frontiers | Frontiers in Earth Science

EDITORIAL
published: 29 April 2022
doi: 10.3389/feart.2022.892664

Editorial: Integrating Paleoclimate, Stratigraphy, Sedimentology, and Paleontology in Human Evolution and Dispersal Studies—from Early Hominins to the Holocene

Verena Foerster[1]*, *Christian Zeeden*[2] and *Annett Junginger*[3,4]

[1]Institute of Geography Education, University of Cologne, Cologne, Germany, [2]Leibniz Institute for Applied Geophysics (LIAG), Hannover, Germany, [3]Department of Geoscience, Eberhard Karls University Tübingen, Tübingen, Germany, [4]Senckenberg Centre for Human Evolution and Palaeoenvironment, Tübingen, Germany

Keywords: paleoclimate, paleoecology, paleontology, human evolution, dispersal of *Homo sapiens*

Editorial on the Research Topic

Integrating Paleoclimate, Stratigraphy, Sedimentology, and Paleontology in Human Evolution and Dispersal Studies—from Early Hominins to the Holocene

In the last decade, both timeframe and regional understanding of human evolution and dispersal has been under profound revision due to a number of new fossil and artifact finds, new advances in dating techniques, fast growing genetic data availability, and comprehensive new insights into paleoenvironmental dynamics (Hublin et al., 2017; Stringer and Galway-Witham, 2017; Hershkovitz et al., 2018; Bergström et al., 2021). Long-established hypotheses on how climate change and human origins are interrelated have been challenged by those advances and force the community to spatio-temporally rethink human-climate concepts in a broader context (Scerri et al., 2018; Galway-Witham et al., 2019; Mounier and Lahr, 2019; Bergström et al., 2021). In order to evaluate the impact that different timescales and magnitudes of climatic shifts might have had on the living conditions of prehistoric humans, we need reliable and continuous reconstructions of paleoenvironmental conditions and fluctuations from the vicinity of paleoanthropological and archaeological sites (Cohen et al., 2016; Campisano et al., 2017; Litt et al., 2021; Cohen et al., 2022).

As a contribution towards a better understanding of these human-climate interactions across time and space, the main objective of this research topic (RT) was to showcase interdisciplinary work in (geo)archaeology, paleoecology, paleoclimate, stratigraphy, and paleoenvironmental reconstructions. New methods for dealing with challenging archive conditions and dating issues are constantly discussed in the community. Integrating those results across disciplines may contribute to providing an improved framework of external threshold conditions that may have been important in limiting but also facilitating population dynamics.

Twenty-one papers were published after peer reviews, comprising seventeen Original Research articles, one Brief Research Report, one Method paper and two Reviews. The contributions presented within the first part of this RT cover sites across Africa, as the region of modern human origins, the Nile Valley and the Levante, representing one of the major trajectories in human dispersal studies as well as paleoenvironmental research. A second focus of this issue is Eurasian climate dynamics during the last glacial cycle as relevant boundary conditions for early modern human occupation (or the lack thereof).

Edited and reviewed by:
Steven L. Forman,
Baylor University, United States

***Correspondence:**
Verena Foerster
V.Foerster@uni-koeln.de

Specialty section:
This article was submitted to Quaternary Science, Geomorphology and Paleoenvironment, a section of the journal Frontiers in Earth Science

Received: *09 March 2022*
Accepted: *06 April 2022*
Published: *29 April 2022*

Citation:
Foerster V, Zeeden C and Junginger A (2022) Editorial: Integrating Paleoclimate, Stratigraphy, Sedimentology, and Paleontology in Human Evolution and Dispersal Studies—from Early Hominins to the Holocene. Front. Earth Sci. 10:892664. doi: 10.3389/feart.2022.892664

HUMAN-CLIMATE INTERACTIONS ACROSS TIME AND SPACE: AFRICA

The first group of contributions focusses on human-climate interactions in Africa, highlighting studies from several key regions associated with milestones in human evolution across time.

Reporting from the Middle and Later Stone Age site of the Umhlatuzana rockshelter, South Africa, Reidsma et al. present a grid-based, multi-proxy geoarchaeological study that illustrates the relationship between environmental change and occupation intensity.

