



DEUQUA2026 Conference

Environmental Records and Landscape Change

Freiburg, 28 September – 2 October 2026

Abstract Volume

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Felix Martin Hofmann , Salome Oehler , Mathias Vinnepand  (eds.)



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Preface

Dear friends of the Quaternary,

A warm welcome to the biannual meeting of the German Quaternary Association that will take place in Freiburg from 28 September to 2 October 2026.

With the theme “Environmental records and landscape change”, we aim on linking high-resolution records of past environmental change with its expression in changes in geomorphic processes. This topic will be also the focus of a full-day workshop, which will combine invited talks, poster exhibitions as well as a general discussion. This will be in addition to oral and poster presentations on all subjects of Quaternary research.

During field trips prior and past the session program, the working group from Freiburg will present highlights of own research.

Sincerely,

Frank Preusser

and the DEUQUA 2026 organisation team

(Jan Henrik Blöthe, Alexander Fülling, Lukas Gegg, Felix Martin Hofmann, Salome Oehler, and Mathias Vinnepand)

1 Programme

1.1 Programme overview

Time	Monday 28th September		Tuesday 29th September	Wednesday 30th September	Thursday 1st October	Friday 2nd October	
08:30 - 08:45			Welcome Message				
08:45 - 09:00			Leitgeb et al.				
09:00 - 09:15	FIELD TRIP I	FIELD TRIP II	Kettler & Hintersberger	Welcome and Introduction	Jouaux et al.	FIELD TRIP III	FIELD TRIP IV
09:15 - 09:30			Hampel & Hetzel		Grimm et al.		
09:30 - 09:45			Hofmann et al.	Melaine Le Roy Glacial Records	Rogalski et al.		
09:45 - 10:00			Henke et al.	Kolb et al.			
10:00 - 10:15			Safaierad et al.	Pierre Antoine Loess-Palaeosol-Sequences	Terraza et al.		
10:15 - 10:30			COFFEE BREAK		Offermann et al.		
10:30 - 10:45				COFFEE BREAK	COFFEE BREAK		
10:45 - 11:00			Ghafari pour et al.				
11:00 - 11:15			Vinnepand et al.	Dominik Fleitmann Speleothem Records	Bungenstock et al.		
11:15 - 11:30			Sauer et al.		Bruns et al.		
11:30 - 11:45			Lünsdorf et al.	Achim Brauer Lake and Peat Records	Hepp et al.		
11:45 - 12:00			Fischer et al.		Pfaff et al.		
12:00 - 12:15	Kaiserstuhl on foot	Central Black Forest	ONE MINUTE POSTER PITCHES	Patrick Ludwig Climate Modelling	Hardt	Southern Black Forest	Southern Upper Rhine Graben
12:15 - 12:30					Rother et al.		
12:30 - 12:45					Closing		
12:45 - 13:00							
13:00 - 13:15							
13:15 - 13:30							
13:30 - 13:45				Introduction	EARLY CAREER RESEARCHERS WORKSHOP Meet the Editor (lunch included)		
13:45 - 14:00			General Assembly (Packet lunch included)				
14:00 - 14:15			POSTERS	Outbreak Rooms			
14:15 - 14:30							
14:30 - 14:45							
14:45 - 15:00		COFFEE BREAK	COFFEE BREAK				
15:00 - 15:15							
15:15 - 15:30		POSTERS	Presentations Discussion Synthesis	GUIDED CITY TOUR From a geoscientific perspective			
15:30 - 15:45							
15:45 - 16:00		Hess et al.					
16:00 - 16:15		Zeeden et al.					
16:15 - 16:30		Rixhon					
16:30 - 16:45		Gegg et al.					
16:45 - 17:00							
From 18:00	ICE BREAKER		WINE TASTING	CONFERENCE DINNER			

EXCURSIONS OFFICIAL-DEUQUA-EVENTS SOCIAL EVENTS ORAL CONTRIBUTIONS POSTERS WORKSHOP I WORKSHOP II

1.2 Detailed programme

Monday, 28 September

9:00 – 17:00	Pre-conference field trips	
9:00 – 18:00	Field Trip I: Kaiserstuhl	Field Trip II: Central Black Forest
From 18:00	Ice Breaker	

Tuesday, 29 September

8:30 – 8:45	Welcome Message
8:45 – 10:15	Oral presentations
8:45 – 9:00	Leonie Leitgeb et al. – A 6000-year reconstruction of flood and debris-flow activity based on the sedimentary archive of Lake Heiterwang (Northern Calcareous Alps, Austria)
9:00 – 9:15	Christoph Kettler & Esther Hintersberger – Establishing the Austrian General Geological Legend (EAGLe) from a Quaternary perspective

9:15 – 9:30	Andrea Hampel & Ralf Hetzel – Deglaciation of the Klagenfurt Basin (Austria) after the Last Glacial Maximum: constraints from ^{10}Be exposure dating and implications for the Lateglacial history of the southeastern Alps
9:30 – 9:45	Felix Martin Hofmann et al. – Chronology of the last deglaciation of the central Black Forest, south-western Germany, inferred from ^{10}Be exposure dating of moraine boulders
9:45 – 10:00	Yamuna Henke et al. – Late glacial and Holocene environmental history of the High Atlas Mountains in Morocco: the ostracod record from Lake Tislit
10:00 – 10:15	Reza Safaierad et al. – Abrupt hydroclimatic shock and the collapse of an early urban system in Bronze Age Iran
10:15 – 10:45	Coffee Break
10:45 – 12:30	Oral presentations
10:45 – 11:00	Amin Ghafarpour et al. – Magnetic Enhancement and Depletion in Northern Iranian Loess–Paleosol Sequences: Implications for Pedogenic Iron Oxide Transformation Pathways
11:00 – 11:15	Mathias Vinnepand et al. – Loess-Palaeosol-Sequences in Southern Baden – Towards a one million years record of environmental change at the Atlantic-Mediterranean climate system interface
11:15 – 11:30	Daniela Sauer et al. – New findings from the Baix loess profile (Rhône Rift Valley, southern France) in the climatic transition zone between Central and Southern Europe
11:30 – 11:45	Nils Keno Lünsdorf et al. – “Grand Solar Minima” in minimal grain size: Can we see solar induced paleoclimate variability in heavy mineral proxies of Loess-Paleosol-Sequences?
11:45 – 12:00	Peter Fischer et al. – The Upper Pleistocene Loess-Palaeosol-Sequence at the Schwalbenberg key-site: A high-resolution age-depth model compared with Arctic and Antarctic isotope records
12:00 – 12:30	One-minute poster pitches
12:30 – 14:00	DEUQUA General Assembly
14:00 – 16:00	Posters and Coffee Break
16:00 – 17:00	Oral presentations
16:00 – 16:15	Katharina Hess et al. – Storms and tsunamis on the edge of Europe: A Holocene lacustrine sediment record from the Shetland Islands
16:15 – 16:30	Christian Zeeden et al. – Loess magnetic properties as quantitative climate proxies? Exploring data from Europe
16:30 – 16:45	Gilles Rixhon – Quaternary river incision dynamics in the Rhenish/Ardenne Massif: Evidence for diachronous landscape evolution
16:45 – 17:00	Lukas Gegg et al. – Drilling Overdeepened Alpine Valleys: a synthesis of Phase 1
From 18:00	Wine tasting

Wednesday, 30 September

9:00 – 10:30	Workshop I: Environmental Records and Landscape Change
9:00 – 9:30	Welcome and Introduction
9:30 – 10:00	Melaine le Roy. – Glacial Records

10:00 – 10:30	Pierre Antoine. – Loess-Palaeosol-Sequences
10:30 – 11:00	Coffee Break
10:30 – 12:30	Workshop I: Environmental Records and Landscape Change
11:00 – 11:30	Dominik Fleitmann. – Speleothem Records
11:30 – 12:00	Achim Brauer. – Lake and Peat Records
12:00 – 12:30	Patrick Ludwig. – Climate modelling
12:30 – 13:30	Lunch Break
13:30 – 14:45	Workshop I: Environmental Records and Landscape Change
13:30 – 13:45	Introduction
13:45 – 14:45	Outbreak Rooms
14:45 – 15:15	Coffee Break
15:15 – 17:00	Workshop I: Environmental Records and Landscape Change
15:15 – 17:00	Presentations, discussion, and synthesis
From 18:00	Conference Dinner

Thursday, 1 October

9:00 – 10:30	Oral presentations
9:00 – 9:15	Jens Jouaux et al. – Late Glacial and Holocene fluvial geomorphodynamics and planform change at the Weser River, northwestern Germany
9:15 – 9:30	Bastian Grimm et al. – Constraining Late Holocene alluvial sediment dynamics through improved chronologies: The Wiesent River Catchment (Franconia, Germany)
9:30 – 9:45	Nico Rogalski et al. – One terrace, many ages? Rethinking Pleistocene river terrace formation between synchronism and diachronism – the Regnitz catchment (Upper Franconia, Germany) as a test case
9:45 – 10:00	Thomas Kolb et al. – How many ages does a terrace need? High-resolution luminescence dating and the complexity of river terrace formation in the Guadix-Baza Basin (SE Spain)
10:00 – 10:15	Monica Terraza et al. – Accelerated uplift of the Rhenish Massif (central Europe) since 700–800 ka revealed by isochron-burial dating of strath terraces
10:15 – 10:30	Martin Offermann et al. – Eco-morphological changes and potential salmon habitat suitability since pre-industrial times in the Mulde river system (Germany)
10:30 – 11:00	Coffee break
11:00 – 12:30	Oral presentations
11:00 – 11:15	Friederike Bungenstock et al. - Rising sea level and palaeo coast in North Frisia - research on the cultural landscape development in the Wadden Sea region during the Common Era
11:15 – 11:30	Ines Bruns et al. – Tracing Prehistoric Storm Surges in Northwest-Germany: Evidence from Holocene coastal sediments
11:30 – 11:45	Daniel Hepp et al. – Submerged Early to Middle Holocene Coastal Landscapes in the Wismar Bay, Baltic Sea

11:45 – 12:00	Maximilian Pfaff et al. – Depth of a potential repository with regard to the influence of subglacial overdeepenings and tunnel valleys in the representative preliminary safety assessments
12:00 – 12:15	Jacob Hardt – Ice sheet induced salt tectonics in northern Germany
12:15 – 12:30	Henrik Rother et al. – Die Forschungsbohrungen Concordia-See und Königsau im nordöstlichen Harzvorland (Sachsen-Anhalt): Neue Multiproxy-Analysen zur detaillierten Gliederung der Weichsel-Kaltzeit in Mitteldeutschland
From 12:30	Closing
13:00 – 14:30	Coffee break
15:00 – 17:00	Guided City Tour from a geoscientific perspective

Friday, 2 October

9:00 – 17:00	Post-conference field trips	
9:00 – 17:00	Field Trip III: southern Black Forest	Field trip IV: southern Upper Rhine Graben

1.3 Field trips

1.3.1 Pre-conference field trip: Kaiserstuhl on foot

Field trip leaders: Lukas Gegg & Mathias Vinnepand

For this excursion, we will take an early-morning S-Bahn from Freiburg station to Sasbach, and then depart on an ~8-km-long hike. Along the way, we will discuss the origin of the Upper Rhine Graben, of Kaiserstuhl volcano and its smaller neighbour Limberg, and their Quaternary evolution through natural and anthropogenic processes. Before returning back to Sasbach, there will be an opportunity for lunch in a riverside Biergarten just below the ruins of Limburg castle. We will then continue on by public transport to the village of Riegel, where we will take a short walk (~2.5 km return) to its famous more than 35 m high loess wall. The outcrop comprises up to five interglacial soils, and loess sediments covering most of the last million years (presence of the Matuyama-Brunhes Boundary (~780 ka) and tephrochronological evidence) at the interface of the Atlantic and Mediterranean climate systems. After this final excursion point, we will return back to Freiburg.



1.3.2 Pre-conference field trip: Central Black Forest

Field trip leaders: Felix Martin Hofmann & Jan Blöthe

The central part of the Black Forest was only locally covered by cirque glaciers during the last glaciation. However, there has been very limited research carried out on this region so far, even though remnants of these glaciations are important evidence of past environmental conditions and atmospheric circulation patterns. A second topic of interest in this area is the change in fluvial dynamics, from a braided pattern during glacial times, to single streams with floodplains that became consecutively more influenced by humans. New evidence from both fields will be presented and discussed.



1.3.3 Freiburg City Tour from a geoscientific perspective

Field trip leader: Wolfgang Werner

This excursion will lead you through the beautiful "old" town of Freiburg with its famous "Bächle" which distribute parts of the waters of the Dreisam River across the city. It is hard to believe that many of the historically-looking buildings have been re-built after the second world war (bombed by both German and Allied forces). However, the city centre of Freiburg preserved some nice examples of stone masonry that will be presented during a tour with emphasis on building stones. A particular focus will be on the history and materials used to build the Freiburg cathedral (Münster).



1.3.4 Post-conference field trip: southern Black Forest

Field trip leader: Felix Martin Hofmann

The region around the Feldberg mountain is one of the first where traces of past glaciations have been described in the early 19th century. The most common theory has been that an ice cap rested on top of the highest summit of the Black Forest from which outlet glaciers departed into all directions. Since 2018, the region was systematically geomorphologically mapped, and a chronology was established through the application of modern methods (cosmogenic nuclides, luminescence and radiocarbon dating). Key results will be presented during the field trip.



1.3.5 Post-conference field trip: southern Upper Rhine Graben

Field trip leaders: Frank Preusser & Lukas Gegg

This excursion will focus on the Quaternary sediment dynamics in the southern Upper Rhine Graben in response to Alpine glaciations. In the morning, we will depart by minibus towards the ice margin of the most extensive Alpine glaciation, just outside of the graben in the border region with Switzerland. From there, we follow the sediments' pathway back north, discussing new results on the region's (glacio-) fluvial and aeolian deposits, the interactions between them, and the impacts of climatic and tectonic processes. Stops include the Isteiner Schwellen, where the Rhine has cut down to Jurassic limestone, the Lower Terrace escarpment at Neuenburg, and the Bad Krozingen area, where meltwater gravels and loess interfinger at the graben margin. The excursion is expected to end at around 6 PM.



2 Abstracts

2.1 List of abstracts in alphabetical order

2.1.1 Keynote presentations

Page	Author(s)	Title	Type of contribution
27	Pierre Antoine, Olivier Moine, Christine Hatté, Charlotte Prud'homme	Permafrost Dynamics and Dansgaard-Oeschger (D-O) Cycles in Last Glacial Loess sequences from Western Europe	Keynote
28	Achim Brauer	Lake and peat records	Keynote
29	Dominik Fleitmann	Speleothems at the interface of the Earth System Spheres	Keynote
30	Melaine Le Roy, Irene Schimmelpfennig, Philip Deline, Laurent Astrade, Cécile Miramont, Marie-Edmée Torcheboeuf, Anaïs Fichot, Théo Armando, Philippe Schoeneich, Myette Guimar, Edouard Bard, ASTER Team	The Lateglacial glacier history of the southern French Alps	Keynote
31	Patrick Ludwig	Regional Climate Modelling: Added Value, Challenges, and Perspectives for Understanding Past Climate Variability	Keynote

2.1.2 Oral presentations

Page	Author(s)	Title	Type of contribution
35	Ines Bruns, Friederike Bungenstock, Martina Karle, Steffen Wolters, Felix Bittmann	Tracing Prehistoric Storm Surges in Northwest-Germany: Evidence from Holocene coastal sediments	Oral
36	Friederike Bungenstock, Juliane Scheder, Hanna Hadler	Rising sea level and palaeo coast in North Frisia - research on the cultural landscape development in the Wadden Sea region during the Common Era	Oral
37	Peter Fischer, Charlotte Prud'homme, Andreas Vött, Olaf Jöris	The Upper Pleistocene Loess-Palaeosol-Sequence at the Schwalbenberg key-site: A high-resolution age-depth model compared with Arctic and Antarctic isotope records	Oral
38	Lukas Gegg, Flavio S. Anselmetti, Markus Fiebig, Gerald Gabriel, Frank Preusser, The ICDP DOVE Scientific Team	Drilling Overdeepened Alpine Valleys: a synthesis of Phase 1	Oral
39	Amin Ghafarpour, Ramon Egli, Erwin Appel, Dario Bilardello, Simo Spassov, Tobias Lauer, Farhad Khormali Amin, Hossein Tazikeh, Madelaine Böhme, Kathryn Fitzsimmons	Magnetic Enhancement and Depletion in Northern Iranian Loess–Paleosol Sequences: Implications for Pedogenic Iron Oxide Transformation Pathways	Oral
40	Bastian Grimm, Christian Zeeden, Alexander Voigt, Andreas Dix, Rainer Schreg, Thomas Kolb, Markus Fuchs	Constraining Late Holocene alluvial sediment dynamics through improved chronologies: The Wiesent River Catchment (Bavaria, Germany)	Oral
41	Andrea Hampel, Ralf Hetzel	Deglaciation of the Klagenfurt Basin (Austria) after the Last Glacial Maximum: constraints from ^{10}Be exposure dating and implications for the Lateglacial history of the southeastern Alps	Oral
42	Jacob Hardt	Ice sheet induced salt tectonics in northern Germany	Oral
43	Yamuna Henke, Laura Bergmann, Katharina Methner, Tobias Lauer, Rik Tjallingii, Abdeslam Mikdad, Abdelfattah Benkaddour, Sylvain Pichat, William J. Fletcher, Steffen Mischke, Christoph Zielhofer	Late glacial and Holocene environmental history of the High Atlas Mountains in Morocco: the ostracod record from Lake Tislit	Oral

Page	Author(s)	Title	Type of contribution
44	Daniel A. Hepp, Agata Feldens, Svea Mahlstedt	Submerged Early to Middle Holocene Coastal Landscapes in the Wismar Bay, Baltic Sea	Oral
45	Katharina Hess, Stephen Roberts, Tim Niederhüfner, Neil Bogs, Sophie Watzelt, Andreas Koutsodendris, Sue Dawson, Max Engel	Storms and tsunamis on the edge of Europe: A Holocene lacustrine sediment record from the Shetland Islands	Oral
46	Felix Martin Hofmann, Silke Merchel, Martin Martschini, Carlos Vivo-Vilches	Chronology of the last deglaciation of the central Black Forest, southwestern Germany, inferred from ^{10}Be exposure dating of moraine boulders	Oral
47	Jens Jouaux, Moritz Nykamp, Pavel E. Tarasov, Markus C. Blaich, Wiebke Bebermeier	Late Glacial and Holocene fluvial geomorphodynamics and planform change at the Weser River, northwestern Germany	Oral
48	Christoph Kettler, Esther Hintersberger	Establishing the Austrian General Geological Legend (EAGLe) from a Quaternary perspective	Oral
49	Thomas Kolb, Laura Kögler, Daniel Wolf, Markus Fuchs, Francisco Juan Garcia-Tortosa, Andrea Schröder-Ritzrau, Dominik Faust	How many ages does a terrace need? High-resolution luminescence dating and the complexity of river terrace formation in the Guadix-Baza Basin (SE Spain)	Oral
50	Leonie Leitgeb, Lena Holler, Patrick Oswald, Michael Strasser, Jasper Moernaut, The ALPHA project team	A 6000-year reconstruction of flood and debris-flow activity based on the sedimentary archive of Lake Heiterwang (Northern Calcareous Alps, Austria)	Oral
51	Nils Keno Lünsdorf, Marie-Christin Speck, Olivier Moine, Pierre Antoine, Markus Fuchs, Frank Lehmkuhl	"Grand Solar Minima" in minimal grain size: Can we see solar induced paleoclimate variability in heavy mineral proxies of Loess-Paleosol-Sequences?	Oral
52	Martin Offermann, Michael Hein, Ronja Hegemann, Kay Gödecke, Lucas Hegner, Yamuna Henke, Nele Schäfer, Hanna Shelukhina, Erik Liebscher, Severin Opel, Johannes Rabiger-Völlmer, Lukas Werther, Christoph Zielhofer	Eco-morphological changes and potential salmon habitat suitability since pre-industrial times in the Mulde river system (Germany)	Oral

