newsletter 22 | 2023

The Role of Culture in Early Expansions of Humans (ROCEEH)

View from Holley Shelter, KwaZulu-Natal, South Africa into the Hlambamasoka gorge. Photo: G. Bader.

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THE ROLE OF CULTURE IN EARLY EXPANSIONS OF HUMANS

Editorial

In this 22nd newsletter we report on the entry of Chinese sites into the ROAD database. Next, we provide new insight into ROCEEH's ongoing work at excavations in South Africa's KwaZulu-Natal province. Finally, the research center also considers how machine learning can be used to design climate models that help explain prehistoric climatic conditions.

ROAD expands into the Far East

Some regions with rich evidence about the biological and cultural aspects of human evolution are well known to a wider public. Hotspots of Paleolithic research in South and East Africa, the Levant, and large parts of Europe shape the general perception of the deep history of our genus *Homo*. For decades, Asia's Far East played only a minor role due to political issues, research history, and even language barriers. Nonetheless, during the late 1920s and 1930s, China was a focus of the budding field of paleoanthropology with the discovery of the Zhoukoudian complex in a limestone hill near Beijing. Especially Zhoukoudian Locality 1 with its impressive Middle Pleistocene stratigraphy yielded numerous fossils of *Homo erectus pekinensis* alongside faunal remains. The rich assemblage of human cranial and postcranial bones increased markedly the geographic range of human fossils in Asia and helped to establish *Homo erectus* as a valid taxon. The site also played an important role for the possible evidence of early use of fire, which is still hotly debated today. Additionally, the coarse lithic artifacts from Zhoukoudian shaped the perception of the Chinese Paleolithic for a long time.

In the 1940s, Hallam Movius noted that advanced bifacial technology preceded Levallois technology in Africa as well as the western and southern parts of Europe, up to India. He contrasted this with the simpler core and flake tool technologies observed in East and Southeast Asia. In Movius' view, human evolution in China appeared to be isolated, and the development of cultural competences seemed delayed. However, since the end of the 20th century, an increase in finds, as well as technological and scientific analyses, and their publication in international journals, has led to a slow erosion of the so-called "Movius line". The discovery of more than 100 sites in Bose Basin in the Guangxi Zhuang Autonomous Region of South China (e.g. Nalai site, Gaolingpo) with large, unifacially or bifacially worked cutting tools suggested Acheulean-like advancements in the Chinese Early Paleolithic. Debates started about their dating to about 800,000 years ago based on tektites from a meteor impact, as well as their typo-technological nature. Archaeological evidence in the Nihewan Basin spanning from more than 1.5 million

▶ Figure 1. The Xiahe mandible is the first confirmed discovery of a Denisovan fossil outside of Denisova Cave. Photo and License: Dongju Zhang CC BY-SA 4.0.

years ago (1.5 Ma) through the Holocene shows periodic human occupation of high latitudes with greater seasonality. Cultural sequences from clusters of sites at Dingcun (7701, 7902, 8001, and 54100) demonstrate the variability of technology between the Early and Late Pleistocene on the Chinese Loess Plateau.

The genomic identification of Denisovan hominins and the assignment of the Xiahe mandible (Fig. 1) from Baishiya Karst Cave (Fig. 2) to this group based on paleoproteomic analysis have again raised interest in biological evolution. The fossil record may also comprise other yet undetected lineages of the genus *Homo* in East Asia, as possibly represented by the late Middle Pleistocene Harbin cranium. An initial expansion of the human range to the margins of the Tibetan Plateau can be attributed to a Denisovan population during the last interglacial phase, as indicated by the Xiahe mandible and the archaeological site of Jiangjunfu 01. Human handprints and footprints preserved in travertine layers at Quesang site dated between 169,000 and 226,000 years provide possible evidence of an even earlier hominin mastering high altitudes of 4,000 m above sea level on the Inner Tibetan Plateau. Between 40,000 and 30,000 years, Homo sapiens reached even greater heights of 4,600 m. At Nwya Devu they produced blades from prismatic cores of local slate. In North China, in contrast, Levallois-Mousterian assemblages were discovered only recently. Tongtian Cave in Xinjiang province (44,000-46,000) and Jinsitai Cave in Inner Mongolia (37,000-47,000) may indicate a Middle Paleolithic hominin dispersal from more western parts of Eurasia. In the meantime, it is clear that East Asia can no longer be regarded as an isolated periphery. Nonetheless, the course and timing of the biological and cultural evolution in China and adjacent countries, as well as their interdependencies with developments in other regions of the world, are still not fully understood.

▲ Figure 2. Baishya Karst Cave, where the Xiahe mandible was discovered. Photo and License: Dongju Zhang CC BY-SA 4.0.