Highlighting a cluster of research activities from eastern Africa, Yost et al. present a phytolith and microcharcoal based record from the Turkana Basin WTK13 drill core in Kenya. A millennial-scale resolution from one of the proven habitats of *Homo ergaster/erectus* revealed cyclic (21-ka) changes in precipitation, fire activity and grass community composition between 1.87 and 1.38 Ma. Phytoliths indicate that Nariokotome Boy walked across a landscape that was seasonally wet, densely vegetated, and dominated by short stature grasses, sedges, and other herbaceous plants. Those tectonic landscapes are characterized by highly variable soil properties creating potentially attractive habitats for animals and humans. The study by Kübler et al. reveals strong correlations between the geotectonic setting and long-term soil nutrient status in the southern Kenya Rift. Importantly, known hominin sites in the region are located either along corridors of long-term Calcium availability or at short-term nutrient hotspots potentially related to active CO_2 degassing along active fault zones. Results imply a strategic advantage of nutrient-rich regions for hominin subsistence strategies, such as provision of predictable constraints on the distribution and mobility of grazing animals in complex tectonic settings.

Presenting first results from an advanced hyperspectral bidirectional analysis on discrete samples from the 620-ka Chew Bahir record in southern Ethiopia, Arnold et al. contribute to an advanced and refined proxy understanding by applying an innovative and minimally invasive method. Specific absorption bands have been found to be diagnostic for the occurrence of clay minerals, analcime and calcite, with analcime pointing at arid to hyper arid intervals. The hyper spectral based findings enable the authors to test proxy formation and weathering models on the one hand and allow for new capacities for climate-relevant studies in the future on the other hand. With the application of cross-species hybridization capture to lacustrine sediment samples from the Chew Bahir record, Krueger et al. were able to determine biological taxa from sedimentary ancient DNA (sedaDNA) traces. The frontier in sedaDNA research could be extended by this contribution as recovering sedaDNA fragments from especially tropical archives had proven to be challenging due to typically highly degraded DNA. In this contribution, different taxonomic groups as far back as ~150 ka BP, give direct insights into changes in the specific biodiversity during major eastern African climate shifts at Chew Bahir.

As an alternative age-model approach and to significantly increase the accuracy of tuned age models, Duesing et al. test a new wavelet-based multiband agemodeling technique (MUBAWA) on a synthetic data set and the Chew Bahir composite core. Unlike in traditional tuning approaches, the authors use here the application of an adaptive bandpass filter that is able to address the problem of continuous sedimentation rate changes, which naturally occur during lacustrine sedimentation. Based on modern surface samples within the Chew Bahir Basin, Gebregiorgis et al., provide information on modern sedimentation processes and authigenic mineral formation in the basin and catchment. This is an important pre-requisite for the understanding of chemical proxy formation through time and therewith ultimately contributes to an improved paleoclimate proxy interpretation. Using whole-rock and authigenic clay geochemistry and geochemical modeling to understand the hydrogeochemical processes in the paleo-lake and saline brines, the authors find modern analogues to Late Quaternary sediments that were deposited during known past humid or arid intervals.

The timing and nature of the insolation controlled but spatially complex African Humid Period (AHP) (~15–5 ka) (e.g., Shanahan et al., 2015) has been an intensely debated topic and several contributions can report new data on this crucial time interval.

Fischer et al. have addressed the void of the unknown pace and magnitude of past moisture fluctuations in southern Ethiopia during the last 20,000 years by applying a new lake balance modeling approach. They combine a Hydro-balance model with a Surface Energy Balance Algorithm (SEBAL) for the last orbital driven dry-wet-dry cycle of the AHP. Therewith Fischer et al. contribute new information on the nature, pace and magnitude of pronounced hydroclimatic shifts and can moreover provide a first regional order-of-magnitude range for hydroclimatic changes on much longer time scales. A geoarchaeological study by Hensel et al. at Sodicho Rockshelter in the southwestern Ethiopian Highlands dates back to ~27 ka BP and provides evidence from sedimentological and geochemical analyses for high altitude settlements by hunter-gatherers during the Late Pleistocene and Holocene, including the arid Last Glacial Maximum (~21 ± 2 ka). The occupation phases were interrupted due to past environmental changes including the AHP and Holocene volcanic activities. The results partially reduce a chronostratigraphic gap corresponding to MIS2, which is common in the Horn of Africa. Jaeschke et al. provide new insights into the 12,500-years moisture history of the Ethiopian Highlands, preserved in Lake Dendi sediments. A combination of plant-wax δD and δ13C values alongside with palynological data showcases the sensitive vegetational response of the high mountain area to shifting monsoonal regimes of moisture influx and therewith contributes new insights into the much debated termination of the AHP.

Much further to the N-West, a set of mid- to late Holocene isotope-based reconstructions on bivalve shells and fish otoliths from Banc d'Arguin, a paleo-estuary in the coastal zone of Mauritania, also addresses the AHP. Based on δ18O records

and Sr isotope ratios, the contribution by Höpker et al. present evidence for a rather gradual aridification pattern at the end of the AHP.