Page	Author(s)	Title	Type of contribution
53	Maximilian Pfaff, Tobias Wengorsch, Yvonne Messerschmidt, Paulina Müller, Anne Bartetzko, Nadine Schöner	Depth of a potential repository with regard to the influence of subglacial overdeepenings and tunnel valleys in the representative preliminary safety assessments	Oral
54	Gilles Rixhon	Quaternary river incision dynamics in the Rhenish/Ardenne Massif: Evidence for diachronous landscape evolution	Oral
55	Nico Rogalski, Markus Fuchs, Thomas Kolb	One terrace, many ages? Rethinking Pleistocene river terrace formation between synchronism and diachronism – the Regnitz catchment (Upper Franconia, Germany) as a test case	Oral
56	Henrik Rother, Elisabeth Endtmann, Peter Fischer, Peter Frenzel, Ivo Rappsilber, Sumiko Tsukamoto, Andreas Vött, Stefan Wansa	Die Forschungsbohrungen Concordia-See und Königsau im nordöstlichen Harzvorland (Sachsen-Anhalt): Neue Multiproxy-Analysen zur detaillierten Gliederung der Weichsel-Kaltzeit in Mitteldeutschland	Oral
58	Reza Safaierad, Enno Schefuß, Harvey Weiss, Bernd Zolitschka, Yusuke Yokoyama, Christoph Vogt, Nathalie Fagel, Martin Kehl, Mahyar Mohtadi	Abrupt hydroclimatic shock and the collapse of an early urban system in Bronze Age Iran	Oral
59	Daniela Sauer, Nora Pfaffner, Annette Kadereit, Theo Kind, Lyudmila Shumilovskikh, Volker Karius, Thomas Kolb, Sebastian Kreutzer	New findings from the Baix loess profile (Rhône Rift Valley, southern France) in the climatic transition zone between Central and Southern Europe	Oral
60	Monica Terraza, Reinhard Wolff, Ralf Hetzel, Benedikt Ritter-Prinz, Steven A. Binnie, Johannes Preuss, Christian Hoselmann, Michael Weidenfeller, Stefan Heinze	Accelerated uplift of the Rhenish Massif (central Europe) since 700–800 ka revealed by isochron-burial dating of strath terraces	Oral
61	Mathias Vinnepand, Felix Martin Hofmann, Lukas Gegg, Alexander Fülling, Frank Preusser	Loess-Palaeosol-Sequences at the Kaiserstuhl – Towards a million years record at the interface of the Atlantic and Mediterranean climate systems	Oral
62	Christian Zeeden, Kamila Ryzner, Mathias Vinnepand, Milica Bosnić, Hannah Müssener, Mathieu Martinez, Zaniar Amiri, Mohammad Paknia	Loess magnetic properties as quantitative climate proxies? Exploring data from Europe	Oral

2.1.3 Poster presentations

Page	Author(s)	Title	Type of contribution
65	Kristine Asch	Towards Improved Harmonization: A Hands-On Cross-Border Review of the International Quaternary Map of Europe and Adjacent Areas (1:2,5M) in Southern Germany and Neighbouring Regions	Poster
66	Margot Böse, Robert Hebenstreit, Jacob Hardt	Late Quaternary shift of the geomorphological-altitudinal zonation in Taiwan	Poster
67	Anna Brisset, Sylvain Pichat, Laura Bergmann, William Fletcher, Abdelfattah Benkaddour, Steffen Mischke, Birgit Schneider, Christoph Zielhofer	Reconstruction of wind circulations over the North African margin since the last deglaciation	Poster
68	Gabriel Fénisse, Pierre-Henri Blard, David Vincent Bekaert, Aurélien Quiquet	Reconstructing the evolution of European paleoclimates since the Last Glacial Maximum: implications for future continental climate change	Poster
69	Anna-Lena Geis, Thomas Kolb, Christoph Schmidt, Markus Fuchs	Assessing the variability of K-feldspar luminescence signal characteristics from recent high-energy flood deposits	Poster
70	Gerit E. U. Griesmeier, Andreas Hausenberger, Cosmin Nacu, Sandra Braumann, Stephanie Neuhuber, Daniel P. Le Heron, Jürgen M Reitner	Weathering properties derived from freeze-thaw experiments on different lithologies used in ¹⁰ Be exposure dating in the Eastern Alps	Poster
72	Hartmut Heinrich, Gerrit Lohmann	A conceptual framework linking Heinrich events and Dansgaard-Oeschger cycles	Poster
73	Marie Felice Henkel, Jacob Hardt	Reconstruction of a periglacial river system in Brandenburg in consideration of glacially induced halotectonic deformation structures	Poster
74	Jerome Houssier, Laurent Schmitt, Serge Dumont	The Upper Rhine alluvial plain as a palimpsest: Evidence from a multi-scale LiDAR DEM analysis (Grand Ried, France)	Poster
75	Olaf Jöris, Tobias Lauer, Felix Bittmann, Bernd Zollitschka, Tina Georg, Andreas Vött, Peter Fischer	A late Middle Pleistocene sequence from a collapsed volcanic crater in the Kärlich open quarry, Central Rhineland, Germany	Poster

Page	Author(s)	Title	Type of contribution
76	Olaf Jöris, Melanie Kranz-Bartz, Gilles Rixhon, Debra Colarossi, Geoff Duller, Helen Roberts, Dustin White, Bernd Zollitschka, Peter Fischer	Revision of the Early and early Middle Pleistocene chronostratigraphic record in the Kärlich open quarry, Central Rhineland, Germany	Poster
78	Elena Jung, Michael Kraml, Alexander Fülling, Moritz Maubach, Frank Preusser, Christina Wehrle, Lukas Gegg	Plio-Pleistocene sedimentary history of the western Upper Rhine Graben: Insights from drill cores near Landau	Poster
79	Martin Kehl, Reza Safaierad	Holocene paleoenvironmental changes in the Iranian Highlands: evidence from wetland sediment sequences	Poster
80	Carolin Kiefer, Leonie Leitgeb, Liliana Gaspar, Laura Schley, Jasper Moernaut, Christoph Mayr, Arne Ramisch, Michael Strasser, Michael Krautblatter	ALPHA „Deciphering ALPine HAZard frequencies by amphibious investigation of Holocene lake inventories“	Poster
81	Kay Krienke, Frank Preusser	Neue Befunde zur marinen Austernbank der Holstein-Warmzeit in der subglazialen Bornhöveder Rinne (Schleswig-Holstein)	Poster
82	Jörg Lang, Sonja Breuer, Andrea Hampel, Vera Noack	Pleistocene salt movement in the North German Basin – related to ice-sheet loading or continuation of the Cenozoic trend?	Poster
83	Melaine Le Roy, Laurent Astrade, Irene Schimmelpfennig, Philip Deline, Cécile Miramont, Marie-Edmée Torcheboeuf, Anaïs Fichot, Théo Armando, Myette Guiomar, ASTER Team (Georges Aumaître, Karim Keddadouche, Fawzi Zaïdi)	Cosmogenic nuclide dating of the Lateglacial glacier history of two contrasting southern French Alps massifs : Les Monges and La Blanche	Poster
84	Yunyi Li, Sakonvan Chawchai, Savanna Kager, Smith Leknettip, Margarita Nuss, Hongshuai Qi, Kannika Wangritthikraikul, Frank Preusser	Analyzing the Sea Level Highstand during the Holocene in the Chanthaburi Plain, Thailand	Poster
85	Josefa Selina Loreth, Olaf Jöris, Felix Bittmann, Bernd Zollitschka, Andreas Vött, Peter Fischer	A multi-proxy study of late Middle Pleistocene crater lake deposits in the Kärlich open quarry, Central Rhineland, Germany	Poster

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86	Marco Nieslony, Cristina Ioana-Balaban, David Krause, Zbyněk Engel, Marek Křížek, Julien Seguinot, Harry Zekollari, Martin Margold	Pleistocene mountain glaciation in central Europe: extents, chronology, and landscape modification	Poster
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91	Peyman Parvizi, Alice Paine, Frederick Held, Alistair Morgan, Sebastian Stumpf, Yugandhar Nighojkar, Christoph Raible, Morteza Djamali, Thomas Pettke, Diary Al Mohammed Al-Manmi, Karen Radner, Mark Altaweel, Hai Cheng, Dominik Fleitmann	Holocene hydroclimate variability recorded in speleothems from Kuna Ba Cave in Northern Iraq	Poster
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93	Maximilian Prochnow, Lisa Danius, Anthony Romano, Michael-Shawn Fletcher	Biomarker δD analyses reveal the impact of the southern Westerlies on Western Tasmania's hydrology	Poster
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96	Philipp Stojakowits, Kerstin Pasda, Christoph Mayr, Gertrud E. Rössner, Christoph Steinmann, Lilian Reiss, Ronny Friedrich, Charalampos Kevrekidis, Susanne Lindauer, Peter Lutz, Andreas Maier, Wilfried Rosendahl, Thorsten Uthmeier, Bernd Zolitschka	A partial mammoth skeleton from the Danube valley (southern Bavaria, Germany) provides evidences of human activity from a harsh periglacial palaeoenvironment	Poster
98	C. Wangenheim, J. Meinsen, M. Helms, S. Sattler, J. Rudmann, R. Schöner	Komplexer als zuvor bekannt – subglaziale Rinnen im 3D-Modell der Quartärbasis Nordwest-Niedersachsens	Poster
99	Michael Zech, Tim Thiele, Paul Burda, Marika Stutzriemer, Bastian Grimm, Markus Fuchs	First alkane biomarker results from Late Holocene alluvial sediments of the Wiesent River Catchment (Bavaria, Germany)	Poster
100	Christoph Zielhofer, Johannes Rabiger-Völlmer, Henriette Westermann, Markus Lothar Fischer, Birgit Schneider, Susanne Lindauer, Azra Khosravichenar, Martin Bauch, Marco Pohle, Ulrike Werban	Fluvial deposits of the Ahr river (western Germany) reveal recurring high-magnitude flood events over the last 1500 years	Poster

2.2 Abstracts

2.2.1 Keynote presentations

Permafrost Dynamics and Dansgaard-Oeschger (D-O) Cycles in Last Glacial Loess sequences from Western Europe

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The NW European loess belt is the largest continental archive of the Last glacial period in Europe. The large periglacial plains of this area (≤ 200 m.a.s.l.), influenced by westerly winds and bounded to the north by the British and Fennoscandian ice sheets and to the south by the Alpine ice cap, were ideally situated to record the impact of millennial climate variations (Dansgaard-Oeschger cycles and changes in ocean circulation (Heinrich events) during the Weichselian Pleniglacial (70 to 15 ka). Numerous evidences of periglacial processes associated with ice-rich permafrost, such as extensive networks of large ice-wedges, cryoturbation horizons and thermokarst erosion gullies, appear in the loess sequences and can be traced at least from northern France to Poland via western Germany. In these sequences a succession of more or less cryoturbated 20 to 50 cm thick tundra gley horizons (Gelic Gleysols), attests to short events of development and deepening of the active layer of the permafrost. The high-resolution sedimentological and malacological studies, combined with ^{14}C dating of earthworm calcite granules, which are particularly abundant in these horizons, shows that the response of loess environments to the Dansgaard-Oeschger cycles is recorded as a succession of loess-paleosol cycles corresponding to an equal number of stage-interstage cycles between approximately 50 and 20 ka. Dating these horizons (mostly tundra gley) and correlating them with reference climate records also demonstrates the existence of several generations of large (>10 m) polygonal ice wedge networks that developed and degraded during short-term events (≤ 1 ka). These structures are typical of specific palaeoclimatic conditions which remain to be defined within the framework of a modelling approach involving the extent of the ice sheet, sea ice, atmospheric circulation and temperature reconstructions. This research also enables us to describe how continental glacial environments responded to past millennial climate variations over long distances, providing a solid database for studying the relationships between hunter-gatherer populations and the environment during the last glacial period. Finally, it is also proposed that the deep incisions resulting from thermokarst erosion gullies (approximately 20×5 m) have favoured major landscape rejuvenation, promoting the outcropping of high-quality flint nodules for the Palaeolithic stone industry.

Lake and peat records

Achim Brauer

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Lake and peat bogs are sediment traps in landscapes which contain continuous records of climate and environmental change. Located in the human habitat, these records integrate information from both, natural climate and environment change as well as past human activity. Disentangling between these different influences is challenging but this offers great potential for investigating human-climate- environment interactions. Another common feature of many lake sediment records is a decadal down to seasonal resolution which enables reconstructions of changes that have occurred with a human lifetime. This presentation will mainly focus on lake sediments although much of the information is also valid for peatlands. Following an introduction about different lake types and their potential life times, a brief overview will be given about geochemical and biological proxies and how knowledge of sedimentary structures can support their interpretation. A major challenge for investigating lake records is the transfer of environmental, climatic and human signals into the sediment record. Since sediment deposition in lakes is influenced by both local and regional factors proxy interpretation requires profound knowledge of sediment facies and related sedimentation processes. Such knowledge can be gained, for example, through lake monitoring of which an example will be given. Further, some examples of different lake sediment facies will be presented and their potential for environmental reconstruction discussed. A particular challenge for interpreting lake records is the potential lack of stationarity of proxy signals over longer time spans because site-specific depositional processes may fundamentally change. Finally, a brief overview about the most common dating methods including radiometric and incremental methods will be given. A focus will be on approaches and methods of synchronising lake records with other lake records as well as other geological archives. Precise synchronisation of records is essential for investigating regional differences in proxy responses to climate and environment. In short, this presentation aims at stimulating discussions about the potential and challenges of lake sediment research for palaeoenvironmental reconstruction.

Speleothems at the interface of the Earth System Spheres

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Understanding the complex interactions among the atmosphere, biosphere, cryosphere, geosphere and hydrosphere over time and space is a fundamental aspect of Quaternary science. Such information can be gained from speleothems, such as stalagmites and flowstones. Over the past three decades, speleothems (e.g., stalagmites and flowstones) have emerged as an important archive of terrestrial climate information. A particular strength of speleothems is their potential to produce continuous and precisely dated records spanning several hundred thousand years at a high-resolution. The chronology of speleothem records is commonly based on Uranium-Thorium and Uranium-lead dating, allowing us to date speleothems back to several million years with very small chronological uncertainties. Furthermore, climatic and environmental data can be gained through a variety of chemical, physical and biological parameters, such as calcite oxygen and carbon isotope ratios, stable water isotopes in fluid inclusions, trace elements, growth layers, calcite textures and organic matter. This extensive array of proxies provides detailed records of temperature and precipitation, extreme events (e.g., flooding; earthquakes), vegetation, glacial activity, soil development, volcanic activity and landscape evolution, thereby enhancing our understanding of interactions of the various spheres of our Earth system. Based on several speleothem-based reconstructions from Europe, I demonstrate how speleothem records can be integrated with other climatic and environmental archives and climate models to enhance our understanding of the complex interdependencies between the spheres during the Quaternary period.

The Lateglacial glacier history of the southern French Alps

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In the French Alps, the deglaciation history was first studied at the large valley glacier complex of the northern Alps (e.g. the Arve Valley) where former compound glacier tongues and post-depositional reworking of moraines located at low elevation both complicate the precise reconstruction of palaeoglacier geometries and the dating of glacial landforms. In contrast, the Lateglacial history of the southern Alps has been largely overlooked, and no large-scale dating program had been conducted until now. However, studying the small ice masses prevailing in this region during the Lateglacial allows for a partial overcoming of above limitations.

Here, we report on several geochronologies (¹⁰Be, ³⁶Cl) obtained at different massifs (Ecrins, Ubaye, Digne Prealps, Upper Verdon). Overall, our results show (1) an advance likely correlative to the Heinrich Stadial 1, (2) a pre-Bølling-Allerød (B-A) advance dated to ca 15.4 ka, (3) an intra-B-A advance dated to ca 14.2 ka, (4) a rapid retreat during the Allerød with positions at 13.3 ka that were not reached again during the YD, (5) multiple Younger Dryas (YD) advances dated at a single site (Ecrins) and a prealpine massif still marginally glaciated during the YD (Monges, 2,115 m a.s.l), contrary to what was previously thought.

In addition to well-preserved glacial landforms, one of the distinctive features of this region is the numerous deposits of subfossil wood in alluvial contexts, the oldest of which date back to the B-A. It has recently been found in these tree ring records that a solar minimum corresponding to the Older Dryas (a short cold spell punctuating the B-A at ca 14 ka) may have caused a cold period contemporaneous with one of the glacial advances dated here by TCN. Integration of different types of records (glacial, tree-ring and lake-sediment) holds great promise for refining the Lateglacial chronology in the region.

Regional Climate Modelling: Added Value, Challenges, and Perspectives for Understanding Past Climate Variability

Patrick Ludwig

Karlsruhe Institute of Technology

Earth's climate exhibits variability across a wide range of temporal and spatial scales, ranging from annual to millennial timescales and from local to global scales. Past climate states often differed substantially from the present, and evidence of these changes is preserved in a variety of proxy archives. While proxy records provide valuable information on past climate variability, they are often limited in their ability to reveal the underlying processes and feedback mechanisms in the Earth system. Here, fully coupled global climate models (GCMs) offer an important complementary perspective by enabling a process-based understanding of climate variability and by serving as virtual laboratories in which hypotheses regarding climate dynamics and feedbacks can be tested.

However, GCMs, including those used in PMIP4 experiments, typically operate at relatively coarse spatial resolutions (100–200 km), limiting their ability to represent regional- to local-scale climate processes. Regional climate models (RCMs) provide a powerful tool to bridge this scale gap between the large-scale climate simulations and the partly spatially heterogeneous signals recorded in proxy archives. Through dynamical downscaling, RCMs can simulate selected regions at much higher resolutions (typically ~10–50 km), thereby resolving processes that are critical for regional climate variability while retaining the large-scale circulation patterns imposed by the driving GCMs.

This contribution highlights the added value of regional climate modelling for investigating past climate variability, with a particular focus on the Last Glacial Maximum (LGM). Several case studies are presented to illustrate how high-resolution simulations improve our understanding of climate processes and land–atmosphere interactions. Topics include regional circulation changes over Europe along with their implications for the glacial dust cycle, the spatial distribution of permafrost across western Europe, and the influence of changing lake levels on regional hydroclimate in the Caspian Sea region. Together, these examples demonstrate how regional climate modelling can connect proxy evidence with climate-system dynamics, providing deeper insights into the mechanisms governing past climate variability and environmental change.

2.2.2 Oral presentations

Tracing Prehistoric Storm Surges in Northwest-Germany: Evidence from Holocene coastal sediments

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Lower Saxony Institute for Historical Coastal Research

The rising sea level has shaped the northwestern German coast since the beginning of the Holocene and peats are prevalent within the sediment succession. Basal peats and several intercalated peat layers can occur, reflecting repeated transgressive and regressive phases associated with non-synchronous coastline migration, erosion and re-deposition. In addition to long-term sea-level rise, extreme events such as storm surges played a major role in the evolution of the palaeo-coastal landscape and must be considered to achieve a more comprehensive understanding of regional landscape development.

In contrast to the modern coastline, the prehistoric coast lacked dikes and other coastal protection structures. Prehistoric storm surges therefore had substantially different impacts on the coastal environment than those observed today. This raises several key questions: (i) to what extent did storm surges inundate the un-diked coast, (ii) were certain regions particularly vulnerable to erosion, and if so, (iii) which geological preconditions controlled this vulnerability?

Within the framework of the interdisciplinary project CoastAdapt we focus on centimetre-thick fine-grained, clastic layers found within Holocene peat horizons ("Klappklei") to better understand the effects of storm surges on the un-diked coast. These deposits formed during extreme high-water events and therefore represent valuable indicators of past storm surge activity. Although Klappklei deposits have long been recognised along the northwest German coast, they have not yet been systematically mapped or analysed.

Here, we present a reconstruction of the spatial distribution of Klappklei deposits across different time intervals along the northwestern German coast, based on legacy borehole data, existing palaeo-landscape maps and updated sea-level reconstructions. In addition, we present a case study from the East Frisian coast, where new borehole data and geochronological analyses by means of palynological analyses and radiocarbon ages are used to correlate individual Klappklei layers.

Rising sea level and palaeo coast in North Frisia - research on the cultural landscape development in the Wadden Sea region during the Common Era

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Starting in 2026, the Research Unit **FOR 5837: Times of Rise and Failure (TORF) – Integrative research on the cultural landscape development in the North Frisian Wadden Sea region during the Common Era** aims for the systematic multidisciplinary investigation and spatio-temporal reconstruction of the medieval coastal landscape of North Frisia (Schleswig-Holstein, Germany), that drowned during a severe storm surge in 1362 AD. Today, abundant relics of the once cultivated land lie hidden in the tidal flats, that are part of the UNESCO World Heritage Site 'Wadden Sea', extending from the Netherlands to Denmark.

In TORF, scientists from archaeology, geophysics, geography, geology, history, molecular biology and geoinformatics join their expertise in an interdisciplinary team, that has formed through intense joint research in the Wadden Sea since 2015 within the course of several research projects.

Despite strong progress in research during the past decade, North Frisia's medieval landscape is far from being fully understood. One important question, still unsolved, concerns the relative sea level (RSL) development as starting point for land reclamation.

Previous RSL reconstructions along the southern North Sea coast are mainly based on the 'classic peat' approach, which has resulted in a data gap for the last 3000 years due to the absence of peat. For this timespan, data is based on upper or lower limiting data and data with high uncertainties, like archaeological evidence. The use of microfauna-based transfer functions represents a powerful tool for addressing this data gap. The application of these transfer functions to Holocene sediment archives results in RSL reconstructions with a decimetre-scale precision. Since its initial application in the British Isles, North America and Denmark, the quality and efficacy of this methodology has been successfully extended and improved. This was achieved by combining modern foraminifers and ostracods for the establishment of a local transfer function in the area of the East Frisian Islands. This approach will be further developed with a particular focus on the TORF study area North Frisia and the medieval period, and on the extension of the dataset for the Sylt-Rømø Basin and East Frisia. The newly derived RSL data will be integrated into the forthcoming glacial isostatic adjustment (GIA) model for the North Sea sector (NKG2022GIA model) in order to quantify the predicted offsets, particularly for the last 1000 to 3000 years along the German North Sea coast. Finally, the gained RSL data will support and improve the palaeo-landscape reconstructions in the study area for integration in the overarching research of TORF.