The entry of Chinese Paleolithic sites into the ROCEEH Out of Africa Database (ROAD) started in 2021. With the help of doctoral candidate Xiangmei Kong, sources published in Chinese could be reviewed. After nearly two years, ROAD comprises more than 330 assemblages from China from the Early to Late Pleistocene. These include human, faunal and plant remains, as well as lithic and symbolic artifacts, organic tools, features, pigments and diverse minerals (see Tab. 1).

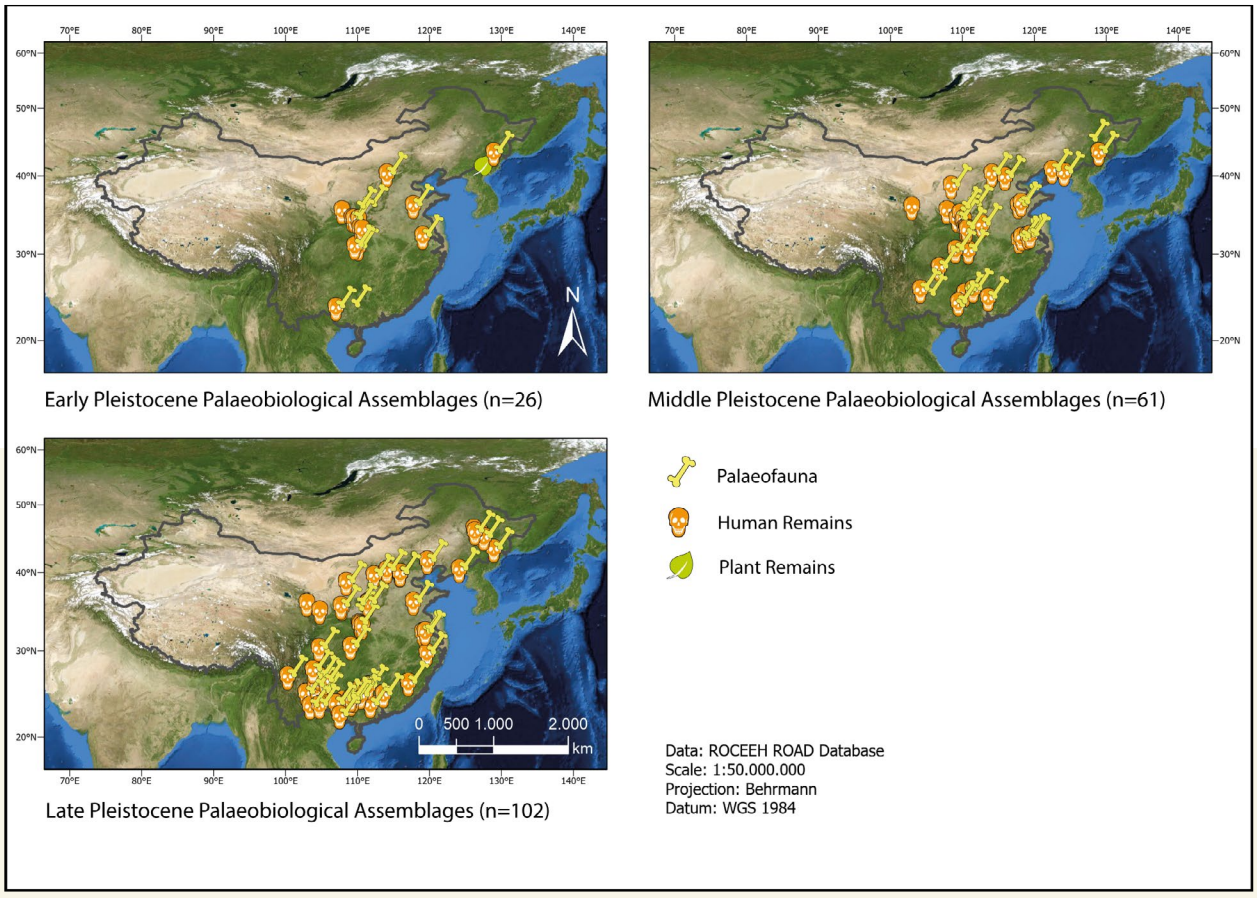
East Asia now offers many fascinating sites to explore with the help of ROAD. For example, one of the oldest Paleolithic sites in China is Shangchen on the southern Chinese Loess Plateau, located near the similar aged Gongwangling site in Lantian county. The 17 layers of loess sediment and paleosoils with 96 artifacts give evidence of repeated—but not necessarily continuous—hominin occupation between 1.26-2.12 Ma. The dating of artifact-bearing layers older than 2 million years implies early hominin dispersal out of Africa prior to the findings from Dmanisi at 1.85 Ma.

