

Contents

1	Introduction	1
1.1	The Scientific Method.....	2
1.2	Some Special Features of Earth as a Planet	3
1.3	Some Special Features of Venus as a Planet	7
	References	10
2	The Origin of the Sun and the Early Evolution of the Solar System	11
2.1	List of Some Important Facts to be Explained by a Successful Model	15
2.2	A Composite Working Model for Origin and Evolution of the Solar System.....	21
	Summary	31
	References	32
3	Models for the Origin and Evolution of the Earth-Moon System	35
3.1	List of Facts to be Explained by a Successful Model	36
3.2	Fission from the Earth Early in Earth History	36
3.3	Co-formation of the Earth and Moon from the Same Cloud of Dust and Gas	37
3.4	Intact Capture of the Moon by the Earth (1952–1986).....	39
3.5	Other Recent Attempts at Intact Capture	39
3.6	Orbital Traceback Models Suggesting Intact Capture	41
3.7	More on the Singer (1968) Model of Prograde Capture	41
3.8	Disintegrative Capture Models	42
3.9	A Multiple-Small-Moon Model.....	42
3.10	A New (Post-Kona) View of the Intact Capture Process.....	43
3.11	Formation of the Moon Resulting from a Giant Impact Early in Earth History	46
3.11.1	The Angular Momentum Problem of the Earth-Moon System.....	46
3.11.2	The Oxygen Isotope Similarities Between Earth and Moon	47
3.11.3	The Mass and Density of the Moon.....	48

3.12	A Report Card for Models of Lunar Origin.....	48
	References	49
4	A Prograde Gravitational Capture Model for the Origin and Evolution of the Earth-Moon System	53
4.1	Place of Origin for Luna and Sibling Planetoids and a Model for Magnetization of the Crust of Luna and Sibling Vulcanoid Planetoids.....	55
4.2	Migration History of Luna and Sibling Vulcanoid Planetoids	60
4.2.1	Stability of Vulcanoid Planetoid Orbits.....	65
4.2.2	Transfer of Vulcanoid Planetoids from Orbits of Origin to Venus-Earth Space	66
4.2.3	Summary for the Transfer Scheme	66
4.3	Prograde Gravitational Capture of Luna and the Subsequent Orbit Circularization: A Two-Body Analysis and a Discussion of the Paradoxes Associated with the Capture Process.....	69
4.4	Numerical Simulations of Gravitational Capture of a Lunar-Like Body by an Earth-Like Planet.....	78
4.4.1	Computer Code Information.....	79
4.4.2	Development of the Computer Code	79
4.4.3	A Sequence of Typical Orbital Encounter Scenarios Leading to a Stable Capture Scenario.....	82
4.4.4	Geometry of Stable Capture Zones for Planetoids Being Captured by Planets	86
4.4.5	The Post-Capture Orbit Circularization Calculation	91
4.4.6	A Qualitative Model for Generation of a Mare-Age Lunar Magnetic Field	93
4.4.7	Subsequent Orbit Expansion due to Angular Momentum Exchange between the Rotating Earth and the Lunar Orbit	98
4.5	Summary and Statement of the Fourth Paradox	100
4.6	Summary and Conclusions for the Chapter	101
	Appendix	101
	References	113
5	Some Critical Interpretations and Misinterpretations of Lunar Features.....	117
5.1	Discussion of Some Speculations of Harold Urey and Zdenek Kopal	117
5.2	Vignette A. Critique of the “Commandments” for Interpretation of Lunar Surface Features.....	118
5.2.1	Purpose	119
5.2.2	Dedication of this Section of the Chapter.....	119

5.2.3	The Scientific Method and its Application to this Particular Problem	119
5.2.3.1	Step A: Some Facts to be Explained by a Successful Hypothesis for the Origin of Certain Lunar Features	120
5.2.3.2	Step B: The Hypothesis to be Tested: Tidal Disruption on the 18th Perigee Passage of a Stable Capture Scenario	122
5.2.3.3	STEP C: Critique of the “Commandments” as a Prelude to Testing of the Hypothesis	134
5.2.3.4	STEP D: Some Testable Predictions for the Model	139
5.2.4	Summary and Conclusions	147
5.3	Vignette B. Directional Properties of “Circular” Lunar Maria and Related Structures: Interpretation in the Context of a Testable Gravitational Capture Model for Lunar Origin	147
5.3.1	Purpose	148
5.3.2	A Cursory Survey of Circular Maria and Some Mare-filled Craters	150
5.3.3	Summary of Observations	150
5.3.4	Examination of Models that can be Tested for an Explanation of the Directional Properties of the Circular Maria	151
5.3.4.1	The Random Impact Model (Wilhelms 1987)	152
5.3.4.2	Tidal Disruption of a Passing Body Model (Hartmann 1977a)	155
5.3.4.3	Impact of a Swarm of Bodies Due to a Tidally Disruptive Encounter with Either Venus or Earth (Wetherill 1981)	161
5.3.4.4	Impact of a Swarm of Bodies from the Asteroid Zone (Nash 1963)	161
5.3.4.5	Impact of Lunar Satellites Model (Runcorn 1983; Conway 1986)	161
5.3.4.6	Tidal Disruption of the Lunar Body and Subsequent Fallback Model During a Close Encounter with Earth (Malcuit et al. 1975)	162
5.3.5	Some Testable Features of a Tidal Disruption Scenario That can be Analyzed on Future Mission to the Moon	163
5.3.6	Major Predictions from the Tidal Disruption Model for the Formation of Some Lunar Features	169
5.3.7	Discussion of the Predictions	169
5.3.8	An Epilogue to This Section on “Directional Properties of Lunar Maria”	173