The Upper Pleistocene Loess-Palaeosol-Sequence at the Schwalbenberg key-site: A high-resolution age-depth model compared with Arctic and Antarctic isotope records

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Global climate forcing and variability over the last glacial period are well documented in both, marine and ice cores.

On the European continent, however, the propagation and impact of such millennial to centennial-scale climate fluctuations are still not fully understood as terrestrial archives are often discontinuous and lack precise and independent age models. Thus, robust correlations with other archives and proxies of regional or global climatic and environmental changes remain challenging. As a consequence, it is often merely assumed that the climatic changes recorded in Greenland ice cores must have propagated more or less directly across the north Atlantic onto the continent. Such assumptions, however, tend to artificially create synchronisms, as they are not suitable to detect potential lags between changing climate signals and environmental impacts.

Against this background, independent and refined age models are required to compare terrestrial with other archives. Loess-Palaeosol-Sequences (LPS) represent outstanding terrestrial archives that record palaeoenvironmental and palaeoclimatic variability across different spatial and temporal scales. Due to their polygenetic character, however, improved understanding of geomorphological, sedimentological and pedogenic processes involved in LPS formation is required to better understand the complex relation to climate change. Here, we focus on the Schwalbenberg LPS located in the Central Rhineland, Germany. This LPS provides one of the most complete terrestrial records covering the Last Glacial Cycle in high temporal resolution. Based on a series of radiocarbon dates obtained from earthworm calcite granules, a detailed age-depth model is presented that covers the period ~ 65–20 cal kBP. This chronostratigraphic model is independent from timescales of other archives that the Schwalbenberg LPS can be opposed to.

Using the established age-depth model allows to compare the temporal evolution of different proxies throughout the Schwalbenberg LPS with Arctic and Antarctic ice core records.

For MIS 3 it becomes apparent that proxies indicative of weathering and pedogenic intensity to a certain degree precede the onset of Greenland Interstadials, whereas during late MIS 3 and towards the Last Glacial Maximum the influence of North Atlantic climate forcing and variability seems to become dominant. We discuss potential driving mechanisms related to LPS formation and climate oscillations leading to the observed differences and similarities between continental LPS and global isotope records.

Drilling Overdeepened Alpine Valleys: a synthesis of Phase 1

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The glaciations of the Pleistocene had severe geomorphic impacts on the mountain regions of the world that include the incision of closed ‘overdeepened’ basins into the glacier bed. In these basins, glacially derived deposits have the chance to be preserved over several glacial cycles, which is otherwise usually not the case. They are therefore the best archives to directly investigate (pre-LGM) glaciations, their timing, associated erosional and depositional processes, and the resulting landscape change.

In the ICDP (International Continental Scientific Drilling Program) project ‘Drilling Overdeepened Alpine Valleys’ (DOVE), we are investigating overdeepened basins and their sedimentary fills all around the (European) Alps. Phase 1 of the project, targeting the northern Alpine fringe and comprising six scientific drillings in Switzerland, Germany, and Austria, is currently nearing completion. Phase 2 will consist of a second set of drillings around the southern and western margins of the mountain range, and complete our pan-Alpine approach.

Here, we present a summary of the results achieved in DOVE Phase 1 including geophysical (primarily seismic, including cross-hole experiments), sedimentological (focusing especially on diamicts and their data-driven interpretation), sequence- (identification of recurring genetic units) and chronostratigraphic (primarily by single-grain luminescence dating) analyses. These have led to significant methodical advances as well as new discoveries regarding the regional Quaternary stratigraphy, the patterns of overdeepened basin formation and infilling, and the magnitude of landscape modification by glaciers.

Magnetic Enhancement and Depletion in Northern Iranian Loess–Paleosol Sequences: Implications for Pedogenic Iron Oxide Transformation Pathways

Amin Ghafarpour, Ramon Egli, Erwin Appel, Dario Bilardello, Simo Spassov, Tobias Lauer, Farhad Khormali Amin, Hossein Tazikeh, Madelaine Böhme, Kathryn Fitzsimmons

Ferrihydrite (Fh) is a ubiquitous metastable precursor in soils that commonly transforms into pedogenic iron oxides during weathering and soil formation. In loess–paleosol systems, magnetic enhancement is generally attributed to the production of fine-grained ferrimagnetic minerals such as magnetite and maghemite. Experimental studies have proposed multiple pathways for these transformations, including progressive ferrihydrite ordering through ferrimagnetic intermediate phases as well as more direct hematite formation under favorable chemical conditions. The loess–paleosol sequence in northern Iran, formed under a Mediterranean-type xeric continental climate, exhibits overall magnetic enhancement in paleosols relative to C horizon (i.e., relatively unaltered loess), with increased magnetic susceptibility indicating the pedogenic formation of SP–SD ferrimagnetic grains. This behavior is broadly consistent with ferrimagnetic nanoparticle formation during pedogenesis.

However, one paleosol exhibits pronounced magnetic depletion, characterized by reduced magnetic susceptibility and frequency-dependent susceptibility despite persistent high-coercivity contributions and comparable remanence ratios relative to other well-developed paleosols. This decoupling suggests that ferrimagnetic and hematitic components did not evolve through a single progressive transformation pathway. Notably, the precursor C horizon associated with both the enhanced and depleted paleosols exhibit broadly similar magnetic properties and comparable mass-normalized magnetizations. However, the precursor of the enhanced paleosol displays higher temperature- and frequency-dependent susceptibility, suggesting a larger superparamagnetic nanoparticle fraction that may have favored subsequent ferrimagnetic enhancement.

We interpret this paleosol as recording episodic redox-driven alteration of pedogenic iron oxides. Transient reducing conditions may have preferentially dissolved fine ferrimagnetic phases, while subsequent oxidation during drier intervals promoted hematite formation or preservation, consistent with enhanced hematite signatures observed in diffuse reflectance spectroscopy. Rather than reflecting progressive aging alone, hematite enrichment may therefore result from dissolution–reprecipitation processes, selective preservation, or direct hematite formation from ferrihydrite under suitable pedogenic conditions. The lower S-ratio of this horizon, together with diffuse reflectance spectrophotometry (DRS) evidence for hematite and hard isothermal remanent magnetization (HIRM) values comparable to other paleosols, suggests preferential loss of ferrimagnetic minerals and relative enrichment of high-coercivity phases, rather than a substantial increase in absolute hematite abundance.

These findings support a more flexible framework for pedogenic iron oxide evolution in loess–paleosol systems, where magnetic enhancement and depletion reflect competing formation, dissolution, and stabilization pathways controlled by local redox and climatic variability.

Constraining Late Holocene alluvial sediment dynamics through improved chronologies: The Wiesent River Catchment (Bavaria, Germany)

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Floodplains in Central Europe are sensitive archives of environmental change, recording the interplay between climate variability, geomorphological processes, and increasing human impact during the Late Holocene. In many Central European river systems, intensified land use has altered sediment fluxes, leading to increased overbank deposition and changes in floodplain architecture. However, reconstructing the timing and rates of these processes remains challenging due to discontinuous sedimentation and reworking in fluvial systems as well as chronological uncertainties. This study investigated the Wiesent River catchment in northern Bavaria, Germany, as a representative Mid-European mesoscale catchment that mirrors the transition from a predominantly natural to a human-dominated fluvial system.

A multi-proxy approach combining sedimentological, geoelectrical and paleoenvironmental analyses with optically stimulated luminescence (OSL) dating is applied to establish a robust framework for floodplain development. Bayesian age-depth modelling integrates stratigraphic constraints with luminescence ages and reduced chronological uncertainty, enabling the identification of successive phases of sediment accumulation. Biomarker, phytolith and ostracod analyses provide complementary information on past vegetation and land use dynamics.

The floodplains are characterised by laterally extensive and locally thick overbank deposits that record pronounced shifts in sediment dynamics during the Late Holocene. Chronostratigraphic patterns indicate that floodplain deposition is not synchronous with phases of intensified land use, but reflects temporal offsets between sediment erosion and deposition. These offsets point to a sediment cascade framework and delayed sediment transfer within the catchment. The chronostratigraphic record highlights the cumulative and time-transgressive nature of sedimentary processes. Despite improved chronological resolution, uncertainties propagate into sedimentation rates, which are therefore best interpreted as indicators of relative changes in sediment dynamics.

Deglaciation of the Klagenfurt Basin (Austria) after the Last Glacial Maximum: constraints from ^{10}Be exposure dating and implications for the Lateglacial history of the southeastern Alps

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The deglaciation history of the European Alps after the Last Glacial Maximum (LGM) is generally thought to be well established, however, the timing of glacier retreat in the eastern Alps remains poorly constrained. Here, we present the first ^{10}Be exposure ages from the Klagenfurt Basin (Carinthia, Austria), which was covered by the piedmont lobe of the Drau glacier during the LGM. The ^{10}Be ages were obtained from glacially polished quartz veins located between ~ 530 and ~ 800 m a.s.l. and range from 17.4 ± 0.6 to 13.5 ± 0.7 ka (mean age: 15.9 ± 1.0 ka) (Hampel & Hetzel, 2026, QSR). Our findings indicate that the deglaciation of the Klagenfurt Basin occurred during the late stage of the Oldest Dryas stadial, which is consistent with published ^{10}Be ages (mean age: 15.0 ± 1.2 ka) from the flat tops of the ~ 2000 -m-high Nock Mountains that are located NW of the Klagenfurt Basin (Wölfler et al., 2022, J. Quat. Sci.). Both datasets challenge previous interpretations, which inferred that the southeastern Alps were already ice-free by ~ 19 - 18 ka based on ^{14}C ages from two post-glacial lakes (Lakes Längsee and Jeserzersee). Our reassessment of the sediment and pollen records from the two lakes shows, however, that the marked transition from non-arboreal to arboreal pollen occurred at the end of the Oldest Dryas after deglaciation of the Klagenfurt Basin and that the ^{14}C ages from bulk sediment overestimate the true sedimentation age due to a lake reservoir effect. A later deglaciation than previously assumed is further supported by our re-interpretation of two published ^{10}Be datasets from the internal part of the eastern Alps, which indicate LGM ice-surface lowering between ~ 18.6 and ~ 14.8 ka (Wirsig et al., 2016, QSR) and rock-glacier stabilization at ~ 16 - 14 ka, respectively (Steinemann et al., 2020, QSR). The prolonged existence of the Drau glacier until ~ 16 ka was likely promoted by enhanced autumn and winter precipitation during the LGM and until ~ 17 ka (Spötl et al., 2021, Nature Commun.; Warken et al., 2024, Comm. Earth Environ.) and, afterwards, by Northern Hemisphere cooling during Heinrich Event 1. The combination of dryer conditions and climate amelioration toward the end of the Oldest Dryas then led to the final retreat of the Drau glacier from the Klagenfurt Basin.

Ice sheet induced salt tectonics in northern Germany

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Several distinct landforms (surface cracks) of the young morainic landscape of northern Germany have been interpreted as surface expansion ruptures due to ice sheet induced subsurface salt movements. This interpretation is based on the geographical distribution of the surface cracks, which strongly correlates with the distribution of Zechstein salt structures in the north German basin. Furthermore, the orientation of the individual surface cracks correlates with the shapes of the deeply buried salt structures. Analog salt model experiments helped to simulate the effects of ice-sheet loading and unloading on salt flow and the corresponding deformation. The modeling results helped to gain a more profound comprehension of the spatial distribution of the surface cracks and the implicated salt tectonic processes. However, at the local scale, many questions remained regarding the actual formation process of the surface cracks and the time frame. The presentation will focus on results of recent sedimentological, geomorphological, and geological studies. The studies comprise the sedimentary infill of the cracks and the chronological classification of related landforms. The findings allow conclusions to be drawn about the initial formation of the cracks, which further improves our understanding of ice sheet induced salt movements.

Late glacial and Holocene environmental history of the High Atlas Mountains in Morocco: the ostracod record from Lake Tislit

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This palaeolimnological and palaeoclimatological study examines the ostracod assemblages and carbon ($\delta^{13}\text{C}$) and oxygen ($\delta^{18}\text{O}$) isotope record of a new 22.45 m sediment core recovered from Lake Tislit in the Moroccan High Atlas Mountains. The core spans approximately 17,600 years, covering the Late Glacial and Holocene. The study aims to investigate hydroclimatic regime shifts in Lake Tislit and reconstruct palaeoenvironmental and palaeoclimatological changes in the High Atlas.

In total, 19 ostracod taxa were identified including *Neglecandona neglecta*, *Cypridopsis vidua*, *Cyprideis torosa*, *Limnocythere inopinata* and *Ilyocypris* spp. Four ostracod assemblage zones reflect changes in environmental conditions. Hydroclimate changes resulted in lake-level fluctuations, shifts between open and closed stages, and salinity variations. Air temperature estimates were derived by identifying the mutual ostracod temperature ranges following Horne's approach, while past salinity trends were reconstructed using an ostracod assemblage-based transfer function.

The multi-proxy record presents valuable new insights into hydroclimatic regime shifts in the High Atlas. The Late Glacial was characterised by fluctuating winter precipitation and cold, oxygen-rich lake conditions, with slightly warmer water during dry phases. The African Humid Period brought increased moisture, whereas the Younger Dryas appears as a dry interval expressed by closed-basin isotopic signatures. During the Holocene, the lake experienced initially warmer and more humid conditions, followed by a long-term shift towards decreasing winter precipitation and rising evaporative influence. This drier phase resulted in increasing salinity and episodic stratification with anoxia at the lake bottom. In the last millennium, the changing lake productivity may reflect growing anthropogenic influence and lake water stratification combined with continued lake-level decline.

Overall, this study shows that Lake Tislit responds sensitively to changes in moisture availability and temperature. The results provide insights into the regional environmental history of the High Atlas and highlight the value of ostracod-based multi-proxy approaches for reconstructing long-term hydroclimatic change.

Submerged Early to Middle Holocene Coastal Landscapes in the Wismar Bay, Baltic Sea

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Since the end of the last glaciation, the Baltic Sea and its pre-stages have been subject to dynamic coastal transformations. The alternation between limnic and marine phases, accompanied by water level fluctuations of up to 30 meters due to successive transgressive and regressive phases, resulted in extensive limnic, marine, and terrestrial deposits. These deposits are also found in former coastal areas that are submerged now. During the early and middle Holocene, the coastal regions were dominated by a vast river and forest landscape and morainic plateaus, while wetlands and beaches defined the shore line zones.

The shallow water areas of Wismar Bay, frequently characterized by low erosion and sedimentation rates, offer exceptional conditions for investigating the settlement patterns of Mesolithic societies amid a dynamically changing coastal landscape. In the frame of the ERC-funded international synergy project SUBNORDICA, hydro-acoustic surveys, sedimentological sampling of the seafloor, and underwater archaeological investigations have been conducted since 2025 in areas off the island of Poel and the peninsula of Darß-Zingst. The project aims to reconstruct former land surfaces in relation to Mesolithic settlement sites and transgression-driven coastline changes, with particular emphasis on landscape features favored by Mesolithic hunter-gatherer communities. These datasets also enable the identification of potential settlement areas along submerged coasts; regions that are less accessible for archaeological research due to greater water depths, erosion, and sediment coverage, as observed in the North Sea and the deeper parts of the Baltic Sea.

The paper presents preliminary geophysical and geological findings regarding the evolution of these submerged Baltic Sea coasts. It also introduces a method for diver-operated seabed sampling in shallow waters and offers a concise overview of ongoing parallel North Sea research within the synergy project, with a focus here on submerged coastal areas of the Elbe Palaeovalley and its tributaries.

Storms and tsunamis on the edge of Europe: A Holocene lacustrine sediment record from the Shetland Islands

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Coastal sedimentary archives provide insights for reconstructing the long-term patterns of extreme marine flooding events such as storm surges and tsunamis. Despite growing interest in palaeostorm reconstructions, synoptic syntheses for north-west Europe remain scarce, and the spatial and temporal patterns of Holocene storminess are still poorly constrained. The Shetland Islands, on the northern edge of the British Isles, are located in the centre of the main North Atlantic storm tracks, and are also exposed to submarine landslide-induced tsunamis, making them a key location for studying overwash processes and their sedimentary imprint.

This study presents a high-resolution, multi-proxy sedimentary record from Loch Flugarth, a coastal freshwater lake on northern Mainland, Shetland. Sixteen gravity and Russian chamber cores in combination with 26 modern surface samples allow provenance assignment of individual sediment layers within the lake. Our current state of analysis integrates grain size data, geophysical and geochemical (XRF, TOC) proxies as well as multivariate statistics. A Bayesian age-depth model incorporating AMS-¹⁴C and ¹³⁷Cs data is currently being established; the record extends to the Mid-Holocene marine transgression and possibly spanning up to 6000–7000 years.

The cores reveal organic-rich background sedimentation interspersed with numerous sub-centimetre sand layers, originating from the adjacent beach and upper subtidal zone and interpreted as storm-induced overwash deposits. A transect across the lake documents consistent landward thinning of these layers, reflecting inland attenuation of overwash dynamics. A distinct thicker sand layer, present in all cores and differing markedly in its sedimentological and geochemical properties, yields an age of approximately 1400 cal. yr BP, consistent with the youngest known tsunami deposit in Shetland. The extended record presented here offers the opportunity to place storm and tsunami activity within a broader Mid- to Late-Holocene context of coastal change and to explore potential links between phases of enhanced storminess and shifts in North Atlantic atmospheric circulation.

Chronology of the last deglaciation of the central Black Forest, southwestern Germany, inferred from ^{10}Be exposure dating of moraine boulders

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Previous studies point to the temporary existence of cirque glaciers and a few valley glaciers in the central Black Forest during the Late Pleistocene. As no attempt has yet been made to date the glacial landforms in this region – some of which are exceptionally well preserved – the chronology of the last glaciation remains largely unknown. Reconstructing the temporal and spatial evolution of glaciation could provide valuable insights into past climatic conditions and atmospheric circulation patterns over Europe. This study focuses on the surroundings of Glaswaldsee 840 m [above sea level (a.s.l.)], a cirque lake in the northernmost part of this region, with the aim of (1) revisiting moraines in its surroundings with a modern approach in geomorphological mapping, including the interpretation of high-resolution remote sensing data, (2) determining minimum ages for the onset of glacier recession from moraines using ^{10}Be surface exposure dating and (3) reconstructing former glacier surfaces and equilibrium line altitudes (ELAs) during moraine deposition. Geomorphological mapping revealed moraines at a total of seven ice-marginal positions. The moraine record around the cirque lake proved to be significantly richer than the last mapping in the 1960s had suggested. Beryllium-10 surface exposure ages of a double-crested moraine (no snow shielding and erosion correction) in the two youngest stratigraphical positions imply phases of glacier recession no later than 19.9 ± 1.1 ka and by 18.1 ± 1.9 ka at the latest, respectively. Two concordant surface exposure ages from a moraine in an older stratigraphical position resulted in a mean age of 15.4 ± 0.5 ka; this conflicts with the moraine's stratigraphical position and might have been caused by delayed exposure to cosmic radiation due to post-depositional reworking processes. ELA reconstruction, based on the common area-altitude balance ratio method, yielded an ELA of 860 m a.s.l. for the presumably oldest ice-marginal position. The ELA rose gradually to 905 m a.s.l. prior to final glacier recession. The ELA thus lay only a few dozen metres lower than the vast plateau to the west and south-west of the cirque's headwall (maximum elevation: 960 m a.s.l.). In the context of glacier chronologies from other mid-elevation mountainous regions in central Europe, the minimum age for the final glacial recession at Glaswaldsee (19.9 ± 1.1 ka) appears to be quite old. It is expected that the ongoing sample preparation and measurements, which are intended to expand the age dataset presented here, will enable further comparisons with other glacial chronologies and allow conclusions to be drawn about the palaeoclimate.

Late Glacial and Holocene fluvial geomorphodynamics and planform change at the Weser River, northwestern Germany

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Since the Late Glacial period, Central European river systems have undergone significant changes in response to climate change, altered hydrological conditions, shifts in vegetation patterns, varying sediment supply, and the onset of Neolithic agriculture. As a result, many former braided and anabranching planforms transformed into single-thread meandering rivers associated with increased floodplain sedimentation. These planform changes are archived within the sedimentary architecture of floodplains and provide valuable insights into past geomorphodynamics and paleoenvironmental processes. However, the timing and drivers of these planform transitions vary substantially across regions and remain poorly understood, particularly in northwestern Germany.

This presentation focuses on the Rinteln Basin, a valley widening along the upper Weser River course located at the northern margin of the low mountain ranges. Previous studies presented contrasting chronologies and interpretations for the transition of the Weser River from a braided or anabranching to a meandering river system. To reconstruct the spatio-temporal development of fluvial landforms in the Rinteln Basin, we coupled geomorphological mapping, analyses of geological and historical maps, geoelectrical prospection, sedimentological and geochemical analyses, palynology, and radiocarbon dating.

Our results indicate that during the Weichselian glaciation the Weser formed a braided fluvial plain. During the Atlantic period (6950–3750 BCE; 8900–5700 cal BP), former anabranches progressively silt up with fine-grained clastic sediments, which are superimposed by organic-rich deposits from the Subboreal (3750–650 BCE; 5700–2600 cal BP). Palynological analyses reveal a shift from densely forested to an increasingly open landscape due to intensified human impact and agricultural activity. Chronological information provided by radiocarbon dating highlights enhanced soil erosion of loess derived material from the surrounding hillslopes since the Late Neolithic period (ca. 3500 BCE; ca. 5450 cal BP). The increased supply of cohesive sediment into the floodplain, combined with a limited transport capacity of the Weser, ultimately promoted the establishment of a single-thread meandering river system in the Subatlantic period (650 BCE – present; 2600 cal BP – present).

