

Contents

Acknowledgements	i
Abbreviations	ii
Figures	viii
Tables	xiii
I Introduction	1
1.1 Preface	1
1.2 Research objectives, methodology and thesis structure	3
1.3 General setting	5
1.3.1 Study area	5
1.3.2 Geology	6
1.3.3 Climate	6
1.3.4 Vegetation	7
1.3.5 Lake Prespa morphology and hydrology	10
1.4 State of research	12
1.4.1 Core lithology and correlation	12
1.5 Chronology of core Co1215	14
II Climate and environmental change in the Balkans over the last 17 ka recorded in sediments from Lake Prespa (Albania/F.Y.R. of Macedonia/Greece)	16
2.1 Introduction	17
2.2 Regional setting	18
2.3 Material and methods	19
2.3.1 Core recovery	19
2.3.2 Analytical work	19
2.4 Results	21
2.4.1 Lithology and biogeochemistry	21
2.4.2 Pollen record	21
2.4.3 Ostracod record	22
2.4.4 Chronology	23
2.5 Discussion and interpretation	26
2.5.1 Late Glacial (17.1 - 15.7 ka cal BP)	26
2.5.2 Late Glacial to Holocene transition (15.7 - 11.5 ka cal BP)	30
2.5.3 Early Holocene (11.5 - 8.3 ka cal BP)	32
2.5.4 The “8.2 ka event” (8.3 - 7.9 ka cal BP)	34
2.5.5 Mid Holocene (7.9 - 1.9 ka cal BP)	34
2.5.6 Late Holocene (1.9 ka cal BP - present)	36
2.6 Conclusions	37

2.7	Acknowledgments	37
2.8	References	38
III	Vegetation and climate history of the Lake Prespa region since the Lateglacial	43
3.1	Introduction	44
3.2	Study site	46
3.3	Materials and Methods	47
3.3.1	Chronology	47
3.3.2	Sedimentological analyses	47
3.3.3	Palaeontological analyses	47
3.4	Results	48
3.4.1	Age model	48
3.4.2	Pollen Assemblage Zones	50
3.5	Discussion	52
3.5.1	Late Pleniglacial/Oldest Dryas (P-2c; c. 17 000 – 15 000 cal BP)	52
3.5.2	Bølling/Allerød Interstadial (P-2b; c. 15 000 – 13 200 cal BP)	54
3.5.3	Younger Dryas (P-2a; c. 13 200 – 11 500 cal BP)	55
3.5.4	Early Holocene (P-1e; c. 11 500 – 8 300 cal BP)	57
3.5.5	8.2 event (P-1d; c. 8 300 cal BP – 7 900 cal BP)	58
3.5.6	Middle and Late Holocene (P-1c, P-1b, P-1a; c. 7 900 cal BP – present)	59
3.6	Conclusions	62
3.7	Acknowledgements	63
3.8	References	63
IV	Understanding past climatic and hydrological variability in the Mediterranean from Lake Prespa sediment isotope and geochemical record over the Last Glacial cycle	68
4.1	Introduction	69
4.2	General setting	69
4.3	Material and methods	70
4.3.1	Stable isotope analysis of modern waters	71
4.3.2	Stable isotope and Rock Eval analysis of organic matter	71
4.3.3	Pollen data	73
4.3.4	Stable isotope and XRD analysis of carbonates	73
4.4	Chronology	74
4.5	Results	76
4.5.1	Modern waters	76
4.5.2	Prespa core Co1215 data	76
4.6	Discussion	77
4.6.1	Modern water oxygen and hydrogen isotope composition	77
4.6.2	Modern water carbon isotope composition	78

