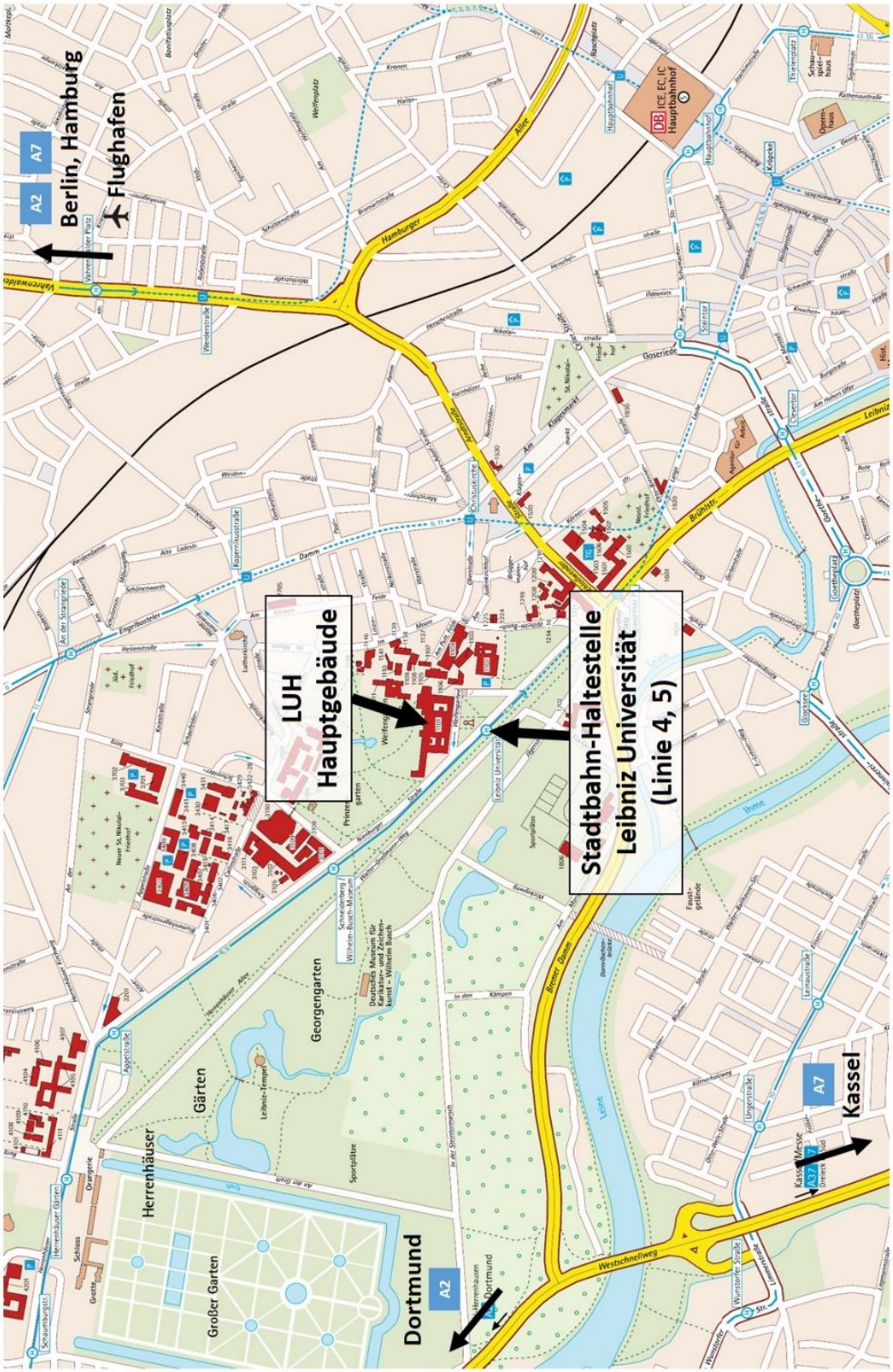
IODP/ICDP-Kolloquium 2023

Quelle: Daniel Vogl / LUH

Leibniz Universität Hannover

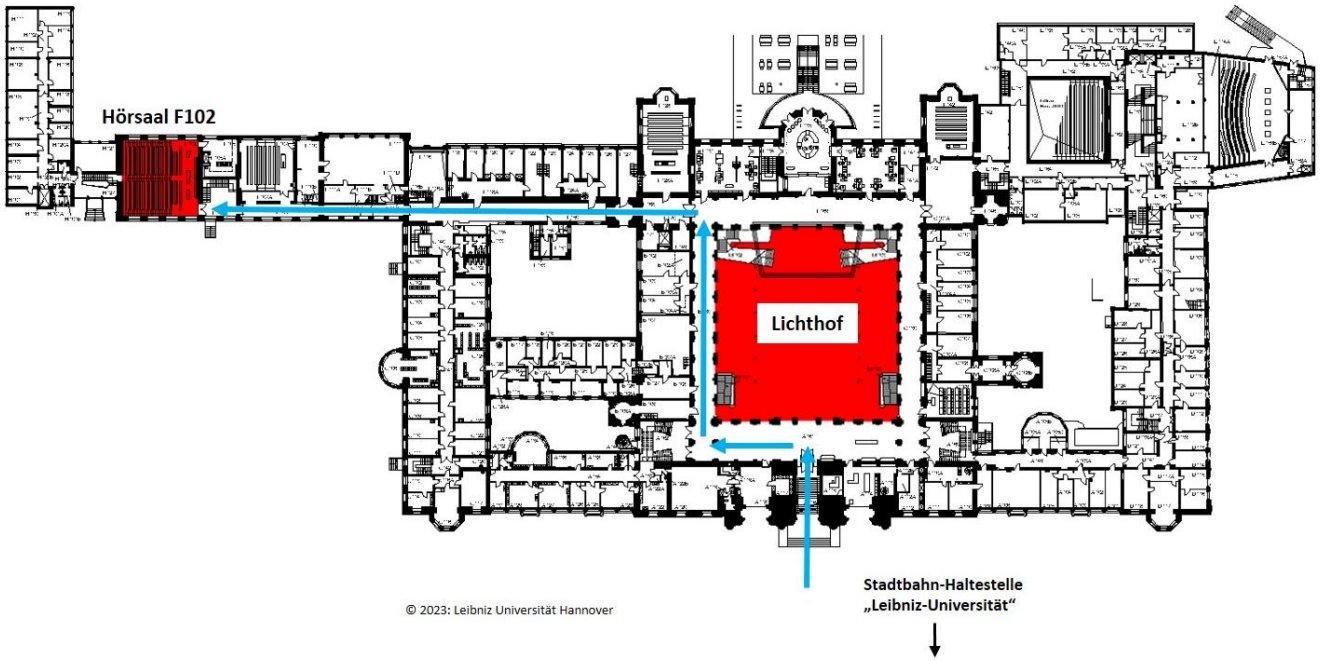
29. – 31. August 2023

Lagepläne und Anfahrt - Site plans and directions



Das Kolloquium findet im Hauptgebäude der Leibniz Universität Hannover (LUH), Welfengarten 1, **Hörsaal F102**, statt.
The colloquium will be held in the main building of Leibniz University Hanover (LUH), Welfengarten 1, **room F102**.

Hörsaal F102 befindet sich im ersten Stock. Sie erreichen ihn über den Haupteingang des Universitätsgebäudes. **Room F102** is located on the first floor. You can reach it via the the main entrance of the university building.



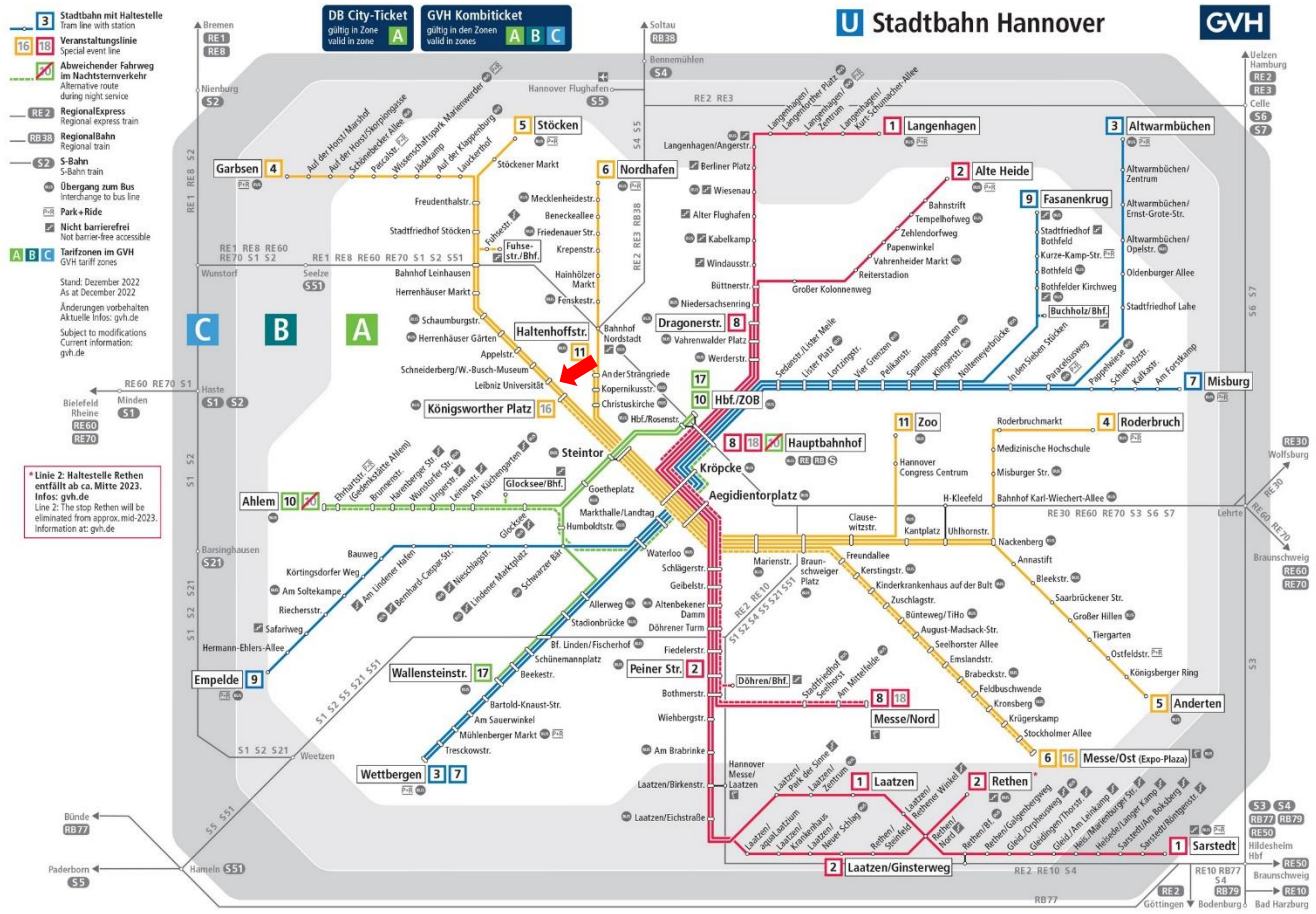
Anreise zum Kolloquium vom Hauptbahnhof Hannover mit Bus und Bahn

Vom Hauptbahnhof Hannover laufen Sie ca. 250 m zu Fuß durch die Innenstadt zur Station **"Kröpcke",** oder Sie fahren dorthin eine Station mit der **Stadtbahnlinie 1** (Richtung Laatzen oder Sarstedt), **2** (Rethen), **3 ,7** (beide Wettbergen), **8** (Messe/Nord) oder **9** (Empelde). Von der Station **"Kröpcke"** erreichen Sie die Universität mit den **Stadtbahnlinien 4** Richtung Garbsen oder **5** Richtung Stöcken. Zum Hauptgebäude der Universität fahren Sie bis zur Haltestelle **"Leibniz Universität"** (Fahrtzeit 5 Minuten). Vor sich sehen Sie das Welfenschloss (Hauptgebäude). Aktuelle Fahrplaninformationen des Großraumverkehrs Hannover erhalten Sie unter Fahrplan GVH.

Travel to the colloquium from Hanover main station by public transport

Walk from the main railway station approximately 250 m into the City Centre to the underground railway stop **"Kröpcke"**, or take the City Railway to reach **"Kröpcke"** using **routes 1** (direction Laatzen oder Sarstedt), **2** (Rethen), **3, 7** (both Wettbergen), **8** (Messe/Nord) or **9** (Empelde). From the tram stop **"Kröpcke"** you will reach the University within about 5 minutes using the City Railway, **route 4** toward Garbsen, or **5** toward Stöcken. To get to the main university building, ride until you reach the stop called **"Leibniz Universität"**. You will see the the Welfenschloss (main building) in front of you. The latest timetable information of the Greater Hanover public transport sytem can be found on the internet site Fahrplan GVH.

Liniennetzplan Hannover / Tram network City of Hanover



Quelle: Ustra Hannoversche Verkehrsbetriebe AG

Weitere Informationen

- Die **Poster** sind während der gesamten Zeit des Kolloquiums im Lichthof des Hauptgebäudes einzusehen.
- Die **Mittagspause am Mittwoch** findet ab 13 Uhr in der Hauptmensa (Callinstraße 23, 30167 Hannover) statt.
- Die **Icebreaker Party** findet im Lichthof des Hauptgebäudes im Anschluss an das Programm am Dienstag statt.
- Das **gemeinsame Abendessen** findet am 30.08.2023 um 19 Uhr ebenfalls im Lichthof des Hauptgebäudes im Anschluss an das Programm statt.
- Die **„GESEP School on Scientific Drilling“** findet am 31.08.2023 im Anschluss an das Kolloquium ab 13 Uhr am Institut für Mineralogie (Raum R129, Callinstraße 3, 30167 Hannover) statt, sowie am 01.09.2023 ab 9 Uhr im Konferenzraum des LIAG (Stilleweg 2, 30655 Hannover).

Additional information

- The **posters** will be on display in the atrium of the main building during the whole colloquium.
- The **lunch break** on Wednesday will take place from 1 pm in the main canteen (Callinstraße 23, 30167 Hannover).
- The **Icebreaker Party** will take place in the atrium of the main building after the programme on Tuesday.
- The **Conference Dinner** will take place on 30th August at 7 pm, also in the atrium of the main building, following the programme.
- The **"GESEP School on Scientific Drilling"** will be held at the Institute of Mineralogy (Room R129, Callinstraße 3, 30167 Hannover) on 31th August from 1 pm following the colloquium, and on 1st September from 9 am in the conference room of the LIAG (Stilleweg 2, 30655 Hannover).

Tagungsprogramm / Agenda (Stand 16.08.2023)

Dienstag, 29. August 2023 Tuesday 29th August 2023		
13:00	14:00	**Registrierung - Registration**
Beginn Kolloquium - Beginning of the Conference		
14:00	14:15	**Begrüßung - Welcome**
14:15	14:40	*Bornemann, A.* **New developments in IODP**
14:40	15:05	*Krastel, S., Wiersberg, T.* **New developments in ICDP**
Wissenschaftliche Beiträge zu IODP und ICDP - Scientific talks related to IODP and ICDP		
15:05	15:40	*Camoin, G. (remote presentation)* **IODP³ – an ocean of opportunities**
15:40	16:30	**Posterpräsentation und Kaffeepause - Presentation of posters and coffee break (Lichthof)**
16:30	16:50	*Najjarifarizhendi, B.* **Early throughflow of Proto Weddell Sea Deep Water in the Falkland/Malvinas Trough**
16:50	17:10	*J. Gruetzner* **Core-Log - Seismic Integration for the Cretaceous to Oligocene sequence in the African-Southern Ocean gateway: First results from the Agulhas Plateau (IODP Sites U1579 and U1580)**
17:10	17:30	*Burschil, T.* **The acquisition concept for seismic surveys within Chatseis**
17:30	17:50	*Trumbull, R* **Scientific drilling in the Bushveld Complex: an update on the BVDP project**
***Im Anschluss: Posterpräsentation und Icebreaker* – Afterwards: Presentation of posters and Icebreaker (Lichthof)**		

Mittwoch, 30. August 2023 Wednesday 30th August 2023		
IODP Expeditionsberichte - IODP Expedition Reports		
09:00	09:20	*Kaboth-Bahr, S.* **Initial results from Expedition 397: Iberian margin palaeoclimate**
09:20	09:40	*Kutterolf, S.* **IODP Expedition 398: Helenic Arc volcanic field**
09:40	10:00	*Kühn, R.* **IODP Expedition 399 'Building blocks of Life, Atlantis Massif'**
Wissenschaftliche Beiträge zu IODP und ICDP - Scientific talks related to IODP and ICDP		
10:00	10:20	*Haberzettl, T.* **NamCore – Finally a drilling on the central Tibetan Plateau**
10:20	10:50	**Posterkurzvorstellung / Poster short presentation (2 min. each, poster no. 1-15)**
10:50	11:40	**Posterpräsentation und Kaffeepause - Presentation of posters and coffee break (Lichthof)**
Wissenschaftliche Beiträge zu IODP und ICDP - Scientific talks related to IODP and ICDP		
11:40	12:00	*Gugliotta, M.* **CycloSalt – Pilot study to investigate cyclicities in halite deposits of the Mediterranean Messinian salinity crisis in the Racalmuto salt mine (Caltanissetta Basin, Sicily, southern Italy)**
12:00	12:20	*Soaga, O.* **Variability of Antarctic Intermediate Water composition in the South Atlantic over the last 600,000 years**
12:20	12:40	*Vinnepand, M.* **An age model for Lake Bosumtwi (Ghana) – A key to reconstruct one million years of West African climate and environmental change**
12:40	13:00	**Posterkurzvorstellung / Poster short presentation (2 min. each, poster no. 16-25)**
13:00	14:30	**Mittagspause und Posterpräsentation - Lunch break and Presentation of posters**

Mittwoch, 30. August 2023	**Wednesday 30th August 2023**	
Wissenschaftliche Beiträge zu IODP und ICDP - Scientific talks related to IODP and ICDP		
14:30	14:50	*Kearney, R.* **The TephroMed project: Linking two key ICDP records of the eastern Mediterranean region using tephras**
14:50	15:10	*Ruiz-Blas, F.* **BioMetArchive - Subsurface biosphere metagenomics along the 1 Ma sedimentary archive of ferruginous Lake Towuti, Indonesia**
15:10	15:30	*Nagakura, T.* **Microbial hydrocarbon uptake and the effect of hydrocarbons on microbial sulfate reduction**
15:30	16:00	**Posterkurzvorstellung / Poster short presentation (2 min. each, poster no. 26-40)**
16:00	16:30	**Posterpräsentation und Kaffeepause - Presentation of posters and coffee break (Lichthof)**
Wissenschaftliche Beiträge zu IODP und ICDP - Scientific talks related to IODP and ICDP		
16:30	16:50	*Jia, Z.* **Genomic assessment of Eger Rift subsurface microbial communities offers glance at specialized archaeal and bacterial processes driven by mantel derived CO_2 degassing and seismic events**
16:50	17:10	*Strack, D.* **Observations from EPSP Reviews - International Ocean Discovery Program 2013-2024**
17:10	17:40	*Spieß, V.* **Three Decades of Pre-Site Survey Work by Bremen University for IODP and ICDP – A Personal Review and Outlook**
17:40	18:04	**Posterkurzvorstellung / Poster short presentation (2 min. each, poster no. 41-52)**
ab 19:00		**Gemeinsames Abendessen – Joint Dinner (Buffet im Lichthof, LUH)**

Donnerstag, 31. August 2023 Thursday 31th August 2023		
Wissenschaftliche Beiträge zu IODP und ICDP - Scientific talks related to IODP and ICDP		
09:00	09:20	*Weber, M.* **IODP Expedition 382 – Pliocene-Pleistocene ice-ocean-atmosphere dynamics in Iceberg Alley**
09:20	09:40	*Petrick, B.* **The development of the Great Barrier Reef has been controlled by temperature change since its origin in the Pleistocene**
09:40	10:00	*Blanchet, C.* **The 8.2 ka event in the Dead Sea: tracking a high-latitude disturbance in the Mediterranean**
10:00	11:00	**Posterpräsentation und Kaffeepause - Presentation of posters and coffee break (Lichthof)**
11:00	11:20	*Perez, L.* **Adapting in the face of climate and environmental change in the American Tropics: responses of freshwater ostracode communities from ancient Lakes Petén Itzá, Guatemala and Chalco, Mexico during the last 80 ka**
11:20	11:40	*Krasheninnikov, S.P.* **Influence of high Chlorine contents on phase equilibria in hydrous dacitic melts of Brothers volcano (IODP Expedition 376)**
11:40	12:00	*Waelkens, C.* **Constraining magma storage and dynamics from complexly zoned crystal cargoes in the Kimana drill core: Snake River Plain volcanic province, USA**
12:00		**Posterprämierung und Schlussworte - Poster Awards and Concluding Remarks**
13:00		***GESEP School on Scientific Drilling: Institut für Mineralogie (Callinstraße 3, Raum 129)***
Ende GESEP School: Freitag, 01.09.2023, 14 Uhr – GESEP School ends on Friday 01/09/2023, 2 pm		

Fahrtberichte und Kurzfassungen / Cruise Reports and Abstracts

Fahrtberichte / Cruise Reports

Kurzfassungen / Abstracts

Fahrtberichte und Kurzfassungen / Cruise Reports and Abstracts

Fahrtberichte / Cruise Reports

IODP

Initial results from Expedition 397: Iberian margin palaeoclimate

S. KABOTH-BAHR[1], H. L. BROOKS[2], J. LINK[3] AND EXP. 397 SCIENTISTS

[1] Institute of Geological Sciences, Freie Universität Berlin, Berlin, Germany
[2] Geological Institute, RWTH-Aachen University, Aachen, Germany
[3] Institute of Earth Sciences, Heidelberg University, Heidelberg, Germany

During International Ocean Discovery Program Expedition 397, we recovered a total of 6176.7 m of core (104.2% recovery) at four sites (U1588, U1385, U1587, and U1586) from the Promontóriodos Principes de Avis (Figure 1), a plateau located on the Portuguese continental slope that is elevated above the Tagus Abyssal Plain and isolated from the influence of turbidites. The drill sites are arranged along a bathymetric transect (1339, 2590, 3479, and 4691 meters below sea level [mbsl], respectively) to intersect each of the major subsurface water masses of the eastern North Atlantic. The Iberian margin is a well-known source of rapidly accumulating sediment that contains a high fidelity record of millennial climate variability (MCV) for the late Pleistocene. Previous studies have demonstrated that surface and deepwater climate signals from the region can be correlated precisely to the polar ice cores in both hemispheres (Shackleton et al., 2000). Moreover, the narrow continental shelf off Portugal results in the rapid delivery of terrestrial material to the deep-sea environment, thereby permitting correlation of marine, ice core, and European terrestrial records (Margari et al., 2014; Naughton et al., 2019;

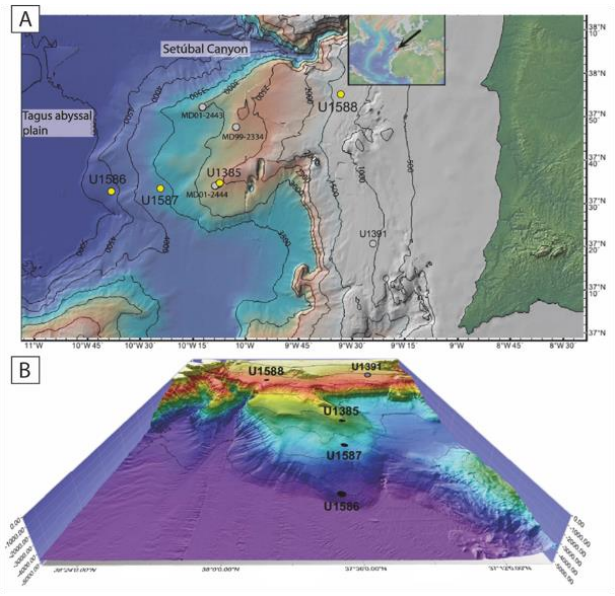


Figure 1. Location maps. (A) Detailed bathymetry of PPA (Zitellini et al., 2009) showing the coring-site locations of Ex. 397 (yellow circles), the Marion Dufrense (MD) piston cores, and the IODP site U1392 (grey circle). Inset map indicates location of study area in the East Atlantic, offshore Portugal. (B) Bathymetry 3D-cube of on the PPA looking onshore to the east. Sites are aligned along a depth transect from the shallowest (Site U1588) to the deepest (Site U1586) at (Figure modified from Ex. 397 initial report, Hodell et al, 2023).

Oliveira et al., 2016, 2020). Expedition 397 recovered sediment sequences dating from the late Miocene to the Pleistocene from a range of water depths to document past changes in vertical water mass structure and its relation to global climate change. Specific scientific objectives that will be tackled during the post-cruise phase are: 1. Document the nature of MCV for older glacial cycles of the Quaternary beyond the limit of Site U1385 (1.45 Ma), including the earliest Pleistocene and the Pliocene prior to the intensification of Northern Hemisphere glaciation (NHG); 2. Derive a marine sediment proxy record for Greenland and Antarctic ice cores to examine the amplitude and pacing of MCV during the Quaternary; 3. Determine interhemispheric phase relationships (leads/lags) by comparing the timing of proxy variables that monitor surface (Greenland) and deepwater (Antarctic) components of the cli- mate system; 4. Study how changes in orbital forcing and glacial boundary conditions affect the character of MCV and, in turn, how MCV interacts with orbital geometry to produce the observed glacial- to-interglacial patterns of climate change; 5. Determine how MCV evolved during the Pliocene–Pleistocene as glacial boundary conditions changed with the progressive intensification of NHG, and 6. Reconstruct the history of changing local dominance of northern-sourced versus southern- sourced deep water using the depth transect of IODP sites on orbital and suborbital timescales during the Quaternary. Multiple holes were drilled at each site, and complete composite sections were constructed. Sites U1586 and U1385 were drilled to the planned depths of 350 and 400 mbsf, respectively. We recovered much older sediment (14 Ma) than anticipated at Site U1586, which extended the expedition objectives into the middle Miocene (Figure 2). At Site U1587, we sought and were granted permission from EPSP to deepen the hole from 400 to 450 mbsf to ensure complete recovery of the Messinian Stage (7.246–5.333 Ma). Site U1588 could only be drilled to 412.5 mbsf out of the planned 500 mbsf because severe gas expansion of the sediment forced us to alter our strategy and drill half advances (4.8 m) with the XCB system, which significantly slowed the recovery rate. Post-cruise X-ray fluorescence core scanning of all sites will aid efforts to further refine the shipboard composite splice.

References:

Blunier, T., and Brook, E.J., 2001. Timing of millennial-scale climate change in Antarctica and Greenland during the last glacial period. Science, 291(5501):109–112. https://doi.org/10.1126/science.291.5501.109

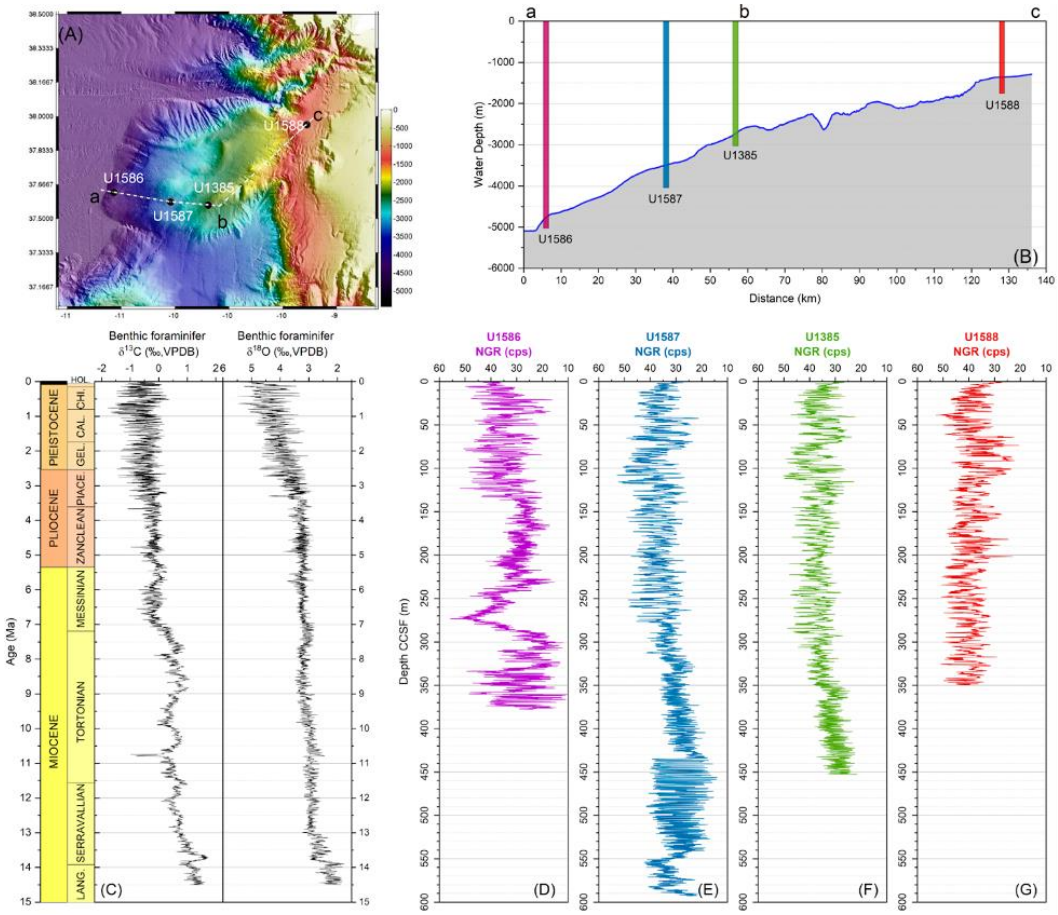
Margari, V., Skinner, L.C., Hodell, D.A., Martrat, B., Toucanne, S., Grimalt, J.O., Gibbard, P.L., Lunkka, J.P., and Tzedakis, P.C., 2014. Land-ocean changes on orbital and millennial time scales and the penultimate glaciation. Geology, 42(3):183–186. https://doi.org/10.1130/G35070.