This presentation thereby provides new spatio-temporal evidence of environmental change triggered by inter alia Neolithic agriculture, which forced fundamental reorganization of Holocene fluvial systems in northwestern Germany and Central Europe.

Establishing the Austrian General Geological Legend (EAGLe) from a Quaternary perspective

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In 2024, GeoSphere Austria initiated the project EAGLe (Establishing the Austrian General Geological Legend) to develop a harmonized nationwide geological dataset at a scale of 1:50,000 by the end of 2026. The primary objective is the creation of a hierarchically structured general legend by standardizing and harmonising the lithostratigraphic terms that are used in the different map sheets. This work is carried out by regional teams with varying starting conditions: The Quaternary and Neogene teams relied on already existing comprehensive lists, such as general legend only for Quaternary lithogenetic and geomorphological terms and the stratigraphic chart description for the Cenozoic eratherm. On the other hand, for the regions with basement rocks at the surface (such as the Tauern Window and the Bohemian Massif), regional teams faced the additional challenge of establishing coherent concepts for the lithostratigraphic and lithodemic terms in the respective regions. In some cases, legend descriptions – particularly from older maps – are either ambiguous or significantly outdated, yet they represent the only available information for certain geological units. Without field surveys, these entries can only be assigned to very general geological units. A comprehensive revision and mapping of all legend descriptions is therefore not feasible at this stage; consequently, the original legend descriptions will be included in the final dataset to ensure transparency.

The data base for this compilation consists of over 25000 legend descriptions from published geological map sheets at the scale of 1:50,000, added by GeoFAST maps at the same scale (maps compiled from selected archival material without additional fieldwork), as well as regional maps, partly at a scale of 1:25,000. However, the corresponding vector datasets exhibit considerable heterogeneity in both geological content and data structure. In some cases – particularly for older maps – vector data are entirely absent. Therefore, the second major objective is to consolidate these different datasets into a unified structure and to digitize older analogue maps to close existing digital gaps. It should be noted that this initial version will not include any geometric adjustments (e.g., correction of “sheet boundary faults”).

The first version of the integrated dataset, incorporating the preliminary general legend as far as possible, will be published on the Tethys Data Repository (www.tethys.at) by the end of 2026 and will be made publicly accessible via the Geosphere Austria web service (www.maps.geosphere.at). An additional metadata layer will provide information on the quality of the underlying published sources.

How many ages does a terrace need? High-resolution luminescence dating and the complexity of river terrace formation in the Guadix-Baza Basin (SE Spain)

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River terraces are key archives of Quaternary landscape evolution, recording the interplay of climatic, tectonic, and geomorphic processes. Traditionally, they have been interpreted as regionally synchronous responses to glacial-interglacial cycles, with chronologies based on geomorphological mapping and a small number of numerical ages per terrace level. But how many ages does a terrace actually need to be properly understood? A growing body of evidence suggests that terrace formation is often spatially variable and temporally far more complex than such simplified frameworks imply – a complexity that largely escapes conventional dating strategies.

Here, we address this question by presenting a high-resolution luminescence chronology from the Guadix-Baza Basin (SE Spain), an intramontane setting that offers an ideal natural laboratory for testing prevailing concepts of terrace genesis. Once an endorheic basin, Guadix-Baza was transformed into an open drainage system during the Middle to Late Pleistocene through river capture. Together with sustained neotectonic activity, this reorganization produced a sequence of spatially discontinuous terrace levels whose chronological relationships have so far remained poorly constrained.

By systematically dating numerous sites across the basin, we reconstruct the temporal architecture of terrace development at a resolution that goes well beyond what traditional approaches – based on geomorphological mapping and a limited number of ages – can deliver. The results reveal a markedly non-uniform fluvial response that cannot be reduced to climatic or tectonic forcing alone. Instead, terrace formation emerges as a mosaic of local controls – including differential uplift, sediment supply, and basin morphology – that only becomes visible once the chronological framework is sufficiently dense. Apparent inconsistencies between sites can then be reconciled within a stratigraphically and tectonically informed model of landscape evolution.

Our findings demonstrate that high-resolution luminescence dating is not merely a refinement of existing chronologies, but a prerequisite for resolving the true complexity of river terrace formation. Its full potential, however, unfolds only in close combination with detailed field work: it is the integration of dense geochronological data with stratigraphic, sedimentological, and geomorphological observations that turns isolated numerical ages into a coherent narrative of landscape evolution – and allows us to move beyond overly simplified, climate-driven interpretations of fluvial archives.

A 6000-year reconstruction of flood and debris-flow activity based on the sedimentary archive of Lake Heiterwang (Northern Calcareous Alps, Austria)

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Due to ongoing climate warming, short-duration heavy convective precipitation is expected to become more frequent and significantly more intense in the Eastern Alps, significantly increasing the risk of debris flows in small and steep catchments. In contrast, trends for large river flooding associated to advective precipitation by large-scale frontal systems over large catchments are less clear. To evaluate such hydrological hazards from a long-term perspective, event deposits in continuous lake sedimentary sequences have been analyzed throughout the Alps and peri-Alpine regions. However, most Alpine lake studies did not differentiate between sediment transport by river floods and by debris flows, and thus event frequency reconstructions potentially represent a mixture of contrasting rainstorm types with different drivers and temporal evolution.

In this study, we present a 14 m long, 6000 yr sedimentary record from Lake Heiterwang in the Northern Calcareous Alps of Tyrol, Austria. The lake has a surface area of approximately 1.37 km², a maximum depth of 61 m and is surrounded by steep slopes composed of intensely jointed dolomite rock. These conditions make the adjacent small catchments (approximately 0.06–6 km² projected area) highly susceptible to debris-flow activity during intense rainfall events. In contrast, the main inflow drains a larger catchment of approximately 45 km² and event-related sediment transport is associated to river floods. By differentiating event deposit types, we aim at gaining insights in how the frequency of convective and advective precipitation events may have changed differently over longer time scales.

The sediment core was analyzed using X-ray fluorescence (XRF) scanning, multisensor core logging (MSCL), computed tomography (CT) scanning, grain-size measurements, sedimentological descriptions, and dated by ¹⁴C and ²¹⁰Pb/¹³⁷Cs. A total of 108 event layers thicker than 1 cm were identified within the 14 m sediment core, spanning approximately the last 6000 years. Among these, 51 layers were interpreted as debris-flow deposits. These are typically thin (1–3 cm), reddish, denser than the background sediment, and enriched in calcium. In contrast, 55 event layers were attributed to flood activity and are characterized by greater thicknesses (3–10 cm), a beige color, medium density, subtle fining-upward trends, and geochemical variations marked by increasing potassium and decreasing calcium concentrations toward the top of the layers. Altogether, event deposits account for approximately 30% of the total sediment core volume.

Preliminary results show that flood and debris-flow activity overall follow comparable temporal patterns, with a clear increase in both activities since the onset of the Little Ice Age (LIA). Two major paleo-earthquakes around 3.0 ka and 4.1 ka BP in the region produced thick coseismic turbidites in the lake and in the neighboring lake Plansee. The 4.1 ka BP event is followed by enhanced debris flow activity in both lakes, potentially linked to increased sediment availability by coseismic rock-falls.

“Grand Solar Minima” in minimal grain size: Can we see solar induced paleoclimate variability in heavy mineral proxies of Loess-Paleosol-Sequences?

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Centennial-scale influence of solar activity on the regional climate has been proposed^{1,2}. Climate models that incorporate the so called ‘top-down’ mechanism that influences the Atlantic and Northern Atlantic Oscillation due to variable ultraviolet solar irradiance indicate reduced temperatures, increased precipitation and more southern Westerlies storm tracks for southern and central Europe during prolonged phases of reduced solar activity³. These phases named “Grand Solar Minima” (GSM) would result from the combination of the solar Gleissberg and Suess cycles with frequency ranges of 60 – 120 years and 200 – 300 years, respectively⁴. However, only archives with appropriate temporal resolution and precise dating allow detecting these phenomena as demonstrated by varved lake sediments^{3,5}.

The Loess-Paleosol-Sequence (LPS) at the Nussloch site in SW Germany has been intensively studied in the last decades. It benefits from a precise ¹⁴C age model and its high sedimentation rate enables sampling at an adequate resolution. We investigated 1 m of sediment (within unit 34 of the P8 profile, -3.35 to -4.35 m depth) in 5 cm increments by means of heavy mineral, single-grain sedimentary provenance analysis using an automated, correlative workflow guided by machine learning⁶. According to the age model this sampling interval corresponds ca. 700 years and one increment to ca. 35 years of sedimentation. 40 silt-sized heavy mineral aliquots (10 – 30 µm, 30 – 63 µm) were analyzed by optical microscopy and Raman-spectroscopy, while garnets of the 30 – 63 µm fraction were analyzed for chemical composition by means of electron microprobe.

Heavy mineral composition data and garnet chemical data show significant variation in the apatite-tourmaline index (ATi) and in the ratio of mafic vs. intermediate-felsic/metamorphic garnets, respectively. Frequency analysis of these time-series reveal cycles at ~200 to 300 years. It is well known that Apatite is very susceptible to weathering during alluvial storage and garnet as well but to a lesser extend⁷⁻⁹. Due to the cyclicity in the ATi-signal and the suggested increase in precipitation during GSM periods, we hypothesize that phases with decreased ATi-values could refer to such periods, by reasoning that increased precipitation leads to increased weathering of apatite in the river Rhine floodplain. If the ATi-proxy is validated at other LPS and considering that the occurrence of GSM is apparently not a random process⁴, this approach could help to better constrain LPS stratigraphy in central Europe.

References

1. Gray, L. J. et al., *Rev. Geophys.* 48, (2010).;
2. Ineson, S. et al., *Nat. Geosci.* 4, 753–757 (2011);
3. Martin-Puertas, C. et al., *Nat. Geosci.* 5, 397–401 (2012);
4. Vecchio, A. et al., *Astron. Astrophys.* 599, A58 (2017);
5. Harding, P. et al., *Clim. Dyn.* 60, 1947–1961 (2023);
6. Lünsdorf, N. K. et al., *J. Geophys. Res. Earth Surf.* 128, e2023JF007364 (2023);
7. Morton, A. C. & Hallsworth, C. R., *Sediment. Geol.* 124, 3–29 (1999);
8. Hurst, A. & Morton, A., *Geol. Soc. Lond. Spec. Publ.* 386, 7–26 (2014);
9. Morton, A. C. & Johnsson, M. J. in Johnsson, M. J. & Basu, A., *Geol. Soc. Am.* (1993). doi:10.1130/SPE284-p171.

Eco-morphological changes and potential salmon habitat suitability since pre-industrial times in the Mulde river system (Germany)

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Channel patterns and river connectivity are widely recognised to be representative parameters for the fluvial-geomorphological behaviour and the eco-morphological properties of rivers. They are sensitive to climate and land-use changes and, in turn, can indicate the habitat suitability for aquatic fauna, i.e., expressed by the diversity of channel width, flow velocity and depositional regimes. Both habitat potential and the overall river connectivity since medieval times have also been influenced by barriers such as weirs and dams.

Here we present the results of a multi-temporal study investigating river morphology, river connectivity and floodplain land use in the Mulde River system. The study is motivated by the local extinction of the Atlantic salmon (*Salmo salar*) within the last two centuries and reintroduction endeavours that have met with very limited success.

In order to test for salmon presence in relation to water body structures, we make use of old maps (*Sächsische Meilenblätter*, 1780-1821; *Von Deckersche Quadratmeilenblätter*, 1816-1821) to pinpoint (i) historical barriers and (ii) anthropogenic changes in channel patterns that may have affected migratory fish populations. Furthermore, we evaluate (iii) historical floodplain land use as a pollution proxy, presuming that this also influences salmon habitat suitability.

Our initial results point to a negative relation between an increasing number of cumulative barriers as well as increased floodplain land use in contrast to the presence of salmon populations during the past. Finally, sinuous and meandering channel patterns correspond with higher probabilities of salmon presence.

Depth of a potential repository with regard to the influence of subglacial overdeepenings and tunnel valleys in the representative preliminary safety assessments

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"The Site Selection Procedure for a repository for high-level radioactive waste in Germany consists of three phases. During Step 1 of Phase I, ninety sub-areas that cover 54% of Germany were identified. In the current Step 2 of Phase I, the ninety sub-areas will be reduced to a limited number of smaller areas. Within this step, so-called representative preliminary safety assessments (rvSU) are applied. During the rvSU, consecutive sets of criteria are applied in four evaluation steps to assess the extent to which the safe containment of radioactive waste can be expected in the areas for a period of one million years.

Safety assessments include the evaluation of potential impact of geological processes on the integrity of the geological barriers of a repository. A prominent process to consider is subglacial erosion, which leads to characteristic overdeepenings and glacial tunnel valleys. Such features were formed during the last glaciations during the Pleistocene in the North German Basin and the alpine Foreland. Subglacial overdeepenings can reach depths of over 500 m. They are formed by basal meltwater, which runs off under a glacier and can lead to deep channels being cut into the subsurface. During the erosion that leads to their formation, large quantities of sediment are transported away within short geological periods. Therefore, they pose a potential threat to the integrity of the geological barriers of a repository, the overburden and the host rock.

The German Federal Institute for Geosciences and Natural Resources (BGR) has mapped the occurrence of subglacial overdeepenings in northern Germany (Breuer et al. 2023). On this basis, predictions were made about the extent and erosion potential of future overdeepenings. The result is a depth zone map, which shows the occurrence of overdeepenings in five zones, with the zone of the deepest expected structures having depths between 400 and 600 m below sea level. The continuation of the glacial cycles as observed in the Pleistocene is expected for the next one million years.

The occurrence of glacial overdeepenings is considered in several of the evaluation steps during the rvSU. The depth of influence of glacial overdeepenings can reach deeper than the legally prescribed minimum depth of 300 m, which is why the minimum required depth for areas with expected glacial overdeepenings is set deeper in the first evaluation step. The second evaluation step applies a further safety margin. In evaluation step 3, subglacial erosion is considered with the derivation of expected evolutions and the quantitative assessment. In evaluation step 4, the distance between the base of the overdeepening and the potential containment providing rock zone is considered, as well as the occurrence of erosion resistant strata, which should pose a hindrance of the formation to subglacial overdeepenings.

Reference

Breuer, S.; Bebiolka, A.; Noack, V.; Lang, J. (2023): The past is the key to the future – considering Pleistocene subglacial erosion for the minimum depth of a radioactive waste repository. *E&G Quaternary Science Journal*, 72, 113–125. <https://doi.org/10.5194/egqsj-72-113-2023>

Quaternary river incision dynamics in the Rhenish/Ardenne Massif: Evidence for diachronous landscape evolution

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Understanding the timing and spatial variability of Quaternary river incision is essential for reconstructing long-term landscape evolution in intraplate Europe. The Rhenish/Ardenne Massif (RAM), extending across Belgium, France, Germany, and Luxembourg, represents a classic example of late Cenozoic rejuvenation of an ancient Variscan basement (e.g. Dremel et al., 2025). Fluvial terrace staircases along the Rhine, Moselle, and Meuse rivers, together with multi-level karst systems, provide key archives of incision and base-level change. However, their interpretation remains limited due to sparse and spatially heterogeneous chronological control. This study (i) reviews and critically assesses existing chronological evidence and (ii) integrates multiple geomorphological archives and dating methods to investigate the timing and rates of incision across the RAM.

A prominent regional marker is the Main Terrace Complex (MTC), composed of thick gravel deposits formed mainly during Quaternary cold stages. While extensively documented along the major valleys, karst systems developed in Palaeozoic limestones drained by Ardennian tributaries provide complementary records. Fossil phreatic tubes preserve former base-level positions linked to phases of fluvial stability. Together, fluvial and karst archives provide a robust framework for reconstructing regional landscape evolution. Cosmogenic nuclide methods (^{10}Be and ^{26}Al) include depth-profile dating of terrace deposits and burial dating approaches, namely simple burial dating of endokarstic deposits and isochron and P-PIN1 methods applied to terrace sediments (e.g. Da Silva Guimaraes et al., 2026). These datasets are complemented by electron spin resonance dating of optically bleached quartz and luminescence techniques, particularly pIR-IRSL and TT-OSL (e.g. Bartz et al., 2024). Their combination enables cross-validation and strengthens chronological reliability across both fluvial and karst archives.

Current evidence indicates that MTC formation was not synchronous across the RAM. In the Rhine–Moselle–Saar system, MTC development is generally dated to the end of the Early Pleistocene, whereas in the Meuse catchment and its tributaries (e.g. the Ourthe), available cosmogenic-nuclide and luminescence ages place MTC formation in the first half of the Middle Pleistocene. This apparent time lag points to a diachronous incision pattern rather than a single massif-wide event. The temporal offset may reflect delayed propagation of uplift and incision signals related to geodynamic processes, including uplift associated with the Eifel mantle plume, far-field lithospheric stresses, and/or major climatic transitions. Nevertheless, uncertainties linked to the limited and uneven chronological dataset remain significant. Future work should focus on expanding terrace dating, investigating levels beneath the MTC, and integrating cosmogenic palaeo-denudation rates, morphometric analyses, and geodynamic modelling. Resolving the origin of this chronological offset remains crucial for understanding landscape evolution in intraplate Europe.

References

- Bartz, M. et al. (2024). Older than expected: fluvial aggradation of the Rhine's main terrace at Kärlich dated around 1.5 Ma by electron spin resonance, *E&G Quaternary Sci. J.*, 73, 139–144.
- Da Silva Guimaraes E. et al. (2026). Mid-Pleistocene uplift-induced acceleration of incision in the lower Meuse valley constrained by cosmogenic burial ages. *Quaternary Sci. Rev.*, 383, 109978.
- Dremel, F. et al. (2025). Old orogen – young topography: Characterizing styles of late Cenozoic uplift and exhumation in the European Variscan belt. *Geomorphology*, 489, 110001

One terrace, many ages? Rethinking Pleistocene river terrace formation between synchronism and diachronism – the Regnitz catchment (Upper Franconia, Germany) as a test case

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The complex, non-linear character of fluvial systems has long been recognized. Yet despite decades of research, our understanding of how river terraces actually form – and how their formation responds to changing environmental conditions – remains surprisingly fragmentary. In particular, the widespread assumption that a given terrace level represents a single, regionally synchronous phase of accumulation has rarely been tested systematically. This contribution introduces a research project that challenges this assumption by hypothesizing that river terrace formation is inherently diachronous, reflecting the spatially and temporally uneven morphodynamics of fluvial systems. If this is the case, such diachronism should manifest itself as a systematic downstream variation in luminescence ages along a river's longitudinal profile – a signal that can, in principle, be detected by means of high-resolution luminescence dating. Testing this hypothesis is the central aim of the project. Beyond demonstrating that diachronism may be a general feature of terrace chronologies rather than an exception, the project explores whether recent methodological advances in luminescence dating allow such diachronism to be quantified. If so, terrace ages could be exploited as a novel source of process information, providing quantitative constraints on response times, incision rates, and knickpoint migration – parameters that have so far been difficult to access directly from the terrace record.

The Regnitz catchment in Upper Franconia (NE Bavaria, Germany), a medium-sized tributary of the Main river, serves as the test case for this project. It provides ideal conditions for such a systematic study: clearly distinguishable Late Pleistocene terrace levels, numerous well-exposed outcrops, excellent accessibility, and quartz and feldspar minerals with favourable luminescence properties. Together, these characteristics make the Regnitz valley a natural laboratory in which the hypothesis of process-immanent diachronism can be put to a rigorous empirical test.