One of the few cave sites chronologically assigned to the early Middle Pleistocene is Bailongdong Cave alias Yunxi in Yunxi County, Hubei Province, central China. In five excavations between 1977 and 2009, eight teeth of *Homo erectus* were unearthed in association with thousands of mammalian fossils. More than one hundred stone artifacts, some probable pointed bone tools and evidence of a combustion feature, give insight into cultural performances 500,000 years ago. While the deposits of Bailongdong Cave were recently assigned to MIS 13 based on Electron Spin Resonance and Uranium Series dating, as well as the composition of the fauna, most of the excavated levels of Panxian Dadong Cave were deposited between MIS 8-6. The site is part of a large karst system located in Guizhou Province, southwestern China. In six excavations between 1992 and 2005, human fossil remains were discovered associated with an Ailuropoda-Stegodon fauna. These hominin teeth contribute new data for the discussion of evolutionary trends in the late Middle Pleistocene populations of Asia. Among the more than 2000 stone artifacts, prepared core technology is an important feature. The teeth of *Rhinoceros sinensis* even served as an organic raw material. Burning, cutmarks and impact fractures on animal bones indicate the human influence on the faunal remains. Although there are no direct signs of human activities found on the remains of several young stegodons, *Homo* probably contributed to their accumulation within the cave.

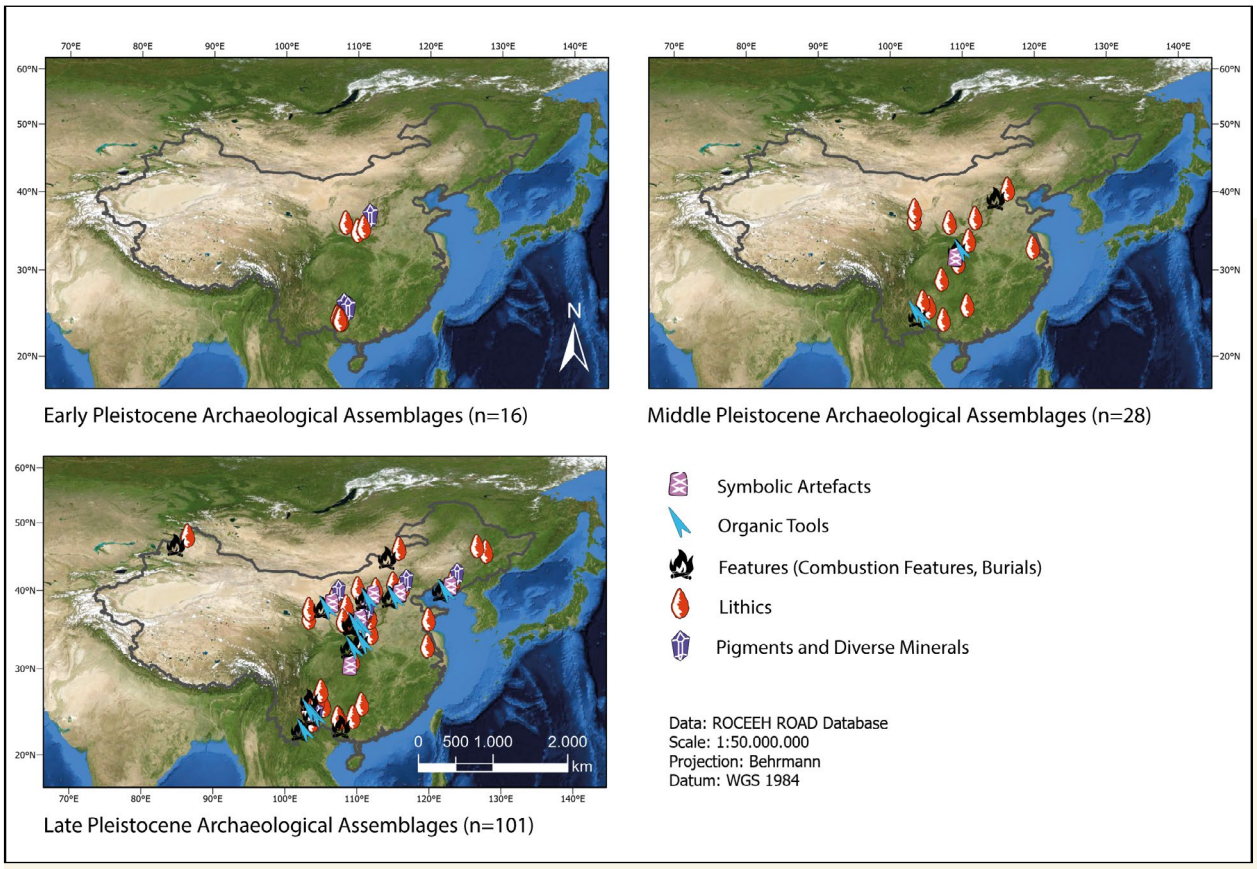
Several sites in ROAD exemplify a significant intensification of human activities in the Late Pleistocene. At Longwangchan Locality 1 on the Yellow River terraces near the Hukou waterfall

Assemblage types	Early Pleistocene	Middle Pleistocene	Late Pleistocene	Total
Human remains	13	30	53	96
Paleofauna	12	31	49	92
Plant remains	1	0	0	1
Lithic artefacts	12	20	49	81
Organic tools	0	3	11	14
Symbolic artefacts	0	1	12	13
Combustion features, burials	0	4	18	22
Pigments and diverse minerals	4	0	11	15
Total	42	89	203	334

▲ Table 1. Status of assemblages from China entered in ROAD on March 30, 2023.