Naughton, F., Sanchez Goñi, M.F., Desprat, S., Turon, J.L., Duprat, J., Malaizé, B., Joli, C., Cortijo, E., Drago, T., and Freitas, M.C., 2007. Present-day and past (last 25000 years) marine pollen signal off western Iberia. Marine Micropaleontology, 62(2):91–114. https://doi.org/10.1016/j.marmicro.2006.07.006.

Oliveira, D., Desprat, S., Rodrigues, T., Naughton, F., Hodell, D., Trigo, R., Rufino, M., Lopes, C., Abrantes, F., Sanchez Goñi, M.F., 2016. The complexity of millennial scale variability in southwestern Europe during MIS 11. Quat. Res. 86, 373e387. https://doi.org/10.1016/j.yqres.2016.09.002.

Oliveira, D., Desprat, S., Yin, Q., Rodrigues, T., Naughton, F., Trigo, R.M., Su, Q., et al. "Combination of insolation and ice sheet forcing drive enhanced humidity in northern subtropical regions duringMIS 13". Quaternary Science Reviews 247 (2020): 106573. http://dx.doi.org/10.1016/j.quascirev.2020.106573.

Shackleton, N.J., Hall, M.A., and Vincent, E., 2000. Phase relationships between millennial-scale events 64,000–24,000 years ago. Paleoceanography and Paleoclimatology, 15(6):565–569. https://doi.org/10.1029/2000PA000513 WAIS Divide Project Members, 2015. Precise interpolar phasing of abrupt climate change during the last ice age. Nature, 520(7549):661–665. https://doi.org/10.1038/nature14401.



S. Kaboth-Bahr et al.:
Figure 2: (A) Locations of sites (see Figure 1) and dashed white line showing depth transect displayed in (B). (B) Depth transect from the shallowest site (U1588) on the right to the deepest site (U1586) on the left. (C-G) Natural Gamma Ray (NGR) data for each Expedition 397 site relative to the global stable isotope curves VPDB = Vienna Peedee belemnite, cps = counts per second.

IODP

IODP Expedition 399 ‘Building blocks of Life, Atlantis Massif’

R. KUEHN[1] AND EXP. 399 SCIENCE PARTY

[1] Martin-Luther-Universität Halle-Wittenberg, Halle

Expedition 399 set sail on the RV *JOIDES Resolution (JR)* on April 15th, 2023 from Ponta Delgada, Azores, towards the Atlantis Massif oceanic core complex at the mid-Atlantic ridge at ~30° N. As it was the first submarine corrugated massif identified as oceanic core complex, and hosts the Lost City Hydrothermal Field, the Atlantis Massif has already in the past been the target of numerous IODP expeditions (304/305, 340T, 357).

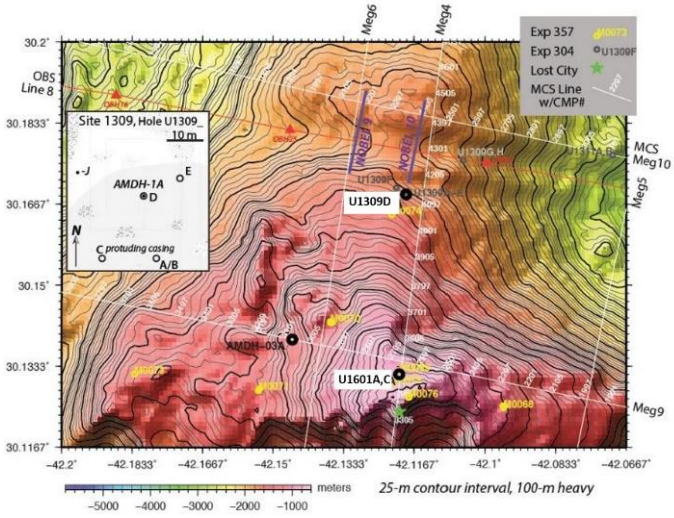


Figure 1. Site map of IODP Expedition 399 modified from McCaig et al. (2019) with Sites U1601 and U1309D indicated. Drill sites of previous expeditions are also indicated as well as the Lost City Hydrothermal Field.

The objectives of the expedition were to 1) explore the life cycle and internal structure of the Atlantis Massif oceanic core complex, 2) search for abiotically formed organic molecules as the building blocks of life necessary to allow first life on Earth to form, 3) explore the deep biosphere down to the limit of life (~122 °C). The initial plan was to deepen Hole U1309D (Figure 1) drilled during IODP Expeditions 304/305 from 1415 mbsf down to ~2100 mbsf and reach 220 °C, where active serpentinization could occur. A new, 200 m deep hole (Site U1601, proposed site AMDH-02A, Figure 1) at the southern wall was planned, aimed to drill serpentinizing rocks and the detachment fault of the oceanic core complex, close to Site M0069 from Expedition 357.

A 56.3 m deep pilot Hole U1601A (Figure 1) was successfully drilled. The subsequent attempt of installing a re-entry system in Hole U1601B failed and a new strategy was necessary. In the meantime, the *JR* transited to Hole U1309D for cleaning the hole successfully and drilling a bit run down to 1497 m, recovering predominantly gabbroic rocks. After fluid sampling and temperature logging, with a new plan for the installation of a re-entry system, the *JR* transited back to Site U1601 and successfully installed a re-entry system in Hole U1601C. Drilling there made very good progress with an average recovery of 69%. Therefore, it continued to greater depth than the originally planned 200 m, ending on June 2nd at 1267.8 mbsf final depth. The rocks recovered at Site U1601 consist mainly of variably serpentinized harzburgites and dunites (~70%) and gabbroic rocks (~30%). Deformation in the rocks is variable. From all recovered cores the microbiology team carefully sampled 191 whole rounds of interesting sections for further analysis.

Finally, fluid sampling was executed, discovering hydrogen in borehole waters of U1601C, as well as a complete logging suite including temperature logging, borehole imaging, and a vertical seismic velocity profile. The temperature at the bottom of U1601C reached >90 °C. Hole maintenance was performed at U1601C and 1309D for legacy purposes and the JR arrived back at the port of Ponta Delgada on June 8th, 2023.

IODP

IODP Expedition 398: Hellenic Arc Volcanic Field

S. KUTTEROLF[1]*, T. DRUITT[2], T.RONGE[3] AND EXPEDITION 398 PARTICIPANTS

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[2] Laboratory of Magmatism-Volcanism, Clermont-Auvergne University, France,
[3] International Ocean Discovery Program, Texas A&M University, USA
* skutterolf@geomar.de

The objectives of IODP Expedition 398 'Hellenic Arc Volcanic Field' (11 December 2022 to 10 February 2023) were to study the volcanic record of the central Hellenic Volcanic Arc, to document the links and feedbacks between volcanism/ magmatism, crustal tectonics and sea level, to investigate the processes and products of shallow submarine eruptions of silicic magma, and to groundtruth the seismic stratigraphy of Santorini caldera. Reconstructing the subsidence history of the southern Aegean Sea, and searching for deep life inside and outside of Santorini caldera, were additional objectives.

The expedition started on the 9th of December with a period of quarantine in a hotel in Barcelona. On the 13th of December the Expedition scientists and the IODP technicians boarded the Joides Resolution and on the 16th of December the 4-days transit to the working area started. During our operational days around the Christiana-Santorini-Kolumbo volcanic field (CSKVF) we experienced very challenging drilling conditions giving us time to drill ten primary and alternate sites originally proposed, plus two extra sites that were requested during the expedition (Fig.1). In total we drilled 7345 meter in 28 holes, retrieved 780 cores with a total recovery of 3356 meters. Outside of Santorini caldera, drilling penetrated the thick basin fills of the crustal rift system hosting the CSKVF, identifying more than 1000 tephra layers, some known from onland and others formerly unknown, pushing back the onset of volcanism in the area into the early Pleistocene or even Pliocene. Sites in the rift basins served to groundtruth the seismic stratigraphy of the basins and to open the way to unravelling relationships between volcanic activity and crustal rift pulses. Two sites of condensed sequences on the basin margins served to sample many tephra layers within the detailed age-depth constraints provided particularly by biostratigraphy. Drilling penetrated the Alpine basement at three basin sites north of Santorini, while in the Christiana Basin to the south it penetrated a thick sequence of Messinian evaporites. Drilling inside Santorini caldera penetrated to ~120 mbsf, less than planned due to hole instability issues but deep enough to groundtruth the seismic stratigraphy and to sample the different layers. Despite variable recovery in the unstable pumice and ash deposits, the expedition was a great success that will enable us to address almost all the science objectives once the laboratory work has been done.

The first science result submitted for publication is the discovery of a large, previously unknown Middle Pleistocene eruption from ancestral Santorini. This eruption discharged 88 ± 8 cubic kilometres of pyroclastic flows into the rift basins, the deposits having the characteristics of a huge shallow submarine eruption ten times larger than that of Hunga Tonga-Hunga Ha'apai in 2022. Breaching of the sea surface by the eruption plume laid down thin subaerial veneers of ignimbrite on Santorini, Christiana and Anafi islands. The discovery extends the explosive eruptive history of the CSKVF back in time, and implies the existence of a large buried caldera on which the modern Santorini is founded.

A dense programme of pre-expedition and shipboard outreach during the expedition was undertaken. Prior to the expedition, the exhibition 'In search of Earth's secrets', ran for a week on Santorini and was visited by over 1800 school children. Fifty-nine onboard ship to shore tours reached 6400 people in seven countries. While in Santorini caldera, the ship hosted twelve documentarians and journalists, the future products of whom will include a 1.5-hour documentary and a four-part TV series on Expedition 398.

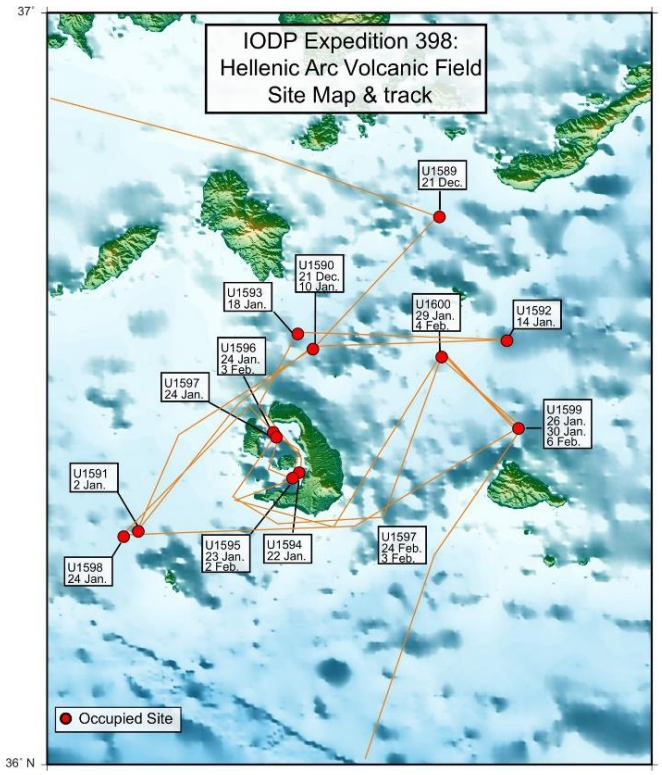

Figure 1. Overview map and cruise path with drilled sites of IODP Expedition 398 - Hellenic arc volcanic field.

Kurzfassungen / Abstracts

IODP

ENSO-Modoki on the rise under global warming conditions? A view from the past

A. BAHR[1], K. HESS[1], A. JAESCHKE[2], O. FRIEDRICH[1]

[1]Institute of Geosciences, Heidelberg University, Heidelberg, Germany
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The El Niño-Southern Oscillation (ENSO) is one of the largest oceanic and atmospheric phenomena on Earth influencing global climate patterns. Over the last decades, a strong warming in the high latitudes of both hemispheres has been observed to coincide with the rise of a third ENSO type — "El Niño/La Niña Modoki", also called Central Pacific ENSO. During El Niño Modoki (La Niña Modoki) events, sea-surface temperature (SST) is higher (lower) in the central equatorial Pacific, flanked by colder (warmer) SSTs in the western or eastern Pacific. This oceanic set up is associated with a twin Walker Circulation (Ashok & Yamagata, 2009), hence, climate anomalies associated with ENSO Modoki are distinct from those of the "classic" ENSO with a more symmetric distribution around the tropical Pacific realm. Related global consequences include a higher frequency of hurricanes hitting the Gulf of Mexico (Kim et al., 2009) as well increased warming in the subpolar realms of both hemispheres potentially accelerating high latitude ice-sheet demise (Ding et al., 2011; Lee et al., 2010).

To shed light onto the potential further evolution of ENSO Modoki, this project aims to provide insights from a paleo-perspective. This will be done via assessing the occurrence of ENSO Modoki-like climatic states during varying climatic background states regarding (i) greenhouse gas concentrations, (ii) global ice volume and (iii) insolation, factors with a well-documented impact on classical ENSO as well as ENSO Modoki dynamics. For this purpose, high-resolution proxy records of sea surface temperature (SST) and subsurface temperature (subT) variability on ODP/IODP Sites from the western (Site U1488), central (Site 871; complementing SST records by Dyez & Ravelo, 2013), and eastern equatorial Pacific (Site 846; complemeting SST data from Herbert et al., 2016) will be generated, covering 300 kyr-long time slices with distinctly different climatic background conditions. These time slices comprise (i) the mid-Pleistocene to Holocene (0–300 ka) with relatively low pCO_2 concentrations and high Northern Hemisphere ice volume, and (ii) the Early Pliocene (4.85–5.15 Ma) with pCO_2 conditions similar to modern and largely absent Northern Hemisphere ice sheets.

Based on the data generated for the Pleistocene interval, a spatial pattern resembling La Niña Modoki-like conditions consistently appeared during warmer, interglacial periods, parallel to a reduced zonal SST contrast. When computing the ENSO Modoki index based on the three SST records, it appears that its variability is clearly distinct from the classical ENSO behaviour. In comparison with potential forcing mechanisms, La Niña Modoki conditions apparently become more frequent with increasing greenhouse gas concentrations and lower ice volume. Our new data point at the likelihood that La Niña Modoki conditions will become more prevalent in the near future as a response to global warming and should hence be more strongly considered in the assessment of future climate scenarios.

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ICDP

Towards the application of 2D elastic FWI to multi-component high-frequency crosshole data acquired in the Quaternary Tannwald Basin

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Within the ICDP project Drilling Overdeepened Alpine Valleys (DOVE), we investigate Quaternary sediments in the Tannwald Basin (5068_1) to understand landscape evolution through sedimentation processes caused by climate change. To obtain a high-resolution image of the sediment structure in 105 to 134 m depth, we conducted a seismic crosshole experiment using a high frequency vertically polarized shear (SV) wave borehole source in borehole 5068_1_B. The wavefield was recorded in borehole 5068_1_C using a three-component geophone string (Geotomographie GmbH), with the strongest SV-wave on the vertical component (Beraus et al., 2022). From initial descriptions of cuttings (boreholes 5068_1_A, 5068_1_B) and the core retrieved from borehole 5068_1_C, we expect a rather homogeneous medium in the surveyed depth. The field data, however, shows a complex wavefield around the arrival time of the SV-wave and indicators of anisotropy.

To gain a better understanding of the data and confirm results, we simulate seismic wave propagation with two 2D finite-difference (FD) codes (DENISE-Black Edition (Köhn et al., 2023) and SOFI2D (Bohlen et al., 2023)). Both codes solve the wave equation at each time step of the simulation under an elastic isotropy or anisotropy wave propagation assumption. To run the simulation, we provide the field geometry, that is projected onto the 2D plane, and 2D subsurface models. We use (1) homogeneous, i.e., spatially constant, P- and SV-wave velocity models and a density model, (2) horizontally layered P-, SV-wave velocity models and a horizontally layered density model. We further test two source wavelets: (a) a traditional Ricker wavelet which has the disadvantage of being zero-phase and thus being non-physical, (b) a bandpass-filtered spike (Jeong et al., 2012) yielding minimum-phase source signals with an almost white frequency spectrum. We set the source frequency to 325 Hz as it is the highest dominant S-wave frequency of the field data. In order to fulfil numerical dispersion and stability criteria using a 6^{th} order FD operator, we require a grid spacing of 0.1 m and a time sampling interval of 0.01 ms. To reduce computing costs, we use both domain decomposition and shot parallelization.

In order to analyze the fit of the synthetic and the field data, we bandpass-filter both datasets to a frequency range of 10 to 650 Hz, which contains most of the S-wave signal. The field data is converted from 3D to 2D to properly compare the datasets. Both

the isotropic and the anisotropic simulation yield SV-wave onsets close to those in the field data. The waveform fit is better for the Ricker wavelet, which can be explained by its non-white spectrum that resembles that of the field data more closely. The results for the horizontally layered model show very similar behavior and do not significantly improve the SV-wave arrival fit. Thus, all assumptions made for the simulations yield wavefields that match the field data equally well regarding SV-wave onset times on the vertical component.

Therefore, we will start with the simple case of an isotropic medium and run a full-waveform inversion (FWI) of the data with the homogeneous models. A source time function inversion

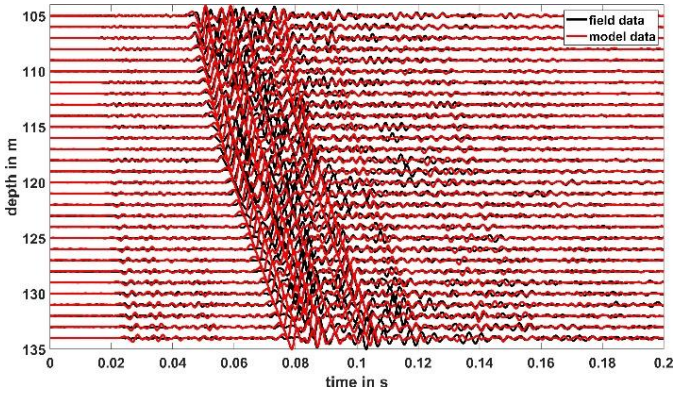

Figure 1. Waveform fit after source time function inversion for a shot at 97 m depth. Both the field data (black) and the modeled data (red) is bandpass-filtered to a frequency range of 10 to 650 Hz. For forward modeling of the data in red, the wavelet from a source time function inversion considering offsets up to 30 m is used.

of the bandpass-filtered spike yields a minimum-phase wavelet with which the SV-wave arrivals already fit within half a period on most traces (s. Fig. 1), which should ensure the convergence of the inversion.

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ICDP

Preliminary magneto-mineralogical data from the ICDP-Eger drill site S4a, Czech Republic (DFG Project 517885783)

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The magnetic properties of volcanic rocks can be used as a complementary tool to reveal information about the cooling history and emplacement conditions of eruptive products. In this study, the lapillituff, basalt layers and tuff of the 400 m deep drill core from the ICDP-Eger drill site S4a (drilled in November 2021) in the Bazina Maar were examined in terms of their mineralogical and magnetic characteristics. The Bazina Maar was just recently discovered on the western uplifted shoulder of

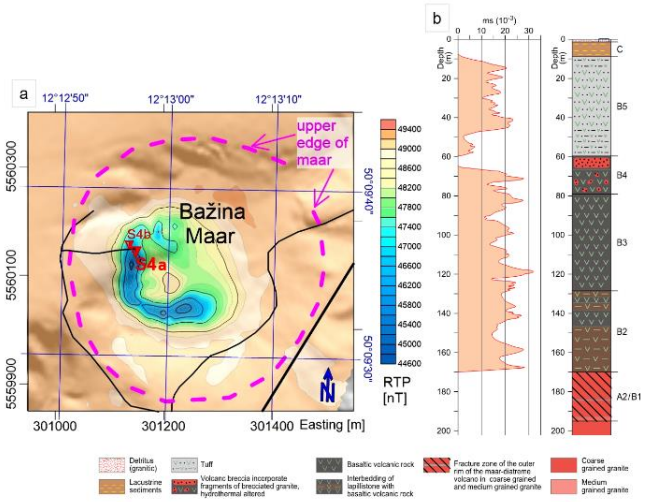

Figure 1. (a) Reduced to pole (RTP) magnetic map of the Bazina Maar NW of Cheb, Czechia with strong negative anomaly in blue color. Morphologial upper edge of maar depression in violet. ICDP drill site S4a and S4b are marked by symbols. (b) Magnetic susceptibility (given in SI units; granite is paramagnetic) and lithological profile from 0-200 m depth of the ICDP-Eger S4a drill core.

the Cheb-Domažlice Graben as a double crater structure (Liba-Bazina) independently by Mrlina et al. (2019) and Hošek et al. (2019) using geophysical field studies (see Fig. 1).

We determined via polarizing and scanning electron microscopy that Mg- and Al-bearing titanomagnetites are the main magnetic phase in all lithologies (Krebs, 2022, unpubl.). Field- and

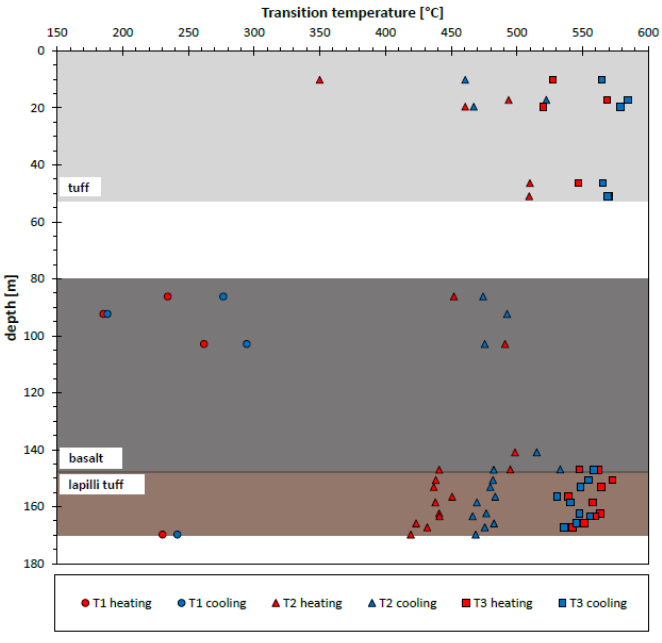

Figure 2. Changes in transition temperature with depth for the S4a drill core. Red and blue indicate temperatures obtained from heating and cooling curves, respectively. Circles represent T1, triangles T2 and squares T3 (see text for further explanation of transition temperatures).

temperature-dependent magnetic susceptibility and corresponding Curie-Temperatures (T_c) were measured for all volcanic lithologies. The thermomagnetic curves show up to three nonreversible transition temperatures T1 (172 – 264 °C), T2 (350 - 510 °C) and T3 (520 – 573 °C, see Fig. 2). ΔT1 (ΔT = T_c during heating – T_c during cooling) ranges from -3 to -42.3 °C for the basalt and the lapillituff. ΔT3 ranges from -58.7 to 1.2 °C

for the tuff and from 3.1 to 18.5 °C for the lapilli tuff. These differences are interpreted as an indication of cation ordering processes with high ordering of cations resulting in higher T_c, lower ordering in lower T_c (Bowles et al., 2013). Hence, a negative ΔT_C indicates faster natural cooling than under laboratory conditions (11°C/min), resulting in low cation ordering within the natural mineral. The overall negative ΔT3 values of the tuff suggest a phreatomagmatic eruption style with resulting fallout as the main deposition mechanism (Lied et al., 2020). The positive ΔT3 values for the lapillituff indicate slower cooling under natural conditions or that oxidation has modified the primary titanomagnetite phases. The emplacement conditions of the lapillituff could be interpreted as flow deposits of a phreato-Strombolian eruption. The data therefore suggests at least two different eruptive events at the Bazinar Maar. This new approach to discriminate different cooling histories in maar deposits shows promising results and will be applied to different volcanic settings. The influence of composition of the titanomagnetite solid solution, vacancy concentration and cation ordering as well as low temperature oxidation processes on the non-reversibility of the T_c are still not fully understood and will be the focus of further studies.

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IODP

Patterns of Mn accumulation in the Miocene-Pliocene Indian Ocean – Initial results and perspective proposal

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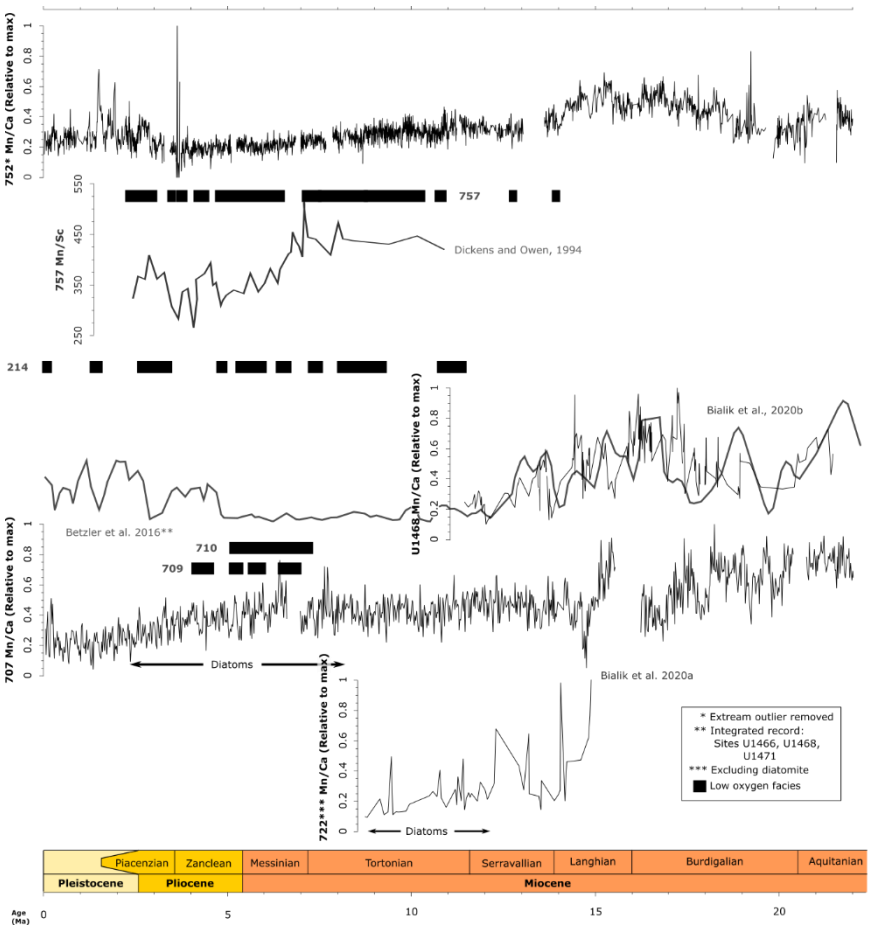
It was suggested that the patterns of Neogene Mn accumulation in the sediment could be used as a way to trace changes in subsurface ocean oxygenation in the Indian Ocean (Dickens and Owen 1994). Sedimentary Mn depletion occurs across the western, northern Indian Ocean (Figure 1). In the Arabian Sea (Bialik, Auer, et al., 2020), the depletion in Mn occurs between ~15 and ~13.5 Ma; it predates the increase in organic carbon and diatom abundances as well as indications for denitrification, which only started at ~11Ma but do correspond to an initial facies indicative of higher primary productivity. At the Maldives (Betzler et al. 2016; Bialik, Reolid, et al. 2020; and new data) Mn depletion also occurred since ~15 Ma and Mn concentrations



O. Bialik et al.:
Figure 1. Mn content and low oxygen facies across the Indian Ocean.

reached a sustained minimum by 13 Ma. The timing of sustained Mn depletion at the Maldives corresponds to the demise of the coeval carbonate platform, suggesting a common link related to oceanographic reorganization (Betzler & Eberli, 2019). In the case of the Arabian Sea, an OMZ developed in the region and has been present until the modern. However, at the Maldives, no clear evidence for an OMZ has been presented, although elevated bulk sediment nitrogen isotope data (Ling et al., 2021) may suggest some oxygen depletion in the subsurface waters. In the Maldives record, Mn content remained low until the early Pliocene (~5Ma, Betzler et al., 2016) although younger ages have been reported elsewhere (Dickens & Owen, 1994, 1999) but may require a re-evaluation of the age models of those sites.

New Mn content was obtained from x-ray fluorescence (XRF) core scans of Sites 752 and 707 (Figure 1). Site 752 on the Broken Ridge in the south-eastern Indian Ocean represents the most far-reaching extent of Mn depletion reported so far (Dickens and Owen 1994). The new XRF indicates a decline in Mn content between 15Ma and 13Ma. Mn content remains low until 5Ma at this Site until recovering between 5Ma and 3Ma. Site 707, located on the Mascarene high between the Saya de Malha Bank and the Seychelles in the north-western Indian Ocean, exhibits a rapid Mn depletion at 15 Ma. This then plateaued until ~9Ma (contemporary with a decline in diatom accumulation in the Arabian Sea, Bialik et al., 2020a) when a small recovery in Mn content occurred, which declined again at ~7Ma and remained low until the Plio-Pleistocene. The pattern of variation in Mn is consistent across multiple sites although their sedimentation rate pattern differs significantly, highlight an extrinsic forcing. However, it is still unclear if this forcing is purly the result of expending oxygen-depleted waters (Dickens and Owen 1994) and Mn redirection or different mechanism. New results from Site 752 chalange the interpretation of the Mn as indiction of low oxygen – thus requiring a reevaluation of the signal and its implications for paleogeographic reconstruction of the Neogene Indian Ocean.

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ICDP

The 8.2 ka event in the Dead Sea: tracking a high-latitude disturbance in the Mediterranean

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The last deglaciation is an ideal time interval to investigate the effect of climatic and oceanic disturbances occurring at high latitude on the hydrological regimes of the Mediterranean Sea. In particular, a series of disruptions of the Atlantic Meridional Oceanic Circulation (AMOC) has punctuated the transition from glacial to interglacial conditions, with the so-called 8.2 ka event being the youngest one. Recent results demonstrated the existence of instable climatic conditions in the Dead Sea during the Younger Dryas (Müller et al., 2022). We examine here the environmental record during the 8.2 ka event to illuminate the effects of the background climate (colder to warmer) on hydrological distrubances linked to AMOC disruptions. We performed a coupled limnological and geochemical analysis of sediments deposited in the deeper part of the Dead Sea (IDCP site 5017A), which showed sedimentological facies associated with increasingly drier conditions between 8.5 and 8 ka BP in the Dead Sea (mass-waisting events and halite). Neodymium and strontium isotopes also show a rapid change in sediment provenance and a hiatus in outcrop sequences from western lake shores, together with salt deposition in the deep basin suggest a drop in lake level at that time (Migowski et al., 2006). These new results will be presented, together with a comparison to the Younger Dryas, available modelling results and regional hydroclimatic data.