Die Forschungsbohrungen Concordia-See und Königsau im nordöstlichen Harzvorland (Sachsen-Anhalt): Neue Multiproxy-Analysen zur detaillierten Gliederung der Weichsel-Kaltzeit in Mitteldeutschland

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Im Jahr 1967 wurden in den ehemaligen Braunkohlen-Tagebauen Königsau und Nachterstedt, im Gebiet des ehemaligen Ascherslebener Sees, bis zu 25 m mächtige Abfolgen oberpleistozäner und holozäner Ablagerungen dokumentiert (Mania 1967). Die beschriebene Sequenz umfasste 13 klimatisch gesteuerte Ablagerungszyklen vom Eem bis ins Holozän und repräsentiert damit eines der vollständigsten Profile der Weichsel-Kaltzeit des norddeutschen Periglazialraums. Zusätzliche Signifikanz erlangen die Profile durch auftretende mittel-paläolithischen Artefakthorizonte saisonaler Jagdlager, welche in die frühe Weichsel-Kaltzeit datieren (Mania & Töpfer 1973). Aufgrund der überregionalen Bedeutung der Sedimentfolgen initiierte das Landesamt für Geologie und Bergwesen Sachsen-Anhalt (LAGB) in Kooperation mit der Johannes-Gutenberg-Universität Mainz eine Neubearbeitung der jungquartären Schichtenfolgen im Rahmen von zwei neu niedergebrachten Forschungsbohrungen. Neben der detaillierten lithologischen Kernaufnahme umfasste das erweiterte Methodenspektrum sedimentgeologisch-geochemische Analysen sowie umfängliche mikro- und makro-paläontologische Untersuchungen (Pollen und Sporen, botanische Makroreste, Ostrakoden, Mollusken) sowie OSL/IRSL-Datierungen zur geochronologischen Einordnung. Südlich der Ortschaft Schadeleben wurde die Forschungsbohrung Concordia-See (CON 1/2020) abgeteuft. Die zwei ca. 14,5 m langen Parallelkerne zeigen eine Abfolge grob- und feinklastischer Sedimente mit insgesamt geringen Humusgehalten. Lumineszenzdatierungen belegen einen Ablagerungszeitraum von MIS 6 bis MIS 3/2, mit erhöhten Sedimentationsraten während MIS 4. Ablagerungen der Eem-Warmzeit (MIS 5e) sind nicht erfasst. Aufgrund starker Beeinflussung durch Umlagerung und Einarbeitung tertiären Materials sowie insgesamt geringer Pollenkonzentration erweist sich die palynostratigraphische Interpretation der limnisch-fluviatilen und periglazialen Sedimente, die überwiegend als Seeuferfazies akkumulierten, als schwierig. Nach weiteren Auswertungen von Manias Profilbeschreibungen und älteren Bohrungen der Braunkohlen-Erkundung sowie eigenen geoelektrischen Untersuchungen im unverritzten Arbeitsgebiet wurde zusätzlich die Forschungsbohrung Königsau (KOE 1/2023), ebenfalls mit zwei Parallelkernen, am Südwest-Stoß des ehemaligen Tagebaus Königsau abgeteuft. Die hier erbohrte 22 m umfassende Sedimentabfolge besteht überwiegend aus einer Wechsellagerung limnischer Schluffe mit eingeschalteten limnisch-fluviatilen Sanden. Zum Liegenden nimmt der Anteil organogener Bestandteile zu, lagenweise kommt es zu Anreicherungen von Molluskenfragmenten. Für die genauere stratigraphische, paläoökologische und geochronologische Einordnung der vorliegenden weichselzeitlichen Folge von Königsau wurden 116 Proben für sedimentologische Untersuchungen, 440 Proben für die Pollenanalyse, 125 Proben zur Bewertung pflanzlicher Makroreste und Ostrakoden sowie acht Proben für OSL/IRSL-Datierungen entnommen. Im Rahmen der Präsentation wird die Gesamtheit der vorliegenden lithologischen, paläoökologischen und geochronologischen Daten vorgestellt.

Literatur

Mania, D. (1967): Das Quartär der Ascherslebener Depression im Harzvorland. – *Hercynia*, N. F. 4, S. 51–82.

Mania, D. & V. Toepfer (1973): Königsau – Gliederung, Ökologie und mittelpaläolithische Funde der letzten Eiszeit. – Veröffentlichungen des Landesmuseums für Vorgeschichte in Halle 26, 164 S., Berlin (VEB Deutscher Verlag der Wissenschaften)

Abrupt hydroclimatic shock and the collapse of an early urban system in Bronze Age Iran

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Abrupt hydroclimatic variability during the late third millennium BCE has been widely linked to societal transformations across West and South Asia, yet the expression of the 4.2 ka event within early urban landscapes of southeastern Iran remains poorly constrained. Here we present the first high-resolution hydroclimate reconstruction from the Jiroft region, derived from a peat archive located within the same floodplain system as the Bronze Age urban center of Konar Sandal. A Bayesian age-depth model constrained by thirteen radiocarbon dates provides near-generational (~17-year) resolution across the critical interval between 4150 and 4000 BP. Hydrogen isotope compositions of leaf waxes (δD_{wax}) and lithogenic dust proxies reveal a two-stage aridification sequence between ~2200 and 2000 BCE characterized by reduced effective moisture and intensified aeolian activity. The most severe arid phase, centered at ~4070 BP, coincides with maximum dust input and overlaps within chronological uncertainty with regional hydroclimatic anomalies associated with the 4.2 ka event. This interval also corresponds to the broader period of urban decline and eventual abandonment reported for the Jiroft cultural landscape after ~4200 BP. The spatial proximity of the archive to Konar Sandal within a shared floodplain setting indicates that the reconstructed hydroclimatic deterioration directly affected the hydrological landscape supporting floodplain agriculture and urban occupation. Our findings demonstrate that severe multidecadal aridity and dust intensification formed part of a regionally coherent hydroclimatic disturbance affecting early urban societies in southeastern Iran. More broadly, the study highlights the importance of urban-proximal, high-resolution paleoclimate archives for evaluating how abrupt environmental variability influenced the resilience of early complex societies.

New findings from the Baix loess profile (Rhône Rift Valley, southern France) in the climatic transition zone between Central and Southern Europe

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Loess paleosol sequences (LPS) are archives of paleoenvironmental changes over time. Comparing different LPS enables the detection of spatial differences in paleoenvironmental conditions for the same temporal period. Here we present the Baix loess profile on the western shoulder of the Rhône Rift Valley in southeastern France at 44°42'36" N and 4°43'21" E. It shows an approximately 14 m thick LPS, which is of particular importance given the location of the Baix profile in the transition zone from the current temperate to the Mediterranean zone. We argue that the LPS exposed in the Baix profile represents a previously missing link between the comprehensively analyzed LPS of the temperate zone in the north (northern France, Alsace, Germany) and those of the Mediterranean region in the south (southern France, Catalonia, Italy, Croatia). We analyzed Baix using common paleopedological methods in combination with OSL dating. In addition, macroremains were isolated by flotation and sieving. Their examination under a binocular resulted in 79 charcoal pieces, approx. 2,100 mollusk shells, approx. 450,000 earthworm calcites, and 250 volcanic ash particles, probably from the Chaîne des Puys (French Massif Central). These proxies provided valuable additional evidence of fires and trees, and supported our paleoenvironmental interpretations.

The base of the profile is a sequence of reddish Btg horizons of an Eemian to early Würmian (MIS 5) pedocomplex. This basal part ends with an erosional unconformity, which is overlain by a layer of relocated soil material and loess, containing volcanic ash and charcoal from deciduous trees. The overlying loess (MIS 4) exhibits a sequence of Bw horizons. The upper boundary of this sequence is very diffuse, indicating that these Bw horizons must have formed syndesimmentarily, during increasing loess deposition. Above, a truncated Calcic Cambisol from the Middle Würmian (MIS 3) has been preserved. Unusually large loess dolls beneath indicate that considerable amounts of carbonate have been leached from this paleosol. The Calcic Cambisol is very similar to the Middle Würmian paleosol remains in the Collias loess profile, located 87 km further south, in today's Mediterranean climate. The top of the Middle Würmian Calcic Cambisol is marked by another erosion unconformity. Above, several slightly brownish horizons follow, developed in slope-wash loess (MIS 3). The lowermost one contains volcanic ash and charcoal from Pinus and deciduous trees. The uppermost section of the profile (MIS 2) does not exhibit any paleosols. Apparently, the sedimentation rate was too high compared to the soil formation rate during this period, and there was no permafrost that would have allowed for the formation of any Reductaquic Cryosols that are commonly observed in similar stratigraphic position in the LPS of Central Europe.

Accelerated uplift of the Rhenish Massif (central Europe) since 700–800 ka revealed by isochron-burial dating of strath terraces

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The uplift of the Rhenish Massif is recorded by strath terraces along major rivers, however, absolute age control for the terraces is still scarce and terrace correlations with Quaternary climate cycles are uncertain and partly contradictory. Along the Middle Rhine, two terrace levels – the Older and Younger Main Terrace (OMT and YMT) – occur above a marked break-in-slope, which separates a steep lower valley from a broad upper valley with gentle slopes. Based on limited paleomagnetic data, an age of 730–800 ka for the YMT was often assumed and used to estimate rock uplift (e.g., Meyer & Stets, 1998). Here, we present the first ¹⁰Be – ²⁶Al isochron-burial ages for the OMT and YMT at two sites: Kasbach-Ohlenberg and Bad Hönningen. At Kasbach-Ohlenberg, the OMT yields a burial age of 1.56 (+0.15/-0.14) Ma, while the YMT is dated to 0.76 (+0.19/-0.17) Ma (Terraza et al., 2026). These ages and the small vertical distance of only four meters between both terraces, indicate a prolonged period with little river incision followed by phase of more rapid incision and rock uplift. The elevation of the bedrock strath of the YMT above the Rhine (i.e., 157 m) implies an average uplift rate of ~200 m/Ma during this phase. At Bad Hönningen, the OMT yields a burial age of 1.25 (+0.16/-0.15) Ma (Terraza et al., 2026). This younger age and the higher elevation of the OMT at this site suggest that rock uplift increases toward the internal part of the Rhenish Massif. The temporal coincidence between the onset of uplift and plume-related intraplate volcanism in the Eifel at ~700 ka (e.g., Lippolt et al., 1983) suggests a mantle-driven origin for the uplift. Our ongoing work will result in additional age-elevation data for terrace sites along the Middle Rhine, thus enabling a more detailed reconstruction of the timing, rate, and spatial variability of uplift in the Rhenish Massif.

References

- Lippolt, H.J., 1983. Distribution of volcanic activity in space and time. In: Fuchs, K., von Gehlen, K., Mälzer, H., Murawski, H., Semmel, A. (Eds.), *Plateau Uplift*. Springer, Berlin, pp. 112–120.
- Meyer, W., Stets, J., 1998. Junge Tektonik im Rheinischen Schiefergebirge und ihre Quantifizierung. *Z. dt. geol. Ges.* 149, 359–379. <https://doi.org/10.1127/zdgg/149/1998/359>.
- Terraza, M., Wolff, R., Hetzel, R., Ritter-Prinz, B., Binnie, S.A., Preuss, J., Hoselmann, C., Weidenfeller, M., Heinze, S., 2026. Accelerated uplift of the Rhenish Massif (central Europe) since 700–800 ka revealed by isochron-burial dating of strath terraces. *Geomorphology* 507, 110334. <https://doi.org/10.1016/j.geomorph.2026.110334>.

Loess-Palaeosol-Sequences at the Kaiserstuhl – Towards a million years record at the interface of the Atlantic and Mediterranean climate systems

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In Europe, few studies are available that deal with the long-term propagation of climate change and associated terrestrial system response at the interface of the Atlantic and Mediterranean system. The existing work does not predate the Last Interglacial which strongly limits our understanding of how both systems contracted and expanded during glacial-interglacial cycles. A better understanding of the interaction of the Atlantic and Mediterranean systems converging along the Rhône-Rhine axis may be achieved, if loess-palaeosol-sequences (LPS) from the Upper Rhine Graben are integrated that are most likely to comprise much of the last million years. Thick LPS of the Kaiserstuhl area (southern Upper Rhine Graben) are suited best to hinge archives along the Rhine River (dominated by Atlantic marine-temperate climate) with those found along the Saône-Rhône axis (rather Mediterranean influence). For this the most favorably complete record is the 30 m thick Riegel LPS that will be subject to detailed investigations in the coming years in the framework of the international KaiserLink project (funder: DFG).

While this master-record will serve as a most valuable reference profile and dating-based correlation target, previous work has highlighted the enormous potential of other LPS in the surroundings which are likely to cover specific time intervals in a higher resolution. Here we present a field- and literature-review based assessment of the potentials of LPS in the Southern Upper Rhine Graben for this task. We critically assess existing age constraints and process geochemical and geophysical data (mostly obtained in the 1980s) using state of the art quality criteria. Together with the outcomes of the crucial KaiserLink project, this will provide a valuable framework towards the acquisition of a million years record at the interface of the Atlantic and Mediterranean climate systems.

Loess magnetic properties as quantitative climate proxies? Exploring data from Europe

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Environmental magnetic properties of topsoils have been used over the last decades to establish climofunctions that allow to reconstruct precipitation regimes recorded in loess-palaeosol-sequences. A suite of proxies has been suggested based on magnetic susceptibility and remanence properties, all with reasonable theoretical background. Yet, most of such studies rely on Chernozems that are widespread in the eastern European realms, and soils experiencing rather low precipitation – and provide little information on the analysed soil types. Here, we provide a dataset of surface soil properties from Europe, combine it with precipitation data, and explore the resulting regressions. We clearly see that soils are partly showing unexpected low susceptibility likely due to (human-induced?) erosion. Single-proxy calibrations are useful on a local to regional scale, but seemingly not applicable across the entire European continent.

2.2.3 Poster presentations

Towards Improved Harmonization: A Hands-On Cross-Border Review of the International Quaternary Map of Europe and Adjacent Areas (1:2,5M) in Southern Germany and Neighbouring Regions

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The International Quaternary Map of Europe and Adjacent Areas (IQUAME2500) is an international project to compile, correlate and harmonise the main Quaternary geological features across Europe and adjacent areas in the scale 1 : 2,5 Million. The IQUAME 2500 is coordinated within the Federal Institute for Geosciences and Natural Resources (BGR) under the auspices of the International Union for Quaternary Research (INQUA), Section of European Quaternary Stratigraphy, and the Commission for the Geological Map of the World (CGMW), Sub-Commission Europe.

Having started at the 2011 INQUA congress in Bern, the project is based on international cooperation and by now encompasses contributing participants from over 30 countries of Europe and adjacent countries. The aim is to build a pan-European, spatial geological (GIS) database, harmonized across regional and political boundaries and thus to provide a summary of the status of European Quaternary geological mapping and research. An international scientific advisory board ensures both the scientific quality and the up-to-dateness of the information.

Within the project, hierarchical vocabularies (e.g. on age, lithology, glaciogenic features, Quaternary faults) have been developed and provided to the national contributors as a base for their input. In addition, mapping guidelines and a digital standard common topographic base map (VMAP 0) with the option to add missing features or correct the drainage system in has been made available. Nevertheless, discrepancies across regional and national boundaries appear in respect to geometries (artificial “map border faults”) and terminology of the Quaternary units.

The IQUAME 2500 GIS aims to depict mainly the chronostratigraphic age, lithology, the maximum extent of the last glaciation(s), glaciogenic features, Quaternary key locations, the actual limits of permafrost and active faults.

This contribution will present an overview of the project’s mapping and harmonisation stage, but will focus on the actual status of the Southern German part overlapping with Austria, Switzerland, France and Czech Republic. The scientific DEUQUA community is invited to contribute regional expertise, engage in a hands-on review and refine the cross-boundary harmonisation and thus optimize the scientific robustness and content of the IQUAME 2500

Late Quaternary shift of the geomorphological-altitudinal zonation in Taiwan

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The mountain ranges of Taiwan, reaching up to 3952 m, represent a unique, isolated climatic archive in East Asia at the Tropic of Cancer. During the last Pleistocene glacial cycle, they were glaciated in the uppermost altitudinal zone with a calculated lowering of the equilibrium line altitude (ELA) of ca. 1500 m down to 2800 m (Hebenstreit et al. 2025). Glacial erosion of the upper valley reaches formed wide trough-valleys. Lateral and terminal moraines are preserved from late glacial and Holocene regression stages (Hebenstreit et al. 2011), while the accumulation of outwash deposits is attributed to the lowest ice marginal positions. Subsequently, slope processes and fluvial activity have been reworking those sediments and reshaping those landforms during and after the glaciation to adjust the relief gradually to its present shape. In the Hsueh Shan range, we mapped a sequence of terraces composed of cobbles and boulders at the confluence of the Taoshan river and the Chijiawan river at an altitude of ca. 1900 m, which corresponds with the assumed lowest altitude of the last-glacial glacier termini. Surface exposure dating with paired in-situ produced terrestrial cosmogenic nuclides (TCN) of meter-sized boulders on the terrace surfaces gives evidence of enhanced glacio-fluvial activity, presumably reworking glacial deposits during the last phase of the glaciation at the Pleistocene-Holocene transition.

Lowering of the altitudinal zones and consequently of surface processes during glacial times entails periglacial processes on slopes not affected by glacial or fluvial processes (Böse 2006). The periglacial zone is presently restricted to altitudes above 3500 m. Frost weathering and solifluction including the formation of periglacial cover beds are documented (Klose 2006). A sediment profile at ca. 2050 m on the slope above the glacio-fluvial terraces shows a composition typical for cover beds in mountainous periglacial environments (Kleber & Terhorst 2024): above debris of local underlying bedrock follow layers enriched by aeolian dust. The sediment has been partly reworked and mixed by solifluction. Optically stimulated luminescence (OSL) ages of the silty matrix confirm its formation during the last glacial cycle; and a lowering of the periglacial altitudinal zone of 1500 m can be inferred, which is comparable with the vegetation records.

Increased sediment transport induced the formation of alluvial fans in the foreland, which were partly incised during the Holocene, forming today table land areas (Liu et al. 2022).

References

- Böse, M., 2006: QI 147, 55–61.
- Hebenstreit, R., Ivy-Ochs, S., Kubik, P.W., Schlüchter, C., Böse, M., 2011: QSR 30, 298–311.
- Hebenstreit, R., Hardt, J., Böse, M., 2025: JQS 40, 831–846.
- Kleber, A., Terhorst, B. (eds.) 2024: Mid-Latitude Slope Deposits (Cover Beds). 2nd Edition. Elsevier Science.
- Klose, C., 2006: QI, 147, 89–102.
- Liu, S.-H., Lüthgens, C., Hardt, J., Hebenstreit, R., Böse, M., Frechen, M. 2022: QR, 1–22.

Reconstruction of wind circulations over the North African margin since the last deglaciation

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The Mediterranean basin, particularly the North African margin, is one of the areas that is the most affected by on-going climate change. Modeling studies for the future still have large uncertainties for the region, e.g. 5 to 50% precipitation decrease for 2100. In this study, we assess variations in wind conditions over the Atlas region, Morocco, over the last ca. 15 ka, i.e. during pre-industrial Holocene, last deglaciation and Green Sahara period. Our goal is to see whether there are tipping points that trigger atmospheric circulation changes over the North African margin. To reconstruct these variations, we used dust provenance proxies (lead (Pb), neodymium (Nd), and strontium (Sr) radiogenic isotopic compositions) measured in two sediments cores from Lake Tisli (High-Atlas, semi-arid climate) and Sidi Ali (Middle-Atlas, sub-humid climate). The preliminary results from the former are the main focus of this study.

Radiogenic isotopic compositions show that there are temporal variations in dust provenances for each lake. We still lack a precise age-depth model for Lake Tisli sediment core. Hence, a direct comparison with Sidi Ali is impossible. Surprisingly, although considered a major source of dust for the northern hemisphere at Present, the Bodélé depression in Chad did not contribute to dust reaching both lakes. Rather, dust appears to come from 1) a common proximal source, i.e. Moroccan surface material and 2) distinct distal sources. Over the entire Tisli record, distal dust came from the Center of Mali and the Southern (Senegal) and/or Northern (Mauritania) parts of the West African coast. There are several abrupt events during which there is an increased contribution of Mauritania-sourced dust. We interpret this observation as a northern shift of the wind trajectories. One event, dated at 12 to 12.1 kcal year BP, hence corresponding to the Younger Dryas (YD), is particularly striking. It is characterized by the highest ostracods $\delta^{18}\text{O}$ values of the core, high terrigenous inputs, and low Pb and Sr radiogenic isotopic compositions. The latter reflects an increase of the relative contributions of the Northern over the Southern part of the West African coast, hence a ca. 5-7° northward shift of the wind system occurring abruptly at the beginning of the YD and also abruptly resuming to its initial position at the end of the YD. A peak of low radiogenic isotopic compositions is also recorded at a younger time, i.e. probably reflecting a shift of the wind system toward the north. However, this later event is not associated with a major change in $\delta^{18}\text{O}$ values. Hence, this meridional shift is likely linked to a climate mechanism different from that of the YD.

Reconstructing the evolution of European paleoclimates since the Last Glacial Maximum: implications for future continental climate change

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The Last Glacial Maximum (LGM; 23–19 ka) is the most recent quasi-equilibrium climate state, drastically different from today and represents a crucial benchmark for climate model evaluation, like for equilibrium climate sensitivity (ECS). While these models have considerably advanced our understanding of climatic processes, their ability to reproduce past climate states must be systematically tested against reconstructions from natural archives to rigorously evaluate their reliability. Europe, marked by strong inter-model dispersion during the LGM and pronounced continental thermal amplification, offers a wide diversity of proxy records. However, LGM data remain scarce, often concentrated at low elevations and semi-quantitative in nature. Comparing these records enables exploration of the full range of possible LGM paleoclimatic conditions and assessment of the limitations of each proxy.

Here, we compile and compare multi-proxy paleoclimate reconstructions of the LGM across Europe, based on results generated during Gabriel Fénisse's PhD thesis (<https://theses.fr/s370680>). Pollen-based climate reconstructions across Europe consistently indicate a mean annual cooling of approximately 6°C during the LGM. Independent estimates derived from noble gas concentrations dissolved in groundwater recharged in northeastern France, particularly in the Vosges region, yield comparable cooling magnitudes, further supporting pollen-based reconstructions.