DISPERSAL OUT-OF-AFRICA AND BEYOND

The timeframe of the worldwide expansion of modern humans as the latest major dispersal event out-of-Africa is generally agreed to have occurred after ~50–60 ka BP as genetic data suggests (e.g., Galway-Witham et al., 2019; Bergström et al., 2021). The expansion along the Nile Valley and into the Levante represents one of the major dispersal routes of modern humans but also earlier human and hominin migration waves (Schultz and Maslin, 2013; Stringer and Galway-Witham, 2017; Litt et al., 2021). The integration of paleoenvironmental records, findings from paleoanthropological archaeological sites and a robust chronology play an important role to an enhanced understanding of human-climate interactions in human dispersal studies (Litt et al., 2021).

Integrating a variety of studies from geology, paleoenvironmental, anthropological, genetic, and archaeological research results, Leplongeon gives an interdisciplinary overview about the role that the Nile valley could have played as an environmental refuge area and/or a natural pathway and corridor facilitating dispersal post "Out-of-Africa" at the end of the Pleistocene between 28,000 and 15,000 years ago. Recent genetic data highlighted complex population dynamics in northern Africa, including "back-into-Africa" dispersals, but the role of the main Nile Valley in these population dynamics remains unclear. Excavations at the site MAR-1 (S-Greece) revealed evidence of hominin presence ~444 ka ago (~MIS12) and Bludau et al. present a first multi-proxy paleoenvironmental reconstruction from this new paleoanthropological key site. The results suggest the site to be a protected region surrounded by high mountains and under the constant influence of water, thus representing potentially ideal refugium conditions for hominins.

A suite of contributions discusses the paleoenvironmental context of early humans, and their possible habitats in Eurasia. This includes several studies on loess-paleosol sequences as well as several contributions which have both a methodological, provenance and a paleoenvironmental focus. Most contributions from Eurasia study loess-paleosol sequences in the Danube catchment, but two papers also explore the Rhine valley in Germany, and the north-western part of the Indian subcontinent.

While for Asia a suite of high-resolution multi-proxy datasets exist from loess, such studies are yet missing or sparse in Europe. Laag et al., provide a multi-proxy ~430 ka dataset from a loess-paleosol sequence in the Middle Danube Basin. Their study combines rock magnetism and colorimetry in a novel way, and demonstrates the added value of combing color and rock magnetic information. Advanced rock-magnetic experiments enabled to identify and characterize preserved (crypto-) tephra layers which provide great potential for gaining absolute age control in loess deposits when traditional radiometric dating methods reach their dating limits. Pötter et al. provide an impressive amount of both grain size and geochemical data from the Lower Danube Basin. Regarding the provenance, the authors find a close relation to loess in the Middle Danube Basin, as well as a transitional (not sharp) north/south separation of the Lower Danube loess.

Fitzsimmons et al. argue for a more holistic integration of paleoenvironmental and archaeological datasets, even in cases where archaeological evidence may be not be particularly rich or diagnostic. Authors make their point using two Paleolithic open-air "off-sites" from Romania, where a combination of sedimentological and pedological description and luminescence dating facilitates the placement of the archaeological finds in the wider paleoenvironmental and archaeological context.

Loess palaeosol sequences provide important evidence about the climate when anatomically modern humans colonized Europe. However, one of the main obstacles for the interpretation of climatic and environmental information preserved in these sedimentary archives is the uncertainty of the age-depth relationship. In order to create a robust age model with reduced uncertainty, Scheidt et al. performed a comparative study of different dating methods on a loess-palaeosol sequence near Lake Balta Alba in Romania and conclude that ages should be obtained using at least two independent, complementary dating methods. Nett et al. investigated the sedimentological and archaeological context and content of the archaeological Site Crveka-At in the Middle Danube Basin. The complex and challenging-to-interpret grain size distributions imply archaeological site formation in contrasting depositional environments typical for fluvial channels, lakeshores, and alluvial fan or delta settings. The study confirms that the Crvenka-At locality is an Aurignacian site with multiple-occupations, dated to 36.4 ± 2.8 ka. Staying in the Danube, Zeeden and Hambach provide data of magnetic susceptibility properties and especially the Anisotropy of the magnetic susceptibility from the famous archaeological site Willendorf (Austria). They investigate the site formation of the Willendorf archaeological site using mainly the anisotropy of the magnetic susceptibility.

The inorganic and organic carbon stable isotope signatures of the Remagen-Schwalbenberg Loess-Paleosol-Sequence in the Rhine valley are investigated by Vinnepand et al. Assessing both carbon pools facilitates insights into the carbonate metabolism and hence, sedimentary and pedogenic processes throughout the Upper Pleistocene at the site. The organic carbon stable isotope signature is regarded as a mixed signal influenced by sediment moisture regimes, decomposition, and stabilization that may be decoded in future contributions.