▲ Figure 3. Map of the geographical distribution of paleobiological assemblages from China in ROAD on March 30, 2023. Maps: M. Malina.



▲ Figure 4. Map of the geographical distribution of archaeological assemblages from China in ROAD on March 30, 2023. Maps: M. Malina.

in Shaanxi province, Northwest China, 40 hearth features were found in three layers together with about 40,000 stone artifacts. A unique plate-like stone implement was interpreted as part of a shovel; together with an intensively worn grinding or quern stone, it may indicate a change in the use of plant resources about 25,000 years ago.

Another site with a similar to slightly younger age is Shizitan 29 in the adjacent province of Shanxi. Eight cultural layers spanning the entire Last Glacial Maximum yielded more than 80,000 stone artifacts and 285 hearths. While Layer 8 is dominated by a lithic industry based on core and flake technology, a shift is observed in Layer 7 towards the use of micro-blade technology. Layer 7 dates between 23,000 and 26,000 and represents a change in climate and vegetation. A fragment of a bone eyed needle, a sandstone slab used to whet needles, ostrich eggshell beads with evidence of use-wear from stringing, as well as flax, hemp and woolen fibers and many pieces of mineral pigments, provide a glimpse of a group making complex clothing and ornaments. The common use of eyed needles in North China during the Last Glacial Maximum is also indicated by three bone needles from Layer 3 at Xiaogushan cave site in Liaoning province, Northeast China. The Upper Paleolithic site excavated in 1983 is known for special bone artifacts like a harpoon, a carefully crafted point or awl, perforated teeth of small canines and deer, and the fragment of a shell disk with a centrally drilled hole and radial cut marks at its margins.

Figures 3 and 4 show the geographical distribution of the current entries of paleobiological and archaeological assemblages from China in ROAD. If you are interested in exploring the Chinese sites and their assemblages, you can do it with ROAD's simple search tool, starting from the home page (https://www.roceeh.uni-tuebingen.de/roadweb/smarty_road_simple_search.php). Select the assemblage categories of interest. If you want to refine the search, you can choose a region, e.g. "Asia - East Asia", an age range, or a culture. The results of your search appear on a map and in a table with basic data about the selected sites. Zoom into the map and move your mouse to highlight a site. To learn more about the site, click on it and then click "ROAD Summary Data Sheet" to generate a compilation of the site's data including a statement summarizing the importance of the site, as well as selected data about its location, schematic representations of geological and archaeological profiles, layers, ages, assemblages, and references.

The ROAD dataset on China will be completed in the coming months and years. The links in the online version of this text will bring you directly to each site's ROAD Summary Data Sheet, updated to include new entries and additions to existing ones. Pass by, have a look, and discover the deep and multifaceted archaeology of the Far East. Don't hesitate to contact us if you

have more detailed or broader research questions which cannot be answered by a simple search in ROAD.

Miriam Haidle, Maria Malina, Xiangmei Kong

New excavations in the Stone Age deposits of Umbeli Belli and Holley Shelter, KwaZulu-Natal, South Africa

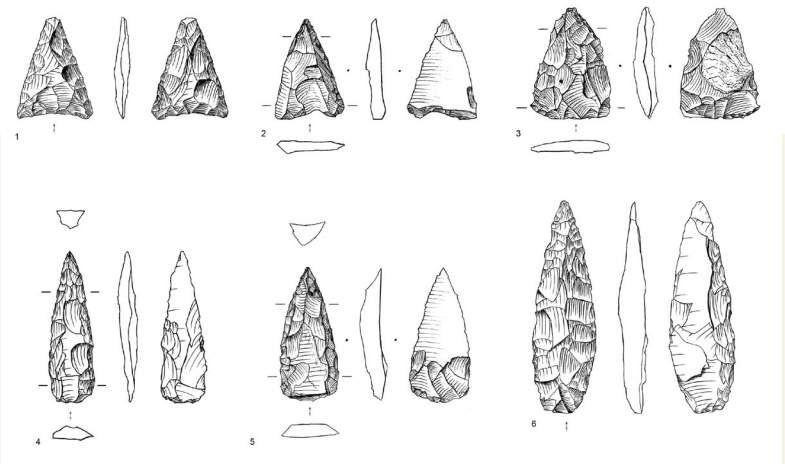
For more than ten years scientists from the ROCEEH Project, the University of Tübingen and the Senckenberg Centre for Human Evolution and Paleoenvironment (SHEP) have conducted intensive fieldwork in the South African Province KwaZulu-Natal. For many years, the Middle Stone Age (MSA) site Sibhudu represented the focus of scientific attention for both local and international researchers. Sibhudu's long and finely laminated stratigraphic sequence extends back more than 100,000 years and the site offers excellent conditions for the preservation for organic materials. Since 2016 we expanded our attention towards other sites in the region to correlate the important data from Sibhudu with these sites (Fig. 5). Our research targets the variability of human material culture, e.g. as seen in stone tools, bone and pigments. It also examines potential drivers such as environmental change, fluctuations in sea level and the availability of raw materials, as well as other invisible factors, like demography and social identity.

