

Contents

PART I COMPOSITION AND CONSTITUTION OF THE EARTH	1
1 The Mantle–Crust System	3
1.1 Principal Subdivisions of the Earth's Interior	3
1.2 The Crust	5
1.3 The Upper Mantle	8
1.4 The Transition Zone	18
1.5 The Lower Mantle	21
2 Geochemistry of the Mantle	26
2.1 Chemical Homogeneity versus Heterogeneity	26
2.2 Abundance Patterns of Compatible Elements and Their Significance	30
2.3 Major Elements and Involatile Lithophile Elements in Pyroxene as Compared to Their Primordial Abundances	32
2.4 Abundance Patterns of Volatile and Siderophile Elements	36
3 Composition and Formation of the Core	41
3.1 The Role of Metallic Iron	41
3.2 Light Elements in the Outer Core	43

3.3	Iron Oxide as a Major Component of the Outer Core	46
3.4	Formation of the Core	52
4	Boundary Conditions for the Origin of the Earth	60
PART II	ORIGIN OF THE EARTH	65
5	Protostars, Disks, and Planets	67
5.1	Cosmogonic Background	67
5.2	Development of Protostars	71
5.3	The Formation of Disks	76
5.4	The Outer Planets and Their Regular Satellite Systems	78
5.5	Angular Momentum Relationships within the Solar System	80
5.6	Possible Relevance for Lunar Origin	83
6	Aspects of Planet Formation in the Primordial Solar Nebula	85
6.1	Mass of the Nebula	85
6.2	Accretion of the Planets	88
6.3	Temperature Regime and the Compositions of Planetesimals	93
6.4	Gas-Solid Equilibria in the Nebula	97
6.5	Chemical Fractionations among the Terrestrial Planets	104
7	Early Theories of Accretion of the Earth	108
7.1	Homogeneous Accretion	108
7.2	Single-Stage Hypothesis	110
7.3	The Heterogeneous Accretion Hypothesis	115
8	Homogeneous Accretion Revisited	122
8.1	Some General Considerations	122
8.2	Accretion of the Earth	124
8.3	Formation of the Core	126
8.4	Siderophile Elements and Oxidation State within the Mantle	127
8.5	Atmosphere and Hydrosphere	130
8.6	Conclusion	134

PART III THE MOON AND PLANETS	135
9 The Terrestrial Planets	137
9.1 Introduction	137
9.2 Mars	137
9.3 Venus	146
9.4 Mercury	150
9.5 Asteroids and Meteorites	153
9.6 Cosmogonic Models Based on Chondrites	161
10 Constitution and Composition of the Moon	163
10.1 Internal Structure	163
10.2 The Lunar Crust–Upper Mantle System	168
10.3 Mare Basalts and the Lower Mantle	178
10.4 Further Limits on the Composition of the Lunar Interior	189
10.5 Lunar Thermal Regime	192
11 Geochemistry of the Moon	198
11.1 Introduction	198
11.2 Siderophile Elements in Lunar-Mare and Terrestrial Basalts	199
11.3 Tungsten and Phosphorus	204
11.4 Eucritic Parent Body	208
11.5 Indigenous Siderophile Component of the Lunar Highlands	211
11.6 Geochemical Constraints on the Existence of a Lunar Core	218
11.7 Volatile Elements in Mare Basalts and Their Source Regions	221
11.8 Volatile Elements in the Lunar Highlands	225
12 Towards a Theory of Lunar Origin	229
12.1 Introduction	229
12.2 The Pre-Apollo Scene	231
12.3 New Variations on Old Themes	239
12.4 The Post-Apollo Scene: Geochemical Testimony	245
12.5 Conclusion	252
References	255
Index	287