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IODP

MICRO2MACRO: Microfossils and data science, a new approach to infer the impact of global climate on plankton macroecology

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One of the most pressing scientific challenges today is understanding the fate of our oceans and marine ecosystems under on-going climate change. Unfortunately, anthropogenic stressors act at a rate and magnitude that exceed recent natural variability, making the use of decadal ecological data and time-series insufficient for predictions of future behaviour of marine ecosystems. I will here introduce the Marie-Skłodowska Curie Action project MICRO2MACRO, which will reconstruct snapshots of marine pelagic ecosystems between 54 and 32 million years ago (Eocene and early Oligocene), when climate and environmental conditions approximated what we will start to experience in the next century and beyond. Using the microfossil record of planktonic Foraminifera (PF), the most complete of any Caenozoic eukaryote, the project will generate the first

methodologically controlled (hence reproducible) early Caenozoic global dataset of ecology, abundance, species composition, diversity, and biogeography (macroecology) of these prolific pelagic calcifiers. Benefiting from the mole of data generated over the last 15 years, the project will apply novel tools in data-science technology to compile ocean temperature and chemistry datasets for the studied time intervals and statistically compare them against the new PF dataset generated with this project. Specifically, this study will test for links between time-specific climate (e.g. sea surface temperatures) and ecosystem (e.g. species composition, dominant ecology) configurations, and understand how plankton biogeography was shaped in a warmer world. Hence, MICRO2MACRO will highlight future ecological and evolutionary analogues if the current climate trajectory remains interrupted and we are to hit climate conditions similar to those in the Eocene and Oligocene.

ICDP

Surface and borehole seismic site characterization around the COSC-2 drill hole (Järpen, Sweden)

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The ICDP funded project COSC (Collisional Orogeny in the Scandinavian Caledonides) is investigating mountain building processes with the help of two ~2.5 km deep fully cored boreholes in Central Sweden (Åre and Järpen/Mörsil). The COSC-2 borehole, drilled in 2020, focuses on defining the character and age of deformation of the underlying greenschist facies thrust-sheets, the main Caledonian décollement and the Precambrian basement. In September and October 2021, we performed an extended walkaway VSP survey at the COSC-2 drill site to derive a high-resolution 3D image of the subsurface in the direct vicinity of the borehole and to assist the geological interpretation by determining the origin of the basement reflections, the nature of the main décollement, and the degree of basement thrusting. The survey mainly consisted of two 2D surface seismic lines approximately perpendicular to each other and centered around the COSC-2 drill site. The obtained surface seismic and VSP data set shows many pronounced and clear reflections, which are observed even at the largest source-receiver offsets (~11 km) and are corresponding to structures at a depth of up to 11 km.

We applied an imaging workflow to the surface seismic data comprising first arrival traveltime tomography, signal processing and Fresnel Volume Migration. A preliminary imaging result for the North-South- and West-East-profile already yields significant findings (Fig. 1). Reflectors observed in the upper part can be well correlated with the lithology observed in the COSC-2 borehole and can be assumed to be related to the Caledonian décollement. Deeper structures show the typical double reflector pattern in the seismic data, which was already observed in seismic experiments around the COSC-1 well. These strong reflectors are likely related to the upper and lower layer boundary of the embedded dolerite intrusions. Furthermore, vertical offsets along the basement reflectors in the N-S-image suggest a steeply dipping fault, which has not been imaged before.

We present results of the ongoing seismic data processing, including a P-wave velocity model obtained from first arrival traveltime tomography, analysis of seismic anisotropy and first imaging results from the surface seismic data. Furthermore, the status of the VSP imaging workflow is shown and results are correlated with the surface seismic data.

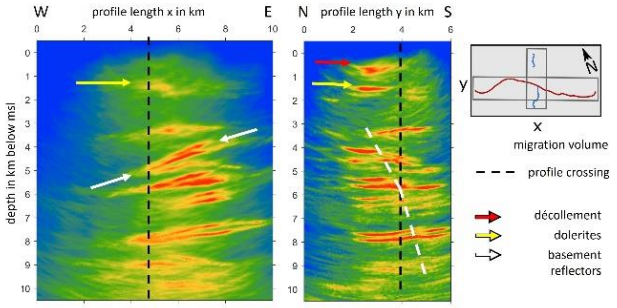

Figure 1. Preliminary Fresnel volume migration result of the surface seismic data (v=const.)

IODP

Stable isotope analysis of foraminifera from the Mid-Oligocene Glacial Interval (MOGI), IODP Site U1579, Agulhas Plateau, southwestern Indian Ocean

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Earth's climate underwent a major change from a Warmhouse to Coolhouse climate state across the Eocene–Oligocene Transition (EOT; ~34 Ma) (Westerhold et al., 2020) resulting in the establishment of a permanent continental-scale ice sheet on Antarctica. Following the EOT, Oligocene climate was particularly enigmatic, with evidence for a large ice sheet but warm global temperatures similar to those of the late Eocene and large amplitude changes in benthic $\delta^{18}O$, suggesting either large ice volume or deep-ocean temperature changes (Liebrand et al., 2017; O'Brien et al., 2020). The Mid-Oligocene Glacial Interval (MOGI; ~28–26.3 Ma) is of particular interest due to its generally cool climate with high amplitude glacial-interglacial cycles, which are thought to be associated with the ~100 kyr Milankovitch cycles of eccentricity modulation of precession (Liebrand et al., 2017). A new, nearly complete Oligocene record spanning the MOGI was recently collected at Site U1579 during International Ocean Discovery Program (IODP) Expedition 392 to the Agulhas Plateau in the southwest Indian Ocean (Uenzelmann-Neben et al., 2022). Oligocene sediments recovered at Site U1579 consist of nannofossil ooze and chalk and contains abundant moderately well to well-preserved foraminifera. We sampled across the MOGI at 20 cm spacing (~13 kyr temporal resolution) to generate benthic (*Cibicidoides mundulus*) and planktonic (primarily *Globigerina bulloides*) foraminiferal $\delta^{18}O$ records, which we compare to barium records derived from X-ray flouresence (XRF) core scanning (an inferred productivity proxy) and use to interrogate Southwest Indian Ocean circulation dynamics. In conjunction with cycles observsed in the XRF datasets, we use new benthic $\delta^{18}O$ record to establish an astrochronology. Since there is uncertainty about the depth habitats of Oligocene planktonic foraminfera species, we selected two samples with different assemblage compositions from our study interval to generate $\delta^{13}C$ and $\delta^{18}O$ records for a number of planktonic species from each sample, which we use to infer relative ecological habitat of the different species. We also conducted SEM analysis of benthic foraminifera specimens from

~20 samples across the MOGI interval to verify the preservation state of these samples. Our results serve as a pilot study for a larger analysis seeking to understand regional climate dynamics relating to the Agulhas Current and Southwest Indian Ocean circulation during the Oligocene.

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ICDP

The acquisition concept for seismic surveys within Chatseis

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In September 2023, as part of the ICDP project „Drilling Overdeepened Alpine Valleys" (DOVE), we start the project Chatseis (BU3894/3-1, KO6375/2-1) with the aim to improve the seismic imaging and characterization of near-surface structures by combining different seismic approaches, i.e. high-resolution reflection imaging and full waveform inversion (FWI). Since both methodologies demand different qualities in the data, we intend to acquire data of a diverse character using vibrator and explosive sources as well as classical high density receivers, low-frequency, wide-spaced geophones, and rotational motion sensors. Furthermore, we will acquire shear wave data to support the FWI by shear wave velocities.

We test our methodical approach at the sedimentary fill of overdeepened valleys. These structures were excavated during the ice ages in the Quaternary by sub-glacial processes and subsequently refilled. Thus, overdeepened valleys and basins compose valuable climatic and environmental archives, which are the objectives of the DOVE. Furthermore, they are relevant for water supply and the assessment of georisks. Overdeepened structures bear a high lateral variability due to their genesis so that 1-D borehole information has to be spatially projected to make a reliable statements about genesis, structure, and physical properties of overdeepened structures. Recent studies have shown (1) the potential of methodical improvement of reflection imaging to make detailed statements about overdeepened basins (e.g. Burschil et al., 2018, 2019; Buness et al., 2022) and (2) that FWI can resolve small-scale, near-surface structures in detail (e.g. Köhn et al., 2019; Schwardt et al., 2020).

Our approach combines both methodologies to improve structural resolution as well as to enhance the reliability of extracted parameters. Therefore, we will acquire data adapted for the required qualities of each method and analyze each method separately as a benchmark. The acquisition parameters of "optimal data" differ for high-resolution reflection imaging and FWI. High-resolution reflection imaging with seismic vibrator source prefer high bandwidth of the emitted signal, but vibrators are technically limited in excitation of low frequencies. On the other hand, state-of-the-art workflows of FWI require low frequent signals for long-wavelength initial models and often use explosive source to excite low frequent signals and to gain the depth of penetration. However, explosives are subject to official regulations and are not allowed everywhere. Newly acquired optimal data will be input for the combined data analysis. In a first step, we intend to constrain the FWI by structural boundaries from reflection imaging and improve reflection imaging by velocities from FWI. In the subsequent second step, we intend to stabilize the FWI by improved initial velocity models and constraints to hopefully relinquish explosives as seismic sources for FWI in the future.

We will acquire data at two locations of the first phase of DOVE, for which cores exits. However, the borehole information lacks some topical questions. In Schäftlarn (Bavaria; ID 5068_3), a core from 2017 contains ca. 200 m of Quaternary sediments, without reaching the valley base. The succession shows ca. 100 m gravel over glacial sediments. The morphology of the valley base, excavated by the Isar Glacier, and characteristics of the sedimentary infill remains unclear. In Bad Aussee (Austria; 5068_5), Steinhauser et al. (1985) identified a gravity anomaly, that was interpreted as a salt body. However, a core drilling in 1998 showed 880 m Quaternary sediments without evidence of salt (van Husen & Mayr, 2007). This leads to the question, how the overdeepened structure was formed and what was the influence of the salt that can be expected in the region.

The first seismic campaign comprises two seismic surveys, in cooperation with LIAG, the Bavarian Geological Survey, the Ludwig-Maximilian-University Munich, and the University of Natural Resources and Life Sciences, Vienna. The seismic surveys are planned for Schäftlarn in fall 2023. In September 2023, we will use the horizontal vibrator source ELVIS and a landstreamer (1) to generate initial S-wave models for FWI and (2) as a pre-survey for the P-wave survey. In October 2023, we will acquire P-wave data using the LIAG hydraulic vibrator and explosives as seismic source. Additional autonomous sensors of the CAU will receive the low frequent spectrum of the seismic waves. As a test, rotational motion sensors will companion the surveys to detect the rotational signal of the active seismic sources. A second seismic campaign is scheduled for Bad Aussee in spring 2024.

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IODP

Variable ice-volume and weathering processes during the late Oligocene at Site 689

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The Oligocene (33.9-23.03 Ma) is a transitional phase of the Cenezoic climate evolution, with the fist major expansion of Antarctic ice sheets (AIS). Continental ice sheets and sea-level changes are major controls of the climate system, therefore, high temporal resolution of Oligocene paleoclimatic and paleocanographic records are essential to better constrain the processes involved in the waxing and waning of the AIS. However, while the long-term evolution of the Oligocene glaciations is relatively well known, current knowledge about the short-term (i.e., orbital to suborbital scale) AIS dynamic is still limited. The focus of this project is thus to investigate the short-term AIS dynamics during the Oligocene using a multi-proxy record from ODP Site 689 (Maud Rise, Weddell Sea). More specifically, the first phase of this project aims (1) to quantify ice-volume changes using stable oxygen isotopes ($\delta^{18}O$) and Mg/Ca from benthic foraminifera; and (2) to characterise changes in sediment provenance and weathering via the analysis of the neodymium isotopic composition (εNd) of the detrital sediment fraction. The $\delta^{18}OSW$ record highlights substantial ice-volume changes between glacial/interglacial conditions. These data display a highly dynamic AIS in the late Oligocene, with glacial conditions characterised by a AIS volume comparable with the modern one ($\delta^{18}OSW$ ~ 0.2‰) and interglacial conditions distinguished by a much smaller AIS ($\delta^{18}OSW$ ~ -0.5‰). The reconstructed bottom-water temperatures (BWT) at Site 689 are surprisingly constant and show only a weak correlation with the $\delta^{18}OSW$ record, implying only a minor contribution of bottom-water cooling to the glacials. We suggest that only minor changes of BWT occurred overtime in the Southern Ocean, whereas the cryosphere was much more responsive to climatic forcing on orbital time scales during the late Oligocene. The detrital εNd varies between -9 to -12 and is synchronised with the $\delta^{18}OSW$ record, with higher $\delta^{18}OSW$ values (glacials) matching less radiogenic εNd, and lower $\delta^{18}OSW$ values (interglacials) matching more radiogenic εNd. This correlation between an ice-sheet proxy and a tracer of sediment provenance supports the interpretation of a highly dynamic AIS and suggests large changes in the provenance of weathering products, synchronised with the orbitally paced waning and waxing of the AIS. The second phase of this project aims to analyse the Pb isotopic composition of Site 689 sediments in order to confirm this interpretation and to get a better insight into the variable inputs of detrital material influenced by glacial erosion. The radiogenic isotope ratios of Pb in marine sediments are primarly controled by the intial ratios of crustal material, the degree of physico-chemical weathering and by freshwater runoff. Authigenic Pb isotopes have thus been used as a tracer of weathering flux from the continent. Preliminary results shows that the authigenic Pb isotopic signal correlates with the $\delta^{18}OSW$ record, displaying more radiogenic/unradiogenic values at phases of larger/smaller AIS. Further analyses of authigenic Pb isotopes will allow a more detailed reconstruction of the weathering response to changing climate boundary conditions; and to verify that the foraminifera-base ice-volume reconstruction is strongly influenced by the large-scale waning and waxing of the AIS which causes significant changes of weathering processes and of the exposure of different source rocks

IODP

Preliminary magenetic polarity stratigraphy of IODP Exp. 392: Agulhas Plateau Cretaceous climate, Southwest Indian Ocean

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International Ocean Discovery Program (IODP) Exp. 392 (5 February–7 April 2022) was designed to recover sedimentary sequences and basement rocks from the Agulhas Plateau and the bordering Transkei Basin. The main objectives of the expedition were to understand the nature of the Agulhas Plateau Large Igneous Province and to answer questions about the evolution and dynamics of Late Cretaceous–Paleogene oceanography and climate evolution. A total of 1971.77 m of sediments and rocks were recovered from ten holes at four sites (U1579–U1582), with overall recovery greater than 76%. Nearly all recovered igneous rocks and sediments were measured onboard the RV JOIDES Resolution for their natural remanent magnetization (NRM) by quasi-continuous measurement of the archive halves of core sections. Measurements were performed with a superconducting rock magnetometer applying a maximum alternating field (AF) magnetic cleaning of 20 mT. The archive-half results were integrated with results from full demagnetization and measurement of 313 discrete samples. Data from fully demagnetized discrete samples aids the interpretation the archive-half measurements, supporting the magnetostratigraphic results. Furthermore, measurement of the anisotropy of magnetic susceptibility (AMS) of all discrete samples helps to identify possible sediment disturbance due to either coring or tectonic processes. Overall, shipboard paleomagnetic data resulted in correlation of the Exp. 392 cores with the geomagnetic polarity time scale (GPTS) spanning (discontinuously) from Chron C1n (Pleistocene) to Chron C34n (Coniacian). Significant gaps in the correlation with the GPTS are present in some critical intervals, such as the Paleocene–Eocene sedimentary record of Site U1579. This is mostly due to the low intensity of the NRM. Post-cruise analyses on 104 discrete samples collected from the Eocene interval of Hole U1579D (Cores 4R to 16R, ~150–260 m core depth below seafloor method A [CSF-A]) resulted in 83 paleomagnetic directions, with alternating positive and negative inclinations that we organize into nine normal polarity zones separated by eight well-defined magnetic polarity reversal intervals. Integration of these data with biostratigraphic results allows us to accurately correlate the identified polarity zones with the GPTS. These results demonstrate that the shipboard paleomagnetic results from IODP Exp. 392 can be improved to ultimately generate an age model of sedimentation robustly anchored to the international GPTS.

IODP

Geochronology of the Agulhas Plateau at the African-Southern Ocean gateway: Preliminary results from IODP Exp. 392

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The Agulhas Plateau (AP) is a large volcanic oceanic plateau located in the oceanic gateway between the South Atlantic and Indian Oceans. It is thought to have formed during the late Cretaceous together with the Maud Rise (MR) and the Northeast Georgia Rise (NEGR). It is debated whether and to what extent the emplacement of these large volcanic features obstructed the exchange of water masses between the Atlantic and the Indian Ocean thereby delaying the onset of the Antarctic Circumpolar Current, crucial for the begin of global Cenozoic cooling (e.g., Sijp et al., 2014; Voigt et al., 2013). Until the recent IODP Expedition 392 (Uenzelmann-Neben, Bohaty, Childress, et al., 2022), few basement samples had been collected from AP and little is known about the age and nature of its origin. Igneous rocks were recovered at two sites on the southern part of the plateau (Sites U1579, U1580) and at one site near its northern edge (U1582). First, preliminary $^{40}Ar/^{39}Ar$ ages vary among the locations and range from 78.61 ± 0.68 to 87.36 ± 0.19 Ma, demonstrating a prolonged constructive period of perhaps up to 10 Myrs for the plateau. Ages from igneous bodies at Sites U1579 and U1580, which were identified as likely sills, seem to be indeed younger than the overlying sediments, that range from 78 to 94 Ma based on initial shipboard biostratigraphic assessments. Pillow basalts from northern Site U1582 did not yield any age plateaus but one sample gives a total fusion age of 86.80 ± 1.04 Ma, which is consistent with intercalating sediment biostratigraphy, giving credence to this total fusion age estimation. Current plate reconstruction models suggest that AP formed at a triple junction (together with MR and NEGR) but our new ages are somewhat younger than the estimates for seafloor creation at the respective drill site locations. This suggests that either the plate reconstruction models need refinement, or that the AP may have formed off the spreading/triple junction axis.

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ICDP

Lake El'gygytgyn – a unique archive to understand long term high latitude fire-vegetation interactions and impacts

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The Arctic is changing rapidly under climate change, with Arctic average temperatures increasing at least 3-times more than the rest of the globe, amplified by biophysical and biogeochemical effects and with strong impacts on the cryo-, hydro- and biospheres, including local and global human livelihoods. A central question is, what long-term trajectories of landscape alteration can be expected and accounted for when modelling the influence of high latitude changes for global change?

Lake El'gygytgyn in the Russian Far East is a 3.6 Myrs old meteorite impact crater lake in the dry high-latitude tundra and famous for its unique preservation of lacustrine deposits from all glacial-interglacial cycles of the Quaternary, even hosting Pliocene deposits, i.e. deposits from periods of varying global ice volumes and CO_2 concentrations. As part of several ICDP related projects, these lake deposits have already been used to gain understanding on long-term climate and vegetation evolution in a global context including large-scale coupling of Arctic and Antarctic ocean-climate-cryosphere interactions (e.g. Melles et al., 2012; Brigham-Grette et al., 2013).

During a DFG project of the last few years, we focussed on regional-scale interactions of fire regime and landcover change, as the ongoing climate change is amplifiying also the modern day fire regimes, characterized e.g. by an increased fire frequency, severity, area, type and amount of biomass burned (Harris et al., 2016). This fire regime intensification might have strong impacts on permafrost and land surface stability or freshwater quality (e.g. Holloway et al., 2020), though instrumental, mostly remote sensing data is too short to understand when and how quickly thresholds might be crossed that impacts on fire regimes also leads to enduring impacts on vegetation and permafrost change. Here, we aim to fill this knowlegde gap by quantitatively reconstructing changes in fire intensities and the type of biomass burnt in comparison with mostly existing pollen-based vegetation composition and sediment-proxies of aquatic productivity and detrital input (C/N, µXRF-element ratios) from same samples independent of the consistency of the age-depth model.

We analysed sediments of cores PG 1351 and ICDP 5011-1 with focus on glacial and interglacial samples of the last 430 kyrs (marine isotope stages, MIS 5e, 6, 7e, 8, 11, 12) and the Early Quaternary (MIS 100-104) of different orbital configuration, land-sea ice and vegetation-fire-CO_2 feedbacks. Multiple fire proxies were analyzed: the monosaccharide anhydrides (MAs) are specific biomass burning residues from low-temperature fires analyzed with ultra-high-performance liquid chromatography coupled to a high-resolution mass spectrometer. Sedimentary charcoal reflects mid-to-high intensity fires and was partly

analyzed in sieved fraction > 150 µm and from pollen slides using classical microscopy. MA isomer ratios and charcoal morphotypes were used to reconstruct the type of biomass burnt. We established statistical links between fire proxy and pollen composition and could find significant relations, for example, between a low-intensity surface fire regime and the summergreen, larch-dominated boreal forest as well as low-fire periods when peatlands spreaded in the Mid-Late Quaternary (Dietze et al., 2020). Focussing on the so-called "superinterglacial" MIS 11, the late glacial to early interglacial succession seems to be partly accompanied by a temperature-driven fire regime intensification. A generally more intense fire regime seem to have occurred at the onset of the Quaternary, c. 2.595-2.620 Myrs ago, when more open, i.e. birch and ericaceous boreal forest surrounded lake El'gygytgyn. During this period, preliminary results suggest that a higher aquatic productivity with less detrital input may have been supported by low-intensity or less frequent fire, which needs to be tested also for the Late Quaternary. Overall, Lake El'gygytgyn sediments are very promising to provide key long-term fire-vegetation-feedbacks and successional information from potential analogue warm periods to inform future trajectories of landcover change and permafrost-related land surface stability.

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ICDP

The long-term interseismic behavior of the Main Marmara Fault, NW Turkey

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In this contribution, we discuss our latest results from the project "Deformation Mechanisms along the Main Marmara Fault (DEMMAF)", funded by the ICDP priority program of the German Science Foundation. The Main Marmara Fault (MMF), is the northern branch of the North Anatolian Fault along the Marmara Sea (NW Turkey). The MMF has produced several major earthquakes (M7+) in the past with a recurrence of about 250 years, and has not ruptured since 1766. The goal of the DEMMAF project is to investigate what controls the deformation mechanisms along the MMF, using data collected at the ICDP GONAF observatory (Geophysical Observatory at the North Anatolian Fault) and a combined work flow of data integration and process modelling approach.

Here, we use a forward numerical approach that implements frictional faults and visco-elastic off-fault materials to investigate the space- and time-scales of the long-term seismic behaviour of crustal faults and their main controlling factors. The faults are modelled following a Coulomb frictional constitutive law and are embedded in a (visco-elastic) medium that can have spatially variable off-fault rock properties. First, we use a synthetic model with a simplified crustal structure and a planar fault geometry. We explore the effect of varying off-fault material properties and fault strength on the seismic cycle. While the frictional properties of the fault (friction coefficient) control stress-drop variations and recurrence time of modelled seismic events, the crustal rheology modulates the synchronization of events, stress-drop variations and the depth of seismogenic zone. Next, we use a more complex model to study the controlling factors on the MMF. The off-fault properties are derived from a data-integrative lithospheric-scale 3D model built in a previous stage of the project. The forward numerical model of the MMF highlights the additional first order effect of the fault geometry on the resulting seismicity distribution.

IODP

Iron speciation and redox conditions in Pliocene to Pleistocene sediments: insights from borehole 680A, site 112 in the Peruvian Margin

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The examination of iron speciation in rocks and sediments is a widely employed method for determining the redox conditions of their depositional environment. This technique involves extracting Fe from various mineral phases and dividing the total Fe (FeT) into highly reactive (FeHR) and poorly reactive (FePR) pools. FeHR/FeT ratios below 0.22 are usually interpreted as oxic conditions, while ratios above 0.38 suggest ferruginous or euxinic conditions. The quantification of iron bound to sulfide (Fepy) distinguishes between anoxic scenarios, with Fepy/FeHR ratios above 0.80 indicating euxinia. Additionally, trace metal enrichment, specifically U and Mo, is used to assess redox conditions in the water column. To explore the relationship between these indicators, we analyzed Fe speciation and trace metals in borehole 680A, which contained Pliocene to Pleistocene sequences from the Peruvian oxygen minimum zone (OMZ) acquired during ODP expedition 112. FeHR/FeT peaks, higher Mo, U, and TOC concentrations, along with enriched $\delta^{15}N$ values, show that in the Pleistocene oxygen depletion was stronger during interglacials (Fig. 1), which might be related to higher temperatures, increased upwelling and nutrient supply.

In the Pliocene, the studied site was shallower(1), and MoEF and UEF indicate that trace metal enrichment occurred under mildly anoxic/oxic conditions. A strong negative correlation between $\delta^{98}Mo$ and Mn content indicates that Mn-oxides were likely a carrier phase of Mo, which is also indicative of oxygen presence in the depositional environment(2). However, Pliocene FeHR/FeT ratios are consistently high and exceed what is considered the anoxic threshold. We calculated the amount of authigenic Fe rain rate necessary to generate the observed FeHR/FeT signatures in the Pliocene, and we obtained a value that is very high and therefore not feasible for Neogene marine environments (Fig. 2). To explain this observation, we suggest that during the warmer Pliocene, stronger chemical weathering may have led to enhanced transport of FeHR to the Peruvian Margin, and a higher initial value of the FeHR/FeT ratio was thus likely responsible for the elevated FeHR/FeT values despite mildly anoxic/oxic bottom waters.

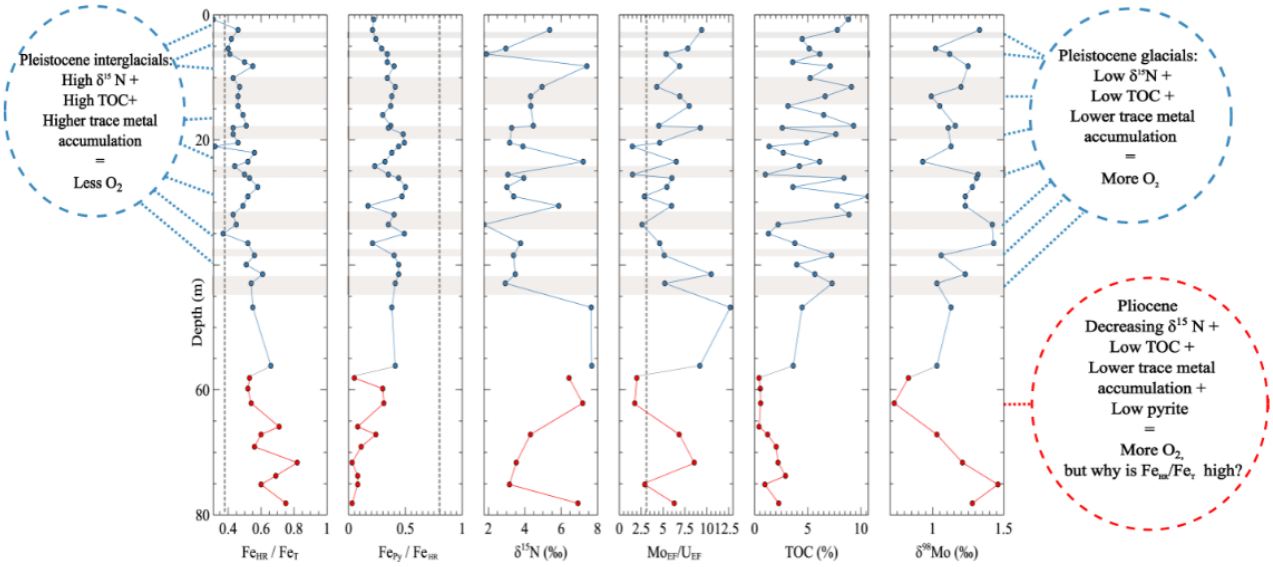

Figure 1. Depth profiles of the analysed geochemical proxies. Pleistocene samples are plotted in blue and Pliocene samples are plotted in red. The grey shaded areas in the Pleistocene represent glacial cycles, while the absence of shading represents interglacials. The dashed line in the Fe_{HR}/Fe_T plot represents the threshold for anoxic conditions, whereas in the Fe_{py}/Fe_{HR} plot, it represents the threshold for euxinic conditions, and in the Mo_{EF}/U_{EF} plot, it represents the composition of seawater. The enrichment factor (EF) is calculated as $(Element_{measured}/Al_{measured})/(Element_{upper\ continental\ crust}/Al_{upper\ continental\ crust})$. Upper continental crustal concentrations were obtained from McLennan (2001)[3].

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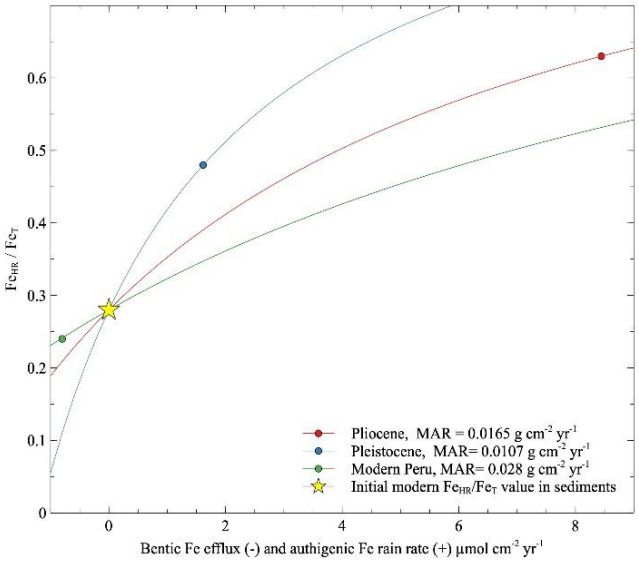

Figure 2. Plot showing the required authigenic Fe rain rate necessary to generate the observed values of FeHR/FeT. MAR = Mass Accumulation Rates. The calculations were made using the formula contained in Scholz (2018)[4] and average FeHR/FeT. For the modern Peruvian environment, MAR was taken from Scholz et al. (2019)[5] and iron speciation data is from Eroglu et al. (2021)[6]. MARs for the Pliocene and Pleistocene were calculated using data from Suess et al. (1988).