The Middle and Later Stone Age (LSA) site Umbeli Belli, near Scottburgh was excavated by G. Bader (SHEP) and N. Conard (SHEP, Tübingen, ROCEEH) between 2016 and 2020. While the site lacks the good organic preservation known from Sibhudu, it delivered an incredibly rich assemblage of stone and ochre artifacts whose number exceeds 40,000 pieces. Several publications over the last years proved the importance of the site (Blessing et al., 2022, Bader et al., 2022), specifically for the younger periods associated with Stone Age hunter-gatherers of the last 40,000 years. The assemblages dating between 30,000 and 40,000 years are assigned to a specific expression of the final Middle Stone Age (final MSA) and associated with particular types of pointed artifacts, e.g hollow based points and narrow unifacial and bifacial points (Fig. 6). These tools were most likely tips of hunting weapons such as spears and arrows or cutting knives. Further investigations to examine the functionality of these pieces using high power microscopy and use wear experiments are needed to confirm our preliminary assumptions. Some of these points are unique and found exclusively in KwaZulu-Natal around 35,000 years ago, indicating a highly specialized and localized tradition of stone tool production.

In the younger periods of Umbeli Belli between 17,000 and 30,000 years ago, the hunter-gatherers inhabiting the site produced entirely different tools. Small quartz pebbles from the nearby river were smashed between hammer and anvil, creating hundreds of small, but razor-sharp edges, which were most likely inserted in wooden shafts of spears and arrows. The periods encompassing this technology are called Early LSA (ELSA) and Robberg, and Umbeli Belli counts among the oldest expression of these cultural traditions in southern Africa.

In 2022 we started new excavations at Holley Shelter (Fig. 7 a and b), about 60 km inland from the coast, near Wartburg, and thus within a completely different biome compared to Sibhudu and Umbeli Belli. After the initial excavations in the 1950s by a local archaeologist named Gordon Cramb, G. Bader completed his Master's Thesis about these assemblages. The results indicate three different occupational horizons associated with different technologies in stone tool production (Bader et al., 2015). At this point, no absolute chronometric ages were available and we proposed a tentative age of the site between 40,000 and 58,000 years based on a techno-typological comparison with other sites in South Africa. In 2022 G. Bader and M. Will (Tübingen) started new excavations at the site. Theirs aim was to correlate Cramb's assemblages with new, more controlled excavations,

▲ Figure 5. Map showing the location of sites mentioned in the text. Map: C. Sommer.



▲ Figure 6. Pointed artifacts from Umbeli Belli. (1-2) Hollow based points. (3) Preform hollow based point. (4-6) Narrow points with basal thinning. Graphic: G. Bader.

▼ Figure 7a, 7b. Different views of the main excavation area at the northern extension of Holley Shelter, KwaZulu Natal, South Africa. Photo: G. Bader.

gain observations on the stratigraphy, and determine absolute chronometric ages using both radiocarbon and Optically Stimulated Luminescence (Bader and Will, 2022).

Holley Shelter turned out to be one of the most important sites on the East Coast of South Africa, not only because of its unique stone tools, but especially due to the good preservation of organic materials, comparable to Sibhudu. This enables us to not only reconstruct past human technology, but also the environment in which these humans lived, the animals they hunted, and the way they organized space in the rock shelter. Within the two uppermost horizons (Fig. 8), encompassing the top 20 to 30 cm of deposits, we identified massive hearth features where people made fire, cleaned out the ash and then restarted the fire. Those features are associated with many artifacts, including stone tools, ochre, and animal and plant remains. The areas without such hearth features show much lower artifact densities. Thus, we are able to reconstruct clear areas of intensified activity within different periods of occupation at Holley Shelter. The stone artifacts in those upper layers are diagnostic, but also site-specific. So-called splintered pieces (Fig. 9), small rectangular flakes with chiseled ends, are most typical. Currently Maria Denys, a Master's student of Veerle Rots at the University of Liège, is performing experimental work and use wear analysis on those pieces to find out more about the use of those specific tools. Many more researchers from South Africa (e.g. Trevor Hill, Marlize Lombard, Stephan Woodborne, Marion Bamford), and Europe (Sara Rhodes, Aurore Val, Christopher Miller, Hervé Bocherens, Susan Mentzer, Dorothée Drucker, Chantal Tribolo) are involved in the Holley Shelter Project working to capture every aspect of human lifeways from a holistic approach. Meanwhile the first radiocarbon dating results performed by iThemba laboratories in Johannesburg arrived and analyses on the faunal and lithic material is almost finalized. While the publication of those results is being prepared, at this stage we can safely state that Holley Shelter holds some unexpected surprises!