5.4	Vignette C. On the Origin of Lunar Maria and Mascons: The Case for a One-body, Isostatic Equilibrium	
	Model Revisited	174
5.4.1	Purpose	174
5.4.2	Some Special Features of Large Circular Maria and Associated Mascons	175
5.4.3	Some Previously Proposed Models for Mascons	175
5.4.4	A Soft-Body Impact Model for Mascons	177
5.4.5	Some Predictions from the Soft-Body Model for the Formation of Circular Maria and Mascons	178
5.4.6	Summary	179
5.5	Vignette D. The Late Heavy Bombardment of Earth, Moon, and Other Bodies: Fact or Fiction?	179
5.5.1	Purpose	180
5.5.2	Some Facts to be Explained and Questions to be Answered by a Successful Model	180
5.5.3	A Series of Quotes, Mainly in Chronological Order, Concerning Unusual Events on the Moon (and Earth) Between 4.0 and 3.5 Billion Years Ago	180
5.5.4	Some Quotes on the Concept of the “LATE HEAVY BOMBARDMENT” from 1974 up to 2007	182
5.5.5	View of the Late Heavy Bombardment in 2006	185
5.5.6	Review of the Situation of the Late Heavy Bombardment in 2007	185
5.5.7	Summary	186
5.6	Vignette E. A Cool Early Earth, Recycled Enriched Crust at ~3.95 Ga, and the Subduction Mechanisms Associated with a Tidal Capture Model for the Origin of the Earth- Moon System	187
5.6.1	Purpose	187
5.6.2	Evidence for a Cool Early Earth	188
5.6.3	The Bedard (2006) Model for Processing a Basaltic Crust on a Stagnant-Lid Planet	188
5.6.4	A Unidirectional Earth-Tide Recycling Mechanism Commencing with the Capture Encounter at ~3.95 Ga	189
5.6.5	A Proposed Mechanism for Recycling an Enriched Primitive Crust in the Broadly Defined Equatorial Zone of the Planet Beginning ~3.95 Ga	190
5.6.6	Summary	200
5.6.7	Discussion	202
5.7	Vignette F. On the Origin of Earth’s Oceans of Water	206
5.7.1	Some Facts to be Explained by a Successful Model for the Origin of Water on Earth and Neighboring Planets ...	207
5.7.2	The Asteroidal Source of Water as Proposed by Albarede (2009)	208

5.7.3	A Proposed Delivery Mechanism for the Water-Bearing Asteroids.....	210
5.7.4	Summary and Conclusions	211
5.7.5	Discussion.....	212
5.8	Discussion of the Speculations by Harold Urey and Zdenek Kopal...	215
5.9	Summary Statement	217
	Appendix	218
	The “Cool Early Earth” Vignette (Sect. 5.6.).....	218
	References	229
	Lunar Geologic Maps Cited.....	234
	Lunar Charts Cited.....	234
6	Origin and Evolution of the Venus-Adonis System:	
	A Retrograde Gravitational Capture Model	235
6.1	Origin of the Concept of Retrograde Capture of a Lunar-Like Body by Planet Venus	236
6.2	Some Facts to be Explained by a Successful Model.....	237
6.3	Place of Origin of Adonis and Sibling Planetoids and the Original Rotation Rate of Planet Venus.....	237
6.4	Migration History of Adonis and Sibling Planetoids	238
6.5	Gravitational Capture of Adonis and the Subsequent Orbit Circularization—A Two-Body Analysis	238
6.5.1	Retrograde Capture of a 0.5 Moon-Mass Planetoid from a Co-Planar, Venus-Like Orbit.....	238
6.5.2	Post-Capture Orbit Circularization Era	242
6.5.3	Circular Orbit Evolution.....	243
6.6	Numerical Simulations of Retrograde Planetoid Capture for Venus and a 0.5 Moon-Mass Planetoid	243
6.6.1	Coordinate System for Plotting the Results.....	244
6.6.2	A Sequence of Orbital Encounter Scenarios Leading to Stable Retrograde Capture.....	245
6.6.3	Post-Capture Orbit Circularization Era	252
6.6.4	Sequence of Diagrams Showing the Possible Surface and Interior Effects on Planet Venus for Retrograde Capture of Adonis and Subsequent Orbit Circularization.....	256
6.6.5	Diagrams Showing Possible Surface Effects During the Circular Orbit Era	257
6.6.6	Summary and Commentary on Conditions during this 3.0 Billion Year Era	259
6.6.7	A Model for the Final Demise of Adonis from the Roche Limit for a Solid Body to Breakup in Orbit and Eventual Coalescence with Planet Venus.....	264
6.7	Summary for the Chapter	266
	References	268

