems mainly from research carried out in the orogenic belts.

Dr. Michael Johnson, a structural geologist, and Professor Simon Harley, a metamorphic geologist, are both from the University of Edinburgh, the same place where James Hutton laid the foundation of modern geology by publishing his “Theory of the Earth” at the end of the eighteenth century. Their book is a state-of-the-art summary of the processes standing behind orogenesis and mountain-building, although geologists educated and practicing on rift-related mountains may not be satisfied by the authors’ focus on their formation in a compressional environment of converging lithospheric plates. Consequently, this book deals with mountain belts like the Alps, the Himalayas, the Andes and the

Cordilleras, in fact the most prominent orogenic structures and related mountain belts on the Earth.

The volume begins with Chapter 1, describing the major structural features of the Earth. It includes brief descriptions of main terms and major features of orogens. Chapter 2 envisages the driving mechanism for plates and the cause of orogenesis, particularly referring to the role of gravity as a driving force in orogenic processes. The leading themes of Chapter 3 are the physical and chemical principles governing rock deformation, rheologic flow, isostatic rebound, geochronology and heat production in the lithosphere. The role of fluids in earthquakes and their pathways in the crust are also discussed. Chapter 4 deals with large-scale features of orogens, represented by thrusts and folds. Explained are, among others, the origin of arcuate orogens and oroclines, the physical properties of thrust faults and their classification and progression time, the origin of imbricated and duplexed structures, the relationship between folds and thrusts, displacement, termination and mechanics of thrust, orogenic wedge theory, folds in shear zones, and the rotation of thrust sheets about a vertical axis, a phenomenon frequently inferred from paleomagnetic studies. Chapter 5 concentrates on the main tectonic events and the peak time of metamorphism of the most prominent Phanerozoic collisional belts. Mechanics of shortening and metamorphic evolution of the Himalayan–Tibetan orogenic belt and the origin of the Tibetan plateau are deliberated first, followed by a description of the evolution of the Alps and the South and North American Cordillera. Evolution of oblique collision belts are treated separately and illustrated by examples of Caledonide and Alpine strike–slip orogens.

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Chapter 6 deals with lateral spreading of orogens, where foreland propagation, channel flow and weak zones in the crust are examined. This chapter explains the processes and phenomena that originate at the peripheral zones of orogens, including low-viscosity layers in the crust.

Chapter 7 deals with metamorphism in orogeny, first outlining work on metamorphism and describing their outcomes in terms of P–T time records, then linking these to the chemical, physical and tectonic processes that inform and constrain models for metamorphism in orogenic systems. Chapter 8 dives into a large topic which covers the decay of mountain belts by erosion, along with controversial issues on possible links between mountain relief and climate. The interplay of tectonics, erosion, and climate determine mountain shapes, influencing one another. If gravity, phase transformation at depth and viscosity of the crust are also taken into account, these factors together control the height of the mountain top. Questions such as how high mountains on the Earth may become, and what happens if their tops are higher than the erosional level (imagine Mt. Everest at the pole, where the troposphere is close to the mountain top), are fascinating, though not yet answered. Since mountain-building and basin-formation processes are geodynamically coupled, Chapter 9 is devoted to the sedimentary history of the foredeep basins and includes discussions of isostasy and Bouger anomalies, the response of the lithosphere to loading, the classification of foreland basins and their evolution, and a more detailed description of the exhumation and uplift of the Alps and Himalaya. Chapter 10 reaches deeper into the crust and

mantle zone, discussing processes that are responsible for orogen support and collapse, and examining the role of deeply seated metamorphic phase changes (eclogitisation vs. granulitisation) in the orogeny collapse and tectonic denudation. In Chapter 11, the discussion goes back to the casual links between mountain building and climate or climate change (cf. Chapter 8). In this chapter, however, these plausible links are explored more in the geologic time domain, focusing on influence of mountain building on global climate cooling.

Chapter 12 seeks the similarities and differences in orogenic processes along the geologic time scale, reviewing heat production over time and describing thermomechanical modeling in the context of subduction initiation. The metamorphic and structural evidence is finally evaluated using examples from the selected stages of the Earth's evolution, the roots of which, now exposed on the surface, allow us to investigate ancient deep-seated tectonic processes.

The volume contains 47 color plates, some 500 references, and an index. It provides a logical arrangement and an attractive narrative style that leads the reader without weariness through the complex topic of the formation of mountains. These factors, together with its legible and very well prepared illustrations, make this volume an important possession for geologists, geophysicists, petrologists and geochemists.

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