



Interactions between Tectonics, Climate and the  
Biosphere in the African-Asian Monsoonal Region



# LANDSCAPE EVOLUTION IN THE WESTERN INDIAN HIMALAYA SINCE THE MIOCENE

Kumulative Dissertation  
zur Erlangung des akademischen Grades  
Doktor der Naturwissenschaften (Dr. rer. nat.)

in der Wissenschaftsdisziplin Geologie

eingereicht an der  
Mathematisch-Naturwissenschaftlichen Fakultät

UNIVERSITÄT POTSDAM

von

PATRICIA EUGSTER  
M.Sc. in Erdwissenschaften, ETH Zürich

im August, 2017

# Contents

<b>Summary</b>	<b>V</b>
<b>Zusammenfassung</b>	<b>VII</b>
<b>List of Figures</b>	<b>XV</b>
<b>List of Tables</b>	<b>XVII</b>
<b>Thesis organisation and author contributions</b>	<b>XIX</b>
<b>Declaration of Authorship</b>	<b>XXI</b>

## MAIN PART OF THESIS

<b>1 Introduction</b>	<b>3</b>
1.1 Overview . . . . .	3
1.1.1 Background . . . . .	3
1.1.2 Glacial processes . . . . .	5
1.1.3 Terrestrial Cosmogenic Radionuclides (TCN) . . . . .	7
1.1.4 Low-temperature thermochronometry . . . . .	9
1.2 Geologic and climatic setting . . . . .	11
1.2.1 Of hot and cold rocks . . . . .	11
1.2.2 Of wind, water and ice . . . . .	13
1.3 Motivation . . . . .	15
<b>2 Rapid Last Glacial Maximum deglaciation in the Indian Himalaya coeval with midlatitude glaciers: New insights from <sup>10</sup>Be-dating of ice-polished bedrock surfaces in the Chandra Valley, NW Himalaya</b>	<b>23</b>
Short title: Chandra Valley LGM glaciation	
2.1 Introduction . . . . .	24
2.2 Study Area . . . . .	25
2.3 Methods . . . . .	25
2.4 Results . . . . .	26
2.4.1 Surface exposure dating . . . . .	26
2.4.2 Glacier reconstruction and deglaciation history . . . . .	29
2.5 Discussion . . . . .	29

<b>3</b>	<b>Ice dams, outburst floods, and glacial incision at the western margin of the Tibetan Plateau: A &gt;100 kyr chronology from the Shyok Valley, Karakoram</b>	<b>35</b>
	Short title: Glacier dams, Karakoram	
3.1	Introduction . . . . .	36
3.1.1	Glacier Dams in the Karakoram Mountains . . . . .	37
3.2	The Study Area . . . . .	37
3.3	Methods . . . . .	38
3.3.1	Mapping and Remote-Sensing Analysis . . . . .	38
3.3.2	Surface-Exposure Dating . . . . .	39
3.4	Results . . . . .	40
3.4.1	Fluvial and Lacustrine Deposits in the Upper Shyok Valley . . . . .	40
3.4.2	The Khalsar Deposit . . . . .	41
3.4.3	Glacial Marks and Deposits in the Nubra and Lower Shyok Valleys . . . . .	42
3.4.4	Surface-Exposure Dating . . . . .	42
3.5	Discussion . . . . .	55
3.5.1	Timing and Extent of Glacial Damming . . . . .	55
3.5.2	Aggradation and Incision History . . . . .	57
3.5.3	Catastrophic Outburst Floods from Ice-Damned Lakes . . . . .	60
3.5.4	Glacial Damming and the Quaternary Evolution of the Shyok Valley . . . . .	62
3.5.5	Signatures of Glacial Damming and Erosion along the Karakoram . . . . .	63
3.5.6	Implications for the Quaternary Evolution of the Western Tibetan Plateau Margin . . . . .	64
3.5.7	Significance of Glacial Dams for Mountainous Landscape Evolution . . . . .	65
3.6	Conclusions . . . . .	66
<b>4</b>	<b>Segmentation of the Main Himalayan Thrust revealed by low-temperature thermochronometry in the western Indian Himalaya</b>	<b>69</b>
	Short title: Segmentation MHT	
4.1	Introduction . . . . .	70
4.2	Topographic and geologic setting of the study area . . . . .	72
4.3	Methods . . . . .	73
4.4	Results . . . . .	74
4.5	Discussion . . . . .	78
4.5.1	Age-elevation profiles and exhumation rates . . . . .	78
4.5.2	Orogen-perpendicular transects . . . . .	82
4.5.3	Potential causes for changes in tectonic style in the NW Himalaya . . . . .	84
4.6	Conclusions . . . . .	86
<b>5</b>	<b>Discussion</b>	<b>89</b>
5.1	Ambiguities in the use of the TCN-method . . . . .	89
5.2	Short-term TCN-exposure ages and landforms . . . . .	91
5.3	Long-term exhumation and resulting landforms . . . . .	92
5.4	Sediment evacuation and landscape forming processes . . . . .	94

<b>6 Conclusion &amp; Outlook</b>	<b>97</b>
<b>Bibliography</b>	<b>99</b>
<b>Acknowledgements</b>	<b>121</b>

## APPENDICES

<b>A Reconstruction of the glacial extent and timing of the Chandra Valley Glacier</b>	<b>127</b>
A.1 Field photographs . . . . .	128
A.2 $^{10}\text{Be}$ ages and production rates comparison . . . . .	132
A.3 References of Figure 2.3 . . . . .	133
A.4 Data Set 1 . . . . .	134
A.5 Data Set 2 . . . . .	137
A.6 Data Set 3: Glacial striations measured in the Lahul area . . . . .	164
References . . . . .	166
<b>B Ice-dams and Outburst Floods</b>	<b>171</b>
B.1 Figures B.1-B.3 containing information about the recalculated $^{10}\text{Be}$ -depth profile modeling	171
B.2 Table B.1: Recalculated $^{10}\text{Be}$ -exposure ages by Dortch et al., (2010) . . . . .	174
B.3 Table B.2: Glacial striations measurements . . . . .	175
References . . . . .	176
<b>C Apatite Fission Track results</b>	<b>179</b>
C.1 Apatite Fission Track results . . . . .	179
C.2 Erosion rate calculation . . . . .	206
C.3 Advection calculation . . . . .	209
References . . . . .	210