▲ Figure 8. Stratigraphy at Holley Shelter showing the upper two horizons AVA and BIB (above). Surface of anthropogenic hearth feature in layer BIB (below). Photo: G. Bader.

▲ Figure 9. Splintered pieces from layer AVA and BIB at Holley Shelter. Photo: G. Bader.

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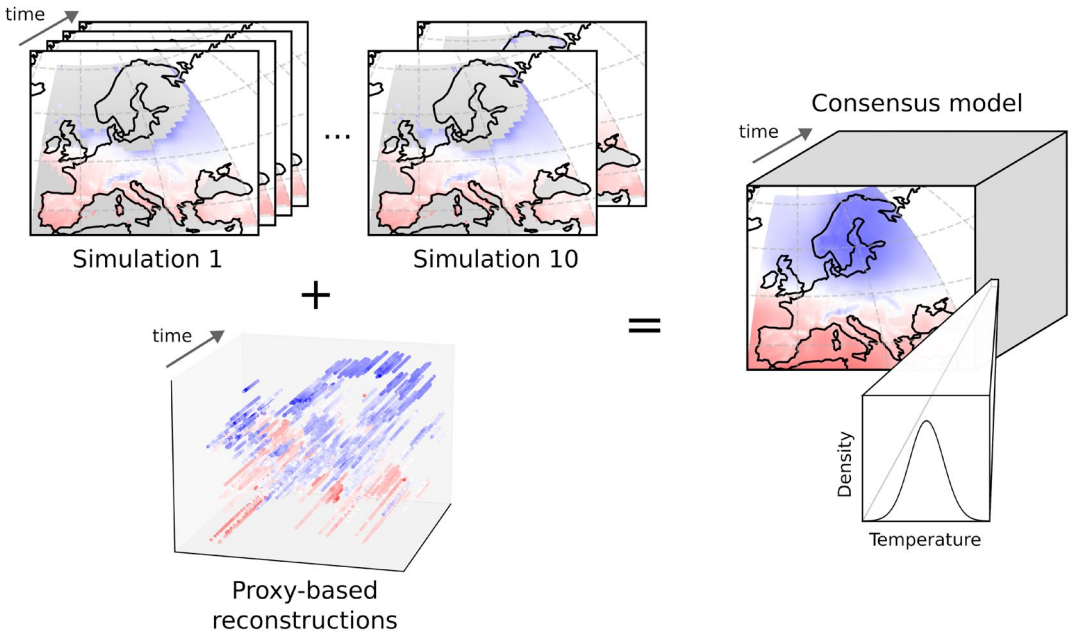
Gregor Bader

Building a consensus model of paleoclimate with machine learning

Prehistoric climate changes and their effect on landscape, hydrology, vegetation, and fauna undeniably affected the availability of resources for early hominins and shaped their way of life. Consequently, many researchers consider paleoclimate conditions to be a crucial driver of the physical, cognitive, cultural, and geographic expansion of our distant ancestors. For example, temporary greening of the Sahara or the Arabian Peninsula is thought to have created livable conditions, while glacial conditions in the Ice Age are believed to be responsible for humans' retreat to refugia or even the demise of whole taxa. Of course, there are many justified opposing theories, and comprehensive explanations are often far more complex. This underlines that good and reliable data about the paleoclimate are essential to test existing hypotheses and develop new ones.