7 A Retrograde Gravitational Capture Model for the Earth-Moon System	271
7.1 Purpose	272
7.2 Overview of a Retrograde Capture Scenario for Earth: A Two-Body Analysis	272
7.3 Numerical Simulations of Retrograde Planetoid Capture for Earth and a Moon-Mass Planetoid and the Subsequent Circularization of the Post-Capture Orbit	274
7.4 Circular Orbit Era	285
7.5 Late Phase of the Circular Orbit Evolution Era	288
7.6 Summary for the Retrograde Capture and Subsequent Orbital Evolution of an Earth-Like Planet and a Lunar-Mass Satellite System	289
7.7 Discussion and Implications for the Search for Habitable Exoplanets	291
References	293
 8 Planet Orbit—Lunar Orbit Resonances and the History of the Earth-Moon System	295
8.1 Purpose	296
8.2 The Perigean Cycle for the Earth-Moon System	296
8.3 A Jupiter Orbit—Lunar Orbit Resonance	298
8.3.1 Geometry of a Jupiter Orbit—Lunar Orbit Resonance	299
8.3.2 Orbital Geometry and Tidal Regime for a Forced Eccentricity Scenario	301
8.3.3 Some Testable Predictions from this Forced Eccentricity Scenario	308
8.3.4 Summary and Discussion	309
8.4 A Venus Orbit—Lunar Orbit Resonance Associated with a Perigean Cycle of 15 Earth Years (24 Venus Years) (A 15:1 VO-LO Resonance)	310
8.4.1 Geometry of a Venus Orbit—Lunar Orbit Resonance when the Perigean Cycle is at 15 Earth Years (24 Venus Years)	312
8.4.2 Tidal Regime of this Venus Orbit—Lunar Orbit Resonance	312
8.4.3 Some Testable Predictions from this Forced Eccentricity Scenario	314
8.4.4 Summary and Discussion	322
8.5 A Venus Orbit—Lunar Orbit Resonance Associated with a Perigean Cycle of 10 Earth Years (16 Venus Years) (A 10:1 VO-LO Resonance)	322
8.5.1 A Note on the Proposed Time Scale for Planet Orbit—Lunar Orbit Resonances	323

8.5.2	Geometry of a Venus Orbit—Lunar Orbit Resonance when the Perigean Cycle is at 10 Earth Years (16 Venus Years) (a 10:1 VO-LO resonance)	324
8.5.3	Snapshots of Four Orbit States and the Associated Tidal Regimes	326
8.5.4	Some Testable Predictions from this Model	326
8.5.5	Summary and Discussion	326
8.6	A Venus Orbit—Lunar Orbit Resonance Associated with a Perigean Cycle of 5 Earth Years (8 Venus Years)	333
8.6.1	Geometry and Tidal Regime of a Venus Orbit—Lunar Orbit Resonance when the Perigean Cycle is at 5 Earth Years (8 Venus Years) (A 5:1 VO-LO resonance)	333
8.6.2	Summary and Discussion for this Section	333
8.7	Summary and Conclusions for this Chapter	341
8.8	A Soliloquy on this Chapter	342
	Appendix	344
	References	352
9	Discussion of the Probability of Finding Habitable Planets for Humans Orbiting Sun-Like Stars	355
9.1	How Simple or How Complicated is the System of Biology on Earth?	356
9.2	My Suggested List of Additional Factors (Models) That Should be Considered in the Development of Higher Forms of Life on Earth	357
9.3	The Long Chain of Complications For Explaining Our Existence on the Third Planet From the Sun	360
9.4	What are the Chances of this Very Long Chain of Complications Happening Elsewhere in a Large Region of Space?	362
9.5	Summary	363
	References	363
10	Summary and Conclusions	365
	References	367
	Glossary	369
	Author Index	393
	Subject Index	397

The Twin Sister Planets Venus and Earth

Why are they so different?

Malcuit, R.

2015, XIX, 401 p. 225 illus., 68 illus. in color., Hardcover

ISBN: 978-3-319-11387-6