

BOOK REVIEW

ORIGINS OF IGNEOUS ROCKS. By Paul C. Hess. Harvard University Press, Cambridge, Massachusetts, 1989. 336 pages, \$65.00 hardback.

In *Origins of Igneous Rocks*, Paul Hess has written a masterful, balanced volume, apparently designed as a text for upper-level undergraduate or graduate courses (the review volume lacks a preface stating the intended purpose of the book, and it also lacks a Table of Contents). The title is an accurate description of the book—its emphasis is on origins and petrogenetic processes, not on geology. The author's goal is to identify the primary magmas, or unaltered original melts, for only through the compositions of such original magmas can the origins of igneous rocks be fully understood. Of necessity, the book emphasizes mafic magmas, although more felsic liquids are not ignored.

The book begins with chapters on the basic tools and concepts of petrology: phase equilibria, magmatic differentiation, geochemistry (trace element and isotope), and the nature of silicate melts. Then follow chapters on the mantle (introducing needed geophysical data) and on primary magmas, the book's holy quest. The remaining two-thirds of the book is devoted to a systematic survey of the Earth's (and the Moon's) magmatism and the putative origins of the magmas. These chapters are arranged primarily by tectonic setting: ocean floor volcanism, intraplate volcanism, island arc volcanism, continental arcs, flood basalts, anorogenic granites and rhyolites, continental rifts, and lunar volcanism. Other important igneous types—layered mafic intrusions, anorthosites, kimberlites, and komatiites—are considered separately.

Overall, the chapters on the tools of igneous petrology are excellent. The chapter on phase equilibria is a brilliant miniature, a distillation of the essence of Morse's *Basalts and Phase Diagrams*. Crystallization and fusion, both fractional and batch, are covered for the range of relevant binary and ternary systems. The chapter on magmatic differentiation includes not only classical processes, but also magma mixing, liquid immiscibility, and the basic ideas of double-diffusive convection. The chapter on geochemistry covers trace element and isotope chemistry, a tall order for a single chapter. The teacher may wish to provide supplementary materials for this chapter, particularly the isotope geochemistry section. The last chapter of this group, the nature of silicate melts (including structure, viscosity, density, diffusion, crystal growth, and liquid immiscibility) is excellent, reflecting Hess's expertise here.

The chapters on magma types and tectonic settings are organized superbly, by a careful distinction between observed data and interpretation. First, the tectonic setting and critical petrographic relationships are introduced. Then, for a typical occurrence (if there is such a thing) of these magmas, the basic bulk chemical, trace chemical, and isotopic data are developed. Finally, in the section on petrogenesis, these data are combined with the constraints of phase equilibria in a detailed discussion. Here, Hess is thorough, cautious, never dogmatic, and evenhanded in presenting various theories. Nor is he afraid of pointing out the current limits of knowledge.

Despite the reviewer's enthusiasm for *Origins of Igneous Rocks*, the book is not without faults. Geochemistry should be emphasized more and phase equilibria less, presuming that the students would have already had some acquaintance with basalt equilibria. It was disappointing that neither the chapter on midocean basalts nor the description of ophiolites (especially the Samail) refer explicitly to the geometry of magma chambers at spreading ridges. Samail is treated as a layered mafic intrusion (and the stratigraphic section seems to imply that the basal member of the ophiolite sequence is cataclastic limestone). Nor is there mention of the ultramafic magmas present in melt inclusions in some MORBs. The discussion of continental arc magmas does not include the near-ubiquitous evidence for complex magma mixing in their geneses. Finally, the section on anorogenic granites and zoned ash-flows includes a discussion of thermogravitational fractionation, although my friends-of-granites acquaintances consider it a discredited hypothesis. The illustrations are almost entirely line drawings (except for three photos of the Moon); it would have been nice to see photomicrographs, back-scattered electron images, and photographs of critical relationships.

Despite these shortcomings, this reviewer strongly recommends *Origins of Igneous Rocks* for an upper-level undergraduate or graduate-level course, or as a helpful reference for the practicing geologist. The book is comprehensive, thorough, well written (even witty), and deserves a place in the classroom.

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