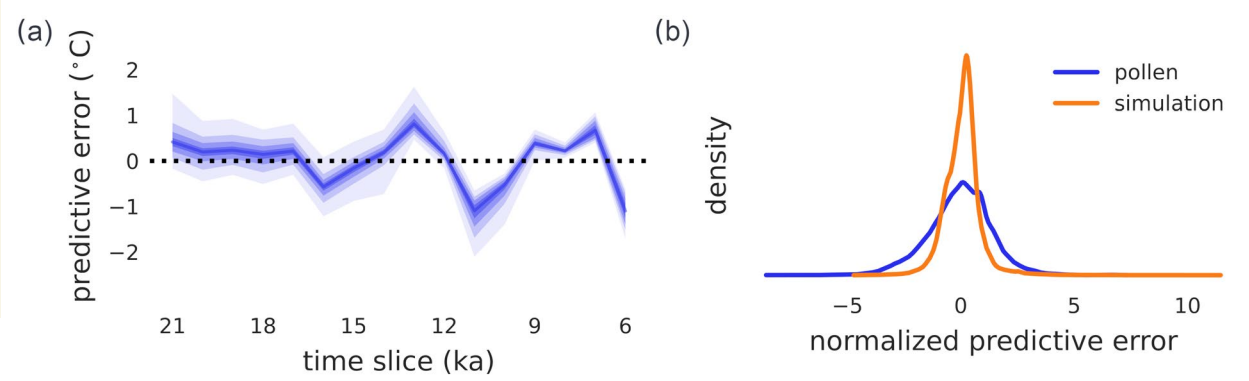
For this reason, the ROAD database is designed to be interdisciplinary and stores information about archaeological and anthropological finds in the context of environmental data, where available. In addition, numerous reconstructions and physics-based simulations of the paleoclimate have been published in recent years. Reconstructions are often built from site-specific so-called proxy data, such as fossilized pollen grains, whereas simulations generally make predictions on discrete spatial and sometimes temporal grids (Fig. 10). These information sources vary in spatiotemporal scope and resolution, the physical properties they represent, the types of computational models used, the boundary conditions, and the choices of input variables.

This wealth of paleoclimate data poses a considerable challenge to anyone who wishes to examine human prehistory in relationship with paleoclimate. In particular, even if a researcher collects all of the available information, how are they to synthesize them, especially when their site and time range of



▲ Figure 10. A sketch of our consensus modeling approach. Input data include gridded climatic simulations, which may be available as a discrete time-series at many time points (Simulation 1) or snapshots of specific points in time (Simulation 10). Another kind of source includes proxy-based reconstructions, which inform paleoclimate at specific points in space and time. These sources together inform the Gaussian Process consensus model. The model is uncertainty-aware, so that paleoclimate predictions have a mean and standard deviation. This standard deviation will be small when data are dense in space and time near the queried point and in mutual agreement. However, they will be large when data are sparse or contradictory. Graphic: S. Axen.

▼ Figure 11. The predictive error of the consensus model on European data. (a) Distribution of error in predicting the temperature at all locations for a single held-out simulation time-slice (x-axis) after training on all other data. Shown are the central intervals of the error distributions containing 80%, 60%, 40%, and 20% of values, as well as the median. (b) Distribution of error in predicting data used in training, normalized by standard deviation in predictions. Graphic: S. Axen.



interest is not explicitly represented in the data? How should they handle disagreements between the data sources? And even if they devise a scheme for synthesizing the data into a unified model, how confident should they be in the result?

To tackle this challenge, we assembled a multidisciplinary collaboration between domain specialists and the Machine Learning ⇌ Science Colaboratory (MLColab). The MLColab is a center within the Cluster of Excellence Machine Learning for Science at the University of Tübingen. The MLColab bridges the gap between ML researchers and scientists at the university through teaching introductory and technical ML workshops, advising on projects, engaging in cooperative projects, and developing free and open-source software. The domain specialists are C. Sommer, a geographer in the ROCEEH team, and Nils Weitzel, who has extensively worked on reconstructing paleoclimate. The Colab members of the project include Seth Axen, whose background is in bioinformatics and probabilistic programming; Alex Gessner, with a physics background and expertise in probabilistic numerics; and Álvaro Tejero-Cantero, who comes from physics and computational neuroscience.

The problem can be framed as one of inferring a spatiotemporally continuous map of paleoclimatic variables, treating both simulations and data-based reconstructions as data. To both build this map and quantify the uncertainty in the map, a natural approach is to perform Gaussian Process (GP) regression, where the fitted model is not just a continuous map, but actually a distribution of such continuous maps. For any point in space and time, the model can return a mean and standard deviation for a paleoclimatic variable consistent with the data used in training (Fig. 11). However, fitting a GP scales poorly with data size, making exact inference intractable. Using recent advances in doubly sparse Markovian GPs, we performed tractable approximate inference. We trained the model for European paleoclimate on over 40,000 site-specific reconstructions and over 600,000 predictions from 10 climate simulations from 21,000 to 6,000 years ago. Early results are quite promising. When validating the temperatures predicted by the model against held-out simulation time-slices, the mean predictive error is 0.05°C (Fig. 11a). When training the model on all data, 99% of all data used fall within three standard deviations of the mean of the predicted distribution (Fig. 11b).

Ultimately, we will train a GP model for all global land masses and provide a web-based utility for researchers to query the model's paleoclimatic predictions, as well as the uncertainties in those predictions. Thus, users can request paleoclimatic predictions for a specific place and time, such as at an archaeological site of interest during the time of its occupation. In addition, the returned uncertainties allow them to gauge the reliability of the predictions. We expect that this resource will be useful for researchers in diverse fields related to human evolution, including archaeology, anthropology, paleobiology, and paleoecology.