ICDP

How dry was dry? Using authigenic minerals to identify hyper-arid intervals in the 620,000-year Chew Bahir record

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The 620,000-year-long climate record from Chew Bahir in southern Ethiopia documents the potential influence of different episodes of climatic variability on hominin biological and cultural transformation and presents therewith an unparalleled opportunity to better understand the environmental context of human-climate interactions during the Pleistocene (Foerster et al., 2022). The coring locality of the 280-m long cores of sedimentary strata is situated near key archaeological and paleoanthropological sites, such as the Omo-Kibish where the Omo 1 and 2 *Homo sapiens* fossils were recovered. The effect, timing and especially the extent of environmental extremes and hydrological threshold conditions in one of the habitats of hominin populations is however not well understood yet. The key question in this context is: how dry was dry?

The Chew Bahir mineralogical record that provides the opportunity to decipher environmental extremes and hydrological threshold conditions (Foerster et al., 2018). The degree of authigenic mineral alteration is indicative of wet, dry and especially hyper-arid climate intervals (Arnold et al., 2021; McHenry et al., 2023). Our results show that the most extreme evaporative phases are represented by authigenic mineral assemblages including Mg-enriched clays, low-temperature authigenic illite and euhedral analcime. Linking the mineralogical profile (XRD) with geochemistry (µXRF) and isotope geochemistry ($\delta^{18}O_{calcite}$) enables us to more finely differentiate levels of aridity, define depositional conditions and environmental thresholds through time. The oscillations between pronounced hydroclimatic conditions have important implications for transforming the habitats of human populations. The time interval described by the core data encompasses several key hominin evolutionary benchmarks, including the transition to the Middle Stone Age, and the origin and dispersal of modern *Homo sapiens*.

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IODP

Pre-treatment of grain-size samples from the Labrador shelf: Blessing or curse?

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The Labrador Shelf is a key area in reconstructing past interactions between the Laurentide Ice Sheet (LIS) and the global thermohaline circulation. It is located in close proximity to the Northern Hemisphere centers of deep-water formation in the Labrador Sea and the northernmost North Atlantic. During past collapses of the LIS at the end of the glacials, strong freshwater pulses were released into the Arctic Ocean and the Labrador Sea/North Atlantic. These fresh-water pulses had a profound influence on the Atlantic meridional overturning circulation (AMOC), and hence on the strength of ocean currents in the North Atlantic / Labrador Sea region.

The strength of past ocean currents can be reconstructed using sortable silt calculations which are based on grain-size analyses of sediment samples. Prior to grain-size measurements, samples are often pre-treated in three steps to remove (i) organic matter by adding H_2O_2; (ii) carbonates by adding HCl, and (iii) biogenic silica by adding NaOH. Subsequently, samples are disperged by adding Calgon and shaking overnight before measurements are performed. These steps are carried out in order to clean the sediment from non-detrital compounds, i.e., to obtain a purely clastic sediment. Moreover, these steps also help to prevent clay particles from forming large aggregates that would distort the measurements.

The LIS retreat at the end of the last glacial was characterized by several short-lived events such as the H0 event, Gold Cove advance, or the drainage of glacial lakes Agassiz and Ojibway. Most of these events can be observed in the Labrador shelf cores as distinct and sharp peaks in detrital carbonates that can make up for up more than 40% of the sediment. The use of hydrochloric acid to remove carbonates would therefore possibly destroy a significant portion of paleoenvironmental information, and probably also falsify the resulting sortable silt calculations. Whether pre-treatment should be performed on samples originating from this regions, therefore, is still under debate.

In order to better understand the impact of pre-treatment, 70 samples of a composite core from Cartwright Trough, Canada, were measured both before and after pre-treatment was carried out. Additional measurements of organic matter, biogenic silica, and carbonate content were performed and compared with the results of the grain-size measurements.

IODP

Sortable silt as current-strength indicator: First results from drift-body sediments of Lake Melville, Labrador, Canada

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The coastline of Labrador, Canada, is characterized by a succession of deep bays and inlets, of which the Hamilton Inlet system stretching some 250 km inland is the largest. Lake Melville is part of the Hamilton Inlet system and opens seawards to the Atlantic Ocean through Groswater Bay with a 2.8 km wide and 30 m deep sill at the Rigolet Narrows that restricts water inflow into Lake Melville. The lake is 170 km long with a maximum width of 35 km and water depths of up to 250 m. It is characterized by a relatively shallow western part and a deeper eastern part that exhibits two parallel, W-E trending valleys separated by a ridge. During the last glacial, Lake Melville was covered but not excavated by the Laurentide Ice Sheet (LIS). At the deglaciation, the LIS retreated to the Rigolet Narrows at the easternmost end of the lake at ca. 10.3 ka, and the lake was completely ice-free at 8.5 ka; the LIS was fully decayed in the Labrador region by ca. 6.3 ka (Dalton et al. 2020).

Vintage seismic data and new sediment echosounder data retrieved during Maria S. Merian expedition MSM84 reveal up to 400 m of total sediment infill. The presumably deglacial and postglacial uppermost sediment unit is well-layered and reveals drift-type structures elongated along the axes of both valleys. It is quite likely that these sediments were deposited in an environment that was dominated by contourite currents. Moreover, subbottom echosounder data reveal a distinct change within the drift body architecture at the eastern part of the northern valley, pointing at a change in current strength.

During expedition MSM84, gravity cores were taken from different positions relative to the drift bodies. Grain-size measurements were carried out on two sediment cores, and sortable silt was calculated to reconstruct current strength. This parameter is often used in marine settings, but studies in lakes or sheltered basins as Lake Melville are rare. Age models for both sediment cores were calculated using ^{14}C dates. Sortable-silt results are then compared to known paleoclimatic records of the area.

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IODP

West Antarctic Ice Sheet dynamics in the Pliocene from IODP 379 drill records and seismic data

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The West Antarctic Ice Sheet (WAIS) reacted highly sensitive to ocean and atmospheric forcing in the Pliocene and Pleistocene. This behavior has also been observed throughout the past decades, with major grounding line retreat, accelerated ice flow and ice shelf thinning characterizing the WAIS. As its future stability appears to be uncertain, information about the past, especially during warmer-than-present times in the Pliocene, can give indications of the future behavior and help better constrain climate projections. During International Ocean Discovery Program (IODP) Expedition 379, cores from two drill sites were recovered from the Resolution Drift on the continental rise in the Amundsen Sea sector, which is a key region for understanding WAIS dynamics. Sedimentary records from the late Miocene to the Holocene were recovered with a highly resolved continuous Pliocene section. We identified seismic key horizons by core-log seismic integration and correlated sedimentological and seismic characteristics across the seismic network of the region. A depth interval with alternating physical properties and high diatom abundance was correlated to a seismic section with distinct reflection characteristics. This interval was identified in the Pliocene between 4.2 and 3.2 Ma and is interpreted to document a highly dynamic WAIS with extended periods of grounding line retreat on the Amundsen Sea shelf. The extended network of seismic lines in the Amundsen Sea and Bellingshausen Sea allows to extrapolate this information onto other sediment drifts for a more regional analysis of the past WAIS dynamics.

IODP

A record of changing marine sediment geochemistry through the PETM

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Volcanic eruptions can have both short-term and long-term effects on the Earth's climate. Episodes of intense volcanic activity and Large Igneous Province emplacement have been linked with both climatic warming and cooling. One such period of intense volcanism was during the breakup of the north Atlantic and the emplacement of the North Atlantic Igneous Province (NAIP) between 60 – 45 million years ago (Ma). NAIP Emplacement occurred in line with a period of rapid global warming known as the Paleocene-Eocene Thermal Maximum (PETM).

The PETM (56 Ma) was a significant rapid global warming event in the earth's history that is considered as a close analogue to anthropogenic carbon dioxide emission. The period was associated with significant addition of 13C depleted carbon into the ocean-atmosphere system, which lead to global warming and ocean acidification, rise in Sea Surface Temperature by ~5ºC, global expansion of Oxygen Minimum Zones, local photic zone euxinia, sea level rise, migration of species, and an enhanced hydrological cycle.

Here we present initial results from a project to identify how sediment geochemistry changed across the PETM. This project

is entirely based on sediment samples collected from the mid-Norwegian margin during IODP Expedition 396, and this work focusses on a number of themes relating to the role large-scale volcanic eruptions play in controlling climate change. Primarily XRF and ICP-MS analysis of sediments to attain a full record of the changing chemistry through the period. This record will be used to investigate chemical weathering, redox conditions, paleo productivity and changing sediment supply.

IODP

Postglacial Atlantic sea-level reconstruction through drilling the Belize Barrier Reef (BBRdrill)

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Contrary to the Indo-Pacific, where postglacial sedimentary successions of coral reefs including relative sea-level data have been obtained from outcrops and coring, e.g., in Vanuatu as well as in Tahiti and the Great Barrier Reef (IODP drilling), there is only one such record in the Atlantic (Barbados, eastern Caribbean). The Barbados core data are extremely valuable, however, there are also limitations and challenges. The cores were not rigorously investigated with regard to sedimentology, paleoecology, and taphonomy. In addition, there are apparent differences to more recent, IODP-based data, e.g., the evidence of meltwater pulse (MWP) 1B, the timing and height of sea level during the last glacial maximum (LGM), the apparent lack of microbialites, as well as mismatches with Holocene sea-level curves.

Therefore, we aim at obtaining glacial-postglacial reef sections by IODP-coring in the western Caribbean, which would provide valuable comparisons with the existing eastern Caribbean (Barbados) and the Indo-Pacific records. The barrier and atoll reef system offshore Belize represent the largest modern tropical reef complex in the Atlantic Ocean, and is well-suited for this purpose. It represents a mixed carbonate-siliciclastic sedimentary system. Late Quaternary reefs were deposited largely during sea-level highstands, like those of the Holocene and marine isotope stage 5, which are well-studied, unlike the reef deposits from lower highstands and lowstands of sea level. The latter deposits, including those from the last postglacial, can be recovered by drilling in fore-reef areas of the 250 km-long barrier reef of Belize.

Based on a 2022 site survey, which obtained highly resolved bathymetric and shallow seismic data from the area, and based on discussions during a MagellanPlus workshop held in 2022, three drill areas have been identified. These include two transects of four and five drillholes, respectively, oriented perpendicular to the modern reef crest. Drillholes will be situated on linear ridges and inter-ridge valleys running along the fore-reef slope. A third transect of four drillholes will be located on a southward shoaling ridge, running more or less parallel to the modern reef crest south of the mouth of English Cay Channel, an incised valley meandering across the barrier reef platform. In addition to these 13 drillholes, one site is planned in deep water east of the barrier reef and one on the delta of the English Cay Channel in order to obtain off-reef reference records with both limited and strong siliciclastic input, respectively. Based on a reviewed pre-proposal (1008-Pre2), the Science Evaluation Panel (SEP) recently recommended to submit a full proposal for IODP-drilling.

IODP

Core-Log-Seismic Integration for the Cretaceous to Oligocene sequence in the African-Southern Ocean gateway: First results from the Agulhas Plateau (IODP Sites U1579 and U1580)

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Climate models have identified significant geography-related Cenozoic cooling arising from the opening of Southern Ocean gateways (e.g., Sauermilch et al., 2021). For example, a gradual strengthening of the Antarctic Circumpolar Current (ACC) has been proposed as the primary cause of cooler deep ocean temperatures associated with the transition from the Cretaceous "Supergreenhouse" to the Oligocene icehouse (e.g., Sijp et al., 2014).

IODP Expedition 392 'Agulhas Plateau Cretaceous Climate' drilled four sites in the African-Southern Ocean gateway in 2022 to significantly advance understanding of how temperatures, ocean circulation, and sedimentation patterns evolved as CO_2 levels rose and fell and Gondwana broke up (Uenzelmann-Neben et al., 2022). Prior to Exp. 392, seismostratigraphic models developed for the African-Southern Ocean gateway relied solely on age data from remote drilling sites and information from piston cores, gravity cores, and dredge samples. As a result, a high level of uncertainty had to be assumed for reflector age information, particularly for the sparsely sampled pre-Miocene sedimentary column.

We here present preliminary findings from a revised seismostratigraphy based on core-log-seismic integration at Sites U1579 (central Agulhas Plateau) and U1580 (southern Agulhas Plateau), both of which are located at the heart of the African-Southern Ocean gateway. Core density and velocity data were edited, corrected to in-situ conditions, and combined with downhole logging data. Synthetic seismograms provide an accurate traveltime to depth conversion and show an excellent correlation of drilling results with the site survey seismic field records.

A first correlation of the seismic reflection data with the preliminary shipboard bio- and magnetostratigraphy reveals that the published seismostratigraphic models are erroneous and need revisions, for example, a reflector interpreted to represent a lower Eocene sea level highstand on the Agulhas Plateau has now been identified as the Cretaceous/Paleogene (K/Pg) boundary. Further prominent reflectors can be associated with the Eocene-Oligocene transition (EOT), the top and bottom of zeolitic siliciclastic sandstones (Santonian) and intra-basalt reflections, interpreted as sills.

The core-seismic correlation allows tying major changes in other physical properties (e.g., colour reflectance, natural gamma radiation), chemical composition (e.g., major element ratios from XRF core scanning) and sedimentological parameters (e.g., grain size) to the seismic grids, which will aid reconstructions of oceanic circulation changes and magmatism variations in relation to the development of the Agulhas Plateau.

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ICDP

CycloSalt - Pilot study to investigate cyclicities in halite deposits of the Mediterranean Messinian salinity crisis in the Racalmuto salt mine (Caltanissetta Basin, Sicily, southern Italy)

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Cyclic environmental changes are preserved in sedimentary rocks with different scales and hierarchies from higher frequencies (e.g., annual) to lower frequencies (e.g., Milankovitch). Understanding these cycles has important implication for reconstruction of past Earth's conditions. In this

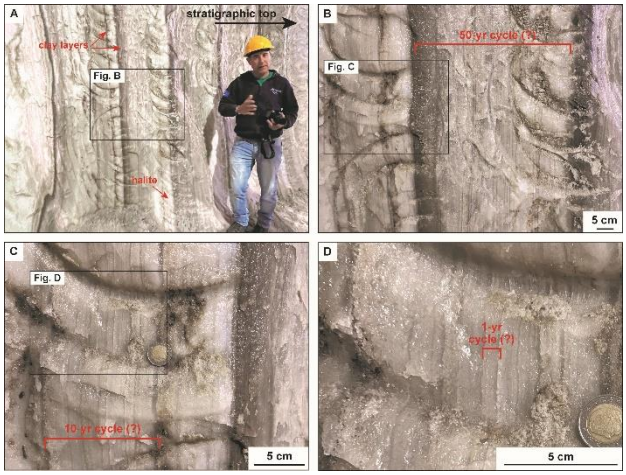

Figure 1. Proof of concepts showing the presence of at least three orders of cyclicities in the targeted study interval of halite deposits. These cycles have been preliminary assigned to cyclicities at 1-yr, ~10-yr and ~50-yr scales.

pilot study, we aim to study high frequency cycles from the Messinian (Late Miocene) evaporitic series of the Caltanissetta Basin, Sicily, southern Italy. These deposits accumulated during the Messinian salinity crisis of the Mediterranean region from 5.96 to 5.33 Ma and hold the key to understand sedimentation controls driven by cyclicities during extreme environmental conditions and in relation to the evolution of evaporitic basins. This study will target a halite deposit interval with intercalated clay layers from the Racalmuto salt mine. We propose to drill and analyze 10-m long section to study the origin of presumably annual to sub-centennial cyclicities. Here we present a proposal submitted to the ICDP SPP to fund a pilot study to investigate the potential and feasibility for a ICDP drilling project in the Messinian successions of Sicily as well as to elucidate the origin of the high frequency cyclicities in the halite deposits of the Caltanissetta Basin. Three parallel 10-m long cores will be extracted by a local company and then studied using state-of-the-art non-destructive core logging techniques to characterize the deposits and their cyclicity. The study will be the starting point to better understand at fine detail the mechanism behind the almost 1000 m thick evaporitic successions of the Messinian salinity crisis. It is societal relevant for the Mediterranean as it documents the regional environmental dynamics on annual to sub-centennial scale (e.g hydrological changes) during extreme environmental conditions. The large scientific community working on this topic will benefit from an ICDP project that will core this entire succession and our pilot study is the key for this achievement.

ICDP

NamCore – Finally a drilling on the central Tibetan Plateau

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Nam Co is one of the largest and deepest lakes on the Tibetan Plateau. Due to this location at the intersection of Monsoon (increased precipitation) and Westerlies (increased evaporation) paleoclimate proxies derived from sediments of Nam Co clearly reflect the spatial and temporal interplay and thus the dominance of one of the two circulation systems. Considering that almost

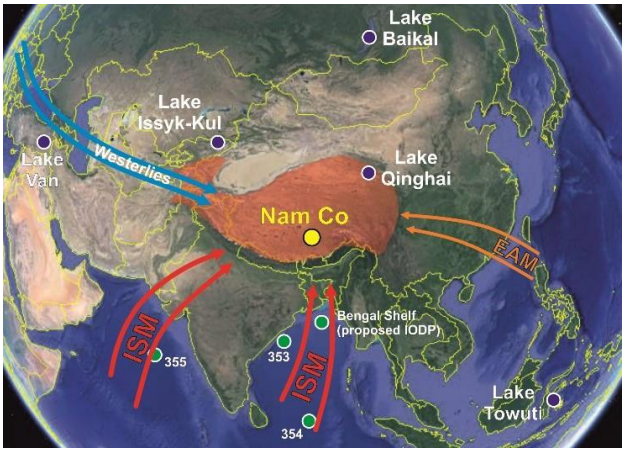

Figure 1

one third of the population of the world depends on the water supply from the Tibetan Plateau the future hydrological development will clearly have a significant societal impact. To define parameters for future climate change scenarios (IPCC) and their consequences for ecosystems, it is of paramount importance to improve our knowledge of timing, duration, and intensity of past climatic variability and subsequent environmental impact, especially on long geologic time scales and in key regions. Situated on the central Tibetan Plateau, Nam Co is thus ideally located to fill a gap of missing long-term

paleoclimate information in two important Asian ICDP/IODP transects (Fig. 1) to allow comparisons of climatic evolution/behavior on a continental scale.

The Tibetan Plateau is characterized by a high degree of endemism of organisms that are dependent on continuously existing water bodies. Nam Co likely served as a dispersal centre for these organisms, as other shallower lakes desiccated during dry glacial periods of the Cenozoic. Nam Co appears to be a first class example for studying the link between geological and

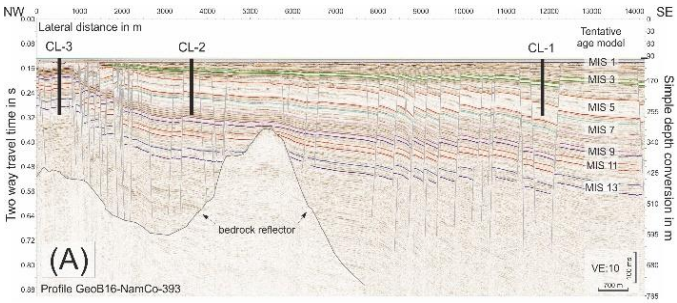

Figure 2

biological evolution in highly isolated Tibetan Plateau ecosystems including the deep biosphere over long time scales. A continuous, high-resolution, record for these long time scales from Nam Co will further enable to study sediment budget changes under varying climatic and tectonic settings, and contribute to a better understanding of the Quaternary geomagnetic field.

Seismic data show that the Nam Co basin contains >800 m of well layered undisturbed sediments. Sediment accumulation rates measured on a 10.4 m reference core, seismostratigraphic investigations, and molecular clock analyses suggest an age of the seismically imaged sequence of >1 Mio years. However, a basement reflector has only been found occassionally suggesting even older sequences. Multiproxy studies on the reference core provide an excellent high-resolution paleoclimate record covering the past 24 ka cal BP validated by extensive modern process studies and multi-dating approaches.

Instead of drilling the entire >800 m sediment sequence in the center of the lake we will use the fact that layers are dipping towards the center of Nam Co producing a higher accumulation rate there. By splicing together multiple 150 m cores from three different sites (the last one extended to 300 m sediment depth) it will be possible to cover the same depositional history found at >800 m in the center, i.e., 0.5 to 1 Ma (Fig. 2). The drilling itself is scheduled for May to July 2024 with a sampling party in fall 2024.

Main German contributions to the drilling operation itself and the subsequent analyses of the sediment cores will initialy be from Hanover and Greifswald. The group from Hanover will focus on downhole logging whereas Greifswald, together with colleagues from the UK, will play a major role in dating the sediments using magnetostratigraphy and AAR. In addition to that, Greifswald will focus on stratigraphical and sedimentological issues as well as paleoecological data in terms of ostracode species distribution and morphometric data.

IODP

Climatically controlled sedimentation and productivity dynamics at IODP Site U1537 in the Scotia Sea

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Ocean circulation and export productivity in the Antarctic and Subantarctic zones were fundamentally different during glacials compared with the modern configuration. To assess the impact of climatic boundary conditions on regional sedimentation dynamics and productivity, we utilize trace metal isotopes from IODP Site U1537 (59°6.65′ S, 40°54.37′ W, 3713 m) in the Southern Ocean (SO). Here, we present first results of a new high resolution uranium decay series isotope dataset, showing the evolution of authigenic uranium (aU) and excess thorium-230 ($^{230}Th_{ex}$) over the past 160 ka.

We observe overall strong sediment focusing ($\Psi > 1$, calculated from $^{230}Th_{ex}$) and high sedimentation rates at the core site. The degree of sediment focusing is higher during warm climate and climate transitions.

During interglacials, bottom water oxygenation levels are rather low (high aU ~ 1.7 dpm/g) accompanied by high surface ocean bioproductivity, as deduced from comparison of our data with sedimentary opal concentrations in the same core published earlier (Weber et al., 2022). Glacial sections on the other hand suggest higher bottom water oxygenation (lower aU ~ 0.7 dpm/g) and thus reduced productivity, likely controlled by increased glacial sea ice coverage, lower surface ocean productivity in the area, or a combination of both.

Further, the isotopic activity ratio $^{234}U/^{238}U$ of the bulk sediment approaches secular equilibrium ($^{234}U/^{238}U = 1.0$) during glacials and shifts towards the modern seawater ratio ($^{234}U/^{238}U \sim 1.147$) during the Holocene. During the Eemian it only reaches stable intermediate values of ~ 1.06, despite comparable opal concentrations between Eemian and Holocene sections downcore. The obvious difference between Holocene and Eemian bulk sediment $^{234}U/^{238}U$ highlights the difference between the last two interglacials in terms of deep ocean circulation in the SO.

Obeserved in context, our data suggest increased surface ocean productivity and export productivity coupled to sea ice retreats and a latitudinal southward shift of the ACC during deglaciation, leading to more dynamic flow and sedimentation regimes in the Antarctic zone of the SO.

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ICDP

Probing the roots of the Rustenberg Layered Suite (Bushveld Complex): drilling through the lower zones into the intrusive floor

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The ultramafic to mafic rocks of the Rustenberg Layered Suite (RLS) are the most voluminous part of the ~2.06 Ga old Bushveld Igneous Complex situated in the northeastern part of South Africa and represent the largest magmatic intrusion on Earth. During the emplacement of the RLS ~1 million km^3 of melt accumulated within ~0.6 Ma in a disc-shaped intrusion in the upper continental crust. The intrusion is exposed as a three-lobed body (eastern, western and northern lobe) with a maximum thickness of ~8 km characterized by a km-long lateral continuity of layering. The eastern and western lobes are emplaced within Transvaal metasediments and slightly older Rooiberg lavas, and have remained well preserved from deformation, metamorphism and low-temperature alteration. From the base to the top, the rocks are subdivided into a Marginal Zone (norite and micropyroxenite), Lower Zone (harzburgite and pyroxenite), Critical Zone (feldspathic orthopyroxenite interbedded with chromites layers), Main Zone (norite) and Upper Zone (ferrograbbro interbedded with layers of Ti-magnetite). It is assumed that the eastern and western lobes are connected through the center at depth, whereas the northern lobe is separated from the other by the E-W trending Thabazimbi-Murchison lineament. The stratigraphy of the northern lobe slightly differs from that established for the other regions of the RLS with the Lower Zone has its greatest thickness in the Grasvally body located immediately north of the Zebediela fault which forms a constituent branch of the Thabazimbi-Murchison lineament). Further north the Lower Zone is limited to few isolated ultramafic intrusions embedded in country rocks. The Lower Zone of the northern lobe has distinct primitive mineral compositions compared to that exposed in the eastern and western lobes, including two chromite layers and a Ni-PGE mineralized horizon. Between the Lower Zone and Main Zone is the Platreef, which is suggested to be an analogue to the Critical Zone because of its silicate geochemistry and stratigraphic position. Thereby, the position of the uppermost pyroxenite layer of the Platreef exhibits high concentrations of PGEs which correlates well with the position of the Merensky Reef in the Upper Critical Zone.

It is generally accepted that the rocks associated with the RLS are predomiantly cumulate rocks, which is why there are still major uncertainties regarding the parental magma(s) composition(s) and their respective sources. Defining these magmas and their sources is fundamental to understand how the RLS formed in a geodynamic context on the one hand, and why its rocks are so enriched in Pt and other metals (Cr, V) on the other. Since the degree of magmatic differentiation generally increase with stratigraphic height in the RLS, previous studies that tried to determine the parental magma(s) composition(s) focussed on the lowermost section of the stratigraphy. Mafic to ultramafic sills from the basal units have been extensively analyzed and the most primitve composition, termed B1, has been evaluated as a likely parental magma for the Lower and Critical Zones by crystallization experiments and geochemical models. However, although the B1 compositions may be a good approximation of the parental magma, the source of this magma is still controversial. To increase the knowledge about these processes, two sets of research boreholes were recovered from the base of the intrusion, one each on the western (Nooitgedacht Site) and eastern (Clapham Site) lobes. Geochemical studies on drill cores recovered from the Clapham Site reported high-Mg olivine ($Fo_{91.5}$) that requires a genuinely ultramafic, komatiitic magma [1]. Furthermore, studies on drill cores from the Nooitgedacht Site found a chilled margin at the base of the Lower Zone, which contain Mg-rich basaltic andesite (B1) and spinefex-textured komatiite indicating partial melting of either subcontinental lithospheric or asthenospheric mantle [2].
In order to build on these previous findings and continue the approaches of earlier studies, a new ICDP borehole covering a section from the Lower Critical Zone through to the floor is planned at a locality at Impala Platinum's Marula mine. One of the aims of this ICDP project is to explore the possible magma sources of the RLS and quantify the proportions and mechanisms of mixing during melt accumulation. For this we intend to carry out a detailed trace element and isotope study on the rock forming minerals of the Lower Zone, using samples from the newly planned ICDP drillcores as well as ~40 handpieces sampled from outcrops located in the eastern and northern lobes. Our new dataset can potentially recognize different crystal populations and help to distinguish different modes of magma crystallization, and between processes of assimilation, fractional and equillibrium crystallization. Thereby, the samples from Grasvally (northern lobe) are of particular interest, since the complex is directly adjacent to the 2.07 Ga Thabazimbi-Murchison lineament which is a major tectonic boundary in South Africa. It is assumed, that during the intrusion of the RLS the Thabazimbi-Murchison lineament could have controlled the structure of the magma reservoir and injection of new melt as well as possibly acted as a dyke-like feeder [3] or as permanent or temporary barrier between the northern lobe and the rest of the RLS [4]. Comparing the Grasvally and eastern lobe samples geochemically could therefore yield valuable information about the geodynamic setting and magmatic processes during the initial stage of emplacement of the RLS.

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IODP

Developing a 3.5-million-year benchmark record of Indian Ocean Dipole variability

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The Indian Ocean Dipole (IOD) is the primary mode of interannual variability of sea surface temperature (SST) in the tropical Indian Ocean. The climatic effects of the IOD are diverse and geographically widespread. Extreme flood events in eastern Africa, weakened summer monsoon intensity over India and Southeast Asia as well as severe droughts in Australia are among the most significant societal consequences of IOD variability. These extreme climate events caused by the IOD are predicted to become more common in the future as greenhouse gas emissions increase (Cai et al., 2018). However, despite its significance, surprisingly little is known about IOD variability during the geological past, which would allow for a better assessment of its

sensitivity to atmospheric CO_2 level changes in the future. In this study, we present the first insights into the spatio-temporal complexity of the IOD over the past 3.5 million years. We utilize geochemical proxy data (XRF core scanning, stable oxygen and carbon isotopes, as well as Mg/Ca paleothermometry of planktonic foraminifera) derived from Site ODP 709, situated in the western equatorial Indian Ocean - a key region for IOD forcing.

ICDP

Improved Methodological Strategies for Extracting Sedimentary Ancient DNA from Tropical Lake Regions

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The Hominin Sites Paleolakes Drilling Project (HSPDP) provides long records from eastern African paleolakes and the Chew Bahir sediment cores in southern Ethiopia provide sediment samples spanning the last ~620kyrs. Sedimentary ancient DNA (sedaDNA) analysis via high throughput sequencing across these cores can provide a record of past environmental conditions via reconstructing past biodiversity. While the approach has a high potential to reconstruct past biodiversity responses to drastic environmental change, the tropical climate of this region increases fragmentation and degradation of sedaDNA, and as a result, the amount of analyzable ancient DNA decreases over time. This study explored the effect of different DNA isolation protocols, sediment type, and amount of sediment samples on the size and quality of sedaDNA extracted from Chew Bahir cores. For this purpose, sedaDNA from 200 mg and 2 grams of 10 sediment samples aged between 8,000 and 200,000 years BP was isolated using three different isolation protocols. Next, single-stranded libraries were prepared for all samples, and shotgun-sequenced reads were analyzed to compare the size and quality of aDNA among the samples. Our first results indicate that, even if sediment samples are very old, using an optimized isolation protocol on at least 2-gram sediment samples can significantly increase the average length of sequences extracted. Comparing the yield of different extraction methods is hence an important consideration when designing sedaDNA studies from tropical regions.