In contrast, glacier-based inversions, constrained by a revised LGM glacier extent derived from recent cosmogenic exposure ages of glacial landforms in the Vosges, require substantially colder conditions to reproduce the reconstructed ice extent. A potential explanation for this discrepancy lies in changes in climate seasonality between the LGM and the present day. Using the GRISLI ice-sheet model, we simulate a large ensemble of glacier configurations forced by different combinations of climatic variables and compare them to reconstructed ice limits. Reduced precipitation limits glacier expansion, whereas enhanced LGM seasonality inferred from pollen data increases the cooling required to match glacier extent, thereby exacerbating the mismatch between glacier-based inversions and other proxy records.

To further investigate this issue, we compile climate model outputs from several General Circulation Models (GCMs) and from the intermediate-complexity model iLOVECLIM, including a newly down-scaled configuration over Europe. These simulations reveal a wide range of LGM annual cooling over the Vosges and more generally across Europe. Modelled changes in seasonality also show substantial inter-model variability, largely driven by differences in simulated winter temperatures, particularly in and around formerly glaciated regions. Sensitivity experiments with iLOVECLIM indicate that none of the tested processes alters seasonality independently of summer temperature changes, and that these relationships are consistent across configurations. Finally, our results suggest that the simplified atmospheric representation in iLOVECLIM leads to seasonality changes that differ markedly from those simulated by GCMs.

Assessing the variability of K-feldspar luminescence signal characteristics from recent high-energy flood deposits

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Since the morphology of rivers depend on hydrological and climatic factors, among others, fluvial deposits are an important archive for recognising environmental changes in the past. In order to assess the chronology of fluvial archives, luminescence dating is a frequently used method since it determines a sample's last sunlight exposure and thus, the timing of sediment relocation. Besides age estimations, luminescence signals hold the potential to carry information about transport histories, making them a promising tool for reconstructing sediment pathways (e.g., Sawakuchi et al., 2018; Gray et al., 2018). Yet, the relationship between geomorphology, especially depositional contexts, and luminescence properties remains poorly understood (Gray et al., 2019).

To address this knowledge gap, the present research project investigates sediments deposited during the 2021 high-energy flood event in the Ahr Valley, Germany. This event is well-documented, including reconstructions of peak discharges (Roggenkamp & Herget, 2024). Here, we present the study design and first preliminary results from the post-Infrared-Infrared stimulated luminescence signal of K-feldspar measured at 290 °C (pIRIR₂₉₀) using a standardised growth curve (SGC) approach. Luminescence characteristics, including sensitivity, residual dose, saturation dose, and statistical properties are evaluated across different depositional settings along the valley.

References

- Gray, H. J., Tucker, G. E., Mahan, S. A., 2018. Application of a Luminescence-Based Sediment Transport Model. *Geophysical Research Letters*. 45, 6071-6080.
- Gray, H. J., Jain, M., Sawakuchi, A., Mahan, S., Tucker, G. E., 2019. Luminescence as a Sediment Tracer and Provenance Tool. *Reviews of Geophysics*. 57, 987-1017.
- Roggenkamp, T., Herget, J., 2024. Flood reconstruction – The unexpected rather frequent event at River Ahr in July 2021. *Global and Planetary Change*. 240, 104541.
- Sawakuchi, A. O., Jain, M., Mineli, T. D., Nogueira, L., Bertassoli Jr., D. J., Häggi, C., Sawakuchi, H. O., Pupim, F. N., Grohmann, C. H., Chiessi, C. M., Zabel, M., Mülitz, S., Mazoca, C. E. M., Cunha, D. F. Luminescence of quartz and feldspar fingerprints provenance and correlates with the source area denudation in the Amazon River basin. *Earth and Planetary Science Letters*. 492, 152-162

Weathering properties derived from freeze-thaw experiments on different lithologies used in ^{10}Be exposure dating in the Eastern Alps

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During the Last Glacial Maximum (LGM), many glaciers in the Eastern Alps terminated in narrow inner-alpine valleys, leaving only a limited number of datable landforms. Cosmogenic Beryllium-10 was extracted from boulders on top of laterofrontal moraine ridges of the former Enns and Mur Glaciers. Boulders at the Mur Glacier consist of weathering-resistant pegmatite gneiss, whereas in the Enns Glacier area, quartz breccia/greywacke represented the only quartz bearing lithology suitable for sampling. This rock type contains large quartz clasts embedded in a fine-grained matrix and is considerably more susceptible to weathering.

The ^{10}Be exposure ages obtained from pegmatite gneiss boulders at the Mur Glacier are around 20 ka and agree well with other age estimates from across the Alps. In contrast, the Enns Glacier boulders yielded unexpectedly young ages ranging from 14–17 ka. To reconcile these values with plausible LGM ages, erosion corrections would require the removal of approximately 30 cm of surface material, assuming continuous surface exposure since deposition.

To investigate whether such substantial erosion is realistic for quartz breccia, freeze–thaw experiments were conducted on both lithologies. Four samples measuring roughly $2 \times 2 \times 4$ cm were prepared: three quartz breccia cubes and one pegmatite gneiss cube. The quartz breccia samples differed in the thickness of their weathering crusts (0–4 cm) and showed numerous cracks and cavities. Their mineralogical composition includes quartz, carbonates, and aligned phyllosilicates. Before the experiment, all cubes were dried, weighed, and measured for volume. They were then exposed to 159 freeze–thaw cycles. To simulate moisture conditions, thawing took place in a water bath maintained at 20 °C. The samples were photographed before the experiment, approximately every three weeks during the four-month test period, and again afterwards. In addition, one quartz breccia cube was scanned using CT imaging before and after the experiment to visualize internal structural changes.

The experiments clearly demonstrate that quartz breccia weathers far more intensely than pegmatite gneiss. No visible alterations were observed in the pegmatite gneiss sample, while the quartz breccia cubes showed continuous deterioration throughout the experiment. Water appears to penetrate preferentially along pathways formed by aligned sheet silicates. These minerals are progressively destroyed, and as the fine matrix is removed, larger quartz grains detach from the rock surface, a process clearly visible in the photographic record. Overall, the weathering process results in a continuous loss of material, although the rate varies between individual samples and even between different surfaces of the same test cube. Consequently, ^{10}Be is steadily removed from the rock surface. Furthermore, irregular weathering patterns create heterogeneous surfaces, where some parts are exposed for a longer time and ^{10}Be production is influenced by edge effects, causing additional nuclide loss around protruding quartz clasts.

In summary, the freeze–thaw experiments indicate that quartz breccia weathers significantly faster than pegmatite gneiss, which may at least partly explain the younger apparent exposure ages from

the Enns Glacier region. These findings highlight the need for caution during sample selection for exposure dating of conglomerates, breccias and similar lithologies.

A conceptual framework linking Heinrich events and Dansgaard–Oeschger cycles

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Dansgaard–Oeschger (D–O) events and Heinrich events represent the dominant modes of millennial-scale climate variability during the last glacial period, yet their physical linkage remains incompletely understood. Here we propose a conceptual framework in which abrupt glacial variability emerges from the interaction of Atlantic Meridional Overturning Circulation (AMOC) dynamics, atmosphere–ocean CO₂ exchange, and dust-driven biogeochemical feedback operating within an orbitally modulated climate state. During stadial phases, enhanced dust transport and iron fertilization in the tropical Atlantic strengthen the biological pump and promote gradual atmospheric CO₂ drawdown, while reduced ocean ventilation facilitates the accumulation of respired carbon and heat in the ocean interior. Heinrich events represent extreme stadial states that amplify these imbalances through freshwater forcing, sea-ice expansion, and atmospheric circulation changes. The resulting buildup of subsurface heat and carbon may precondition the stratified North Atlantic for abrupt AMOC reinvigoration, releasing stored CO₂ and producing rapid interstadial warming. This framework provides a conceptual perspective on the asymmetry and recurrence of D–O cycles and suggests that orbital forcing could play a role in modulating the probability of Heinrich events through its influence on the background stability of the climate system.

Reconstruction of a periglacial river system in Brandenburg in consideration of glacially induced halotectonic deformation structures

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In the last few years, surface structures (surface cracks) have been mapped across northern Germany, which are interpreted as expansion ruptures resulting from ice sheet induced salt movements. Based on a relative chronology, the maximum age of these cracks was estimated around 30–20 ka. To determine this maximum age more precisely, we used geomorphological, sedimentological and geophysical methods to reconstruct a periglacial drainage channel that was disrupted by the surface cracks. Thus, runoff in that valley must have taken place before the cracks had developed. The channel is situated south of the W2 ice margin in the Schorfheide forest (northern Brandenburg). The top 1.5 m of the channel infill in what is now a dry valley consists of a multilayered colluvium, which was dated using radiocarbon analysis of macro-charcoal remains. The results indicate that a first phase of soil formation occurred as early as the beginning of the Holocene, and that the runoff must therefore have already ceased at that time. Further radiocarbon dating of the colluvium documents several phases of activity spanning from the early to the late Holocene. While this does not provide clear evidence of direct human influence, it also does not directly rule it out. The study provides illustrative examples of the impact of these surface ruptures on their immediate surroundings and enable them to be dated within the context of regional landscape history. They thus demonstrate that these structures go far beyond their significance as markers of ice-sheet-induced salt movements and have had a lasting impact on regional landscape development.

The Upper Rhine alluvial plain as a palimpsest: Evidence from a multi-scale LiDAR DEM analysis (Grand Ried, France)

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The “Ried Durable” project aims to co-construct, with stakeholders, sustainable management scenarios for the highly sensitive groundwater-fed streams of the Alsatian Grand Ried. These streams correspond to the remnants of Holocene Rhine and/or Ill palaeochannels within a vast and complex sector of the Upper Rhine alluvial plain. Early studies have established geomorphological and ecological insights, whereas more recent investigations are either incomplete or cover only part of the study area.

As a first step, we aimed to update the geomorphological map of the entire study area by identifying and characterizing alluvial landforms topographically preserved. To this end, we used recent LiDAR data acquired by IGN and available since 2023. Conventional visualization methods, such as hillshading or hypsometric colour scales, mainly emphasize broad altitudinal variations and do not provide detailed representations of fluvial landscapes across different spatial scales. We therefore implemented a method derived from residual statistical analysis that enhances the visualization of macroforms while minimizing the effects of the longitudinal topographic gradient. Our results highlight the following fluvial landforms: Rhine inner terraces (and associated scarps); braided and anabranching Rhine subcurrent- and palaeochannels; Rhine anastomosing current- and paleochannels; several major Rhine palaeocorridors; current anastomosing channels of the Ill River; extensive Rhine and Ill floodplain deposits; alluvial levees; Rhine and Ill flood channels; Ill crevasse splays; evidences of river avulsions; and other associated alluvial features.

The reconstructed geomorphological pattern suggests a northward migration of Rhine braided corridors flowing to the north-north-west, followed by a river shift characterized by flow to the north-north-east and subsequent eastward lateral migration. Most Rhine terraces remained hydrologically connected to the Rhine, as indicated by abundant floodplain deposits. The sedimentological effects of modern Rhine dikes are visible, mainly in the southern part of the area. Longitudinal profiles also show greater terrace amplitudes in the south, progressively decreasing northwards. This transition coincides with a drop of the general slope and a local plain widening. Compared to the Rhine, the Ill River is characterized by low-energy anastomosing hydrosystem. In the western Grand Ried, it has only incompletely overlaid former Rhine deposits.

Overall, the results provide a detailed geomorphological map and a relative spatio-temporal model of the Holocene Rhine and Ill River systems, including their confluence. This model reveals the remarkable diversity and complexity of superimposed, spatially interlocked, and asynchronous alluvial forms, which are typical of a palimpsest. This geomorphological framework will support further sedimentological, geochronological, and palaeoecological investigations, helping to refine the proposed relative model and assess potential controlling factors such as climate change, land-cover evolutions induced by human activities, neotectonic evidences, etc. Taking this multi-temporal geomorphological legacy into account may improve our understanding of the original current functioning of the groundwater-fed streams, upon which sustainable management strategies will be built.

A late Middle Pleistocene sequence from a collapsed volcanic crater in the Kärlich open quarry, Central Rhineland, Germany

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The so-called “Kärlicher Brockentuff”, KAE-BT4, represents the most prominent stratigraphic marker horizon within the open quarry of Kärlich. KAE-BT4 is a tephra facies proximal to the vent, composed of high quantities of local non-volcanic material, including fragments of the Devonian bedrock, Tertiary clay clasts and Quaternary gravel. In the quarried area the “Kärlicher Brockentuff” reaches several meters in thickness, preserving all older Pleistocene deposits (units A-H) from erosion. In former studies, younger deposits (units Ja and Jb), post-dating KAE-BT4, have only been documented along the north-eastern slope towards the Rhine valley. Sections that have been assigned to Unit J are characterized by numerous unconformities and do not provide great chronostratigraphic detail.

Over the past few years, however, intensified clay extraction in the Kärlich pit extended the quarry area further north, exposing new sections that preserved more than 15m of sediment within a caldera-like collapsed volcanic crater. It is this locality at which the “Kärlicher Brockentuff” had erupted. Following a layer that sealed the crater after a major erosional phase following crater rim collapse, the crater-fill deposits which are exposed in a stepped section, have been documented in two field campaigns during which we conducted Direct Push (DP) measurements prior to sediment coring, using a Geoprobe K6052 Hydraulic Profiling Tool (HPT) in combination with a Geoprobe MT 540 DP-device. A Nordmeyer RS 0/2.3 drilling rig was used to recover 1 m long core sections using steel probes (63 mm diameter), equipped with opaque plastic tubes (50 mm diameter). From top to bottom, cores KAE_3A, KAE_4A and KAE_1A have been obtained to record the crater-fill sequence. The combined record is divided into a basal limnic sequence of ~8m thickness that most likely developed under temperate conditions (MIS 9?) in a rather deep crater lake, and a ~7m thick overlaying loess-palaeosol sequence (LPS) with several thin intercalated tephra horizons. The record bridges the period that was so far poorly recorded in the quarry and connects the Kärlich sequence with other late Middle and Upper Pleistocene regional archives, allowing for refined chronostratigraphic correlations of a period hitherto poorly documented in the Central Rhineland of Germany.

Revision of the Early and early Middle Pleistocene chronostratigraphic record in the Kärlich open quarry, Central Rhineland, Germany

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Together with the nearby site of Miesenheim I, the Kärlich Pleistocene sequence provides one of the most complete terrestrial sedimentary records of Europe north of the Alps, covering the period since the late Lower Pleistocene in great stratigraphic detail. Following a marked unconformity above Tertiary deposits, the Pleistocene sedimentary record at Kärlich starts with a long fluvial sequence of gravels, sands and silts (units A to C). This sequence is overlain by thick deposits of generally more fine-grained sands and mostly fluvially re-worked loess-like material (units D to E), together with loess and loess derivatives (units E to J) and – locally – limnic deposits (Unit Ja) in the upper stratigraphical units. Several interglacial palaeosols have formed throughout the sequence during periods of greater landscape stability, but erosional unconformities also characterize changes in depositional regimes, mostly defining the stratigraphic boundaries between the units. Volcanic macro-tephra layers are interbedded within units G to J. They provide important well-dates chronostratigraphic marker horizons of regional importance. Initial palaeomagnetic studies placed certain units of the fluvial sequence near magnetic boundaries. Unit A has been aligned to the Jaramillo Normal Subchron at ~1 Ma, whereas the upper part of Unit B has been assigned to the Matuyama-Brunhes geomagnetic polarity boundary close to 0.8 Ma. However, ESR dates from the base of Unit Ba resulted in much older age-estimates of ~1.5 Ma for the Rhine Upper Terrace gravels and sands. They agree well with recent results from isochron-burial dating of correlated terrace deposits near Bad Hönningen and Kasbach-Ohlenberg, some 25 and 30 km downstream the river. Together, these dates, obtained by different dating methods, challenge the published chronostratigraphic interpretation of the lower part of the Kärlich sequence and question the current palaeomagnetic interpretation. Recently obtained thermoluminescence (TL) dates on slug plates from units D and E yielded stratigraphically consistent ages of around 0.9–1.0 Ma, implying that the Matuyama-Brunhes boundary should be found further up in the stratigraphy, i.e., near the transition from Unit E to Unit F. In this context it is important to mention that the snail-rich sands („Schneckensande“) in basal Unit E represent the last fluvial deposit in the sequence and that from mid-Unit E on, loess, loess derivatives and palaeosol formation characterize the sequence, which frequently is interrupted by erosional unconformities. At the base of Unit F, reworked Tertiary „Kieseloolith“-gravels are indicative of a major spatially extent erosional episode during which these much older deposits have been reworked across vast land surfaces, indicating rapid incision of the major drainage systems, likely in tandem with accelerated uplift of the Rhenish shield. The chronostratigraphic interpretation of the sequence from Unit F, which has been correlated to MIS 16, until Unit H (MIS 12) remains unchanged. The existing age estimates are further supported by new TL measurements on slug plates from the s.c. Kärlich Interglacial I palaeosol at the top of Unit H that resulted in dates indicative of an MIS 11 age. The so-called “Kärlicher Brockentuff” (KAE-BT4), which represents the most

prominent stratigraphic marker horizon within the Kärlich open quarry, sealed the lower part of the Pleistocene sequence (units A to H); it defines the base of Unit J.

Plio-Pleistocene sedimentary history of the western Upper Rhine Graben: Insights from drill cores near Landau

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The Upper Rhine Graben (URG) is a prominent Cenozoic rift basin where subsidence has created an extensive sediment trap, resulting in increased sediment accumulation. Research on unconsolidated, Plio-Pleistocene sediments in the URG has focused mostly on the southern and north-eastern parts, while the western-central portion remains comparatively understudied. To reconstruct the sedimentary history and paleo-environmental development of this region, we investigate two drill cores from the Trappelberg and Schleidberg sites, which are located in the wider Landau area, ~10 km from the graben shoulder formed by the Palatinate Forest.

Both boreholes fully penetrate the Quaternary and Pliocene sediments at the respective sites. Interestingly, the core from the Trappelberg site records different facies development compared to the Schleidberg core, despite the proximity of only ~2.5 km. To gain insight into the depositional history of both sequences, we evaluate the cores by multi-method sedimentological analyses. Luminescence dating provides geochronological control, and heavy mineral analysis is used to determine sediment source areas. Furthermore, promising targets have been identified for palaeo- environmental and palaeo-seismological study. We present the current status of the project and include results from the Schleidberg core as well as first insights into the Trappelberg core.

Holocene paleoenvironmental changes in the Iranian Highlands: evidence from wetland sediment sequences

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The Iranian Highlands provide relatively mild climatic and environmental conditions that have long supported human occupation and activity, in contrast to the surrounding arid lowlands. However, the nature of Holocene paleoenvironmental changes in these highland regions, their influence on pre-modern societies, and the extent of human impact on highland environments remain poorly understood. Here, we present preliminary results from multiple sediment sequences recovered from high-altitude wetlands (>2200 m asl) in the Zagros Mountains. At Gandoman Wetland (31.51° N, 51.06° E; 2217 m asl), two sediment cores – one 450 cm long retrieved using a Russian corer and another 750 cm long obtained with a vibracorer – together with corresponding sister cores, provide valuable archives for reconstructing past environmental conditions in the Iranian Highlands. A pronounced lithological transition from peat and gyttja to organic-poor grey sediments below ~400 cm depth indicates a major environmental shift. Although chronological control is not yet available, this transition is tentatively interpreted as reflecting the change from cooler, drier Late Glacial conditions to warmer and more humid Holocene environments. High-resolution (1 mm interval) X-ray fluorescence core scanning (XRF-CS) data reveal coherent downcore variations in lithogenic elements (Ti, K, Si, Fe, and Zr) that differ markedly from the trends observed in calcareous elements (Ca and Sr). These contrasting patterns likely indicate an aeolian origin for the lithogenic elements and a basin-derived source for the calcareous components. In particular, elevated concentrations of lithogenic elements associated with the transition from gyttja to organic-poor grey sediments suggest intensified aeolian activity and increased dust deposition within the Gandoman Wetland catchment during the Younger Dryas. Ongoing chronological analyses and additional multiproxy investigations will further refine these preliminary interpretations and provide high-resolution evidence for Holocene paleoenvironmental and hydroclimatic changes in this highland region.

ALPHA „Deciphering ALPine HAZard frequencies by amphibious investigation of Holocene lake inventories“

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The recent increase of Alpine hazard frequencies and magnitudes documented in studies and predicted in numerical models emphasizes the need for long-term natural hazard records to anticipate their likely non-linear increase in the future. Fluctuations, e.g. in the Holocene Climatic Optimum provide the closest analogy for future scenarios. ALPHA investigates Alpine sediment cascades from catchments to lake depocentres in four Alpine lakes to distinguish sediment-producing terrestrial hazard processes and derive magnitudes and recurrence rates. We (i) distinguish processes recorded in lake sediment layers and their triggers, (ii) estimate corresponding ranges of terrestrial trigger magnitudes, and (iii) decipher the frequency and magnitude increase in phases with elevated climatic forcing.

The four study sites Plansee/Heiterwanger See, Achensee, Walchensee and Eibsee are located in the Alpine hazard hotspot Bavarian-Tyrolian Landslide Cluster. The project partners TU Munich, FAU Erlangen and UIBK Innsbruck (i) apply a 4D approach on subaquatic sediment transport by repeated geophysical surveys, repeated coring and calibration using sediment traps and dendrogeomorphology, (ii) relate erosion, transport and subaquatic deposition in mass and momentum balances, and (iii) link sediment volumes in the lacustrine sink with measured terrestrial mass movement rates.

