

Contents

Tributes	xi
Eduardo GARZANTI, Vincent GODARD, Rodolphe CATTIN, György HETÉNYI, Jean-Luc EPARD and Martin ROBYR	
Foreword	xvii
Rodolphe CATTIN and Jean-Luc EPARD	
Preface. From Research to Education: The Example of the Seismology at School in Nepal Program	xix
György HETÉNYI and Shiba SUBEDI	
Part 1. Tectonic Framework of the Himalaya and Tibet	1
Chapter 1. Plate Reconstructions and Mantle Dynamics Leading to the India–Asia Collision	3
Gweltaz MAHÉO and Guillaume DUPONT–NIVET	
1.1. Introduction	3
1.2. The India–Asia convergence and the age of the collision	6
1.2.1. The India–Asia convergence	6
1.2.2. The age of the India–Asia collision	7

1.3. Plate collision configurations	14
1.3.1. Reconstructing lost continental margins	14
1.3.2. Alternative collision configurations	16
1.4. Reconstruction of the Neotethys Ocean closure dynamic	17
1.4.1. Number of subduction accommodating the Neotethys closure	17
1.4.2. Location of the Intraoceanic subduction zone and associated arc	19
1.4.3. Driving forces of the India–Asia convergence during Neotethys closure	20
1.5. Conclusion	23
1.6. References	23
Chapter 2. Building the Tibetan Plateau During the Collision Between the India and Asia Plates	33
Anne REPLUMAZ, Cécile LASSERRE, Stéphane GUILLOT, Marie-Luce CHEVALIER, Fabio A. CAPITANIO, Francesca FUNICIELLO, Fanny GOUSSIN and Shiguang WANG	
2.1. Introduction	33
2.2. Present-day Tibetan crustal deformation	36
2.2.1. GPS velocity field and focal mechanisms in Tibet	36
2.2.2. Surface motions and deformation due to Indian indentation	38
2.3. Tibetan lithospheric mantle subduction during collision	39
2.3.1. Imaging ongoing subduction beneath Tibet	39
2.3.2. Imaging subduction of lithospheric Tibetan mantle during the collision	41
2.3.3. Volcanism in Tibet showing the subduction of lithospheric Asian mantle during the early collision	43
2.4. Modeling the Tibetan plateau formation during the indentation of the Indian continent into Asia	45
2.4.1. Analogue modeling of the Tibetan lithosphere subduction during the indentation of India	46
2.4.2. Numerical modeling of Asian thickening and extrusion during the subduction of a continental–oceanic plate	49
2.5. Conclusion	51
2.6. References	52
Chapter 3. The Major Thrust Faults and Shear Zones	57
Djordje GRUJIC and Isabelle COUTAND	
3.1. Introduction	57
3.2. Some basic concepts	58

3.3. Main faults and shear zones	59
3.3.1. South Tibetan detachment system (STDS)	60
3.3.2. Main Central thrust (MCT)	67
3.3.3. Main Boundary thrust (MBT)	74
3.3.4. Main Frontal thrust (MFT)	77
3.3.5. Main Himalayan thrust (MHT), continental megathrust	81
3.4. Tectonic models	81
3.4.1. Fold-and-thrust belt versus channel flow	81
3.4.2. Coeval slip along the STDS and the MCT	84
3.5. Conclusion	87
3.6. References	87

Part 2. Along Strike Variations 101

Chapter 4. Seismological Imaging and Current Seismicity of the Himalayan Arc 103

György HETÉNYI, Jérôme VERGNE, Laurent BOLLINGER, Shiba SUBEDI,
Konstantinos MICHAÏLOS and Dowchu DRUKPA

4.1. Introduction	103
4.2. Imaging by elastic waves	104
4.2.1. Active seismics	105
4.2.2. Passive seismics	105
4.2.3. Tomographic imaging for bulk properties	106
4.2.4. Wave reflections and conversions for interfaces	107
4.3. Exploring the Central Himalaya along cross-sections	108
4.3.1. Field experiments	108
4.3.2. Main interfaces	109
4.3.3. Where do subducted plates go?	115
4.4. Lateral variations	116
4.4.1. Lateral ramps on the MHT, along-arc Moho variations	116
4.4.2. Segmentation of the India plate lithosphere	117
4.4.3. The western and eastern syntaxes	119
4.5. Current seismicity of the Himalaya	120
4.5.1. Earthquake detection, location and activity	120
4.5.2. Seismicity of the Himalaya: an incomplete patchwork	121
4.5.3. Seismicity of the Himalaya: main features	123
4.6. Conclusion	125
4.7. References	126