ICDP

The TephroMed project: Linking two key ICDP records of the eastern Mediterranean region using tephras

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The eastern Mediterranean region is located between two contrasting climatic zones and precipitation regimes. Precipitation rates show a strong N-S gradient between the Mediterranean climate that is dominated by winter-rain, and the hyper-arid Saharo-Arabian desert belt. Lake sedimentary archives provide important insight into past hydroclimatic

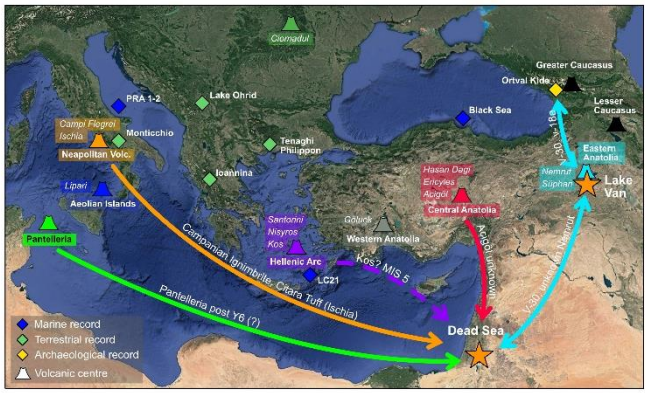

Figure 1. Map highlighting the tephra correlations made in the TephroMed project between the different volcanic centres in the Mediterranean region, the Dead Sea and Lake Van. (Satellite map data: Google Earth, SIO, NOAA, U.S. Navy, GEBCO).

variability through multiple environmental proxies. However, chronological uncertainties prevent detailed insight into regional climatic (a)synchronies. The identification of tephra (volcanic ash), both visible and non-visible (cryptotephra), can be a powerful chronologic tool to correlate palaeoclimatic records, particularly over vast distances.

The TephroMed project aims to precisely synchronise two important ICDP palaeoclimatic records from the eastern Mediterranean through the use of tephrostratigraphic investigations: Lake Van, Turkey (PALEOVAN, Litt et al., 2014) and The Dead Sea, Israel (DSDDP, Stein et al., 2011). Previous palaeoenvironmental and climatic research on these records have indicated contrasting regional responses to large-scale climatic events (e.g. Finne et al., 2019; Neugebauer et al., 2015). Both records are dated by absolute and relative methods (radiocarbon, U-Th, varve counting, wiggle-matching), yet have inherited large chronological uncertainties. This has prevented us to obtain detailed insights into the potential climatic time-transgressive nature between the two sites. However, both sediment sequences contain tephra deposits that bear strong potential to align both records (Neugebauer et al., 2021).

Here, we present new volcanic glass chemical data from key tephra layers in both Lake Van and The Dead Sea ICDP cores. The use of major, minor and trace element volcanic glass chemistry (EPMA and LA-ICP-MS) has allowed the

identification and geochemical characterisation of these important tephra layers. New geochemical data from fourteen selected visible tephra layers in Lake Van will be presented. This data has facilitated direct correlations made between the ICDP cores of the Lake Van and the Dead Sea using the V-30 layer (~42kya) from Nemrut volc ano, as well as an important archaeological site close by (Figure 1). In addition, new cryptotephra results from the Dead Sea have allowed correlation to several important volcanic regions within the Mediterranean including the Hellenic Arc, Pantelleria, the Campanian Volcanic Field and Eastern Anatolian Volcanic Province (via Lake Van; Figure 1). An important discovery has been the identification of the widespread, well-dated Campanian Ignimbrite from Campi Flegrei around 39kya within the Dead Sea ICDP core. As a result of this finding, the current chronology for the Dead Sea has been refined and has allowed direct comparisons for the timing of the cold Heinrich Event 4 across the Mediterranean to be investigated.

The results from this project have highlighted the importance of tephra layers in refining chronological uncertainty but also help to answer questions associated with regional expression of past climatic events and their temporal transgression. Future work needs to be conducted to ensure potential correlations to currently understudied tephra layers in Lake Van are geochemically characterised. This will help to facilitate additional chronological alignments using tephra between Lake Van, the Dead Sea and other well-dated archives in the region.

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IODP

Carbon dynamics and sea surface temperature from the late Eocene through the Oligocene from South Pacific: Site U1553, IODP 378 Expedition

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The late Eocene and the Oligocene is an intriguing period encompassing different climate states from “warmhouse” to “coldhouse” periods[1]. This is also a time with likely dynamic ice sheets on Antarctica and potentially variable atmospheric CO_2 concentrations (CO_2). The relationship between CO_2 and ice sheet growth-and-retreat (i.e. through sea level reconstructions) is largely unknown for this time period, but important for constraining thresholds of CO_2 for ice sheet stability at different climate states. This is also a time with scarce CO_2 reconstructions. The high latitude site U1553 in the South Pacific allows for orbital scale reconstructions from planktonic and benthic foraminifera. We analyze multi-species foraminifera for stable isotopes, trace elements and boron isotopes. Through these we explore foraminiferal “vital-effects” and aspects of the marine carbonate system, providing a robust base for generating long term, continuous CO_2 and seawater temperature records through the late Eocene and the Oligocene. We will present our first reconstructions for this period and explore our evolving understanding of the link between temperature, carbon cycle, and salinity.

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IODP

Partial melting of refractory harzburgite – Implications for the genesis of boninitic magmas of the Izu-Bonin-Mariana fore-arc investigated by IODP Expedition 352

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IODP expedition 352 was designed to sample magmatic rocks of the Izu-Bonin-Mariana (IBM) fore-arc in the western Pacific Ocean to study magmatic processes that occurred during the beginning of intra-oceanic subduction. Boninitic rocks that are generally associated with nascent subduction zones were recovered from boreholes U1439 and U1442 (Reagan et al. 2015).

It is generally accepted that boninitic melts can form during partial melting of a refractory, cpx-poor peridotite at relatively low pressures during subduction initiation (e.g. Pearce and Reagan 2019). Experimental studies emphasized the importance of melting beyond the exhaustion of clinopyroxene in the mantle to produce MgO-rich and SiO_2-rich boninitic melts (e.g. Wood and Turner 2009). However, thermobarometry calculations based on natural boninite samples as well as experimental studies resulted in varying P-T conditions for their genesis and hence the exact conditions of the mantle wedge melting remain unclear.

The aim of this experimental study is to constrain the conditions of boninitic melt genesis. By performing partial melting experiments using a refractory harzburgite, we plan to constrain the conditions at which the compositions of primitive, natural boninitic melts from the IBM fore-arc can be reproduced. The experiments are conducted at 0.5 GPa using internally heated pressure vessels (IHPV) and at 1 GPa using a piston cylinder apparatus. Different amounts of H_2O are added to the starting materials because mantle melting is expected to occur under hydrous conditions. We further plan to carry out near-liquidus crystallization experiments using natural boninite compositions to study the P-T-H_2O conditions at which the melts are saturated with a harzburgitic assemblage (cotectic crystallization of olivine and orthopyroxene).

Preliminary results of partial melting experiments at 0.5 GPa indicate that high-silica boninitic melts are generated at 1200 °C whereas low-silica boninitic melts are produced at 1150 °C at lower degree of partial melting. However, a large discrepancy between our experimental partial melts and natural compositions is observed for alkalis (Na_2O, K_2O). This indicates that an input

of alkali-rich melts from the subducted oceanic crust into the mantle wedge is required for the genesis of boninites from the IBM fore-arc and that partial melting of refractory harzburgite only cannot generate natural boninite melts.

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IODP

Uniquely low stable iron isotopic signatures in deep marine sediments of Site C0023, Nankai Trough, caused by Rayleigh distillation

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Microbially mediated iron (Fe) reduction is suggested to be one of the earliest metabolic pathways on Earth and Fe(III)-reducing microorganisms might be key inhabitants of the deep and hot biosphere [1, 2]. Since microbial Fe cycling is typically accompanied by Fe isotope fractionation, stable Fe isotopes (δ^{56}Fe) are used as tracer for microbial processes in modern and ancient marine sediments [3, 4]. Here we present Fe and Fe isotope data for dissolved and sequentially extracted sedimentary Fe pools from subseafloor sediments that were recovered during International Ocean Discovery Program Expedition 370 from a 1,180 m deep hole (Site C0023) drilled in the Nankai Trough off Japan where temperatures of up to 120°C are reached at the sediment-basement interface. The expedition aimed at exploring the temperature limit of microbial life and identifying geochemical and microbial signatures that differentiate the biotic and abiotic realms [5, 6]. The study site experienced a tectonic migration for 15 Ma from the Shikoku Basin to the Nankai Trough, which caused significant changes in depositional and thermal conditions and postdepositional mineral alterations [7]: Iron (oxyhydr)oxides were found to have been transformed into pyrite millions of years after their initial deposition.
Dissolved Fe ($Fe(II)_{aq}$) is isotopically light throughout the ferruginous sediment interval, but some samples have δ^{56}Fe values much lower than what has ever been reported for natural marine environments. These signatures cannot be solely attributed to microbially mediated Fe(III) reduction, which is a process known to preferentially release ^{54}Fe. We show that the light δ^{56}Fe values are best explained by a Rayleigh distillation model where $Fe(II)_{aq}$ is continuously removed from pore water by adsorption onto mineral surfaces. While the microbially mediated $Fe(II)_{aq}$ release has ceased due to an increase in temperature beyond the threshold of mesophilic microorganisms, the abiotic adsorptive $Fe(II)_{aq}$ removal continued, leading to the uniquely light δ^{56}Fe composition of pore water. These findings have important implications for the interpretation of dissolved iron isotope data especially in deep subseafloor sediments.

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ICDP

Subglacial, deglacial, and postglacial lake sediments underneath the Laurentide Ice Sheet: First evidence from Lake Melville, Canada

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Lake Melville is a fjord-type estuary located in Labrador, Eastern Canada, as part of the Hamilton Inlet System. It is characterised by a major salinity gradient and estuarine circulation: Riverine freshwater flows into the western, inland end of the lake while saline water from the Labrador Sea enters eastern Lake Melville through the 2.8 km wide and 30 m deep Rigolet Narrows. During the last glacial, Lake Melville was covered by the Laurentide Ice Sheet (LIS). At the end of the last glacial, the retreating LIS reached the Rigolet Narrows at ca. 10.3 ka BP and left Lake Melville completely ice-free at ca. 8.5 ka BP (Dalton et al. 2020). As for many Canadian lakes, early studies suggested that the lake was fully excavated during the last glacial, and that the sediment infill consists of syn-, para-, and postglacial sediments. However, more recent studies on other Canadian lakes (e.g., Great Slave Lake; Christoffersen et al. 2008) have indicated that some lakes might have persisted underneath the thick ice mass of the LIS during the glaciation. With its thick sediment infill of 400 m in places, Lake Melville might also have persisted as a subglacial lake and thus contain glacial sediments.

Three gravity cores were recovered during expedition MSM84 in 2019. Core MSM84_09-2 was taken at a position where the uppermost, presumably postglacial sediment package was thickest. Cores MSM84_18-1 and MSM84_26-1, in turn, were taken at locations where the postglacial sediments are condensed, allowing for penetration into deeper sediment layers.

Based on similarities in lithology, sediment-physical parameters and XRF data, a composite profile (LM-CP) was composed from these three cores. First age information was derived from ^{14}C dating of bivalve and gastropod shells, indicating that the composite core reaches a basal age of ca. 13 cal ka BP. This indicates that the lower part of the sediment core was indeed deposited while the LIS was still at the Labrador coastline, i.e. in a water body that persisted underneath the ice sheet. Pore water analyses of the lowermost sediments revealed brackish water with 28 psu, which is comparable with the present-day salinity of Lake Melville bottom waters. In addition, dinoflagellates were

encountered in all sediment depth. This indicates that the lake indeed persisted underneath the ice sheet, but was not isolated from the Labrador Sea.

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IODP

Influence of high Chlorine contents on phase equilibria in hydrous dacitic melts of Brothers volcano (IODP Expedition 376)

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This research proposal focuses on the determination of magma storage conditions (pressure, temperature, volatile fugacities) of dacitic rocks of the submarine intraoceanic Brothers volcano which was cored by IODP Expedition 376. These dacitic rocks are considered to be extremely chlorine-rich (in addition to H_2O)

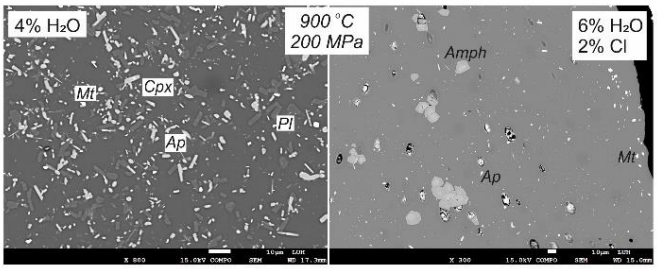

Figure 1. BSE images of the experimental run products produced at 900 °C and 200 MPa with the addition of 4 wt. % H2O (left) and 6 wt.% of H_2O and 2 wt% of Cl (right) to the starting glass composition representative of the dacite of Brothers volcano. Abundant small crystals of clinopyroxene, plagioclase, apatite and magnetite were formed in runs with lower water and Cl contents whereas fewer larger crystals of amphibole, apatite and magnetite cystallized in runs with higher H_2O and Cl concentrations.

as reported from matrix glass and melt inclusions studies (Haase et al., 2006; Keith et al., 2018). In the course of our study magma storage conditions were determined using available thermobarometers, melt inclusion analyses, and experimental work at high pressure and temperatures. Here we report on experimental results performed so far. Crystallization experiments were conducted at 200 MPa in Internally Heated Pressure Vessels to unravel the influence of Cl on phase equilibria and melt evolution in hydrous system.

Various Cl/H_2O ratios ranging (from 0 to 6 wt.% H_2O and 0-2 wt% Cl) were added to a representative dacite sample powder from the U1527 drill core (de Ronde et al., 2019) and melted at 900-950 °C and 200 MPa at oxidized conditions relevant to 2 log units above FMQ oxygen buffer. At the same temperature, Cl-rich and water-saturated experimental runs generally have less crystals (if any) and their size is found to be larger than that in low- or Cl-free runs. Clinopyroxene was found to be the first and dominant phase crystallizing at 925-950 °C in low-Cl runs, while the addition of Cl at the same temperature produced the pure glasses. The clinopyroxene-plagioclase mineral assemblage was dominant in 900 °C runs with low Cl and H_2O contents. In Cl-rich systems higher Anorthite contents in plagioclase, and higher Mg# (Mg/Mg+Fe) for clinopyroxene are observed. Amphibole is observed in Cl-rich compositions only (Figure 1), indicating that Cl enhances the stability field of this phase. Apatite and oxide were also present in the majority of experiments. The residual melts coexisting with mineral phases vary in major element contents from dacite to rhyolite (64-72 wt.% SiO_2). Adding Cl to a starting composition limits the compositional range of the matrix glasses to 64-68 wt.% of silica.

In summary, adding Cl influences the stability and composition of mineral phases and suppresses the liquidus temperature compared to water-rich and Cl-free systems. Amphibole is not observed in the mineral assemblage of Brothers volcano, indicating that the pre-eruptive temperatures were higher than 925 °C. Since water activity is known to influence the Anorthite content of plagioclase and Mg# of clinopyroxene, the comparison of natural and experimental mineral phases is in progress to constrain the water content of the dacitic melts.

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IODP

The role of Subantarctic Pacific dust provenance changes in Pleistocene climate transitions

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Atmospheric mineral dust is an important component in the global climate system. Dust influences the Earth's radiative budget and supplies micronutrients to remote marine and terrestrial environments. Due to the large distances to continental source regions, the primary productivity in the Southern Ocean is limited by iron (Fe) supply. Increased airborne Fe supply by mineral dust can reduce this limitation thus promoting primary productivity, sequestration of atmospheric CO_2 in the deep ocean and a reduction in global atmospheric temperatures. This mechanistic link between Southern Ocean dust deposition, primary productivity, atmospheric CO_2 and temperature has been identified as a powerful amplifier of global cooling during glacial intervals. The magnitude of this positive feedback role depends on the total amount and partial (Fe) solubility of the dust deposited in the surface ocean. These are related to the rock

composition (mineralogy) in the source region as well as dust transport distance and conditions (organic complexation, (photo)chemical reactions, pH variations, and particle sorting). However, relatively little is known about dust provenance and transport in the Southern Hemisphere over the glacial-interglacial cycles of the mid- to late Pleistocene. Here, we use the geochemical fingerprint of the dust fraction from marine sediments of Sites U1540 and U1541 collected during IODP Expedition 383 in the Subantarctic Zone of the Central South Pacific. Our data constrain the contribution of individual dust source regions to the dust-climate feedbacks in the Southern Ocean during Pleistocene climate transitions, thus providing reference datasets for future climate modelling studies.

IODP

Calcareous nannofossil biostratigraphy and paleoecology across the Paleocene–Eocene Thermal Maximum from International Ocean Discovery Program (IODP) Site U1580, southern Agulhas Plateau, southwestern Indian Ocean

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The Paleocene-Eocene Thermal Maximum (PETM) was an abrupt and extreme warming event associated with rapid input of light carbon into the ocean–atmosphere system at 56.0 Ma. The carbon cycle perturbations associated with this short-lived event caused significant changes to calcifying marine plankton, including extinction of some benthic foraminifera and the appearance of malformed calcareous nannoplankton, possibly related to ocean acidification during the event. Although relatively slower in its onset than modern warming, the PETM is a partial analog for the effects of anthropogenic climate change due to its rapid onset and magnitude; thus, study of PETM records offers an opportunity to better understand the effects of geologically rapid climate change on marine phytoplankton communities. Here we present calcareous nannofossil assemblage data across a new PETM section from International Ocean Discovery Program (IODP) Site U1580, drilled on the southern Agulhas Plateau during IODP Expedition 392 in early 2022. Modern water depth at this site is 2560 m and it is presently located at 40° 47.15'S, although it has moved progressively northward since the Agulhas Plateau formed in the mid-Cretaceous when the site was located about 20° further south. The PETM interval was identified during the expedition by a change in sediment color, increase in magnetic susceptibility, and calcareous nannofossil biostratigraphy. Low-resolution bulk $\delta^{13}C$ measurements conducted following the expedition confirm a negative isotope excursion and decrease in calcium carbonate content across the interval. The shipboard age model based on nannofossil and planktonic foraminifer biostratigraphy, together with magnetostratigraphy, suggests relatively high sedimentation rates (~2.5 cm/kyr). Nannofossil assemblages are quite well preserved, with PETM-specific taxa present including *Rhomboaster calcitrapa*, *Rhomboaster cuspis*, *Rhomboaster bramlettei*, *Discoaster araneus*, and *Discoaster acutus*. Initial qualitative analysis indicates that *Zygrhablithus bijugatus* is particularly abundant within the PETM interval, whereas *Fasciculithus* spp. decrease in abundance. *Discoaster* spp. are also more abundant in the earliest Eocene, as are *Neochiastozygus* spp. *Neococcolithes* spp., and *Ellipsolithus bollii*. The position of this new site between Maud Rise Site 690 and Walvis Ridge Sites 1262, 1263, and 1265 will shed new light on this event in the southern mid-latitudes, where PETM records are sparse.

ICDP

The unexpected sedimentary contact between Proterozoic igneous rocks and its Lower Palaeozoic sediment cover in the COSC-2 core

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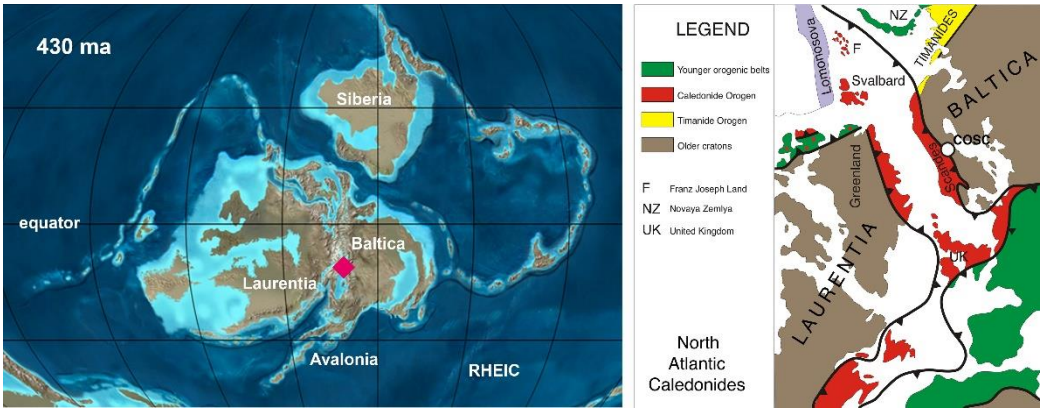
The COSC (Collisional Orogeny in the Scandinavian Caledonides) project focuses on processes related to the closure of the Iapetus Ocean causing a continent-continent collision between Baltica and Laurentia and the formation of a Himalayan-type orogen during Early Palaeozoic times (Fig. 1, Gee et al. 2010). It represents a multidisciplinary project linked to the International Continental Scientific Drilling Program (ICDP). Two sites in western central Sweden have been cored 2496 m and 2276 m, respectively, in a deeply eroded segment of the Early Palaeozoic Caledonide Orogen. COSC-2 drilling targets included a continuous Lower Palaeozoic sedimentary succession, the 2496 m and 2276 m, respectively, 2496 m and 2276 m, respectively, the underlying main Caledonian décollement in the Cambrian Alum Shale Fm, and the upper kilometre of the Fennoscandian granitic basement (Hedin et al. 2012, Juhlin et al. 2016).

Already at the drill site it became clear that the basement is of a different composition than expected, when a succession composed of a thick Transscandinavian Igneous Belt (TIB) porphyry was encountered below the Paleozoic sediments. These rocks were subsequently dated to 1.66–1.65 Ga by Andersson et al. (2022) and are intruded by Hallandian dolerite dykes (1.47



O. Lehnert et al.:
Figure 1.
Silurian palaeogeography (left) shows equatorial position of Baltica during the interval of its amalgamation with Laurentia and Avalonia (modified from a file available at the website of Ron Blakey, http://www2.nau.edu/rcb7/; red diamond - position of COSC drill sites); palaeogeography to the right (Gee et al. 2010) shows part of the Caledonian Belt ca. 60 Ma before the opening of the North Atlanic.

Ga) and Central Scandinavian Dolerite Group dykes (CSDG; 1.27–1.26 Ga) (Lescoutre et al. 2022). This basement is weathered towards the top and is composed of typical saprock and saprolite, and its regolith cover (immature soil preserved at the level of the Sub-Cambrian peneplain?) is overlain by a continuous sedimentary succession. This sequence starts with basal conglomerates and some metres of heterogeneous sediments, including silty marls with shell fragments, thus indicating an early Lower Cambrian (pre-trilobitic?) instead of any Neoproterozoic age. The developing early Cambrian basin was presumably very rapidly filled, initially by mostly coarse-grained sediment gravity flows covered by turbiditic sediments

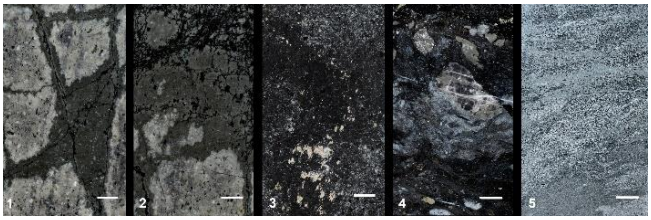


Figure 2. Basement-sediment transition illustrated by some slabs: 1 – saprock - fractured porphyry bedrock (weathering along margins of fractures; transition into saprolite), 2 – saprolite shows intense chemical weathering (transition to regolith), 3 – regolith, 4 – basal conglomerates (partly reworking the regolith), 5 – intercalated marl with shells in basal 2 m of sediment succession; scale bar equals 1 cm.

below the Alum Shale Fm, which formed during a long and tectonically quiet period (Middle Cambrian/Maolingian through Lower Ordovician/Tremadocian).

This shale deposition transitioned into a late Lower Ordovician turbidite sedimentation. Logging and early studies demonstrate that there is no indication for an imbricate zone composed of Proterozoic and Cambrian sandstones, and overlain by a deformed Alum Shale comprising the main detachment, as suggested on site (Lorenz et al. 2022).

The autochthonous Lower Cambrian passive margin succession in the lower COSC 2 core is dominated by only local detritus derived from the eastern part of the Sveconorwegian Orogen (including the COSC-2 basement). The provenance shifts upwards towards TIB-1 and Svecofennian Orogen sources, and the youngest part of the investigated sequence is characterized by a significant input of Timanian Orogen detritus, including material derived from the uplifted Karelian protocraton (Ziemniak et al. 2023). Maximum depositional age (MDA) of 530.5 ± 4 Ma is calculated by Ziemniak et al. (2023) for the upper part of the Lower Cambrian succession based on a maximum likelihood age algorithm. The estimated MDA would correspond to the upper Fortunian Stage of the Terrenuvean Series (Cambrian Stage 1 - characteristic of the first mollusc/hyolith/ halkieriid small shelly assemblages) and shows that a Cambrian Stage 1 (Fortunian) or Stage 2 age estimate for the basal part of the COSC-2 Early Palaeozoic sedimentary sequence is reasonable.

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ICDP

Synthetic rotational seismograms in software "Pyrocko“

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We present an extension of the pyrocko Greens function (GF) store to derive rotational seismic ground motions from translational data allowing to generate synthetic seismograms of both translational and rotational ground motions within the same framework. In the GF-store, precomputed seismic greens functions are stored on a regular grid. Seismograms can be extracted for any combination of source and receiver location (within the boundaries of the grid) and moment tensor. GFs are interpolated from the nearest grid points to the requested locations.

With the new extension, rotational GFs are derived from an existing translational store using finite differences, exploiting the fact that rotational motions mathematically result from spatial derivatives of translational motions. The rotations from finite-differences correspond perfectly to analytically computed ones. The rotational GF store also integrates with the software package “grond” which allows to include rotational seismic data in the inversion for seismic moment tensors.

We show first comparisons between the synthetic data and seismograms of two portable rotational sensors (BlueSeis3A) deployed in the Vogtland area as part of the project NonDCBoVo which is part of the ICDP EGER project. The EGER project investigates the geodynamic processes of the West-Bohemian/Vogtland area, an intraplate region that is affected by Tertiary-Quarternary volcanism, neotectonic crustal movements, thermal springs, mofettes and earthquake swarms. NonDCBoVo aims to improve the resolution of the moment tensors for the earthquakes by adding rotational data which was shown to be beneficial in synthetic studies. A clearer moment tensor helps to constrain the nature and origin of the quakes, which are presumably caused by rising mantle fluids.

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IODP

Reconstruction of the Laurentide Ice Sheet based on a geomorphological analysis of Grounding zone wedges on the Labrador Shelf

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The eastern Canadian margin, especially the Labrador Shelf, is one of the key areas to study climate variations from the Cenozoic to the present. During past glaciations, vast areas of Northern North America were covered by thick ice sheets, such as the Laurentide Ice Sheet (LIS). In periods of melting, these ice sheets released significant amounts of freshwater into the North Atlantic and influenced the ocean circulation, particularly the Atlantic Meridional Overturning Circulation (AMOC). Since changes in the AMOC are mainly caused by natural climate fluctuations between glacials and interglacials, it is critical to examine the dynamic behavior of the LIS in detail. However, data on the dynamics of the LIS are mainly derived from sediment cores located far offshore in the Labrador Sea and onshore information. Therefore, we carried out expeditions to the Labrador Shelf in 2015 and 2019 to investigate the transverse troughs and intervening banks of the shelf by a combination of bathymetric mapping, sediment echosounding, seismic profiling and sediment coring. The aim of the study presented here is to map and describe discovered grounding zone wedges on the Labrador Shelf using high-resolution geophysical data and to discuss their implications on the dynamics of the LIS during the deglacial.

ICDP

Astronomical calibration of the Early Jurassic Sinemurian Stage based on cyclostratigraphic studies of downhole logging data of the Prees-2 borehole (England; ICDP JET Project)

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In late 2020, an approximately 650 m long core was drilled at Prees in Shropshire, England, as part of the ICDP project JET (Integrated Understanding of the Early Jurassic Earth System and Timescale). The main objective of this project is to obtain a complete and continuous sedimentary archive of the Early Jurassic. The Early Jurassic (~200-175 million years) was a period of extreme environmental changes, which will serve as an analogue for present and future environmental transitions. The project plans to provide a reference record for an integrated stratigraphy (bio-, cyclo-, chemo- and magnetostratigraphy) of this period. Analysis of geophysical borehole logs will allow the description od sedimentary cycles related to orbital parameters and paleoclimatic history if sedimentation environment and –rate permits. Here, downhole logging data from the Prees-2 borehole is used to construct an astronomical timescale for the Sinemurian stage, contributing to an integrated timescale for the Early Jurassic. Cyclostratigraphic methods including a statistical and

visual approach lead to preliminary results of ~6.8 ± 0.2 million years duration for the Sinemurian stage.

ICDP

Genomic assessment of Eger Rift subsurface microbial communities offers glance at specialized archaeal and bacterial processes driven by mantel derived CO_2 degassing and seismic events

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Seismic activity and consistently high CO_2 fluxes make the Eger Rift in Western Bohemia (CZ) a rare subsurface ecosystem and scientifically relevant location to study microbial behavior and assess how geologically derived compound are used in the deep subsurface. Studying microbial life in this ecosystem provides the opportunity to investigate how high CO_2 levels and mineralogy influence microbial community composition and metabolic activity. Seismic activity in this region can also release H_2, a process which may provide the basis for primary production through methanogenic archaea and should be explored.

To assess microbial processes associated with the Eger Rift subsurface we investigated diversity, community structure and metabolic attributes of bacterial and archaeal communities in drill core sediments and groundwater samples. We also analyzed the geochemical conditions in this subsurface system and studied the physiological responses of native Eger microbial communities to high CO_2 via enrichments.

Genomic analysis of sediment and water samples, covering depths between 17m and 230m, provided novel insights into a CO_2 adapted microbial community. We detected strong Cyanobacteria and Proteobacteria signatures as well as unexpected archaeal diversity in sediments, and high abundances of acidophiles and sulfate reducers in water samples. Enrichment cultures from the recovered sediments suggested subsurface populations can actively utilize CO_2 and H_2, while reconstruction and annotation of MAGs provided insights into microbial processes driven by CO_2.

Going forward our data will be used to further investigate cellular processes under high CO_2 conditions and identify pathways and biomolecules which may be of industrial and biotechnological relevance.

