

Contents

1. Abstract	V
2. Kurzfassung	IX
3. Introduction and Motivation	1
I. Introduction to the Background Theory and Open Scientific Issues	5
4. The Base of Our Knowledge – The Moon, Earth and Venus	7
4.1. Geologic Evolution of the Moon	8
4.2. The Chronostratigraphy of the Moon	9
5. The Adaptation from the Moon to Mars	15
5.1. The Reference System, Moon: Cratering Record	15
5.2. The Reference System, Moon: Impactor Flux	15
5.3. The Mars–Moon Cratering Rate Ratio	16
6. Martian Global Geology	19
6.1. What Do Martian Meteorites Tell Us About Mars	20
6.2. The Viking–based Stratigraphic System of Mars	22
6.3. Towards A New Time–Stratigraphy	26
6.4. The Geophysical Mars after Mars Global Surveyor	28
7. Cratering on Mars	31
7.1. Cratering Mechanics	31
7.2. Crater Modeling	33
7.3. Impact Crater Morphologies	33
7.4. Crater Morphologies: Indicators of Sub–Surface Water	34
II. Application and Improvement of the Age Dating Techniques, Secondary Cratering, and the Martian Crater Size–Frequency Distribution	41
8. Age Dating Techniques	45
8.1. Cumulative Crater Size–Frequency Distribution	45
8.2. Cumulative Cratering Rate	46
8.3. Relative and Absolute Ages	46
8.3.1. Errors in the Relative and Absolute Ages	46
9. Absolute Ages in Resurfaced Units – Refinement of the Method	49
9.1. How Do Crater Counts Reveal Resurfacing?	50

10. Secondary Cratering	55
10.1. Remote Secondary Cratering: The Zunil Case	56
10.1.1. Characteristics of the Zunil secondary strewn field	58
10.1.2. Reasoning for a steep primary crater size distribution branch	60
10.2. Gedankenexperiment: Secondary Cratering	60
10.2.1. Construction of a hypothetical total crater distribution	62
10.3. Hypothetical Secondary–Crater Contribution	65
10.4. Small–crater production on Mars observed by MGS	67
10.5. Conclusion	68
11. The Observed Martian Crater Production Function	69
III. Re–Assessment of the Martian Stratigraphy	73
12. Athabasca Valles: A Case Study	77
12.1. Implications for the Martian Crater Size–Frequency Distribution and Age Determination	79
13. Martian Cratering and Implications for the Chronostratigraphy	81
13.1. Martian Impact Basin Ages	82
13.2. Gusev Crater – The MER Spirit Landing Site	85
14. Northern Lowlands, Highland–Lowland Dichotomy, and Fluvial Activity	89
14.1. Northern Lowland Stratigraphy	90
14.1.1. The Geology of the Chryse Region (Zone 1)	90
14.1.2. The Chrono–Stratigraphy of the Chryse Region	91
14.1.3. The Geology of the Utopia Basin and its Vicinity (Zone 2)	93
14.1.4. The Zone–2 Chrono–Stratigraphy	95
14.1.5. The Elysium Volcanic Province and Amazonis Planitia (Zone 3) – Geology and Chrono–Stratigraphy	96
14.1.6. Between Alba Patera and the North Pole (Zone 4) – Geology and Chrono–Stratigraphy	97
14.1.7. The Viking–Based Chronostratigraphy of the Northern Lowlands, Summary	98
14.2. The Highland–Lowland Dichotomy Boundary between -30°W and 270°W . . .	100
14.2.1. Geology	101
14.2.2. Chronostratigraphy	103
14.3. Giant Polygonal Trough Units in the Northern Lowlands	105
14.3.1. Geology	106
14.3.2. Crater Morphologies	108
14.4. The Medusae Fossae Formation	111
14.5. Outflow Channels: Mangala, Kasei, and Ares Valles	113
14.6. Implications of the Evolutionary History of the Highland–Lowland Boundary, and the Northern Lowlands	117

15. Volcanic Activity on Mars	121
15.1. The Tharsis Volcanic Province	124
15.1.1. Alba Patera	124
15.1.2. The Tharsis Montes	125
15.1.3. Olympus Mons	127
15.1.4. The Tholi and Paterae on Tharsis	130
15.2. The Elysium Volcanic Province	132
15.3. Highland Paterae	135
15.4. Volcanic Plains	137
15.5. The Volcanic Constructs – Discussion of Results	138
16. Fluvial, Glacial and Volcanic Interaction	141
IV. The Evolutionary History of Mars	145
17. Stratigraphic Type Areas Re–Visited	149
17.1. Ages of Martian Basins and the Noachian Epoch	149
17.2. The Hesperian Epoch	150
17.3. The Amazonian Epoch	152
18. Results, Prospects, and Applications	153
A. Northern Lowlands – Crater Size–Frequency Distributions and Images	I
A.1. Kasei Valles – Images and Crater Size–Frequency Distributions	XV
B. Volcanism on Mars – Crater Size–Frequency Distributions and Images	XVII
C. Fluvial, Glacial, and Volcanic Interaction	XXXVII
D. Curriculum Vitae	LXXV