First results from 54 debris flow fans at Plansee reveal a 9-fold increase in debris flow volumes since 1920 derived from sediment cores. A 36% increase in rainfall days since the 1980s corresponds to a 12% increase in catchment erosion. Comparing photogrammetric reconstruction of onshore debris flow volumes with volumes derived from turbidite deposits in sediment cores shows that results from both methods align: $300 \times 10^3 \text{ m}^3$ of debris flow material have been transported into the lake over the last 7 decades.

Dendrogeomorphological studies on selected fans at Plansee provide up to 400 yrs of fan activity in yearly resolution based on *Pinus mugo* ssp. *uncinata*. The present focus is on identification of burial events and providing minimum ages of land surfaces for temporal reconstruction of geomorphological fan dynamics. Dendrogeomorphological data will be linked later to event chronologies in an “amphibious”, multi-archive approach. Long cores at the neighboring Heiterwanger See document a significant increase of flood and debris flow activity since the onset of the Little Ice Age. In addition, enhanced debris flow activity occurred after a major regional earthquake 4.1 kyr BP, and is interpreted as a consequence of increased sediment availability by coseismic rockfalls in the steep catchments.

ALPHA advances process-understanding of drivers and sediment dynamics under fluctuating environmental controls. It is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation – Project number 558963977) and the Austrian Science Fund (FWF, grant: PIN7180424).

Neue Befunde zur marinen Austernbank der Holstein-Warmzeit in der subglazialen Bornhöveder Rinne (Schleswig-Holstein)

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Im Gebiet der Bornhöveder Seenkette (Schleswig-Holstein) entstand während der Elster-Vereisung eine subglaziale Rinne, deren Sedimentfüllung während des Saale-Komplexes in Phasen der Vergletscherung zu Stauchkomplexen aufgepresst wurde (Piotrowski 1991). So stehen in diesem Gebiet Sedimente des Elster- Spätglazials, der Holstein-Warmzeit und der Saale-Vereisung teilweise oberflächennah an.

Die Sedimente der Holstein-Warmzeit sind als marine Sande mit einem hohen Anteil an Mollusken beschrieben und als Austernbank von Tarbek bezeichnet worden (Grahle 1936, Wosidlo 1962). Sie entstanden nach Hinsch (1993) im Wärmemaximum des Holstein-Interstadials und sind nur in einem Streifen im Südosten Schleswig-Holsteins bekannt. Im Raum Tarbek wird die Höhe der ungestörten Oberfläche der Ablagerungen der Holstein-Warmzeit mit -30 bis -10 m NHN angegeben (Hinsch 1993, Piotrowski 1991).

In den Jahren 2019 und 2020 wurden im Raum Tarbek Ablagerungen kartiert, die bislang der Austernbank zugeordnet wurden. Bohrsondierungen im Stauchkomplex Grimmelsberg erbrachten auf einer Höhe von 70 m NHN sandige fluviatile Ablagerungen, in die Schichten mit einem hohen Anteil an Mollusken eingelagert sind. In einem südlich an den Grimmelsberg angrenzenden Kiessand-Tagebau wurden unterhalb Sanderschüttungen der Weichsel-Kaltzeit teilweise stark deformierte (glazi-)fluviatile Sande mit Mollusken kartiert, die auf einer Höhe von ca. 45 m NHN lagern. Meng (2021) wies hier eine Fauna nach, die der Zusammensetzung der Austernbank entspricht. Alle kartierten Ablagerungen werden von Sedimenten des Elster-Spätglazials (Lauenburger Ton) unterlagert (Piotrowski 1991).

Die Synthese aus Arbeiten von Piotrowski (1991) zur Geologie des untersuchten Gebietes und den Ergebnissen aus eigenen Aufnahmen und Lumineszenz-Datierungen legt eine ursprüngliche Ablagerung der Sedimente der Austernbank im Marinen Isotopen Stadium 11 und eine Resedimentation und glazitektonische Aufpressung während des Saale-Komplexes bzw. der Weichsel-Kaltzeit nahe.

Literatur

Grahle, H.-O. (1936): Die Ablagerungen der Holstein-See (Mar. Interglaz. I.), ihre Verbreitung, Fossilführung und Schichtenfolge in Schleswig-Holstein. Abhandlungen der Preußischen Geologischen Landesanstalt, NF 172, 4–110.

Hinsch, W. (1993): Marine Molluskenfaunen in Typusprofilen des Elster-Saale-Interglazials und des Elster- Spätglazials. Geologisches Jahrbuch Reihe A, 138, 9–34.

Meng, S. (2021): Mollusken (Bivalva und Gastropoda) aus der holsteinzeitlichen „Austernbank“ von Tarbek (Bornhöved, Schleswig-Holstein). Der Aufschluss. 72(5).

Piotrowski, J.A. (1991): Quartär- und hydrogeologische Untersuchungen im Bereich der Bornhöveder Seenkette, Schleswig-Holstein. Berichte/Reports, Geologisch-Paläontologisches Institut der Universität Kiel, 43, 1–194.

Wosidlo, H. (1962): Foraminiferen und Ostracoden aus dem marinen Elster-Saale-Interglazial in Schleswig-Holstein. Meyniana, 12, 65–96.

Pleistocene salt movement in the North German Basin – related to ice-sheet loading or continuation of the Cenozoic trend?

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The North German Basin contains a multitude of salt structures, which reflect the evolution of the North German Basin. The youngest developments of the salt structures, however, are poorly resolved. Almost all salt structures were overridden by the ice sheets during the Pleistocene glaciations and it has been suggested that ice-sheet loading triggered salt movement (e.g., Lang et al., 2014; Lang & Hampel, 2023). Ice-sheet loading may impact salt structures by stress changes that trigger faulting in the vicinity of salt structures or by direct (“submarginal”) loading if salt structures are overridden by an ice sheet.

In the ongoing German site-selection process for a radioactive waste repository, rock salt represents one potential host rock. The safety of a repository has to be assessed for one million years and future glaciations are considered as an expected development. Therefore, understanding the potential impact of glaciations on rock salt is an important contribution to long-term safety assessments. To improve the understanding of the interaction between salt structures and ice-sheet loading, our study aims to (i) review the existing evidence for Quaternary activity of salt structures, (ii) document the characteristic features and their distribution, and (iii) identify potential trigger mechanisms

Compiling the available data suggests that ~60 salt structures in the North German Basin show indicators of Pleistocene and Holocene activity. Interestingly, most of these salt structures are located in the northeastern part of the basin, which experienced the most and the youngest ice advances. Most interpretations of salt structures being active during the Quaternary are based on geomorphological features, such as uplift or tilting of surfaces, deflection of river courses, or surface cracks. Evidence for the deformation of Quaternary deposits by salt structures are rare due to the lack of suitable outcrops or high-resolution subsurface data. New high-resolution 3D seismic data from the North Sea provide an exceptional image of the crestal fault system of the Belinda salt structure. Faults have displaced the Pleistocene glacial erosion surface by ~20 m and some faults even reach the modern sea floor, clearly demonstrating Quaternary rise of the salt structure. So far, no widely accepted model for Quaternary salt movement exists. Quaternary salt movement may be interpreted as a continuation of the Late Cenozoic trend, where salt tectonics were mostly related to the regional stress field. Alternatively, previously inactive salt structures may have been mobilised by submarginal ice-sheet loading when the Fennoscandian ice sheet extended into the study area or due to a reactivation of deep-rooted faults by glacial isostatic adjustment.

References

Lang, J., and Hampel, A.: Deformation of salt structures by ice-sheet loading: insights into the controlling parameters from numerical modelling. *Int. J. Earth Sci.*, 112, 1133–1155, <https://doi.org/10.1007/s00531-023-02295-5>, 2023.

Lang, J., Hampel, A., Brandes, C., and Winsemann, J.: Response of salt structures to ice-sheet loading: implications for ice-marginal and subglacial processes, *Quaternary Sci. Rev.*, 101, 217–233, <https://doi.org/10.1016/j.quascirev.2014.07.022>, 2014.

Cosmogenic nuclide dating of the Lateglacial glacier history of two contrasting southern French Alps massifs : Les Monges and La Blanche

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The terrestrial record of Lateglacial glacier advance is still sparse in the Western Alps, particularly along its southern fringe. Taking advantage of the numerous well-preserved moraines found in the Mediterranean Southern Alps, we present the first cosmogenic nuclide ages constraining the deglaciation history of two massifs, Les Monges (2,115 m asl) and La Blanche (2,961 m asl). Our chronology is based on 11 ³⁶Cl ages on limestone and 16 ¹⁰Be ages on sandstone, respectively. While La Blanche paleo-glacier was confluent with the Durance glacier system during the LGM, Les Monges massif had only three small local glaciers at that time. This region also stands out by a large number of Lateglacial subfossil wood deposits trapped in alluvial sediments of small river systems.

At Les Monges, we focused on two N-oriented small cirques and found at least five moraine stadials since the LGM, based on our composite chronology. The outer moraine is dated to 20.8 ± 2.4 ka ($n = 1$) and marks a glacier front located at $\sim 1,600$ m asl. The second one is dated to 17.4 ± 2.0 ka ($n = 1$) and could correspond to the HS1 – which additional samples should help clarify. The next two stadials are dated in both cirques. The first occurred around 15.4 ± 0.1 ka ($n = 3$). And the second main moraine bastion was deposited at 14.2 ± 0.3 ka ($n = 3$). Upstream, a small moraine found only in one cirque ($\sim 1,860$ m asl) is not dated but is thought to be the local expression of the Younger Dryas. As a result, Les Monges would have been only very marginally glaciated during this period.

At La Blanche, we focused on the Laverq Valley, where a glacieret was still present up to the late-20th century and which, during the LIA, had deposited a moraine down to 2,580 m asl. Downvalley, the outer glacial landforms studied here likely date back to the Younger Dryas. At Plan Bas ($\sim 1,900$ m asl), a paired erratic/roche moutonnée yielded a mean of 12.3 ± 1.0 ka ($n = 2$), which could tentatively be linked to the left lateral Séléta moraine (2,230 m asl) dated to 13.4 ± 0.5 ka ($n = 2$). The La Blanche Younger Dryas glacier consisted of the convergence of several ice streams, which must have separated rapidly during the course of this period, causing the fronts to rise rapidly in altitude. Thus, further upstream, a moraine dated to 11.9 ± 0.3 ka ($n = 2$) likely marks the end of the Younger Dryas, with an assumed front around 2,200 m asl. Finally, the innermost moraine dated here to 10.6 ± 0.3 ka ($n = 1$) is located 700 m outboard the LIA moraine, and likely marks a Preboreal advance. Interestingly, a rock avalanche detached from the Grosse Barre ridge (2,872 m asl) at 9.8 ± 0.1 ka ($n = 2$) and traveled more than 2 km downvalley. This event occurred during one of the marked optima of the early Holocene, as has already been evidenced at several sites in the Western Alps.

Analyzing the Sea Level Highstand during the Holocene in the Chanthaburi Plain, Thailand

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This study presents new sedimentological and chronological evidence for Holocene coastal evolution and a possible relative sea-level highstand in the Chanthaburi Plain, eastern Gulf of Thailand. It is based on six sediment cores from the Laem Sing area: WNP1, WNP2, WNP3, WNP4, WNP5 and ALC. The cores were analysed using sedimentological descriptions, grain-size analysis, loss-on-ignition measurements at 550 °C and 950 °C, and chronological constraints from optically stimulated luminescence (OSL) and radiocarbon dating.

The core records show repeated changes between fine-grained lagoonal or estuarine sediments and coarser beach-related sands. These changes reflect long-term coastal progradation, while some upper-core sections also show evidence of later disturbance. The main evidence for the inferred sea-level position comes from WNP1 and WNP3. In WNP1, lagoonal deposits with higher organic matter are overlain by coarse and better-sorted foreshore to backshore sands at about +1.7 to +1.9 m a.m.s.l. This transition is constrained by OSL ages of 5.16 ± 0.14 ka and 4.59 ± 0.39 ka. In WNP3, a similar change from lagoonal or tidally influenced deposits to higher-energy foreshore sands occurs at about +1.1 to +1.3 m a.m.s.l. An OSL age of 4.96 ± 0.14 ka is located close to this transition.

These facies changes are interpreted as possible local expressions of a mid-Holocene relative sea-level highstand. WNP2 mainly records poorly sorted sediments influenced by an estuarine branch, while WNP5 is dominated by lagoonal and estuarine facies with shell-rich layers and partly mixed chronological signals. WNP4 mainly records lagoonal deposition with a brief foreshore signal and an upper part affected by disturbance. ALC reflects tidally influenced estuarine conditions with probable mangrove influence, with organic loss and bioturbation in the upper section.

Overall, the available evidence tentatively suggests that the Chanthaburi coastal plain recorded a mid-Holocene relative sea-level highstand of about +1 to +2 m above present mean sea level. After this maximum, the shoreline appears to have prograded and beach ridges developed across the coastal plain, while late Holocene relative sea level gradually stabilized or fell slightly towards its present position. These results provide new core-based constraints on Holocene shoreline evolution and relative sea-level change in the eastern Gulf of Thailand.

A multi-proxy study of late Middle Pleistocene crater lake deposits in the Kärlich open quarry, Central Rhineland, Germany

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The eruption of the so-called “Kärlicher Brockentuff” (KAE-BT4) in the northern part of the Kärlich open quarry left a crater depression in which some ~8m of limnic sediments had formed (Poster Kärlich-2). To document and study this sequence Direct Push (DP) measurements were conducted prior to sediment coring. Core KAE_1A records a 12.5 m long sequence that entails the limnic sequence between reworked KAE-BT4 that sealed the base of a volcanic crater, and overlaying loess and loess derivatives

In the 1980ies and 90ies archaeological, geoscientific and palaeobotanical studies documented an interglacial sedimentary sequence (Kärlich Interglacial II) followed by interstadial deposits which had formed in a depression left after the “Brockentuff” eruption. Whereas this “Kärlich- Seeufer” (lakeshore) site preserved at the shore of a shallow lake, the limnic crater lake sequence recorded in KAE_1A represents deposits of a larger water body that most likely formed simultaneous with “Kärlich-Seeufer”. As such, the Kärlich crater lake deposits may represent one of the rare preserved late Middle Pleistocene limnic sequences in Central Europe. Prior to pollen analyses and building on electrical conductivity (EC) and HPT pressure data obtained during DP-logging, a series of initial laboratory analyses is carried out. Colour (CIE Lab*) and magnetic susceptibility (MS) were measured at 1 cm intervals, while X-ray fluorescence (XRF) analyses were performed with 2 cm measurement intervals.

Based on these proxies core KAE_1A can be divided into the following superordinate stratigraphic units (SSU): reworked KAE-BT4 (SSU A) which sealed the crater depression, followed by the deposits of the crater lake phase (SSU B1 and B2), which is overlain by loess and loess derivatives (SSU C). Geochemical proxies indicate fluctuating lake levels and sedimentation phases in SSU B. Whereas high clay contents and fine lamination especially in SSU B1 as well as partly reduced sediments indicate a larger water column, some weathering proxies and increased oxidation hint at episodal low-stands or drying of the crater lake.

Once the palynological sequence has been studied, a more detailed understanding of the detected fluctuations can be established. The data combined will enhance correlation with other late Middle Pleistocene archives of the wider region, such as the crater-fill deposits of Döttingen and Rodderberg.

Pleistocene mountain glaciation in central Europe: extents, chronology, and landscape modification

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During the Pleistocene, the central European uplands formed a largely unglaciated corridor between the Fennoscandian Ice Sheet and the Alpine ice complex. Small ice masses existed in the higher mountain ranges, yet their extent, chronology, glaciation style, and erosional imprint remain poorly resolved. Existing reconstructions are mostly restricted to the Last Glacial Maximum (LGM) and western ranges, while the character of pre-LGM glaciation farther east (e.g. Ore Mountains) remains largely unknown. Resolving these knowledge gaps will improve our understanding of cold-climate extremes, as mountain glaciers provide direct records for periods when other proxies are often unavailable. Furthermore, the resulting paleoclimatic reconstructions are important for the understanding of permafrost distribution as well as biotic and human responses to cold-climate change across central Europe.

This project addresses those gaps by identifying and dating glacial landforms such as cirques and moraines to reconstruct former ice extents and glaciation style within the central European uplands. Geomorphological mapping is combined with terrestrial cosmogenic nuclide dating, with particular attention to deposits beyond the LGM moraine limits that may record older glaciations.

The poster presents the project outline as well as 21 new cosmogenic Be-10 surface-exposure measurements from boulders and bedrock in the Giant and Ore Mountains, the Bohemian Forest, and the Eastern Sudetes, testing for pre-LGM glacier advances in those regions.

Validating a new luminescence-based temperature proxy for late Pleistocene and Holocene surface temperature

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Proxy records for past terrestrial temperature, particularly for the late Pleistocene, are limited by the vast extent of Last Glacial Maximum ice sheets at high latitudes and quick biomass turnover in the tropics. In the face of ongoing climate change, an understanding of the Earth's past temperature response is becoming increasingly important. Climate models, however, rely on proxy records to accurately calibrate and predict past and future climate scenarios.

In this context, recently, a new luminescence-based proxy for terrestrial temperature (Biswas et al., 2018) has been under continued development to improve and test its applicability to surface samples (Biswas et al., 2020; Oehler et al., 2026). Thermoluminescence (TL) palaeothermometry exploits the sensitivity of metastable trapping sites in feldspar crystals to surface temperature, below the range of stabilities typically used for luminescence dating. Combining laboratory measurements with modelling of the evolution of the trapped charge population over geological timescales allows the reconstruction of the thermal history of a feldspar sample at temperatures typically experienced at the Earth's surface.

In our contribution, we present the general methodological framework of TL palaeothermometry and provide insight into our attempts at method validation following internal method development on three borehole samples. Modelled borehole temperatures are benchmarked against improved estimates of borehole temperature from the KTB and MIZ-1 boreholes (located in Germany and Japan, respectively) as compared to previous studies.

We show the potential of TL palaeothermometry as a proxy for late Pleistocene and Holocene surface temperature and highlight its use for extension of the global proxy database to be used in future climate models.

References

- Biswas, R., Herman, F., King, G., Braun, J., 2018. Thermoluminescence of feldspar as a multi-thermochronometer to constrain the temporal variation of rock exhumation in the recent past. *Earth and Planetary Science Letters*, 495, 56–68.
- Biswas, R.H., Herman, F., King, G.E., Lehmann, B., Singhvi, A.K., 2020. Surface paleothermometry using low-temperature thermoluminescence of feldspar. *Climate of the Past* 16, 2075–2093.
- Oehler, S., Niyonzima, P., King, G.E., Herman, F., Biswas, R.H., Schmidt, C., 2026. Towards robust measurement protocols for palaeothermometry – addressing sensitivity change in feldspar TL. *Radiation Measurements* 195, 107687.

Integrating Local Dynamics and Basin-Wide Change: A Historical View on Atlantic Salmon extinction in the Mulde River, Germany)

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Atlantic salmon (*Salmo salar*) is a flagship species for river restoration and a widely used indicator of freshwater ecosystem health, yet European populations have contracted markedly since the early 20th century: stocks remain comparatively stable in the far north but have declined or disappeared across central and southern Europe. This collapse is driven by multiple human pressures acting across the life cycle, including river fragmentation by barriers, pollution and emerging contaminants that can disrupt homing, climate-related warming and extreme floods or droughts that hinder migration and reduce spawning success, and continued exploitation. Restoration is further hampered by limited monitoring data and by historical catch records that are uneven, locally specific, and often compiled second-hand, which can create misleading “trends.”

To reduce these biases and establish realistic pre-industrial baselines, this study applies a source-critical “ground-truth” approach in the Elbe basin, with a focus on the Mulde system. We systematically transcribe and formalise local primary sources to reconstruct fisheries information (revenues and occasional catch quantities) together with the construction and damage histories of weirs that shaped fishing practice and potentially fish passage. To connect basin-scale patterns with on-the-ground mechanisms, two microhistorical case studies are pursued: (1) Leisnig on the Freiburger Mulde (1617-1770), where records document annual catch variability alongside detailed accounts of infrastructure costs, flood/ice/war damage, and recurring conflicts over access and rights; and (2) the Zwickauer Mulde south of Zwickau (1570-present), where a long-term reconstruction of a weir- and mill-dense waterscape combines written and pictorial evidence with catch data to infer changes in passability and identify threshold barrier configurations that likely blocked upstream migration.

Together, these microhistories show how connectivity loss emerged from cumulative local decisions and institutional arrangements. The synthesis supports contemporary restoration by linking historically passable barrier designs, reach-scale channel form (sinuosity), and land-use settings to feasible pathways for re-establishing salmon migration in the Mulde system.

Is the 4.2-ka event visible in speleothem records from southwest Asia?