IODP

The impact of marine silicate diagenesis in the Norwegian Sea on Early Eocene climate

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The silica cycle is a driver of global climate change over million-year (Myr) timescales. In the Cenozoic, the cycling of silica was intense during the hothouse Early Eocene 56–48 million years ago (Ma). The supply of highly reactive biogenic silica and volcanic ash from the North Atlantic Igneous Province, coupled with high temperatures and an enhanced hydrological cycle, likely facilitated intense diagenetic reactions in marine sediments. However, studying these reactions in Eocene sediments is challenging, with hallmarks lost through the diffusion of in situ pore waters and overprinting by subsequent reactions. Here we present high resolution sedimentological, geochemical and interstitial water (IW) analyses, detailing the history of silicate diagenesis in the North Atlantic region. The sedimentology and geochemistry provide evidence in situ evidence for substantial reverse weathering in the form of widespread deposition of authigenic clays on the Norwegian continental margin. This is a process that produces CO_2 and returns it to the ocean-atmosphere system occurred in the region during the early Eocene. Evidence suggests that these diagenetic reactions were occurring on a large scale in North Atlantic sediments, constituting an important source of CO_2 and potentially sustaining the hothouse conditions of the Early Eocene period.

ICDP

Changes in precipitation during the last 420 kyr in the northern Neotropics decoded from Lake Petén Itzá, Guatemala

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Lake Petén Itzá, Guatemala, is one of the oldest environmental archives in the northern region of the Neotropics and is sensitive to different climatic factors that distribute rainfall in the region, such as variations in the Intertropical Convergence Zone (ITCZ) and the Atlantic Meridional Oceanic Circulation (AMOC). Therefore, the lake sediments have been used to study climate conditions of the last glacial-interglacial cycle, mainly of the last 80 kyr (Hodell et al. 2008; Martínez-Abarca et al. 2023). The lack of a robust master sequence and chronology has been an obstacle to inferring the climate beyond 80 kyr, including some of the coldest periods of the late Quaternary (e.g. Marine Isotope Stage [MIS] 6). We improved the existing chronology of the sedimentary record from the lake and extended the record by establishing a master sequence based on the correlation of the drilled sites PI-06, PI-01, and PI-07, as well as on a more robust age-depth model back to 420 kyr. Magnetic susceptibility, geochemistry, and pollen evidence were used to reconstruct

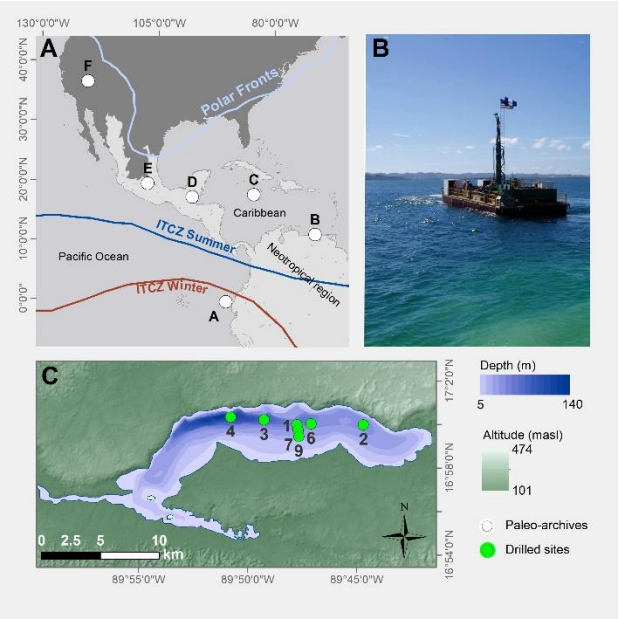

Figure 1. A) Geographical position of Lake Petén Itzá (D) as well as other paleo-archives discussed in our study, which include: marine sedimentary records ODP 1239 in the eastern equatorial Pacific (A), ODP 1002 in the Cariaco Basin (B) and the MD03-2628 in the northern Caribbean (C), the lacustrine sedimentary record from Lake Chalco in Central Mexico (E), and the speleothem record from Devils Hole Cave in California, USA (F). The position of the Intertropical Convergence Zone (ITCZ) is shown for summer (red) and winter (blue), while the average position of the polar front for January is given (maximum extension time). B) Photography of the lake and the GLAD09 platform used during the drilling campaign in 2006 (photo: PISDP sampling party, 2006). C) Digital elevation model of the catchment area, bathymetry and drilled sites.

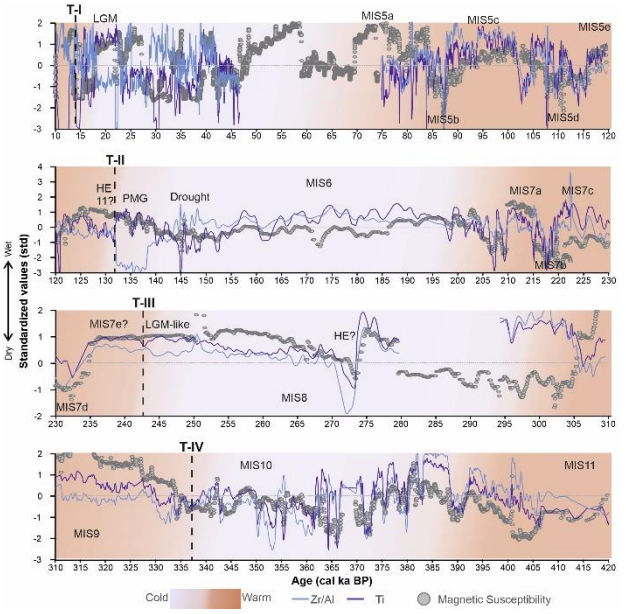

Figure 2. Comparison of standardized CLR Ti, CLR Zr/Al, and magnetic susceptibility data for the last four glacial-interglacial cycles. The glacial terminations (T) are indicated with dashed, vertical lines. Specific events are highlighted. This includes Marine Isotope Stages (MIS), Last Glacial Maximum (LGM), Penultimate Glacial Maximum (PGM), and potential Heinrich Events (HE).

hydrological variability at the lake, including runoff, evaporation, aeolian input, and tropicality of the ecosystem. This information helps us to understand changes in precipitation and its probable sources during the last four glacial-interglacial cycles (MIS 11-2, 420-14 ka cal BP). Based on our findings, it appears that the northernmost position of the ITCZ enhanced the precipitation in Petén Itzá during interglacial periods. The increase in the precipitation during interglacials was accompanied by the dominance of tropical species as our high tropical index suggests. During these times, we observe high Ti levels and low Ca/Al ratios, indicating increased runoff, decreased evaporation, and higher precipitation. However, each glacial period behaves differently showing a dry and a wet phase each one. The reduction in precipitation during dry phases corresponds to the southward movement of the ITCZ and the weakening of the AMOC. Particularly, the dry phase during MIS 6 (160-135 ka cal BP) may have resulted in such a significant drop in water levels that sedimentation almost ceased. Nevertheless, a transregional comparison with other climate archives in the area, such as Lake Chalco (Central Mexico; Abadi et al. 2022) and Devils Hole Cave (USA; Landwehr et al. 2011), indicates that the increase in precipitation during wet phases might be related to stronger polar fronts. Based on the geochemical data, the fluvial (Ti) and aeolian (Zr/Al) inputs seem to be connected throughout most of the record. However, during the last 6 kyr of each glacial cycle in Lake Petén Itzá (such as the Last and Penultimate Glacial Maximum), there seems to be a discrepancy. Specifically, the fluvial input increases while the aeolian input decreases during this time. It is possible that the weakening of easterly winds, which are responsible for carrying a significant amount of dust from the Sahara to Lake Petén Itzá, and an increase in winter rainfall from the north may explain this phenomenon. This study serves as a first reference point for future research on older climate events in Lake Petén Itzá and transregional studies of the late Quaternary climate in the northern Neotropics.

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ICDP

ICDP Oman Drilling Project: Drilling through the crust mantle transition zone - the formation of massive dunites

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The formation of oceanic crust at mid-ocean ridges is one of the dominant processes in the chemical differentiation of our planet. Oceanic crust formed at fast-spreading ridges exhibits a relatively uniform seismic stratigraphy and is regarded as layered and relatively homogeneous. Because of the lack of natural in-

situ exposures at the base of the crust of recent oceans, existing models on the geodynamics of the deep processes during crustal accretion have never been tested directly using natural samples. Using the CM1 and CM2 drill cores, recovered by the ICDP Oman Drilling Project, penetrating the crust-mantle transition of the Oman ophiolite, which is regarded as the best analogue for fast-spreading ocean crust on land, we started a study to shed light on the nature of this the poorly understood zone. The drill cores CM1 and CM2 cover the upper mantle harzburgites at the bottom, followed by a 150 m thick massive dunite layer with layered gabbros at the top. NiO and Mg# in olivine as well as Cr#, Mg# and trace elements in chrome spinel were analyzed by EPMA and fs-LA-ICP-MS. The data reveals a homogeneous harzburgite composition, followed by homogeneous dunites in the lower part, and an upper dunite section showing decreasing Mg#, and therefore more differentiated compositions towards the top. We conclude that the 150 m thick dunite section has a cumulative origin, leading to the formation of a structurally homogeneous MTZ. The trace element data in spinel of the massive dunites allow us to identify individual differentiation cycles, implying the presence of meter to decameter thick, sill-like melt lenses at the base of the crust. Primitive gabbros, cutting the massive dunites, are interpreted as late, sill-like gabbroic mushes, intruding the dunites and the uppermost mantle, which is well-known from other crust-mantle localities in the Oman ophiolite (e.g., Kelemen et al., EPSL 1997).

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ICDP

Establishment of a novel approach to trace Lake Tanganyika's gastropod faunal evolution

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ICDP corings have opened a new era of exploration of lake histories and have also increased their focus on biological evolution. Lake Tanganyika (LT) is Africa's oldest and deepest lake and well known to be a global hotspot of freshwater biodiversity (Salzburger et al., 2014; Russell et al., 2020). LT has faced a series of marked shifts in the ecological conditions including lake-level fluctuations at different magnitudes, separation and re-joining of sub-basins, opening and closing of the basin, and varying connections to major river systems (Cohen & Salzburger, 2016). The thalassoid (marine-like) gastropods of LT represent the most outstanding example of any freshwater gastropod radiation in terms of morphospace and size occupation of the shells. Remarkably, the origin of the superflock has been intensively debated but remains unclear to date. In addition to standard DNA analyses, there is an exciting new approach for species delimitation, namely proteomic fingerprinting. It uses the discriminative power of specific mass profiles of peptides and small proteins generated with Matrix-Assisted Laser Desorption/Ionization Time-Of-Flight Mass Spectrometry (MALDI-TOF MS). Another novel approach – shell palaeoproteomics – holds significant potential for a new proxy system for reconstructing lacustrine palaeofaunas (Sakalauskaite et al., 2020). It extents the proteomic fingerprinting approach to non-living material, here proteins embedded in crystalline structure of mollusc shells (so-called intracrystalline proteins).

By developing a protein reference library based on both recent and fossil shells of all gastropod (and bivalve) species of a particular region or ecosystem, palaeocommunities could be reconstructed even with reworked and largely destroyed fossil material. These conditions are often met in lake sediments and particularly in those of ancient lakes such as LT. The main goal of our project is to understand how the extraordinary biodiversity and endemicity in LT evolved by developing a new integrated analytical approach employing proteomic fingerprinting, shell palaeoproteomics, DNA barcoding and biodiversity modelling to trace species diversification and (meta-)community evolution. Based on general questions that are relevant for the overall scientific deep-drilling goal – Identifying drivers of endemic biodiversity through deep time – the following specific objectives are targeted during this study: (1) Establishment of the proteomic fingerprinting and shell palaeoproteomic approach, (2) Identification and characterization of recent and fossil gastropod assemblages to spatially trace community gradients and turnover, and (3) Testing Pleistocene faunal affinities and limnological connections of LT to connected rivers and lakes Kivu and Rukwa.

In the initial phase of the project, we tested various bleaching steps on a variety of shell samples by using different concentrations of NaOCl. In order to remove excess minerals and achieve higher protein contents, we followed demineralization and intracrystalline protein purification by using single-pot, solid-phase-enhanced sample preparation (SP3) samples and C18 solid-phase extraction tips. Subsequently, purified samples were resuspended in 0.1% trifluoroacetic acid (TFA) solution and mixed with α-cyano-4-hydroxycinnamic acid matrix solution on MSP 96 MALDI plate. Finally, samples were measured by a MALDI-TOF mass spectrometer (Bruker Daltonics, Germany).

We observed a variety of distinct peaks representing proteins of different weights from live as well as fresh and Holocene shell samples of LT endemic species such as *Lavigeria* spp., *Paramelania* spp. *Spekia zonata*, *Tiphobia* sp., *Neothauma tanganyicense* as well as unionid bivalves. The preliminary findings of the present study strongly support the approach taken to obtain intracrystalline proteomic data. It has been proven that sufficient protein amounts of high quality can be obtained from shells of various preservation stages. Moreover, the data obtained allowed distinguishing between the taxa tested so far.

Developing the technical and analytical pipelines further, we will provide a novel and integrated approach in studying ancient lakes' biological evolution. Due to the lack of well-preserved fossils in many lake sediments, the approach of using intracrystalline proteomic data from shell remnants and a library from recent taxa to model major evolutionary events in the past will be of great interest for geologists and palaeontologists.

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ICDP

Microbial hydrocarbon uptake and the effect of hydrocarbons on microbial sulfate reduction

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Guaymas Basin, located in the Gulf of California, Mexico, is a young marginal ocean basin with high sedimentation rates of >1 mm/year, active seafloor spreading, and steep geothermal gradients in its sediment. It hosts a unique subseafloor biosphere as these conditions lead to the thermal cracking of sedimentary organic matter and the production of bioavailable organic carbon compounds and hydrocarbons already at shallow depths. The abundance and diversity of potential microbial substrates raise the question of which substrates are being used for catabolic and anabolic microbial metabolism.

We thus analyzed the microbial uptake of hydrocarbons using nanoscale secondary ion mass spectrometry (nano-SIMS) analysis after incubation with stable-isotope labeled substrates. Incubations were carried out with samples from two IODP Exp. 385 drill sites, Site U1545 with undisturbed sedimentary strata and a temperature gradient of 225°C/km, and Site U1546 with a sill intrusion led to temporary heating of the sediment. The temperature gradient of 221°C/km indicates thermal equilibration with the surrounding sediment since sill emplacement. Incubations were carried out with ^{13}C-benzene + ^{2}H-hexadecane or ^{13}C-methane at in-situ temperature (4-62°C) and pressure (25 MPa) for 42 days. Additionally, sulfate reduction rates (SRR) were measured by incubating the samples with four aliphatic hydrocarbons + four aromatic hydrocarbons or methane and radioisotope-labeled $^{35}SO_4^{2-}$ at in-situ temperature (4-63°C) and pressure (25 MPa) for 10 days. The nano-SIMS analyses reveal that a few samples showed detectable microbial assimilation of hydrocarbons. Nitrogen (from $^{15}NH_4Cl$ in the medium) was assimilated in some samples incubated with methane. The assimilation mostly occurred in samples from near the seafloor (2 and 44 mbsf). We hypothesize that the relatively short incubation time of 42 days was insufficient to detect extremely small incorporation rates in deep sediments. The results of the SRR measurements indicate that a mixture of hydrocarbons and methane increases the SRR in samples from near the seafloor (2 mbsf) and around the sulfate-methane transition zone (44 and 55 mbsf) but not in samples from greater depths. Our results show that anaerobic microorganisms in Guaymas Basin can use hydrocarbons for anabolic and catabolic metabolism in this extreme environment.

IODP

Early throughflow of Proto Weddell Sea Deep Water in the Falkland/Malvinas Trough

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Opening of the Drake Passage-Scotia Sea zone in combination with the cessetion and slab-retreat of the Ancestral South Sandwich Arc are considered to have removed the last barriers for the completion of a full circum-Antarctic pathway. This is believed to have allowed for the onset of the Antarctic Circumpolar Current (ACC) and the vast climatic modifications leading to the Glaciation of Antarctica. Downstream of the Drake Passage, the northward flow of the ACC is blocked by the North Scotia Ridge (NSR) and is restricted to narrow but deep passages. The Falkland/Malvinas Trough (F/MT) with an average water depth of 3000 m bounds the northern extremity of the NSR and lies on the pathway of the ACC as it flows northward towards the South Atlantic through these passages. This bathymetric depression developed since at least the Middle Cretaceous times as the foreland basin of the NSR in association with the early compressive phase of the Andean orogeny. The Cenozoic strata across the F/MT carry a history that is linked with the tectonic evolution of the Drake Passage-Scotia Sea zone in a transpressional setting along the South American-Scotian plate boundary. The current-controlled sedimentary and erosional features in the F/MT provide valuable information on the Cenozoic oceanographic modification of the Southern Ocean with the onset of the ACC. Here, we discuss the structural and morphological evidence of the Cenozoic strata across the F/MT with respect to the regional tectonic history via a set of 2D high-resolution seismic reflection data acquired in 2019 by the Alfred Wegener Institute. Development of the deformational folds and reactivation of Mesozoic faults during Oligocene-Middle Miocene times argue for a compressional regime linked with the growth of the Drake Passage-Scotia Sea zone. Current-related depositional processes by the action of sluggish abyssal water masses initiated prior to middle Miocene times in the F/MT. An extensive erosional event in the Middle Miocene is argued to be related to the full opening of the Drake Passage-Scotia Sea to the deep circulation along with the subduction of the Ancestral South Sandwich Arc as the last barrier to the complete development of

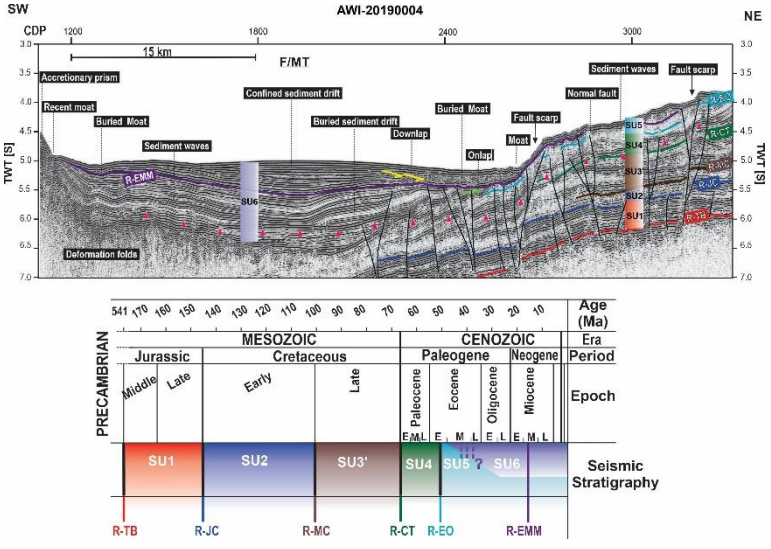

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Figure 1. Part of the interpreted seismic profile AWI-20190004 crossing the Falkland/Malvinas Trough (F/MT). Superimposed are the seismic stratigraphy and the marker horizons (summarized in the chart below). The pink triangles mark the cross-cutting reflector associated with a fossilized silica diagenetic front. Note the reactivated Mesozoic faults at the northern flank and the deformation folds at the southern flank of the F/MT which have affected Cenozoic strata mainly prior to the Middle Miocene. Note the onset of minor drift deposition in the F/MT prior to the Middle Miocene, Reflector R-EMM which represents the Early-Middle Miocene erosional unconformity, and the subsequent formation of the mounded confined drift deposition which persists till today by the evidence of recent moats at the seafloor.

the ACC. Since then, in combination with the enhancement of abyssal circulation, a deep water mass (precursor of the Weddell Sea Deep Water) has circulated in the trough and shaped a confined sediment drift at the trough's floor, in an oceanographic setting analogous to that of the present.

IODP

Comparison of paleomagnetic and AMS-based age models for sediments of Lake Melville, Labrador, Canada

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Lake Melville is an estuarine-type fjord inlet at the Labrador coast, Eastern Canada. It receives riverine freshwater input at its western end and input of marine water at the eastern end where it is connected to the Labrador Sea through the 2.8 km wide and 30 m deep Rigolet Narrows. During the last glacial, Lake Melville was covered by the thick ice mass of the Laurentide Ice Sheet (LIS). At the end of the last glacial, the LIS margin reached the Rigolet Narrows by ca. 10 ka BP and was completely inland to the west of the lake at ca. 8 ka BP. Lake Melville, as many lakes of Canada, has been described as fully excavated during the last glacial. Its ca. 400 m thick sediment package was regarded as containing mostly syn- and paraglacial sediments, with only a relatively thin cover of postglacial sediments. Only during the past few years, studies started to reveal that deeper lakes may have persisted even underneath the LIS during the last glaciation. With its deep morphology and the thick sediment infill, Lake Melville could be a candidate for a past subglacial lake, and hence hold a paleoclimate record that spans beyond the deglaciation.

During expedition MSM84 in 2019, five gravity cores were retrieved from the well-layered uppermost part of the sediment package. Three of the cores were spliced into a composite profile and further investigated for geophysical and geochemical parameters. In order to develop an age model for the composite core (MSM84_LM-CP), two approaches were chosen: (1) AMS dating was performed on calcareous shells of bivalves and gastropods, and (2) paleomagnetic means were applied by utilizing the core's relative paleointensity (RPI) estimate for the Earth's magnetic field. The AMS-derived age model was obtained using the R tool "rbacon", while paleomagnetic dating was based on the correlation of the RPI estimate to geomagnetic field models and global RPI reference curves. Lake Melville sediments for most intervals are well suited as recorders of past variations in the Earth's magnetic field as is visible from their magnetic properties. Comparison of the two independent age models (AMS, RPI) shows a good agreement throughout the entire sediment profile. Only towards the base of MSM84_LM-CP the RPI-based model yields slightly older ages compared to the AMS-based model. Reasons for this age discrepancy are the current subject of investigation.

ICDP

Adapting in the face of climate and environmental change in the American Tropics: responses of freshwater ostracode communities from ancient Lakes Petén Itzá, Guatemala and Chalco, Mexico during the last 80 ka

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The northern American Tropics is a region that hosts ancient Lakes Petén Itzá, in the karst lowlands of northern Guatemala (110 masl), and Chalco, in the highlands of central Mexico (2240 masl), each of which possesses a sediment record of climate and environmental change that spans the last ~400 ka. We used the ~80-ka record from ~75.9-m-long core (PI-6, water depth 71 m) from Lake Petén Itzá (Pérez et al. 2021) and the ~70-ka record from a 122-m-long master sequence (CHA-11-VII and CHA-08, dry lake bed) from Lake Chalco (Chávez et al. 2022) to explore ostracode responses to abrupt climate and environmental changes, including Heinrich Stadials 6-1 (HS6-HS1) and the Pleistocene/Holocene transition.

Ostracode species richness in both ancient lakes has remained low as a result of continuously fluctuating limnological conditions in the late Pleistocene, which included dramatic changes in water level and conductivity in Lake Petén Itzá, and in salinity and alkalinity in Lake Chalco. Only three species were found in sediments from Lake Chalco, whereas nine species were encountered in Lake Petén Itzá deposits, probably because environmental conditions in the karst lowlands were more favorable, with warmer temperatures, higher precipitation, and lake waters dominated by calcium, magnesium, carbonate and sulfate. Most ostracode species reproduce sexually and are endemic, contributing to their high degree of adaptation and resilience. Lower ostracode species richness and diversity, along with the greatest magnitudes and rates of ecological change, were observed during Heinrich stadials HS6-HS1 and during the Pleistocene/Holocene transition (Pérez et al. 2021). Freshwater ostracode communities appear to have recovered from abrupt changes in water level, temperature, and conductivity within 2-5 millennia.

This is the first study in the northern American Tropics that used long sediment cores to explore the effects of past climate change on ostracode ecological traits, including body size and reproductive strategies. We selected *Paracythereis opesta* and *Limnocytherina axalapasco* for study, as they were present in most sediment samples throughout the cores and display sexual dimorphism, making it possible to distinguish between males and females. Our results suggest there was a reduction in body size

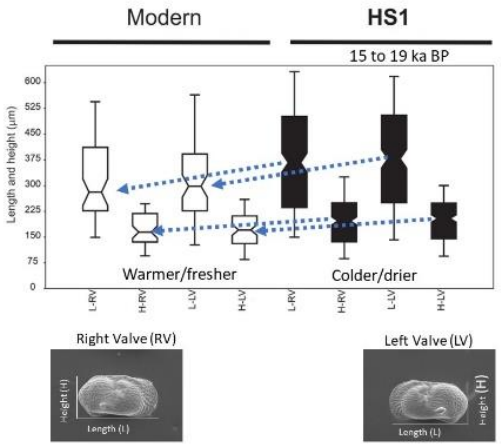

Figure 1. Boxplots of the length (L) and height (H) of measured right (RV) and left valves (LV) of ostracodes (Paracythereis opesta) from surface sediment samples collected in 2006 and 2008 (white boxplots), and sediment core samples corresponding to the Heinrich Stadial 1 (HS1, black boxplots) in Lake Petén Itzá, Guatemala. In the modern samples, 68 LV and 56 RV were measured, whereas 223 LV and 232 RV were measured in the HS1 samples.

of the freshwater calcifiers over time (HS1 vs modern samples), probably caused by higher water temperatures and lower conductivities (Fig. 1). We also found that females were more abundant during dry and stable conditions, whereas males suddenly appeared during times of environmental disturbance

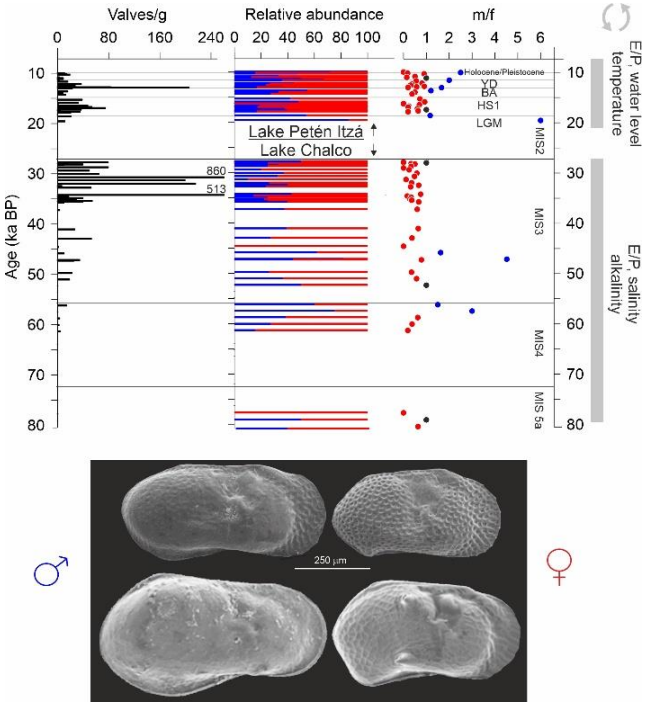

Figure 2. Total valves per gram, relative abundance of males and females and sex ratio (m/f: males/females) of the endemic ostracodes Paracythereis opesta in the PI-6 record from ancient Lake Petén Itzá (20-10 ka BP) and of Limnocytherina axalapasco in the CHA-11-VII and CHA-08 records of Lake Chalco (80-27.7 ka BP). Males are shown in blue, and females in red. E/P: Balance between evaporation and precipitation; YD: Younger Dryas; BA: Bølling–Allerød; HS1: Heinrich stadial 1; LGM: Last Glacial Maximum; MIS: Marine Isotope Stage.

such as increasing water levels (Fig. 2). Our findings highlight the advantages of paleolimnological approaches for elucidating aquatic invertebrate species reproduction and adaptation strategies. They also illustrate the potential of incorporating male/female ratios in future ostracode studies to identify times of past environmental disturbance.

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IODP

The development of the Great Barrier Reef has been controlled by temperature change since its origin in the Pleistocene

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The Great Barrier Reef (GBR) is a unique environmental resource. Modern studies show the reef system is vulnerable to future climate changes. However, there is a lack of paleo Sea Surface Temperature (SST) records for the area around the GBR. Furthermore, the few existing SST records do not show temperature changes during the start of the GBR's development, leading researchers to suggest that factors other than temperature, such as sea-level change or sediment transport, explain the start of the reef. Therefore, this has led to a conflict between the modern studies suggesting SSTs have a major impact on the future of the GBR and paleo studies, which suggest no role for SST at all in the GBR. To investigate this conflict, we used TEX_{86} to produce a new SST record starting at 900 ka from ODP Site 820. This core is located next to the northern GBR. In this new record, we show that SST changes are responsible for the development of the GBR. First, there is an increase in temperature around MIS 17 when the GBR is supposed to have first developed. This seems to indicate a southward expansion of the West Pacific Warm Pool during MIS 17. This is followed by a period of relatively stable SST between MIS 17-13, with no major glacial cooling during this time. This matches evidence from reef cores, which suggest that the GBR was still maturing during this time. This period of relatively stable SSTs might have allowed the system to develop and expand within a narrow window ideal for coral growth, even during glacials. This allowed the current coral system, which first established in its present form during MIS 13, to survive cooler conditions during MIS 12. After MIS 12, this relatively stable SST system was reestablished and continued to the modern day, with MIS 11 and 5 being particularly warm interglacials. Therefore, our research suggests that significant steps in the development of the Great Barrier Reef system are linked to changes in the SSTs. Our record also suggests that SST changes are the primary driver of reef development and that sustained periods of optimal temperatures are a prerequisite for the development and maintenance of the GBR.

ICDP

Investigating Early Stage Quaternary Overdeepening in Oberschwaben (EQuOs)

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Overdeepenings are closed basins incised into the bedrock by subglacial erosion, and following ice retreat, they become infilled with water and sediments. The sedimentary fillings, some of which are composed of multiple cycles representing separate glaciations, are archives of enormous scientific value. Investigation of overdeepenings and their infills is the key to understanding the processes and drivers of subglacial erosion, the timing and sequence of past glaciations, and thus their cumulated impact on landscape and topography.

This investigation acts as a complement and an expansion to the project “Drilling Overdeepened Alpine Valleys” (DOVE; Anselmetti et al. 2022) of the International Continental Scientific Drilling Program (ICDP). It is centred around two already acquired drill cores from the Lake Constance area in southwestern Germany (Oberschwaben; Ellwanger et al. 2011), which recovered the infills and the underlying bedrock of two separate overdeepenings in high quality. What is special about these overdeepenings is their exceptional stratigraphic position: Preliminary results show that both drill cores comprise complex successions that presumably reach back to the early Middle and Early Pleistocene, respectively, a time span that is currently only poorly constrained, and could not yet be identified in drillings of ICDP DOVE.