4.6.3	Sources of organic matter in the Lake Prespa sedimentary record	78
4.6.4	Carbon isotope composition of organic matter from Lake Prespa	80
4.6.5	Oxygen and carbon isotope composition of carbonate from Lake Prespa: MIS 5-1	82
4.6.6	Comparison of $\delta^{18}\text{O}$ between Prespa, Ohrid and other lakes in the region from 15 ka	84
4.6.6.1	Late Glacial to Holocene transition	84
4.6.6.2	Early Holocene	85
4.6.6.3	Middle Holocene humidity	86
4.6.6.4	Late Holocene	86
4.7	Conclusions	87
4.8	Acknowledgements	88
4.9	References	88
V	Climate variability since MIS 5 in SW Balkans inferred from multiproxy analysis of Lake Prespa sediments	93
5.1	Introduction	94
5.2	Physical setting	95
5.3	Material and Methods	96
5.3.1	Geochemical analyses	96
5.3.2	Palynological analyses	97
5.3.3	Chronology	98
5.4	Results	99
5.4.1	Lithology and Geochemistry	99
5.4.2	Pollen Assemblage Zones (PAZs)	99
5.5	Discussion	101
5.5.1	The Prespa paleoarchive	101
5.5.1.1	Vegetational and limnological feedbacks to climate variability at a local scale	101
5.5.1.2	Temporal and spatial development of local ecosystems	105
	<i>MIS 5 (c. 92 – 71 ka cal BP; P-10 to P-8)</i>	<i>105</i>
	<i>MIS 4 (c. 71 – 57 ka cal BP; P-7 and P-6)</i>	<i>105</i>
	<i>MIS 3 (c. 57 – 29 ka cal BP; P-5 and partly P-4)</i>	<i>106</i>
	<i>MIS 2 (c. 29 – 14 ka cal BP; partly P-4 to P-2c)</i>	<i>106</i>
	<i>MIS 1 (c. 15 ka cal BP to Present; partly P-2b to P-1)</i>	<i>108</i>
5.5.1.3	Understanding ecological processes, triggers and thresholds	108
5.5.2	Comparison with regional and global records	110
5.5.2.1	Mediterranean records	110
5.5.2.2	Global records	111
5.5.3	Environmental constraints posed on hominid populations	112
5.6	Conclusions	114
5.7	Acknowledgements	115
5.8	References	115

VI	Towards a theoretical framework for analyzing integrated socio-environmental systems	119
6.1	Introduction	120
6.2	The theory of resilience and adaptive cycles (according to Gunderson and Holling)	120
6.3	Case studies	122
6.3.1	The small scale of observable human-environment interaction and its simulation in forager studies (TW, MS - project E3)	123
6.3.2	Demographic cycles in the Central European Neolithic (RP, AZ - project D2)	126
6.3.3	Analysis of the palaeodemography of hunters and gatherers during the Late Upper Palaeolithic in Europe (IK, AZ - project E1)	128
6.3.4	The cascade model - societal reorganization by Palaeolithic hunter-gatherers as a reaction of climatic instability (MB, AP, GCW - project C1)	130
6.3.5	Adaptive cycles: the lake Prespa case study (FS, KP, AA, BW - project B2)	132
6.3.6	Environmental response to agricultural land use practices in relation to sediment flux and storage in hillslope systems (MSch, TH, RD - project D3)	134
6.4	Time series, spatial scales and models	137
6.4.1	Where do we come from?	137
6.4.2	Where are we heading to?	137
6.5	Conclusion	139
6.6	Acknowledgments	141
6.7	References	141
VII	Exploratory analyses and microcharcoal results	144
7.1	Microscopic Charcoal	144
7.2	Numerical analyses	144
7.2.1	Box plots	144
7.2.2	Ordination	146
7.2.3	Rarefaction	148
VIII	Synthesis and Discussion	149
8.1	Watershed hydrology and sedimentation mechanisms	149
8.2	Reconstructing Prespa's ecosystems over the last 92 ka	153
8.3	Vegetation dynamics at the Dessarate Lake region	156
8.4	Conclusions and outlook	160
	References	163
	Summary	167
	Zusammenfassung	168
	Περίληψη	169

A	SEM Images	170
B	Pollen and spore taxa	171
C	Palynological data of Co1215	174
	Chapter Contributions	175
	Erklärung	177
	Curriculum Vitae	178