Finally, Dar and Zeeden review the current state of paleoenvironmental research and information derived from loess in Kashmir. While multiple studies have been carried out on the loess-paleosol sequences, high-resolution physical property data were yet sparse or missing. Yet, an integral picture of the Kashmir loess-pleosol sequences is missing,

while the potential of understanding Indian Monsoon dynamics better is enhanced.

This Research Topic summarizes recognizable progress that has been achieved in broadening methodological perspectives, connecting focus areas and thinking outside the box highlighting the integration of interdisciplinary research in human evolution and dispersal studies.

AUTHOR CONTRIBUTIONS

All three authors equally contributed to this Research Topic and wrote the Editorial, with VF and AJ focussing on the research activities in Africa and CZ highlighting the contributions in Eurasia and Europe. All authors have approved the Editorial for publication.

REFERENCES

Bergström, A., Stringer, C., Hajdinjak, M., Scerri, E. M. L., and Skoglund, P. (2021). Origins of Modern Human Ancestry. *Nature* 590, 229–237. doi:10.1038/s41586-021-03244-5

Campisano, C. J., Cohen, A. S., Arrowsmith, J. R., Asrat, A., Behrensmeyer, A. K., Brown, E. T., et al. (2017). The Hominin Sites and Paleolakes Drilling Project: High-Resolution Paleoclimate Records from the East African Rift System and Their Implications for Understanding the Environmental Context of Hominin Evolution. *PaleoAnthropology*, 1–43. doi:10.1130/abs/2017am-295426

Cohen, A., Campisano, C., Arrowsmith, R., Asrat, A., Behrensmeyer, A. K., Deino, A., et al. (2016). The Hominin Sites and Paleolakes Drilling Project: Inferring the Environmental Context of Human Evolution from Eastern African Rift lake Deposits. *Sci. Dril.* 21, 1–16. doi:10.5194/sd-21-1-2016

Cohen, A. S., Campisano, C. J., Arrowsmith, J. R., Asrat, A., Beck, C. C., Behrensmeyer, A. K., et al. (2022). Reconstructing the Environmental Context of Human Origins in Eastern Africa through Scientific Drilling. *Annu. Rev. Earth Planet. Sci.* 50, 451–476. doi:10.1146/annurev-earth-031920-081947

Galway-Witham, J., Cole, J., and Stringer, C. (2019). Aspects of Human Physical and Behavioural Evolution during the Last 1 Million Years. *J. Quat. Sci.* 34 (6), 355–378. doi:10.1002/jqs.3137

Hershkovitz, I., Weber, G. W., Quam, R., Duval, M., Grün, R., Kinsley, L., et al. (2018). The Earliest Modern Humans outside Africa. *Science* 359 (6374), 456–459. doi:10.1126/science.aap8369

Hublin, J.-J., Ben-Ncer, A., Bailey, S. E., Freidline, S. E., Neubauer, S., Skinner, M. M., et al. (2017). New Fossils from Jebel Irhoud, Morocco and the Pan-African Origin of *Homo sapiens*. *Nature* 546 (7657), 289–292. doi:10.1038/nature22336

Litt, T., Richter, J., and Schäbitz, F. (2021). *The Journey of Modern Humans from Africa to Europe. Culture-Environmental Interaction and Mobility*. Stuttgart: Schweizerbart Science Publishers.

Mounier, A., and Lahr, M. M. (2019). Deciphering African Late Middle Pleistocene Hominin Diversity and the Origin of Our Species. *Nat. Commun.* 10 (1), 3406–3413. doi:10.1038/s41467-019-11213-w

Scerri, E. M. L., Thomas, M. G., Manica, A., Gunz, P., Stock, J. T., Stringer, C., et al. (2018). Did Our Species Evolve in Subdivided Populations across Africa, and Why Does it Matter? *Trends Ecology Evolution* 33 (8), 582–594. doi:10.1016/j.tree.2018.05.005

Shanahan, T. M., McKay, N. P., Hughen, K. A., Overpeck, J. T., Otto-Bliesner, B., Heil, C. W., et al. (2015). The Time-Transgressive Termination of the African Humid Period. *Nat. Geosci* 8 (2), 140–144. doi:10.1038/ngeo2329

Shultz, S., and Maslin, M. (2013). Early Human Speciation, Brain Expansion and Dispersal Influenced by African Climate Pulses. *PLoS One* 8 (10), e76750. doi:10.1371/journal.pone.0076750

Stringer, C., and Galway-Witham, J. (2017). On the Origin of Our Species. *Nature* 546 (7657), 212–214. doi:10.1038/546212a

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.