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IODP

An open access platform to document and retrieve composite records from ocean drilling sites - the Ocean Drilling Composite Tracker (ODCT)

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A key concept in scientific ocean drilling in order to recover continuous multi-million year spanning successions from the sea floor is the formation of composite records. Drilling multiple holes at a given site and the subsequent assemblage of an undisturbed and complete sediment sequence allows scientist to retrieve outstanding, several hundreds of meters thick records for paleoclimate reconstructions. More then fifty years of ocean drilling clearly revealed that a single drilled hole is not adequate to be able to resolve the progression of climate change needed to identify causal mechanisms. The composite records from multiple drilled holes have become the backbone of paleoceanographic research to better understand Earth past climate changes. Typically during a two month-long ODP/IODP Expedition targeting to retrieve full sediment successions from the sea floor a composite is formed routinely onboard by the Stratigraphic Correlator. The quality of the composite record depends mainly on the careful correlation of prominent features in the core, which in turn depends on the quality of the data used for correlation. In addition, to evaluate, verify and improve shipboard composite records other more time consuming techniques with higher signal-to-noise-ratio help to substantially revised composite records, and sometime reveal major gaps or repeated interval in composite records. Thus, years after an expedition checks and revisions can result in an iteratively evolving composite with multiple published versions.

The main goal of the project is to develop an open access and cross-platform software tool to document and track all of the published and future composite records of scientific ocean drilling core sites, the Ocean Drilling Composite Tracker. We have collected, checked and formatted initial and revised versions of core offsets and the complementary composite tables of 250 sites from 55 ODP Legs or IODP Expeditions. To be able to calculate the initial depth of a given sample from the sample position in a core section we gathered and verified all core section summary tables. Using this basic information and the core offsets of the respective composite the depth can be calculated. To test the functionality of the envisaged software tool we utilise test data sets from ODP Site 982 and ODP Site 1263. We are currently developing a routine that will allow to generate sample lists with sample identification as well as composite depth and vice versa for different composite versions, retrieve alternative sample locations in parallel sections that are not part of the composite record if mapping pairs exist, extract data according to the composite from the drill core database, and retrieve ages for the samples or data using published age models. This tool is one step towards applying machine-aided data analysis and extraction. Here we present first results showcasing the functionality of the Ocean Drilling Composite Tracker.

IODP

Pulses of diatom productivity off NW Africa during late Pleistocene Terminations: The impact of atmospheric forcing

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Pulses of diatom productivity are evident in the Eastern Boundary Upwelling System off Mauretania during late Pleistocene glacial terminations I through VII. Peaks in biogenic silica have been observed to occur in the late Pleistocene sediments of ODP site 658, always shortly before the lowest precession and hence highest northern hemisphere insolation. This correlates with periods of the largest ice sheet melting and weakest Atlantic Meridional Overturning. This setting might have led to a strengthening of the Siberian High and a southward migration of the trade winds, which led to more intense winds during arid conditions, increased weathering, and enhanced dust transport.

Two possible scenarios for biogenic pulses during late Pleistocene terminations are discussed: (1) change in intermediate and deep-water circulation which allows for the mixing of silicate-rich deep waters into the low-latitude Atlantic thermocline (Meckler et al. 2013, Nature). However, this hypothesis doesn't consider the impact of atmospheric circulation and the intensity of upwelling during these events. Or (2) a more intense aeolian input which goes along with shift of the ITCZ, a change in the main sources of lithogenic particles, and stronger winds, which altogether might have led to more intense upwelling, higher productivity and in particular a rapid increase of diatom productivity. Our multiproxy dataset based on

biogenic silica measurements, grain size determintations, diatom assemblage countings and element concentrations based on XRF scanning suggests that not each termination developed in the same way. Instead a highly variable response of proxies in the studied terminations reflects different mechanisms behind the siliceous signal.

IODP

Calcareous Nannofossils from the Paleocene-Eocene Thermal Maximum, IODP Site U1557, South Atlantic Ocean

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Calcareous nannoplankton are the most abundant calcifying organisms in the modern ocean; they are widespread and evolve rapidly, making them ideal for assessing biotic change during periods of transient climate change. The Paleocene-Eocene Thermal Maximum (PETM, ~56 million years ago) was an abrupt and dramatic global warming event that resulted from huge amounts of isotopically light carbon being released into the atmosphere, and which had profound effects on the biosphere. The rapid carbon released during the PETM is considered a partial analog to modern rates of greenhouse gas emissions. This study utilizes material from a newly recovered PETM section collected during the joint International Ocean Discovery Program (IODP) Expeditions 390 and 393 (South Atlantic Transect I and II), Site U1557 (30°56.4651′S 26°37.7892′W). The PETM interval at Site U1557 was identified by a distinct layer of reddish-brown clay, the calcareous nannofossil *Rhomboaster calcitrapa*, and a significant increase in magnetic susceptibility. Post-expedition research should confirm the presence of a negative carbon isotope excursion across the interval, and high-resolution carbon isotopic measurements will determine the completeness of the sequence. The shipboard age model indicates that through the late Paleocene at Site U1557, sedimentation rates are extremely high (11.53 cm/ky; normal pelagic sedimentation rates are generally <1 cm/ky). Total organic carbon (TOC) values are also unusually high in this interval. Together, the high sedimentation rates and TOC content indicate overall high surface water productivity through this time. Initial analyses indicate that the nannofossil assemblage is relatively diverse and well preserved. Site U1557 is the first PETM record from the western South Atlantic and we will compare our results to other records from Walvis Ridge (mid-latitude eastern South Atlantic), Maud Rise (Southern Ocean), and Agulhas Plateau (southwestern Indian Ocean). Improving our understanding of the relationship between plankton and climate will better equip us to evaluate the magnitude and impact that future climate change will have on the ocean ecosystem.

IODP

Temporally and spatially stable εNd gradient in the Atlantic Ocean

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The deep Southern Ocean (SO) circulation is of major significance for the understanding of the ocean´s impact on Earth's climate as uptake and release of CO_2 strongly depend on the redistribution of well and poorly ventilated water masses.
Here, we present new authigenic neodymium isotope data (ε_{Nd}) of the deep sea sediment at site ODP 1093 (1) in the Southern Atlantic near Bouvet Island in comparison with further existing ε_{Nd} records across the Atlantic Ocean. The ε_{Nd} values of ODP 1093 have constantly the most radiogenic signature and show a strong glacial-interglacial oscillation by approximately 6 ε-units similar to ODP 1063 (2-5) from the Bermuda Rise. The ε_{Nd} records from site ODP 929 (6) in the Central Atlantic and RC11-83/TNO57-21 (7, 8) from the Cape Basin reflect a smoothed oscillation pattern in between. The ε_{Nd} gradient Δε is defined as the North-South difference in ε_{Nd} per 10° latitude and is a measure for the sensitivity to changes in ε_{Nd} signature over a given distance. The two closest sites ODP 1093 and RC11-83/TNO57-21, show a great gradient variability between 0 and 4.1 ε-units/10° latitude that may reflect local gradients caused by depth and E-W differences. In contrast, all gradients between the other cores, are not only showing almost no variability over the past 150 ka but are independent of the considered locations. Thus, the mean ε_{Nd} gradient for the Atlantic Ocean is approximately 0.89 ε-units/10° latitude. Together with the ε_{Nd} record at site ODP 1093 as southern boundary the neodymium isotopic signature of the Atlantic Ocean at any given site up to ODP 1063 becomes theoretically predictable. This suggests, that the changes in ocean circulation during glacial-interglacial transitions are not purely induced by the Northern Hemisphere currents but rather strongly influenced by equally strong changes of the Southern Ocean circulation. This reinforces the importance of the Southern Ocean in past and future climate changes. Lastly, the synchronous basin scale Nd-isotope changes through time, potentially offers the possibility to use the Nd-terminations as additional time markers in the SO, where stable isotope records are often impacted by the lack of foraminifera.

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ICDP

BioMetArchive - Subsurface biosphere metagenomics along the 1 Ma sedimentary archive of ferruginous Lake Towuti, Indonesia

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Lake Towuti is a tectonic lake seated in an ultramafic catchment on Sulawesi Island, Indonesia. Tropical weathering of lateritic soils supplies the lake with high inflows of iron, but a dearth of sulfate. Although the lake's 203 m deep water column exhibits weak thermal stratification (31ºC-28ºC), modern bottom waters are persistently anoxic below 130 m depth and sporadic overturning of the watercolumn only occurs on geologic timescales (Russell et al., 2016). Due to phosphate adsorption onto iron oxides, the lake faces low primary productivity and is characterized by anoxic ferruginous (high iron, low sulfate) conditions, which makes it a suitable modern analog for Archean and Proterozoic oceans (Bauer et al., 2019).

In 2015, a 113 m long sediment core was retrieved from 156 m water depth by the International Continental scientific Drilling Program (ICDP) as part of the Towuti Drilling Project (TDP) and dedicated to geomicrobiological investigations. To achieve this, a contamination tracer was added to the drilling fluid to enable the identification of uncontaminated core sections (Friese et al., 2017).

The main aim of the project *BioMetArchive* is to characterize the subsurface biosphere of Lake Towuti's sedimentary archive in terms of microbial density, taxonomic diversity and metabolic functions, and to identify key taxa responsible for iron mineralization and organic matter remineralization under ferruginous conditions. Comprehensive taxonomic and metagenomic profiling of microbial populations will illuminate biogeochemical transformations of elements and minerals throughout Towuti's sedimentary sequence (Vuillemin et al., 2023). These results will be then integrated with available geochemical and environmental data to disentangle relationships between microbial ecology and depositional conditions to cover 1 Ma of diagenetic history, with further implications for microbial processes that operated in the Earth's early ferruginous oceans (Friese et al., 2021).

Geochemical profiles show that stratified conditions in the ferruginous water column lead to rapid pore water depletion in terminal electron acceptors below the sediment-water interface, i.e. oxygen, nitrate and particulate ferric iron are already reduced in the water column, whereas the minute amount of sulfate available (<20µM) is rapidly reduced in surface sediments. This depletion in electron acceptors and easily biodegradable organic matter translates into a drop in cell counts by four orders of magnitude and a massive change microbial community composition, transitioning from a sulfate-reducing to a fermentative assembly, predominantly composed of the as yet-uncultivated class Bathyarchaeia, driving organic matter remineralization to methane (Vuillemin et al., 2018). Putative metabolic features assigned to Bathyarchaeia, namely sulfur transformation coupled to (homo)acetogenesis, and potentially methanogenesis, may offer an explanation for their increase relative abundance at the transition to the fermentative zone, becoming the dominant phylum at depth.

Thus, our study aims to elucidate cryptic sulfur cycling and Wood-Ljungdahl pathway in Bathyarchaeia, which are hypothesized to be the primordial mechanisms for energy generation and carbon fixation in Archaea (Borrel et al., 2016). By analogy, their role in Lake Towuti's ferruginous system may support new models of biogeochemical processes that were prevalent in ferruginous deposits formed in the Archean and Proterozoic oceans.

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IODP

Pleistocene evolution of eastern Pacific Southern Ocean surface water conditions

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International Ocean Discovery Program Expedition 383 recovered sediment records from three drill sites of the Eastern Pacific Southern Ocean to reconstruct the Pleistocene palaeoceanographic development and sea surface processes from the open ocean environment of the Subantarctic Zone. The Pacific sector of the Southern Ocean (SO), marked by past changes in Sea Surface Temperature (SST), implies an exceptional climate sensitivity to external and internal forces at both millennial and orbital timescale. Glacial-interglacial SST

changes in the Subantarctic Pacific sector of the SO indicate large latitudinal shifts in Antarctica´s Polar Fronts, i.e., the Subantarctic Polar Front (SAF). These shifts control the extent of sea ice, which appears to play a key role in SO surface water's physical, chemical, and biological properties. Only a little information is available from the long-term SO climate development during the Pleistocene, which matches the period of the new "Oldest Ice" ice core intended to reach up to 1.5 million years. The sediment records of Expedition 383 will allow for an improvement of our knowledge and an establishment of time series of SST variations, winter sea ice (WSI) extent, and productivity changes of the Pleistocene eastern Pacific SO (Sites U1539, U1540, and U1541).

The main goal of this project is to establish high-resolution diatom records from the three Subantarctic central-eastern Pacific sites to reveal Pleistocene environmental changes focusing on peak interglacials (e.g., MIS 5, MIS 9, and MIS 11) and especially the super interglacial MIS 31 (1.07 Myr). To address past changes in SST, sea ice extent, and productivity, palaeobiological analyses (diatom census) will be applied to Sites U1539, U1540, and U1541 and compared with geochemical proxy results. Transfer functions used to the diatom census will provide information on changes in SST and WSI concentration from the Early Pleistocene 41,000-year glacial periodicity across the Mid-Pleistocene Transition to the Late Pleistocene 100,000-year periodicity, with the results intended to be correlated with the "Oldest Ice" record and to be compared with the POLARSTERN PS58/273-1 Antarctic Zone sediment core. A further opportunity for the diatom analysis will be the refinement of the Subantarctic Pacific diatom stratigraphy.

IODP

Variability of Antarctic Intermediate Water composition in the South Atlantic over the last 600,000 years

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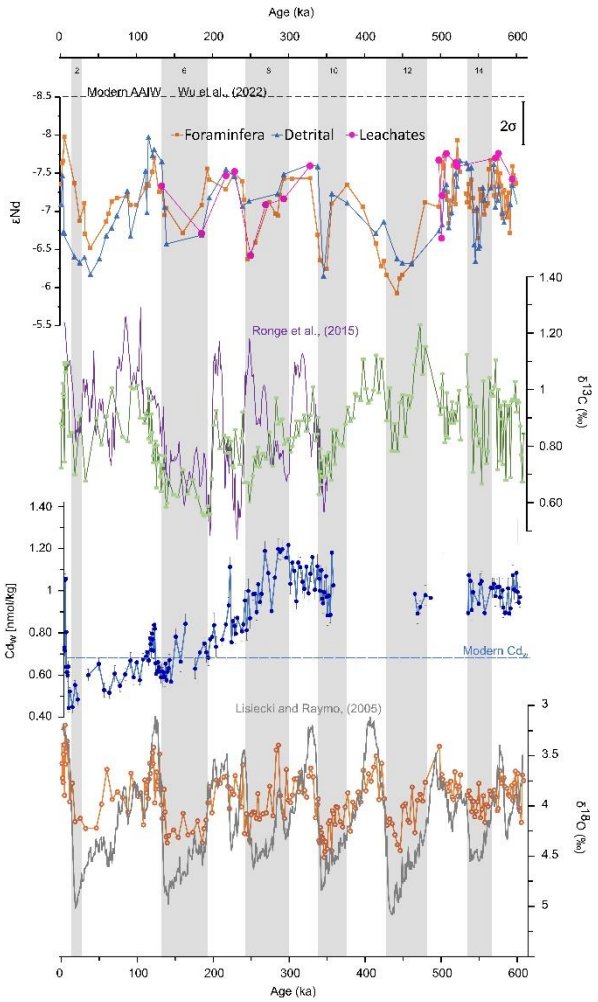
Antarctic Intermediate Water (AAIW) forms an integral part of the global thermohaline circulation as it redistributes heat, salt, CO_2 and nutrients from the Southern Ocean to the nutrient deprived tropics. Although there is clear evidence that the transport and composition of AAIW played a key role in the climate change of the last deglaciation, there are only a few longer records of AAIW variability. Here we reconstruct variations in AAIW water mass sourcing and nutrient content in the South Atlantic using Neodymium (Nd) isotopes and benthic Cd/Ca records complemented by benthic stable carbon isotope ($\delta^{13}C$) data. This study is based on a sediment core from DSDP Site 516 at 1300m water depth from within the modern-day core of the AAIW.

The Nd isotope signatures exhibit a glacial-interglacial variability of up to 1.2 εNd units over the last 600 kyr with interglacials characterized by unradiogenic Nd signatures close to modern AAIW while more radiogenic signatures of up to -6.4 prevailed during glacials. This suggests a reduced contribution of unradiogenic northern sourced waters to the Southern Ocean during glacial periods.

The $\delta^{13}C$ record displays a similar amplitude with another intermediate depth record from the southwest Pacific [1] showing glacial $\delta^{13}C$ values as low as 0.55‰. This can be attributed to a reduced ventilation at that depth during glacials.

The intermediate depth Cd/Ca record indicates a higher nutrient content during interglacials consistent with other Cd/Ca reconstructions from the Atlantic for the last 55kyr. In addition,



we observe a pronounced and steady nutrient decrease of AAIW starting ~270 ka and continuing until the Holocene. This trend is similar to that of the iron content records of DSDP Site 516 and that of Southern Ocean ODP Site 1090 [2] which show an overall increase in glacial Fe supply over the last ~270 kyr. This has likely increased productivity and has impacted the nutrient inventory of AAIW as reflected by Cd/Ca.

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IODP / ICDP

Three Decades of Pre-Site Survey Work by Bremen University for IODP and ICDP – A Personal Review and Outlook

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A key element of a successful drilling expedition is a seismic data set, preferably complimented by seafloor samples. In DSDP times, these data were collected during the drilling cruises with onboard equipment, recorded on paper along lines between drill sites, rarely supported by additional data. Sites were selected based on such data, and short crossing lines were shot before drilling. And commercial data were also used, where companies explore for hydrocarbon on continental margins.

But in the 1980's and 90's, more suitable digital seismic equipment beyond single channel recording became available to

academic institutions worldwide. And also the exploratory style of ocean drilling in the DSDP program was replaced in the ODP program by a science-driven approach. Accordingly, often pre- or full drilling proposals were taken to subsequently propose a research cruise, where seismic data and samples were collected to both locate and characterize potential drill sites, but also on a broader scope to gain an understanding of the depositional and structural setting.

Bremen University is contributing since 1993 with dedicated site survey expeditions on vessels such as Meteor, Sonne and Merian, where a scientific research program for seismic surveying and sampling was combined with a dedicated search for suitable drilling locations.

Real-time processing and interpretation could be developed and stepwise improved through better computer and processing capacities. Also, acquisition technology has much improved from low frequency seismic sources, long streamer groups, and low sampling frequencies to small volume airguns, single hydrophone streamers and high sampling rates. Storage type and capacity improved from analog, paper recording through storage on magnetic tapes and DLT tapes to hard disks, and accordingly the data volume from MegaBytes to TeraBytes.

Germany has contributed during the last 3-4 decades to very many drilling proposals and expeditions through institutions such as the BGR, AWI and Universities of Hamburg (Hübscher, Lüdmann), Kiel (Krastel) and Bremen. A wealth of seismic data has been acquired and is still available, at Bremen University we host results from more than 100 multichannel seismic cruises, which can also be used in the future for drilling proposals.

To illustrate the integration of seismic research with drilling, a few brief examples will be given from our work, such as for the Benguela Upwelling System, on Cascadia Basin Hydrology and the Bengal Fan. In the course of drilling initiatives, also shallow water sites came into the focus, as e.g. the Baltic Sea, Gulf of Naples or the Nice Airport Slide, which required dedicated technology, higher structural resolution and better processing capabilities. It should be noted, that the modern survey work for renewable energies in North and Baltic Sea for siting windmills, which we strongly promoted during the last decade, would not be as advanced without the strong support of site survey work through funding agencies as DFG and BMBF.

IODP

Observations from EPSP Reviews International Ocean Discovery Program 2013-2024

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The Environmental Protection and Safety Panel (EPSP) provides independent advice to the JOIDES Resolution Facility Board (and other IODP entities as requested) with regard to safety and environmental issues that may be associated with general and specific geologic circumstances of proposed drill sites ("JRFB Advisory Panels Terms of Reference, 29th April 2021", http://www.iodp.org/top-resources/program-documents/policies-and-guidelines).

Since the start of the International Ocean Discovery Program (IODP) in October 2013, the EPSP has reviewed 62 Proposals with a total of 878 primary and alternate drill sites (status 31st March 2023). Almost 80% of these sites were approved as proposed, 5% were approved with depth restrictions, 8% were re-located to a new location by the panel to avoid geologic safety issues at the original sites, and 4% of the proposed sites were declined without replacement. Safety reviews of three proposals were initially rejected due to incomplete data and insufficient preparation in view of serious safety issues and had to be reviewed again. Previews of 16 proposals allowed proponents to get EPSP feedback on their proposed sites with respect to data requirements and safety issues in preparation for the final EPSP review.

Most common reasons for re-positioning or decline of proposed drill sites were presence of seismic amplitude anomalies (potentially gas-charged reservoirs), poor seismic imaging and/or insufficient data coverage, position on closed structural highs, faults and/or disturbed section, and proximity to active fluid flow features (e. g. pock marks). In some cases there were issues with the quality, consistency and completeness of the safety package, and presenters not qualified to discuss seismic data specifics and uncertainties of time-depth conversion, or proponents did not seem to understand limitations of the proposed drill sites ("EPSP 1809 Minutes", http://www.iodp.org/epsp-minutes).

Proponents are therefore advised to (1) image proposed drill sites with good-quality seismic and seafloor data, (2) ensure consistency and completeness of the data base, safety review report and safety presentation prior to EPSP review, (3) have a dedicated data lead present at the EPSP review, (4) prepare enough alternate drill sites for operational flexibility, and (5) understand and avoid areas with potential geologic risks. And please read and follow instructions in the "Guidelines for the EPSP Safety Review Report and Presentation and Expedition Safety Package (last revision May 6, 2022)" (http://www.iodp.org/top-resources/program-documents/policies-and-guidelines). These may also be helpful to proponents planning drilling projects under the future ECORD-JAPAN joint scientific ocean drilling programme "IODP3" (from 1st Jan. 2025).

IODP

Deep ocean circulation during the Pliocene from a South Pacific perspective - evidence from radiogenic isotopes

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The deep ocean plays a significant part in the Earth's climate system due to its ability to store and redistribute heat and carbon. Studying the circulation patterns of deep water masses is therefore crucial for understanding climate feedbacks. Today, global ocean circulation is characterized by active formation of North Atlanatic Deep Water (NADW) and Antarctic Bottom Water (AABW), while Pacific Deep Water (PDW) is the result of diffsuive mixing in the North Pacific. Studies of the past allow us to understand the deep ocean in different climate states and identify feedback mechanisms. The Pliocene (5.3 to 2.6 Ma) was the most recent period with temperatures substantially higher than modern but atmopsheric CO_2 and tectonic boundary conditions similar to today, making it a possible anaolgue for a warmer future. While a majority of studies investigated the Atlantic deep ocean circulation, this study aims to give a Pacific perspective based on radiogenic isotopes covering a time period from 5.0 to 3.0 Ma. We measured the isotopic composition of neodymium (expressed as εNd) and lead in authigenic phases (fish debris, foraminifera and leachates) complemented by isotope analyses on sortable silt in sediments from Central South Pacific cores U1540 and U1541 of IODP expedition 383. The cores are located east and west of the East Pacific Rise, respectively, at a water depth of ~3600 m, which is currently bathed in Lower Circumpolar Deep Water (LCDW). U1540 is

thus located in the northward extension of the AABW flow path. Today, LCDW is fed by the denser NADW, while the less dense PDW feeds the overlying upper circumpolar deep water. For the most part, both cores show a more radiogenic than modern εNd signature with U1541 displaying values between -7.2 ±0.2 and -5.8 ±0.3 compared to modern -7.2 ±0.4[1], and U1540 between -6.2±0.4 and -7.3 ±0.3 compared to -7.7± 0.2[1]. This suggests a slightly increased Pacific input into LCDW during the Pliocene, which contrasts with observations in the Atlantic, where studies indicate a higher production of NADW and thus an increasing Atlantic input to the Southern Ocean (SO)[2,3]. This suggests, that the South Pacific deep water signatures were driven by processes in the SO and/or Pacific, rather than by changes in NADW. While εNd in core U1540 stayed around -7.0 from 5.0 Ma to 3.6 Ma, core U1541 shows a trend from -7.2 ± 0.2 at 4.71 Ma to -6.1 ± 0.3 at 4.2 Ma followed by constant εNd of -6.3 ± 0.2 until 3.6 Ma. The early Pliocene is characterized by an important threshold in the closure of the Central American Seaway at 4.6 Ma, which resulted in cooling of the SO[4] and potential extension of ice sheets around Antarctica[5]. These climatic conditions probably influenced the formation of AABW, resulting in a higher density of AABW and consequently of PDW. Denser PDW is able to displace parts of NADW from LCDW, a possible explanation for the observed +1 εNd trend at site U1541. The overall high AABW ventilation from ~4.8 to 3.6 Ma[6] could explain the constant εNd at U1540, driven by continuous high AABW admixture. Around 3.5 Ma, we observe a radiogenic peak at both sites reaching -5.8 ± 0.3 at U1541 and -6.3 ± 0.3 at U1540. Given the warmer climatic conditions in the SO at this time and low ventilation of AABW[6], in contrast to before, it is unlikely that the same mechanisms as before caused the further influence of radiogenic PDW in LCDW. One possibility is an active PDW formation in the Pacific, as proposed by several studies for the warm Pliocene[7,8]. The short-lived nature of the eNd peak suggests these conditions only lasted for 0.2 Ma and were followed by a gradual trend towards more unradiogenic εNd, equalling higher Atlantic influence in LCDW. The intensification of the Northern Hemisphere Glaciation (NHG) at 3.6 Ma that likely coincided with an intensification of NADW, appears to have started the change to modern deep water conditions, with LCDW eNd values reaching -7.1 ± 0.4 at site U1541 and -7.3 ± 0.3 at U1540 at ~3.0 Ma. Our study shows, that the Pacific played an important role in the deep ocean circulation during the Early and Middle Pliocene, by promoting a densification of PDW or active PDW formation. With the intensification of the NHG, the structure of the deep water column seems to have moved towards the modern situation, with NADW feeding LCDW. One possible implication of the changing contribution of PDW to LCDW may be a change in the carbon inventory of the deep ocean and hence an impact on global climate.

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ICDP

Scientific drilling in the Bushveld Complex: an update on the BVDP project

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The Bushveld Drilling Project (BVDP) in South Africa has the ambition to acquire two full stratigraphic drillcore profiles through the ca. 9 km-thick Rustenburg Layered Suite of the Bushveld Complex, one each on the northern and eastern limbs. The Bushveld Complex is by far the largest layered intrusion in the world; in fact it qualifies as a Large Igneous Province all by itself. But the complex is perhaps best known as the world's prime source of platinum group metals and a major producer of other commodities including chromium and vanadium. The BVDP is unusual among ICDP projects because of the strong support it receives from industry. A full 6 km of the 9-km profile on the eastern limb was donated by Impala Platinum's Marula mine, and the project received about 5 km of drillcore from the northern limb. The donated cores and related data sets are currently being worked on by science teams in Germany (see below) and in South Africa (Witwatersrand University, Council for Geoscience and the Free State University), with two publications having resulted so far (Magson et al., 2023; Mandendet et al., 2023).

Impala Platinum's Marula mine also plays host to the new drilling by the BVDP on the eastern limb, which aims to complete the profile downward about 2500 m to the intrusion floor. The operational phase of new drilling is expected to commence in September, 2023, with completion in July, 2024. In addition to obtaining drill cores to complement the donated section, the new work will also entail downhole geophysical logging, sampling at regular intervals for microbiology, and analysis of deep groundwater and gas (composition and abundance) in the drilled section. The science team is focussed on improving our understanding of magma chamber processes, the origin of layering and the formation of ore deposits within the Rustenburg Layered Suite; the quality and quantity of deep groundwater (>300 m) in the Eastern Bushveld; and the ecology of deep microbiological communities.

Three research projects are currently funded by the DFG; two of them work with donated drillcores from the Marula mine and the third is focussed on the lower part of the intrusion that is the target of new drilling. We will present results from the project "How was the Bushveld Complex assembled?" (PIs Trumbull and Veksler) that studies ca. 1500 meters of continuous drillcore from the Main Zone to assess magma recharge and cryptic layering. A companion project working on Marula cores of the Bushveld Upper Zone "Spectroscopic mineral - chemical

analysis of drill cores" (PIs Rammlmair, Meima, Holtz, Junge) is described in the contribution by Wang et al. The third DFG project "Probing the roots of the Bushveld Complex" (PIs Haase, Klemd) has begun work on existing samples but its main phase awaits recovery of cores from new drilling of the Lower and Marginal Zones.

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ICDP

An age model for Lake Bosumtwi (Ghana) – A key to reconstruct one million years of West African climate and environmental change

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Lake Bosumtwi fills a 1.07 million years old meteorite crater in Ghana and is considered as a key site for understanding climatic and environmental changes in sub-Saharan West Africa. The area in which the 294 m thick limnic sequence evolved is especially climate sensitive as it is located within the influencing area of the annually N-S wards shifting tropical rain belt. The migration of this low pressure system is driven by changes in atmospheric circulation considering longer (millennial) timescales, but also on an annual level. Cold conditions in the Northern Hemisphere lead to a southward shift of the tropical rain belt allowing hot, dry and dusty air masses from the Sahara to enter the area. In contrast, during warmer periods and northern hemisphere insolation maxima the tropical rain belt extends further north blocking the Harmattan in favour for the moist North African Monsoon. West Africa is also considered as part of the cradle of anatomically modern humans. Yet, detailed climatic and environmental reconstructions are largely constrained to the Late Pleistocene, despite the potential of the limnic archive to inform us about the living environment of early anatomically modern humans. The major reason for this is the lack of robust age constraints beyond 200 ka. To overcome this, we examine the cyclicity in natural gamma ray (NGR) data determined on a core in the centre of the lake, for which independent datings are available (14C, OSL, U/Th) for the uppermost part covering the Upper Pleistocene. In this interval, high NGR coincide with warmer interstadials and interglacials and the inverse for glacials. The NGR in sediments originates mostly from radiogenic isotopes of K that have been found to be enriched in soils around the crater rim of Lake Bosumtwi. Thus, high NGR values during warm and moist periods may indicate relocation of soil material by runoff from the steep crater rims and subsequent sedimentation in the hydrologically closed Lake Bosumtwi. In contrast input of K-depleted and Si-enriched dust and de-creased decomposition of organic matter during colder periods is capable to relatively decrease the NGR signal. Based on this coherence, available independent datings and cyclostratigraphic testing, we define tie points for correlating our NGR data to the age model of a SST record from the North-East Atlantic. Comparing our results to global temperature records and Sahara dust flux data supports our proxy understanding. This allows us to provide crucial chronological context to numerous datasets along with environmental constrains that can be used to study the habitat availability of early anatomically modern humans in West Africa.