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The '4.2 ka event' (~4200–3900 yr BP) is now a globally-recognised Holocene chronostratigraphic marker, delineating the boundary of the middle-to-late Holocene (1). First identified as a drought signal corresponding to ~2200 BCE in the Tell Leilan stratigraphy (Syria), correspondence between this signal and the collapse of the Akkadian empire was interpreted as sign of a causal association, and one of the first explicit links made between a major climate shift and civilizational transformation (2). Several studies have more recently presented evidence suggesting this drought was in fact a globally-pervasive phenomenon, linked to the decline of the ancient Egyptians, the de-urbanization of the Harappans, and the demise of the Neolithic Culture of China (3,4,5). However, no clear consensus exists on whether the 4.2-kyr event was truly global in scale, nor whether the event was consistently marked by aridity (6,7). But perhaps most critically, it is unclear whether a clear drought signal at 4.2-ka (2) occurs consistently in paleoclimate records across southwest Asia (8). Without a clear perspective on if, and how, regional climate signals relate to one another across this interval, it is difficult to ascertain whether changes occurring at ~4.2 ka are mechanistically distinguishable from internal noise in a highly sensitive, and complex climate system (9). To address this uncertainty, we present a first look at new stable isotope, trace element, and fluid inclusion measurements from speleothems grown in Kuna Ba cave (~400 km SE of Tell Leilan) in Iraqi-Kurdistan. By combining these results with published geochemical data from paleoclimate archives across southwest Asia, we will assess whether the hydro climatic changes recorded in these archives capture a distinct anomaly corresponding to the 4.2-ka event. Hence, providing a chronologically-robust framework with which to assess the regional-scale timing, expression, and coherence of climate variability before, during, and after the proposed 4.2-ka event.

References

1. Walker et al. (2018) *Episodes* 41: 213–223
2. Weiss et al. (1993) *Science* 261: 995–1003
3. Weiss & Bradley (2001) *Science* 291: 609–610
4. Carolin et al. (2019) *PNAS USA* 116: 67–72
5. Zhang et al. (2021) *Science Advances* 7: 1–9
6. McKay et al. (2024) *Nature Communications* 15: 6555
7. Nan et al. (2025) *Earth-Science Reviews* 265: 105128
8. Finné et al. (2011) *Journal of Archaeological Science* 38: 3153–3173
9. Zittis et al. (2022) *Reviews of Geophysics* 60: e2021RG000762

To what extent can multi-frequency susceptibility be used as an indicator for complex sedimentation in terrestrial settings?

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Multi-frequency susceptibility assesses the homogeneity or heterogeneity of nanometer-scale particles, especially ferromagnetic compounds. In loess it is generally linear, and therefore two frequencies can describe the frequency dependency well. However, in sediments with more complex grain size distributions and therefore generally more complex sedimentation history, the frequency dependency can be more complex and/or noisy. Here, we explore a suite of data from different terrestrial settings from Europe, and discuss the challenges of multi-frequency susceptibility measurements, and point towards possible application in geosciences.

Holocene hydroclimate variability recorded in speleothems from Kuna Ba Cave in Northern Iraq

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Southwest Asia sits in a climatic transition zone where the North Atlantic/Siberian weather systems and the Indian monsoon interact, and diverse topography of the Zagros Mountains results in steep hydroclimatic gradients (Fleitmann et al., 2025; Xoplaki et al., 2004). Understanding the hydroclimate dynamics of this water-stressed region is important for several perspectives. Paleorecords are also crucial for placing modern droughts, such as those of 1998–2000 and 2007–2010, in a meaningful historical context. First for anticipation of the future, as it is projected to experience increasingly frequent droughts over the coming decades (Flohr et al., 2017), and second for understanding the past, as the Fertile Crescent is where agriculture and the first cities emerged during the Holocene, against a background of increasing precipitation during the mid-Holocene (Fleitmann et al., 2025; Zeder, 2011). Paleoclimate reconstructions derived from natural archives can shed important light on both these perspectives. However, there is a clear need to address prevailing spatial and temporal gaps in archive availability; gaps that limit our ability to track how the regional hydroclimate regime has evolved during the Holocene. The SNSF-funded Sinergia project 'MITRA' (<https://mitra.duw.unibas.ch/en/project-objectives>) will address these gaps, by developing a detailed network of Holocene hydroclimate reconstructions from speleothems, lake/wetland, and marine sediments across southwest Asia. These reconstructions will be combined with state-of-the-art regional climate model simulations to improve our knowledge on drought dynamics in northern Iraq and the surrounding areas.

Focussing here on the northern Zagros region, we present an absolutely-dated (U-Th) record of hydroclimate variability derived from three stalagmites from Kuna Ba Cave (northern Iraq). Several overlapping sections of stalagmites KBC-3, KBC-6, and KBC-7 show evidence for continuous growth, and good agreement between stable isotope ($\delta^{18}\text{O}$, $\delta^{13}\text{C}$) and trace element (e.g., Mg, Sr) profiles, suggesting that they are not significantly influenced by cave- or sample-specific effects. They also exhibit high uranium and negligible initial thorium concentration, which allows for precise ^{230}Th dating ($n = 21$), and excellent age control. By combining our new data with previously published late-Holocene records from Kuna Ba (Sinha et al., 2019), we construct a composite hydroclimate record spanning the Holocene period. The record reveals a progressive shift to increasingly positive $\delta^{18}\text{O}$ values throughout the Holocene, punctuated by a series of transient increases in $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ at 8.4, 7.2, 6.1, and 5.7 ka BP, and a distinct isotope minima corresponding with the mid-Holocene climate optimum identified in previous studies (Fleitmann et al., 2025). Together, our work suggests that the Kuna Ba stalagmites are sensitive to both short and long-term fluctuations in regional hydroclimate, and so further investigation will be undertaken to ascertain how these patterns may reflect varying contributions of moisture source, precipitation amount, and seasonality effects.

***n*-Alkanes and PAHs from sediments of a Central European upland floodplain reveal the regional Late Holocene vegetation and fire history**

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The Central European uplands were intensively used for human activities during the last millennium, especially since the 'Medieval Industrial Revolution'. This was fostered by the regular occurrence of metal ores and an often dense wood cover allowing charcoal production, being the preconditions for metal production. Due to the general high hydropower potential of the upland rivers facilitating mill construction, especially the upland floodplains and their surroundings were economic centers since that time. Consequently, these environments were strongly impacted by human activities in the form of e.g. economic infrastructures, overbank aggradation, heavy metal pollution, vegetation changes or fire activities.

During this study we applied leaf wax-derived long-chain *n*-alkane biomarkers and polycyclic aromatic hydrocarbons (PAHs) to Late Holocene overbank sediments derived from the floodplain of the upper Weiße Elster River in the Vogtland Uplands (eastern Germany) as proxies for the regional vegetation and fire history. The average chain length of *n*-alkanes suggests a transition from deciduous trees towards grasses due to deforestation. The abundance of the PAH retene in parts of the older floodplain sediments documents the combustion of wood from coniferous forests, and a higher PAH-concentration in younger sediments suggest the increasing occurrence of fires with time.

Biomarker δD analyses reveal the impact of the southern Westerlies on Western Tasmania's hydrology

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During the Late Pleistocene the spatial extent and variability of the southern Westerlies varied in response to southern hemisphere temperature fluctuations. One example is the Antarctic Cold Reversal (ACR) which coincides with the warm Bølling-Allerød interstadial in the northern hemisphere. Tasmania is directly influenced by the southern Westerlies, however the impact of shifting Westerlies and temperature on the hydrology of terrestrial ecosystems in Tasmania during such periods are not well understood. This is in part due to the scarcity of direct hydrological reconstructions of the precipitation-evaporation balance.

Here we present a first attempt to reconstruct past evaporation during the Late Pleistocene-Holocene transition (ca. 19,000 until 8,000 years before present) using compound-specific δD on *n*-alkanes from three lakes in Western Tasmania (Lake Selina, Blythe and Basin). These selected closed basin lakes are relatively small and are within a region characterised by a positive relationship between rainfall and windspeed. As such, these lakes are sensitive to changes in the regional precipitation-evaporation balance and are thus suitable for hydrological reconstructions using stable isotopes.

Within all three lakes, the δD -signals of aquatic short chain ($n\text{-C}_{23}$ and $n\text{-C}_{25}$) and terrestrial long-chain ($n\text{-C}_{31}$) *n*-alkanes reveal a consistent pattern. Our results show that short-chain *n*-alkanes are isotopically enriched compared to long-chain *n*-alkanes, which is likely due to their sensitivity to changes in the evaporative enrichment of lake water, which in turn is linked to the past precipitation-evaporation balance. While a local calibration of leaf wax pattern is currently underway, to refine our hydrological interpretation for future studies applying this method, we conclude that changes in the aquatic δD signal in all three lakes during the Late Pleistocene-Holocene transition suggest a clear relationship between the southern Westerlies and the regional hydrology (wetter versus drier) in Western Tasmania.

Phase of early Lateglacial ice-decay: progress and challenges of a 20 year-old concept

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"For the early deglaciation, which occurred just after the Alpine LGM around 19–18 ka, Reitner (2005, 2007) proposed the term "phase of early lateglacial ice decay" as the classical old model of receding stabilised glacier tongues into the interior of the Alps during the Bühl and the Steinach stadial (Mayr & Heuberger, 1968) does not work. Instead, sedimentary and morphological evidence indicates that the Inn glacier and other large Eastern Alpine glaciers (like the Traun and the Drau glacier) became stagnant in the big Alpine valleys followed by massive down-wasting. Only the separated glaciers showed small glacier advances towards their "Lateglacial Maximum Position" (LMP). Furthermore, in the overwhelming cases no terminal moraines were produced during the LMP that could serve as a proof of glacier tongues in equilibrium with climate. As all the local glacier reactions occurred in contact to collapsing, down-melting large valley glaciers, an approach to look at the thickness loss with respect to AlpLGM conditions was proposed in order to get an (albeit crude) hint for the chronology of the processes.

Getting numerical ages for this early ice decay in the Eastern Alps is still a great challenge with little success. Currently age constraints are restricted to luminescence dating of kame terrace deposits (Klasen et al. 2007), ^{10}Be dates boulders and rock surfaces indicating ice surface lowering the Zillertal Alps (Wirsig et al. 2016) and few ^{14}C data for early ice-free conditions after the LGM (see overview in Reitner 2022, Ivy-Ochs et al. 2023).

Geological mapping in the Austrian Alps during the last two decades resulted in the discovery of further sites where delta deposits of kame terraces are covered by till, indicating limited glacier advances of small local glaciers in the course of ice-decay. Hence, the number of sites indicating glacier oscillations during early lateglacial ice-decay has increased to c. 20 cases showing also more mountain groups with such a glacier dynamics. Regional studies, like that in the area of Lienz (Eastern Tyrol; Reitner et al. 2016), also confirmed the findings of the Kitzbühel Alps (Reitner 2005, 2007) that the local glacier advances occurred during different stages of downwasting and, hence, asynchronously during this short period.

The mapping campaigns have also shown that unambiguous identification of tills associated with these early lateglacial glacier oscillations is problematic in some cases. Sequences consisting of delta deposits formed during the phase of ice-build up at the beginning of the AlpLGM, which were then eventually overridden by glaciers and show a subglacial till of AlpLGM age on top, may be confused with their lateglacial counterparts. Hence the search for regional lithostratigraphic / allostratigraphic type sections in different parts of the Eastern Alps is still a challenge.

Overall, the "phase of early lateglacial ice-decay" has become widely accepted over the last 20 years and, together with the Gschnitz and Egesen stadials, is a major element of the lateglacial chronology and stratigraphy (van Husen & Reitner 2022, Reitner 2022, Ivy-Ochs et al. 2023).

Tracing Waterway Dynamics in Southern Mesopotamia: Geoarchaeological Insights from the Shatt al-Nil and a Natural Canal System near Uruk

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Many ancient waterway structures in southern Mesopotamia have so far been identified through remote sensing data, meaning that their relationships and connectivity have largely been inferred from surface morphology alone. However, these interpretations remain uncertain, and understanding landscape evolution requires investigation below the land surface. Waterways played a fundamental role in early state formation in southern Mesopotamia, shaping settlement patterns, economic integration, and urban development. This study compares two waterway systems in the hinterland of ancient Uruk: the engineered Shatt al-Nil canal and a naturally formed but intensively used waterway. Methods included geomorphological trenching, characterization of fluvial architecture, and chronological analysis using radiocarbon and luminescence dating.

Preliminary results indicate that both systems followed a similar chronological development, implying possible functional or hydrological connectivity. During the 2nd millennium BCE, both experienced rapid fluvial aggradation of surrounding floodplain sediments, followed by progressive silting and abandonment during the 1st millennium BCE. The natural waterway provides exceptional evidence of human activity, including the only excavated boat currently known from Mesopotamia, demonstrating the intensive use of the channel. In contrast, the Shatt al-Nil represents a large-scale engineered canal system, preserved as a linear feature visible in satellite imagery, which connected Uruk with other urban centers such as Kish.

Together, these results highlight the importance of integrating absolute dating methods with geomorphological and archaeological evidence to move beyond interpretations based solely on remote sensing. This integrated approach provides a more robust understanding of hydrological connectivity, watercraft use, and the processes of urban and regional transformation in ancient Mesopotamia.

A partial mammoth skeleton from the Danube valley (southern Bavaria, Germany) provides evidences of human activity from a harsh periglacial palaeoenvironment

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During a routine archaeological heritage management procedure in 2020, an unexpected discovery of a partial woolly mammoth skeleton (*Mammuthus primigenius*) was made in the village of Taimering. One tusk and remains of skeletal elements were unearthed, which can be attributed to 72 documented cranial and postcranial skeletal elements. The remains of the mammoth were embedded with almost no orientation in an Upper Würmian palaeo-channel fill including adjacent overbank deposits. The taphonomy and the absence of duplicate bones indicate that the recovered bones originated from a single individual. The vast majority of the long bones was missing. Cut marks on several ribs point to human activity. Four radiocarbon dates gained from the same mammoth rib provide an age range for the mammoth of Taimering between 26.9 and 25.3 ka cal BP. Accordingly, the mammoth died in the late Gravettian, a period, when large parts of Central Europe were virtually depopulated. Additionally, the surrounding sediments were studied in order to reconstruct the environmental context of the excavation area. Sedimentological and geochemical analyses support the stratigraphical interpretation that the bones were embedded in a former pond, oxbow lake or slow-flowing stream, with the exception of the tusk and ilium, which were buried in topographically higher overbank deposits. Pollen analyses revealed tundra vegetation with small patches of dwarf shrubs in climatically more favorable locations. The pollen assemblages associated with the mammoth bones document that harsh environmental conditions prevailed during the Greenland Stadial (GS) 3 of early marine isotope stage 2. The stable isotope composition of a rib bone shows an exceptionally high $\delta^{15}\text{N}$ value, which is typical of mammoths that lived in the so-called Mammoth Steppe during the Last Glacial Maximum.

References

Pasda, K., Rössner, G.E., Steinmann, C., Maier, A., Mayr, C., Rosendahl, W., Lindauer, S., Friedrich, R., Stojakowits, P., Kevrekidis, C., Uthmeier, T., Reiss, L. & Zolitschka, B. (2026): A cold case from the last Glacial Maximum: A partial mammoth skeleton from southern Germany (Danube valley) – Part 1: Traces of human activity and archaeological context. – *Journal of Archaeological Science: Reports* 73, 105839.

Stojakowits, P., Mayr, C., Steinmann, C., Reiss, L., Lutz, P., Rössner, G.E., Kevrekidis, C., Rosendahl, W., Pasda, K., Maier, A., Uthmeier, T. & Zolitschka, B. (2026): A cold case from the last glacial maximum: A partial mammoth skeleton from southern Germany (Danube valley) – Part 2: Fossil record, sedimentology, and palaeoenvironment. – *Journal of Archaeological Science: Reports* 73, 105793.

Komplexer als zuvor bekannt – subglaziale Rinnen im 3D-Modell der Quartärbasis Nordwest-Niedersachsens

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Glaziale Prozesse, insbesondere während der Elster-Kaltzeit, prägten das Relief der Quartärbasis in Niedersachsen. Sie formten ein komplexes Netz aus subglazialen Rinnen, welche syn- und postglazial mit Lockersedimenten aufgefüllt wurden. Diese Rinnen sind sowohl für die Rohstoffgewinnung als auch für die Grundwasserförderung von zentraler Bedeutung. Auch bei der Planung von Bohrungen, beispielsweise für die oberflächennahe Erdwärmegewinnung, ist die Tiefenlage der Quartärbasis ein entscheidendes Kriterium. Darüber hinaus ist eine präzise Analyse ihrer dreidimensionalen Strukturen bei der Standortsuche für die Endlagerung radioaktiver Abfälle notwendig, da sich dadurch die Geometrien und Erosionstiefen zukünftiger Rinnen konkreter prognostizieren lassen. Das Ziel des Landesamtes für Bergbau, Energie und Geologie (LBEG) ist es daher, ein aktualisiertes, hochaufgelöstes 3D-Modell der Quartärbasis von Niedersachsen zu erstellen.

Unter Verwendung der Software Aspen SKUA© V15 werden sehr umfangreiche und heterogene Datensätze analysiert und in das neue 3D-Modell integriert. Dazu gehören die Isolinienkarte der Quartärbasis von Kuster & Meyer (1995), Bohrdaten, seismische Daten, geologische Profilschnitte und regionale 3D-Modelle. Insbesondere in Bereichen, in denen qualitativ hochwertige Seismikdaten ausgewertet wurden, konnte eine deutlich höhere und präzisere Auflösung der subglazialen Rinnengeometrien erreicht werden als bisher bekannt (vgl. Kuster & Meyer, 1995). Darüber hinaus konnten bisher unbekannte Rinnen entdeckt und neue Erosionstiefen von bis zu -415 m NHN ermittelt werden. Das erste Teilmodell der Quartärbasis für Nordwest-Niedersachsen wurde kürzlich veröffentlicht und kann auf dem NIBIS© Kartenserver des LBEG visualisiert werden. Die Modelldaten werden auf Anfrage unentgeltlich zur Verfügung gestellt. Die Modellierung der Quartärbasisfläche der verbleibenden Landesfläche Niedersachsens wird fortgeführt.

Literatur

Kuster, H. & Meyer, K.-D. (1995): Quartärgeologische Übersichtskarte von Niedersachsen 1:500 000 - Tiefenlage der Quartärbasis. – Landesamt für Bergbau, Energie und Geologie (LBEG); Hannover.

First alkane biomarker results from Late Holocene alluvial sediments of the Wiesent River Catchment (Bavaria, Germany)

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The Wiesent River alluvial sediments in northern Bavaria, Germany, are in the focus of ongoing multi-proxy research. Namely, sedimentological, geoelectrical and paleoenvironmental analyses are combined with optically stimulated luminescence (OSL) dating to establish a robust framework for floodplain development. Our poster contribution presents and discusses the first alkane biomarker results from two sedimentary profiles, Steinfeld and Muggendorf. The alkanes were obtained by a bulk lipid extraction using DCM/MeOH (9:1) in an ultrasonic bath for 15 min. Separation of the neutral and alkane fraction was realized over aminopropyl and silica gel columns, respectively. Quantification was performed on a gas chromatograph equipped with a flame ionization detector. As proxies, we calculated and interpret the total alkane contents (TACs), the average change length (ACL), the odd-over-even predominance (OEP), the ratio $(C_{23}+C_{25})/(C_{23}+C_{25}+C_{29}+C_{31})$ (Paq) and the content of C18 and C20. We propose that our results reflect the deposition of eroded soil material from the catchment as well as alluvial leaf waxes. Events like the famous Magdalenen flood event of 1342 are documented. The ACL and the Paq allow inferring vegetation changes with regard to an "alluvial" versus "Juniperus-pasture" signal. Last but not least, C18 and C20 maxima coincide with anthropogenic events (e.g. fire events and war).

Fluvial deposits of the Ahr river (western Germany) reveal recurring high-magnitude flood events over the last 1500 years

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Floods are one of the most critical environmental threats in Central Europe. In Germany they are responsible for more than half of the economic damage caused by environmental hazards. The magnitude of the 2021 Ahr flood has far exceeded what was forecast in previous flood hazard assessments. This was due to significant underestimation of hazards, as the former hydrological models considered instrumental discharge records exclusively. Because the recording period only began in the second half of the 20th century, high-magnitude flood events prior to that period were not considered in flood hazard assessments. Historical flood events from written sources were also not included in official flood hazard assessments. In this study, we show the importance of geomorphological records from Ahr flood deposits for reconstructing past high-magnitude flood events. Our chemo- and lithostratigraphical analysis of four recovered cores from the Ahr floodplain shows that centennial- to millennial-scale high-energy flood deposits are not the exception but the rule. The four floodplain sediment cores record the catastrophic flood of 2021 and the two historical floods of 1804 and 1910, as well as a previously unidentified flood event dated approximately to the 5th century A.D. In addition, the geomorphological analysis in combination with near-surface geophysical prospection shows that the Ahr floodplain is dominated by high-energy flood deposits and that low to medium-magnitude flood events are not preserved in the floodplain stratigraphy. The results document the high potential of floodplain archives for reconstructing high-magnitude flood events in Central European rivers, allowing a systematic reassessment in terms of the occurrence and frequency of high-magnitude flood events. The occurrence of the large floods in the Ahr valley does not show any clear coupling with the Central European hydroclimatic history. However, what is noticeable is that the historically documented high-magnitude Ahr floods occur during the summer season, which is in parallel with high atmospheric moisture loads.

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