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https://mlcolab.org/resources/integration-of-paleoclimate-models-and-proxies

Christian Sommer, Seth Axen

Forthcoming

- INQUA Congress 2023

15-20 July 2023, Rome, Italy

Session 45 "Plants as Resources for Early Humans – Availability and potential exploitation of useful wild plants through Pleistocene human history" organized by A. Bruch and K. Hahn.

Session 109 "Animals, environments, and humans: Diverse perspectives from the Quaternary" organized by C. Hertler, P. Sukumaran and P. Chauhan.

Session 131 "A global view on Early Pleistocene climate and vegetation dynamics" organized by K. Sniderman and A. Bruch.

For more details see:
https://inquaroma2023.org/

- NECLIME Annual Meeting

30 August-6 September 2023, Matsudo/Chiba, Japan

Organized by A. Momohara, Y. Watanabe, C. Yamakawa, A. Bruch and T. Utescher

For more details see:
https://www.neclime.de/conferences.html

- International Conference Ritual in Human Evolution: Interdisciplinary Perspectives

4-6 October 2023, Tübingen, Germany

Co-organized by ROCEEH with support from the Fritz Thyssen Stiftung.

For more details see:
https://uni-tuebingen.de/fakultaeten/mathematisch-naturwissenschaftliche-fakultaet/fachbereiche/geowissenschaften/arbeitsgruppen/urgeschichte-naturwissenschaftliche-archaeologie/ina/aeltere-urgeschichte-quartaeroekologie/aktuelles/tagungen/

- 41st Annual Conference of the Deutsche Gesellschaft für Geographie (DGfG) Climate Working Group

12-14 October 2023, Tübingen, Germany

Organized by H.-J. Rosner, M. Mauz, T. Schober and C. Sommer

Contributions to current issues in climatology and meteorology (including paleoclimatology) are welcome.
For more details see:
http://www.akklima.de/

- 12. NECLIME Workshop on Palynology

18-19 October 2023, Antalya, Turkey

Co-organized by A. Bruch

For more details see:
https://www.neclime.de/workshops.html

- Big Historical Data Conference

22-25 November 2023, Jena, Germany

Session: „Insights from reusing large prehistoric and interdisciplinary databases" organized by C. Sommer, A. Bruch, N. Conard, C. Hertler, M. Haidle, V. Hochschild, Z. Kanaeva, A. Kandel, and the ROCEEH Team

For more details see:
https://bhdc.earth/sessions/

Who's who?

This issue: Xiangmei Kong and Maria Malina

After obtaining her Bachelor's degree in Archaeology from Jilin University in China, **Xiangmei Kong** participated in many Paleolithic excavations in China and developed a strong interest in lithic technological analysis. She continued her Master's degree at Jilin University, studying the blade and bladelet assemblages from the Houtaomuga site in Northeast China. Based on her good understanding of the Paleolithic remains in China and great enthusiasm for lithic research, she joined the ROCEEH team in August 2021 and began entering the archaeological information of Chinese sites into the ROCEEH Out-of-Africa Database. During this process, she gained much experience in the field through excavations in Germany and South Africa. After receiving a scholarship from the LGFG, she started her Ph.D. at the University of Tübingen, focusing on the variability of bifacial technology in the MSA of Southern Africa, and in particular, the Still Bay assemblage of Sibhudu Cave, Kwazulu-Natal, South Africa.

Maria Malina is an archaeological technician who has been part of the ROCEEH team since the advent of the project in 2008. From the start of her training at the University of Tübingen in 1998, she has been involved in widespread excavation projects located in southwestern Germany, the United Arabic Emirates, Syria and South Africa. After her training, her work focused on the transition from Neanderthals to Anatomically Modern Humans in Germany. In the Swabian Jura she was field director of new investigations at Geißenklösterle and long-term excavations at Hohle Fels. Correlating with her work on these excavations, she dealt with the coherence and systematics of data acquisition in the field, worked to systematize and improve excavation techniques, field documentation and data management. In addition, Maria has a passion for organic artifacts and reconstructing them. In recent years she has mainly been involved in performing quality control of the ROAD database. She also furthered her education in GIS by learning advanced techniques in data visualization and analysis.

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THE ROLE
OF CULTURE
IN EARLY
EXPANSIONS
OF HUMANS

The Heidelberg Academy of Sciences and Humanities is a member of the Union of German Academies of Sciences and Humanities, which coordinates the Academies' Program. The research project, "The Role of Culture in Early Expansions of Humans", was incorporated into the Academies' Program in 2008.

UNION
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DER WISSENSCHAFTEN

August 2023