ICDP

Mineral biosignatures record pore water geochemistry during microbial diagenesis - modern Lake Towuti as a ferruginous case study

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Ferruginous conditions prevailed in the oceans through much of Earth's history. However, past biogeochemical cycling inferred from mineral components identified in ancient iron formations remain poorly understood in terms of microbial processes prior to lithification. In Lake Towuti, Indonesia, iron-containing minerals sink through a stratified water column and ferruginous sediments are deposited under anoxic conditions similar to Earth's early oceans (Bauer et al., 2020), thereby allowing the study of both pore water geochemistry and long-term diagenetic evolution of the stratigraphic record.

In May to July 2015, the Towuti Drilling Project of the International Continental scientific Drilling Program (ICDP) recovered a 100-m-long core (TDP-1A), drilled with a contamination tracer mixed into the drilling fluid to identify core sections suitable for geomicrobiological studies (Friese et al., 2017). The drill cores contain 1 Ma of uninterrupted lacustrine sedimentation that documents long-term environmental and climatic changes in the Indo-Pacific Warm Pool and lake catchment (Russell et al., 2020; Ulfers et al., 2021), as well as the

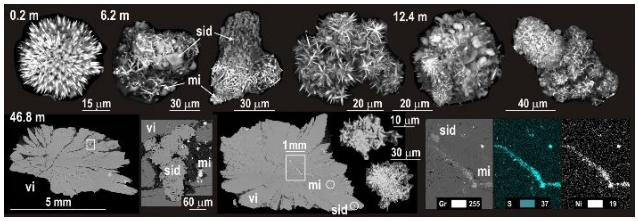

Figure 1. SEM images of millerite in acicular aggregates, with gradual siderite precipitation and overgrowth, and as inclusions in vivianite crystals.

geomicrobiology of a subsurface biosphere entombed in ferruginous deposits (Vuillemin et al., 2018; Friese et al., 2021). In the field, core TDP-1A was sectioned and sampled in a protective atmosphere for pore water geochemistry, cell counts, and DNA extractions. Minerals were also extracted from sediments sampled on split core halves in 50 distinct layers. By combining detailed pore water geochemistry and stratigraphic proxies with scanning electron microscopy imaging of authigenic phases, we studied the (trans)formation of iron minerals during reductive diagenesis (Vuillemin et al., 2019, 2020 and 2023).

While the presence/absence of Fe-bearing phases in specific sedimentary layers relate to past dynamics in the lake catchment, water column, and at the sediment-water interface (Morlock et al., 2018), the ensuing variability in the relative burial of ferric iron and organic matter is critical to the subsequent diagenetic imprint by microbial processes in the sediment. Although variability in elemental profiles attests to climate- and tectonic-driven processes along the 100-m-long sediment core (Morlock et al., 2021), deposition of ferruginous minerals appears transient as particulate iron, reworked from surrounding lateritic soils, undergoes partial dissolution-precipitation during sinking and after burial. Minerals found to form *in situ* included magnetite (Fe_3O_4), millerite (NiS), siderite ($FeCO_3$) and vivianite ($Fe_3[PO_4]_2 \cdot 8H_2O$). Here, we document millerite as an authigenic phase, its formation being mediated by microbial sulfate reduction (Figure 1). Acicular millerite aggregates overgrown by siderite (Fig. 1, top) and vivianite (Fig. 1, bottom) indicate that these minerals directly precipitate from saturated pore waters (Ostwald ripening). These mineral phases also entail a diagenetic sequence stemming from the progressive consumption of terminal electron acceptors with sediment organic matter remineralization during shallow burial. They can thereby act as biosignatures of redox processes and microbial control on pore water geochemistry after deposition. The combination of pore water geochemistry and XRF core-scanning profiles further show that authigenic phases act as discrete sinks for pore water solutes. To conclude, the identification of successive mineral phases, namely magnetite, millerite, siderite and vivianite, provides a means to trace microbial processes of early diagenesis in soft ferruginous sediments, identify their differential imprints on the sediment stratigraphy, and draw analogies to the ancient rock record.

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ICDP

Constraining magma storage and dynamics from complexly zoned crystal cargoes in the Kimana drill core: Snake River Plain volcanic province, USA

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The Snake River Plain (SRP) volcanic province, located in the western United States, is a prime example of a continental hotspot. It records 12 million years of bimodal volcanism, with early rhyolite caldera complexes covered by extensive younger basaltic flows. The ICDP Snake River Scientific Drilling Project completed three drill holes in the SRP, which combined offer an overview of the entire volcanic sequence. In this project, we focused on basaltic samples from the Kimana drill core to disentangle the interaction between basaltic magma reservoirs located in the crust. We examined entrained mush crystals in the basalts, in order to distinguish differentiation processes that took place in the crystal mush and constrain the magmatic plumbing system of the SRP basalts.

In recent years, the model of a magma chamber as a long-lived body of liquid, eruptible magma has been abandoned. Magmas are now assumed to spend most of their lifetime as a crystal mush, a non-eruptible reservoir of crystals with small fragments of liquid. Key differentiation processes such as magmatic recharge, magma mixing and fractional crystallisation take place in the crystal mush, and evidence of this is recorded in the composition of the growing crystals. Upon disruption of the crystal mush, the liquid can be mobilised, extracted from the mush and erupted at the surface. Small fragments of the crystal mush can be entrained with the extracted liquid. These crystals, found in volcanic rocks as enclaves or large clusters of crystals, can reveal details of the differentiation processes that took place in the crystal mush, the traces of which are not preserved in the liquid extracted from the mush.

The Kimana drill core samples 1912 m of continuous basalts, which were erupted over a time span of 6 million years and represent lavas from 78 separate monogenetic volcanic centers. It offers a unique opportunity to study an entire sequence of SRP basalts, of which only the upper part is exposed at the surface. The tholeiitic basalts contain mm-scale macrocrysts of plagioclase and olivine with zoning patterns too complex to have grown in situ, which are interpreted to be entrained mush fragments. The groundmass is crystalline and consists of plagioclase, olivine, pyroxene and oxides. Plagioclase macrocrysts often display different types of zoning in a single crystal, and are intergrown in large glomerocrysts. Plagioclase cores can be divided into three categories: (i) low-anorthite resorbed, (ii) patchy and (iii) sieved, and are the result of different stages of mush disaggregation and different rates of decompression. They are overgrown by oscillatory mantles with repeated resorption surfaces and narrow late-stage low-anorthite crystal rims. Anorthite contents of crystal cores and oscillatory mantles overlap (~An50-70), except for sieved cores which have slightly higher anorthite contents (~An55-75). Oscillatory rims do not display clear increases in minor elements (Fe, Mg) along resorption surfaces, indicating resorption events are due to convection or to episodic influx of heat rather than direct interaction with recharge magma. Sieved crystal cores have narrow oscillatory mantles and are not fused with other crystals as part of glomerocrysts, and are interpreted to have been brought into the magmatic system as part of a mafic recharge event at a late stage before eruption.

The complex plagioclase textures show evidence of several stages of mush disaggregation and remobilization of mush

crystals, due to episodic magmatic recharge and heat influx before eruption. They indicate a complex magmatic plumbing system under the Snake River Plain with different interconnected crystallization environments. Thermobarometric studies are in progress to further constrain the pressure and temperature conditions at which magma replenishment and mush disruption occurred in the system.

ICDP

Plagioclase-Orthopyroxene Symplectites in the Upper Zone of the Bushveld Complex: Evidence for Interstitial Silicate Liquid Immiscibility?

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Replacive symplectites in layered intrusions provide valuable insights into late-stage magma differentiation and interstitial liquid-primocrysts reactions. Using energy-dispersive X-Ray Fluorescence and microscope observations, we conducted a detailed investigation on three core sections from the Eastern Lobe of the Bushveld Complex (core BH7772) donated by Impala Patinum Ltd. On the second section (sample UZ248) including the smaller oxide layer 17 at 248 m with the surrounding gabbro-norite, plagioclase-orthopyroxene (±amphibole) symplectites are commonly observed, particularly at the contact boundary between magnetite and anorthosite layers. These symplectites occur between primocrysts of plagioclase and magnetite and replace primocryst plagioclase. Notably, the symplectites contain amphibole, both as rims surrounding the oxides and as vermicules within replaced plagioclase in the symplectite itself. Elemental mapping using Backscattered Electron Microscope reveals that the symplectite plagioclase exhibits significantly higher calcium enrichment and lower sodium content compared to the adjacent primocrysts while maintaining similar compositions for other elements. As for the symplectite orthopyroxene, its composition varies in a broader range than the composition of primocrysts. Similar symplectites were also reported in Skaergaard and Sept Iles intrusion, and previous studies have suggested that the plagioclase-orthopyroxene symplectites were formed through reactions between plagioclase primocrysts and Fe-rich interstitial immiscible melts (Holness et al., 2011; Keevil et al., 2020). Based on the mineral assemblage and overall composition trends of the observed symplectites in the Upper Zone of the Bushveld Complex, which resemble those reported in the Skaergaard and Sept Iles intrusion, we propose that during the late-stage of magma differentiation, the anorthosite crystal mush in the Upper Zone of the Bushveld Complex also underwent interstitial silicate liquid immiscibility. Consequently, the denser Fe-rich interstitial immiscible melts would sink to the contact boundary between magnetite and anorthosite layers, where they reacted with plagioclase primocrysts to form the observed plagioclase-orthopyroxene symplectites.

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ICDP

Seismic imaging of the Ivrea Zone and the Balmuccia peridotite (Project SEIZE)

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The Ivrea-Verbano Zone is one of the most complete crust-mantle sections on Earth (e.g. Pistone et al., 2017). Various geophysical studies indicate the presence of the Ivrea geophysical body, which is characterized by high-velocity and high-density anomalies and which might extends from the Moho to the shallow sub-surface (e.g. Diehl et al. 2009, Scarponi et al. 2021, Liu et al. 2021). However, it is still unclear if the Ivrea geophysical body is connected to isolated mantle peridotite bodies which are exposed in the Ivrea-Verbano Zone.
With project SEIZE (SEismic imaging of the Ivrea ZonE), we aim at exploring the shallow sub-surface in the Val Sesia area (Italy) to obtain a structural image (depth, extent and shape) of the outcropping Balmuccia peridotite body, characterize its properties and investigate its relation to the Ivrea geophysical body. A controlled-source seismic experiment that comprised two crossing profiles of ~27 km length was conducted in the region around Balmuccia. By using a fix-spread setup with 110 receivers (~250 m spacing) and a roll-along setup with 330 receivers (~20 m spacing) 432 vibro points (~60 m spacing) were acquired.

Several seismic techniques are utilized to derive a structural image of the Balmuccia peridotite and its surroundings: Reflection seismic processing is applied to the roll-along data set. Seismic acquisition took place in difficult terrain settings (large altitude differences, deep mountain valleys with sedimentary filling) causing complex wave propagation. Since that is challenging for conventional seismic reflection processing, pre-stack migration techniques are applied. The occurance of strong shear waves enables additional Vp/Vs ratio analyses. To recover the 3D velocity structure down to 3 km depth, a Markov chain Monte Carlo travel time tomography is performed using first break picks of the fix-spread data set (Ryberg et al. 2023). The resulting 3D P-wave model shows a high-velocity body (Vp > 6 km/s) that broadens downwards and reaches the surface East of Balmuccia. Its outcrop coincides with the exposed Balmuccia peridotite (Ryberg et al. 2023). A sharp velocity change marks the boundary of the high-Vp body in the West correlating with the location of the Insubric Zone (ISZ), the Europe–Adria plate boundary. Considering rock physics and gravity data (Pistone et al. 2020, Scarponi et al. 2021), this high-Vp body is interpreted as mantle material (peridotite). The seismically imaged peridotite (Ryberg et al. 2023) has a larger extend than interpreted from previous geological cross-sections (Quick et al. 2002) and requires a revision of previous models.

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IODP

IODP Expedition 382 – Pliocene-Pleistocene ice-ocean-atmosphere dynamics in Iceberg Alley

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Several decades of research on the paleoceanography and paleoclimatology of the Scotia Sea using short cores and remote-sensing data have revealed a wealth of information on Late-Pleistocene ice sheet-ocean-climate interactions. However, the understanding the evolution of these interactions and their sensitivity to different boundary conditions over longer timescales is lacking. International Ocean Discovery Program (IODP) Expedition 382 (Iceberg Alley) recovered time series on Antarctic Ice Sheet (AIS) variability as well as ocean and atmospheric circulation in the southern and central Scotia Sea, covering the last 4 Ma continuously.

We deliver the first spatially integrated record of variability in Antarctic icebergs flux, which accounts for about half of the total AIS mass loss. Our study focusses on Iceberg Alley, the major gateway where Antarctic icebergs route to and melt down once they come into contact with the warmer Antarctic Circumpolar Current (ACC), releasing iceberg-rafted debris (IBRD) into the underlying deep-ocean sediment. We also study proxies for ocean productivity (opal contents, color reflectance b*, Si/Al and Si/Ti ratios) and dust deposition (magnetic susceptibility, Fe and Ca fluxes) to provide key insights into how iron fertilization and oceanic productivity developed through Pleistocene ice ages and their role in influencing the carbon cycle. In particular, we analyze potential tipping points of climate: the mid-Pliocene warm interval, the Mid-Pleistocene Transition, warm interglacials of the last 0.6 Ma, and glacial terminations.

For the last 1.5 Ma, we found a strong coupling of atmosphere-ocean processes. In the Antarctic Zone, dust deposition was ≥10-fold increased during glacials and ocean productivity was ≤5-fold increased during interglacials, indicative of enhanced upwelling during warm times. This antiphasing persisted throughout the last 25 glacial cycles (Weber et al., 2022), opposite to the Subantarctic Zone, where both productivity and dust deposition were elevated during glacials, implying active CO_2 drawdown from the atmosphere during cold times (Martínez-Garcia et al, 2011). In the Antarctic Zone, however, glacials experienced extended sea-ice cover, a more stratified surface ocean and reduced bottom-water export, which diminished air-sea gas exchange and helped lower atmospheric CO_2 levels during cold periods.

Previous studies on short cores have revealed that IBRD deposition in Iceberg Alley increased substantially during glacial terminations (Weber et al., 2014), indicative of AIS instability, and driven by ocean thermal forcing and interhemispheric sea-level variability (Gomez et al., 2020). This is also the case for previous glacial terminations. Peak warm times, however, imply relative AIS stability. Increased AIS mass loss is again indicated for glacial inceptions, whereas glacials are mostly relatively stable. The strong coupling of ice-sheet and sea-level changes observed on orbital time scales for the Late Pleistocene, however, only occurred since ~0.9 Ma.

Our combined data-model analysis of the past 4 Ma shows that prior to 1.5 Ma, ocean and atmosphere processes in high southern latitudes were not coupled to the global climate system. This also implies that CO_2 variations were minor during that period. Around 1.5 Ma, the response to obliquity forcing becomes stronger, indicative of the begin of synchronization between Southern Hemisphere and global climate. These ocean-atmosphere couplings became stronger during the Mid-Pleistocene Transition and include, since 0.9 Ma, synchronization of AIS variability. The couplings were specifically strong, with high-amplitude variations, since the Mid-Brunhes Event at ~0.4 Ma.

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IODP

Synchronising Equatorial Pacific and Atlantic Miocene Climate Evolution

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During the Miocene, the period in Earth's history from 5.33 to 23.03 million years ago, the modern ocean thermohaline circulation evolved accompanied by fundamental changes in global ocean chemistry and continental climate. Drastic and repeated reductions of calcium carbonate contents characterize pelagic sediment sequences in the equatorial Pacific and equatorial Atlantic at that time. Atmospheric CO_2 was similar to today. Temporarily, during the Miocene Climate Optimum (13.9 to 17 Ma), CO_2 levels were even as high as predicted for the year 2100 if greenhouse gas emissions will not be reduced. Despite numerous studies the exact sequence of events in the Miocene between equatorial Pacific and equatorial Atlantic as well as their causal relationship is poorly understood. Reason for this dilemma is the lack of a synchronized highly accurate astronomical age models for both regions.

The DFG IODP SPP project *Comparing changes in regional response to orbital forcing in the Equatorial Pacific and Atlantic during the Miocene* is designed to drastically improve this unfortunate situation by generating an astronomically calibrated high-resolution deep-sea benthic isotope reference curve for the equatorial Atlantic by intensively studying sediments retrieved from Ceara Rise during Ocean Drilling Program (ODP) Leg 154 spanning the 5 to 23 Ma interval. Benthic stable isotope records from the equatorial Pacific (IODP Exp. 320/321), supplemented by new data, will be synchronized with the anticipated Ceara Rise equatorial Atlantic benthic reference curve for the entire Miocene. These records in combination with new XRF core scanning data hold the potential of an unprecedented detailed view on changes in carbonate accumulation between equatorial Pacific and equatorial Atlantic in relation to the evolving modern ocean circulation pattern. In particular, with these new project data we will be able to investigate if drastic changes in carbonate accumulation both in the Pacific and the Atlantic Oceans are synchronous, decipher any kind of lead – lag relationships, decode the orbital cyclicity pattern and frequencies, potential connections between both regions, and exploring if CCD variations on Milankovitch time scales are in- or anti-phased between the equatorial Pacific and Atlantic. The latest results from new X-ray fluorescence core scanning and benthic stable isotope data will be presented and discussed.

IODP

The redox state of basalts from mid-oceanic-ridges, oceanic islands oceanic plateaus and island arcs revealed from ferric-ferrous ratio in natural glasses determined by electron microprobe

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The determination of the redox state of the mantle is a challenging task and often derived from glasses collected in the oceanic crust, since they are considered to freeze the Fe^{3+}/Fe^{2+} ratio of mid oceanic ridge basalts (MORB) generated in the mantle. Variations in the $Fe^{3+}/\sum Fe$ strongly affect the inference of potential temperature annd extent of melting in the sub-ridge mantle as well as petrological formation models of erupted basalts and of the complementary cumulate lower oceanic crust (Asimow, 2021).

Many studies have been conducted to determine $Fe^{3+}/\sum Fe$ in MORB magmas with a general agreement that glasses equilibrated around QFM, but the mean values proposed in the literature are ranging from 0.07±0.02 up to 0.16±0.01.
Although these varations may appear to be low, they have important implications on the prevailing redox state of the mantle. In particular, this variation range in $Fe^{3+}/\sum Fe$ precludes a complete understanding of fO_2 as a function of tectonic setting and there is a general agreement that further investigations of primitive melts (e.g. pillow glasses) from diverse tectonic environments are needed.

Available methods for local scale determination of $Fe^{3+}/\sum Fe$ include micro-Raman spectroscopy, micro Mössbauer spectroscopy, µ-XANES or Synchrotron based Mössbauer Spectroscopy. These methods can provide high accuracy and precision but have certain disadvantages (e.g. price, beam damage, signal decomposition). The determination of the $Fe^{3+}/\sum Fe$ with the EPMA Flank method could allow us to perform routine measurements with high spatial resolution at low cost, but its current precision described in literature and its need for calibration standards have hampered the wide use of that technology.

New conditions were tested utilizing different accelerating voltages and the different parameters available for the beam scan option implemented in the JEOL-EPMA software on a JEOL-JXA-iHP200F microprobe. With the newly developed TAPL crystal, the acquired intensity is three times higher compared to the normal TAP crystal. We present new data for reference materials with refined conditions for the flank method to demonstrate its improvement in accuracy and precision. During the progress of this project, this method will be applied to measure naturally quenched basaltic glasses collected by IODP in key localities typical of different geodynamic environments, such as mid oceanic ridge, oceanic island, oceanic plateaus and islanc arcs to clarify the controversy on the oxidation state of the mantle and check for differences between the different geotectonic environments.

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ICDP

How wet is wet? Using strontium isotope ratios to quantify wet intervals in the 115,000-year Chew Bahir Lake record, East Africa

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The role that climate and environmental history may have played in influencing human evolution has been controversially discussed among paleoanthropologists for decades (e.g., Trauth et al., 2005; Potts, 2013; Mounier & Lahr, 2019). Inspired by these discussions, the Hominin Sites Paleolakes Drilling Project (HSPDP) conducted five deep drilling campaigns adjacent to key hominin fossil sites in Eastern Africa (Cohen et al., 2016) (Fig. 1A). The Chew Bahir Basin in Southern Ethiopia is one of these sites, near to the oldest site of finds of Homo sapiens in Eastern Africa and neighboring basin of Lake Turkana which is rich in even older hominin fossils. Analysis of the ICDP-Chew Bahir drill core CHB14 reveals that over the past 620 ka phases of environmental stability and instability occured contemporaneously with milestones in human history, including pulsed dispersal events out of Africa coinciding with potential

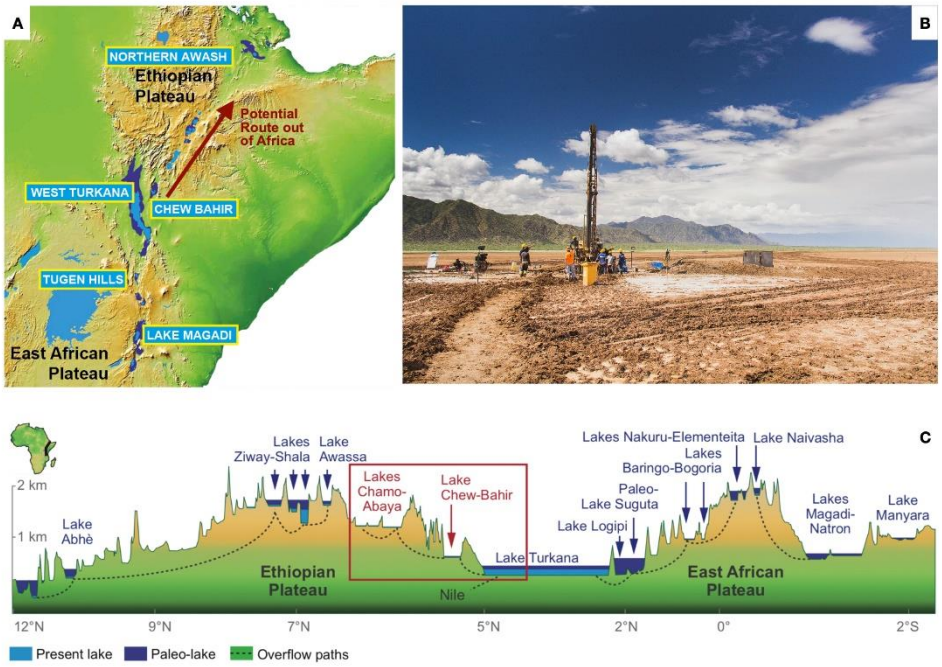

Figure 1. Study region Chew Bahir basin within the East African Rift System (EARS). (A) EARS with ICDP-HSPDP drill sites and lakes with current (light blue) and paleo-lake levels (dark blue) during pluvials such as the late Pleistocene-early Holocene African Humid Period (AHP). (B) Picture of the ICDP Drill Site of CHB14. (C) North-South cross section thought the EARS showing the cascade-like connections of lake basins during the AHP. (Map modified after Junginger and Trauth, 2014).

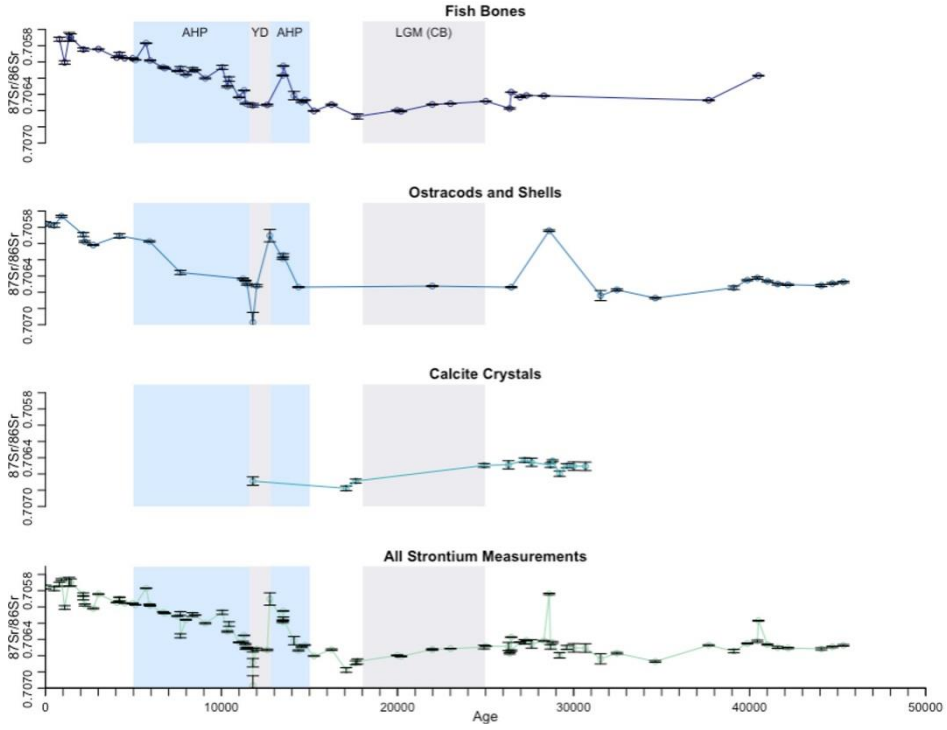

Figure 2. First results of $^{87}Sr/^{86}Sr$ ratio measurements of fish bones (FB), ostracods and shells (MBS), calcite crystals (CC) and combined plot, measured with a Thermion mass spectrometry. Error is 1 SD.

humid periods (pluvials) (Foerster et al., 2022; Roberts et al., 2021; Schaebitz et al., 2021; Trauth et al., 2021). Although proxies in Chew Bahir sediments have been intensely tested for their reliability we still lack quantitative information on water availability and an understanding of the driving and competing mechanisms.

The overall aims of this project are therefore to provide a 620-ka record of hydrological changes in the South-Ethiopian Rift by applying a multi-isotope study ($^{87}Sr/^{86}Sr$, $\delta^{18}O$, $\delta^{13}C$) on microfossils extracted from the CHB14 cores. Here we present the first results from the multi-isotope study covering the past 115 ka in the Chew Bahir basin. $^{87}Sr/^{86}Sr$ are used to reconstruct connectivity (today not the case) of S-Ethiopian lakes Abaya, Chamo and Chew Bahir (Fig. 1B,C) (Junginger & Trauth, 2013). Connected lake basins reflect +25-40% precipitation (Fischer et al., 2020; 2021) and present several connected large freshwater bodies along the route out of Africa. $\delta^{18}O$ and $\delta^{13}C$ provide additional information on the evaporative and open/closed status of Chew Bahir paleo-lake.

The outcome of this project will provide the longest (nearly) continuous record of water availability in the S-Ethiopian Rift and shed light on the impact and interference of orbital parameters and glacial-interglacial cycles as well as short-term influences on it region's water budget. The results will help to refine hypotheses on hominin dispersals which presently suggest that wetter environmental conditions facilitated long-range human expansion (Schäbitz et al., 2021; Foerster et al., 2022).

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ICDP

Comparing lacustrine sedimentation rates and their response to climatic and environmental change

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Continuous limnic archives may record millions of years of climatic and environmental change at their locality. Typically, such archives reflect environmental conditions in the lakes' catchments, but also the imprint of large-scale atmospheric systems e.g. related to insolation and/or global ice-sheet dynamics. These parameters may vary considerably in space and time, and our understanding on patterns across continents that relate to this forcing is still incomplete. Comparing sedimentation rates from limnic archives covering fundamental changes in the Earth's system like the Mid-Pleistocene transition (change from 41 kyr to 100 kyr cycle world) has potential to shed light into spatial differences in Earth's climate response, if applied carefully.

To better understand the sedimentation history of lakes, and especially their reaction to climate transitions, we compare sedimentation rates from lakes. In a second step, we systematically align several records to facilitate best comparability. We focus on limnic records that have been investigated during ICDP projects, and specifically assess the influence of the Mid-Pleistocene transition and the Mid-Brunhes transition on sedimentation rates.

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Hydraulic and strength characteristics of the DFDP-1 drilling samples, Alpine Fault, New Zealand

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The Alpine Fault in New Zealand is a major plate boundary fault between the Australia and Pacific plates and is late in its 200–400 yr seismic cycle (Sutherland et al., 2007). In order to investigate its hydraulic and strength characteristics, we used drilling core samples from the Deep Fault Drilling Project 1 (DFDP-1) borehole to conduct permeability and direct shear tests. Five samples were selected, including one fault gouge, three foliated cataclasites and one unfoliated cataclasite. Initially, each sample was carefully trimmed to a cylinder with a diameter of 2.54 cm and a height of ~2 cm, room-dried, and subjected to shear testing at 1 µm/s with no applied normal stress to measure its dry intact cohesion. Subsequently, the sample was rehydrated using a permeameter, and a permeability test was performed under quasi in-situ pressure conditions of the borehole. The sample was then placed in a shear sample cell and flooded with de-ionized water to determine the wet intact cohesion. After completion of the cohesion test, the sample was reset to its original position and loaded to in-situ vertical effective stress, following which velocity step friction experiments were conducted at velocities ranging from 0.1 µm/s to 30 µm/s. Finally, the sliding cohesion was tested by removing the normal stress and continuing to shear the samples at 1 µm/s. Our data indicate that the fault gouge sample exhibits high dry intact cohesion (~800 kPa), moderately low permeability (~1×10^{-18} m^2)

and velocity-weakening frictional behavior (a-b < -0.002). Previous studies have suggested that cohesive strength could be present not only before failure but also throughout the shearing process (Ikari and Kopf, 2011). In this study, we interpret the measured sliding cohesion as the cohesive strength during sliding slip. For the fault gouge sample, the sliding cohesion is only ~100 kPa, implying a significant loss of cohesion when forced to slide, which can contribute to stress drop and facilitate earthquake propagation. Together with the observed velocity-weakening frictional behavior, our data could explain how the fault gouge layer could allow surface-breaking earthquake slip. However, it is important to note that our interpretation is based on the assumption that the high dry intact cohesion reflects in-situ cementation or clay formation resulting from fluid-rock interactions near the principal slip zone (PSZ). To address the possibility of post-coring cementation, additional experiments will be conducted on powder samples. Ongoing experiments will further quantify the hydraulic and strength characteristics of the DFDP-1 cataclasite samples and may provide insights into how the shallow Alpine Fault may host earthquake slip.

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