Chapter 5. Gravity Observations and Models Along the Himalayan Arc	129
Rodolphe CATTIN, György HETÉNYI, Théo BERTHET and Jamyang CHOPHEL	
5.1. Introduction	129
5.2. Methods	130
5.2.1. Measurements	130
5.2.2. Corrections	131
5.2.3. Anomalies	133
5.3. Isostasy	134
5.3.1. Local compensation	134
5.3.2. Regional compensation	136
5.3.3. Effective elastic thickness	137
5.4. Flexure of the Indian plate	138
5.4.1. Gravity anomaly across the Himalayan belt	138
5.4.2. Along-strike variation between Nepal and Bhutan	141
5.5. Satellite data contribution	143
5.5.1. Gravity measurements from space	143
5.5.2. Towards a three-dimensional image	145
5.6. Conclusion	147
5.7. References	148
Chapter 6. Topographic and Thermochronologic Constraints on the Himalayan Décollement Geometry	151
Peter A. VAN DER BEEK, Rasmus C. THIEDE, Vineet K. GAHALAUT and Taylor F. SCHILDGEN	
6.1. Introduction	151
6.2. Methods	156
6.2.1. Quantitative geomorphic analysis	156
6.2.2. Measures of erosion at different timescales: cosmogenic nuclides and thermochronology	158
6.2.3. From exhumation to kinematics: thermo-kinematic models	162
6.3. Regional case studies	163
6.3.1. Central Himalaya – Nepal	163
6.4. Discussion	176
6.4.1. Constraints on MHT geometry and kinematics at different timescales	177
6.4.2. Nature and evolution of ramps on the MHT	178
6.4.3. Evidence for out-of-sequence thrusting?	179
6.4.4. Lateral segmentation of the MHT	181

6.5. Conclusion	182
6.6. References	183

Part 3. Focus 195

Chapter 7. Application of Near-surface Geophysical Methods for Imaging Active Faults in the Himalaya 197

Dowchu DRUKPA, Stéphanie GAUTIER and Rodolphe CATTIN

7.1. Introduction	197
7.2. Near-surface geophysics	198
7.2.1. Geophysical methods for fault mapping	200
7.2.2. Case study data and inversion technique	205
7.3. Geophysical results of case study from south Bhutan	208
7.3.1. Electrical resistivity tomography	208
7.3.2. Seismic tomography	211
7.3.3. Micro-gravity	213
7.4. Implications of near-surface geophysical findings	215
7.4.1. Subsurface imaging	215
7.4.2. Overthrusting slip rate assessment	216
7.4.3. Deformation at the topographic front	218
7.5. Conclusion	218
7.6. References	219

Chapter 8. Overview of Hydrothermal Systems in the Nepal Himalaya 225

Frédéric GIRAULT, Christian FRANCE-LANORD, Lok Bijaya ADHIKARI, Bishal Nath UPRETI, Kabi Raj PAUDYAL, Ananta Prasad GAJUREL, Pierre AGRINIER, Rémi LOSNO, Sandeep THAPA, Shashi TAMANG, Sudhan Singh MAHAT, Mukunda BHATTARAI, Bharat Prasad KOIRALA, Ratna Mani GUPTA, Kapil MAHARJAN, Nabin Ghising TAMANG, H el ene BOUQUEREL, J er ome GAILLARDET, Mathieu DELLINGER, Fran ois PREVOT, Carine CHADUTEAU, Thomas RIGAUDIER, Nelly ASSAYAG and Fr ed eric PERRIER

8.1. Introduction	225
8.2. Measurement methods	228
8.2.1. Exploration approach	228
8.2.2. Thermal spring water measurements	229
8.2.3. CO ₂ flux and radon flux measurements	230
8.2.4. Carbon content and isotopic composition measurements	231
8.3. Summary of results at the hydrothermal sites in the Nepal Himalaya	232

8.3.1. Overview of hydrothermal sites in Far-Western Nepal	234
8.3.2. Overview of hydrothermal sites in Mid-Western Nepal	235
8.3.3. Overview of hydrothermal sites in Western Nepal	238
8.3.4. Overview of hydrothermal sites in Central Nepal	240
8.3.5. Overview of hydrothermal sites in Eastern Nepal	246
8.3.6. Overview of hydrothermal sites in the MFT zone	246
8.4. Conclusion	247
8.5. References	248
Conclusion	255
Rodolphe CATTIN and Jean-Luc EPARD	
List of Authors	257
Index	263
Summaries of other volumes	267