Igneous and Metamorphic Petrology

Myron G. Best

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Preface

Many petrology texts have appeared during the revolutionary growth of geology in the past two decades. Most of these texts are specialized state-of-the-art presentations designed for the advanced student or research worker. I have attempted in this text to present reasonably comprehensive coverage of the fundamental concepts, principles, and factual data that form the foundation of igneous and metamorphic petrology for the undergraduate student. At the same time, I have emphasized the uncertainties and limitations in our current knowledge, in the hope that the reader can discern lines of fruitful research in the future. The text is designed to be a balanced instructional tool, showing which properties of rock bodies are relevant to an understanding of their origin and how these properties can be specifically interpreted to provide genetic information on ancient geologic and planetary systems. Descriptive material on composition, fabric, and field relations on all scales of observation—from global to submicroscopic—is presented along with basic thermodynamic principles and experimental data. Abundant illustrations encourage the student to make direct observations of real rock bodies. The intimate association between the origin and evolution of rock bodies and tectonic processes and environments, especially on a global scale, is a pervasive theme of the text.

The level of treatment varies somewhat among chapters but is generally intended for the undergraduate geology major who has had introductory courses in physical and historical geology and mineralogy. Some knowledge of basic physics and calculus would be helpful but is not necessary, as I realize that many students in the United States enter geology with uneven backgrounds in science and mathematics. The organization of topics and the level of treatment have been designed for flexibility in classroom use. Some beginning courses of a more classical, descriptive nature can omit Chapters 7, 8, 9, 13, and 14. But the more advanced topics in these chapters could be considered in a subsequent intermediate-level course as a springboard toward graduate studies. Another option for a two-semester sequence is to cover Chapters 1 through 9, essentially on igneous petrology, followed by Chapters 10 through 16, on metamorphic, global, and planetary topics. Many of the essentially descriptive chapters (3, 4, 5, 6, 12) are more or less self-contained and could be omitted without unduly jeopardizing an understanding of the remainder of the text. Numerous cross-references link factual or descriptive material in one chapter with theoretical concepts in another.

In writing and illustrating this text, I became acutely aware of the necessity for balance between clarity and precision and depth and breadth. Because of my commitment to the undergraduate student, I tried to opt for clarity and breadth; I hope there are not too many errors of fact or principle that will have to be unlearned in subsequent in-depth studies.

Numerous persons helped to make this text a reality. W. Kenneth Hamblin contributed countless hours of discussion and guidance in the formative stages and set me on the right track with his persistent question, "Why is it important?" John Merrill, Bevan Ott, Paul Baclowski, Ronald Kistler, Alan White, Keith Cox, Herbert Shaw, J. G. Liou, Harry Green, Robert Baragar, Gordon Goles, Ronald Emslie, Michael Drake, Allan Cox, and Lehi Hintze reviewed individual chapters, and Dana Griffen, Paul Robinson, Howard Day, and especially Douglas Coombs courageously critiqued major parts of the entire text. Their encouragement, skill in ferreting out many errors, and constructive comments are greatly appreciated. Copy editing by Sean Cotter was remarkably astute and insightful. Without the skillful help of Keith Rigby, Revell Phillips, Stephen Leedom, Daniel Harris, Gary Harris, and Steven Knowles, the photography never would have been done. Richard Best assisted in assembling the figures. The forbearance of my colleagues in the Geology Department at Brigham Young University during the lengthy and trying gestation of the book was greatly appreciated. The positive attitude of John Staples, Inez Burke, and everyone else at W. H. Freeman and Company encouraged me when I needed it most; in the final stretch, the burden of reading a flood of proofs was lightened by the cheerful patience of Larry Olsen. Cheryl Nufer, Kathy Monahan, and Nancy Warner assisted in the final preparation of the line drawings. Finally, my special thanks to my wife Vivian, who typed countless drafts of the manuscript while keeping things running at home, and to Karen, Jenny, Karl, Teresa, Katrina, Richard, Laura, and Tyler, who missed many special outings but didn't complain.

November 1981 Myron G. Best

Symbols

A	Area; also a constant in various equations
a	Activity
C	The number of components in a thermodynamic system
c	Specific heat
D	Diffusion coefficient
E	Energy
E_a	Activation energy
E_i	Internal energy
E_s	Surface energy
E_t	Thermal energy
F	The variance, or the degrees of freedom of a thermodynamic system
f	Fugacity
G	Gibbs free energy
g	Acceleration of gravity
h	Height of a column of rock
J	Time rate of diffusion of an atom or molecule
K	Rate of a chemical reaction; also designates thermal diffusivity
K_D	Distribution coefficient
m	Mass
P	Confining, load, or lithostatic pressure
P_f	Fluid pressure
P_i	Partial equilibrium vapor pressure of a component i, which may be H_2O, CO_2, O_2, S, and so on.
$\Delta Q,q$	Quantity of heat transferred
R	Gas constant; also the dimensionless Rayleigh number
r	Radius
S	Entropy
S_m	Entropy of melting
T	Temperature

T_e Temperature of melting or freezing

t Time

V Volume

v Velocity

dw Increment of mechanical energy, or work

X Chemical composition expressed in terms of the mole fraction of a component

α Coefficient of thermal expansion

δ A function that expresses the ratio of oxygen isotopes per mil in a sample; see Equation 2.1

ϵ Strain

$\dot{\epsilon}$ Strain rate

γ Radioactive decay constant

μ_i^β Chemical potential of a component i in a phase β

η Coefficient of Newtonian viscosity

ϕ The number of phases in a thermodynamic system

ρ Density

σ Normal stress

σ_1 Maximum, or compressive, stress

σ_3 Minimum, or tensile, stress

τ Shear stress

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