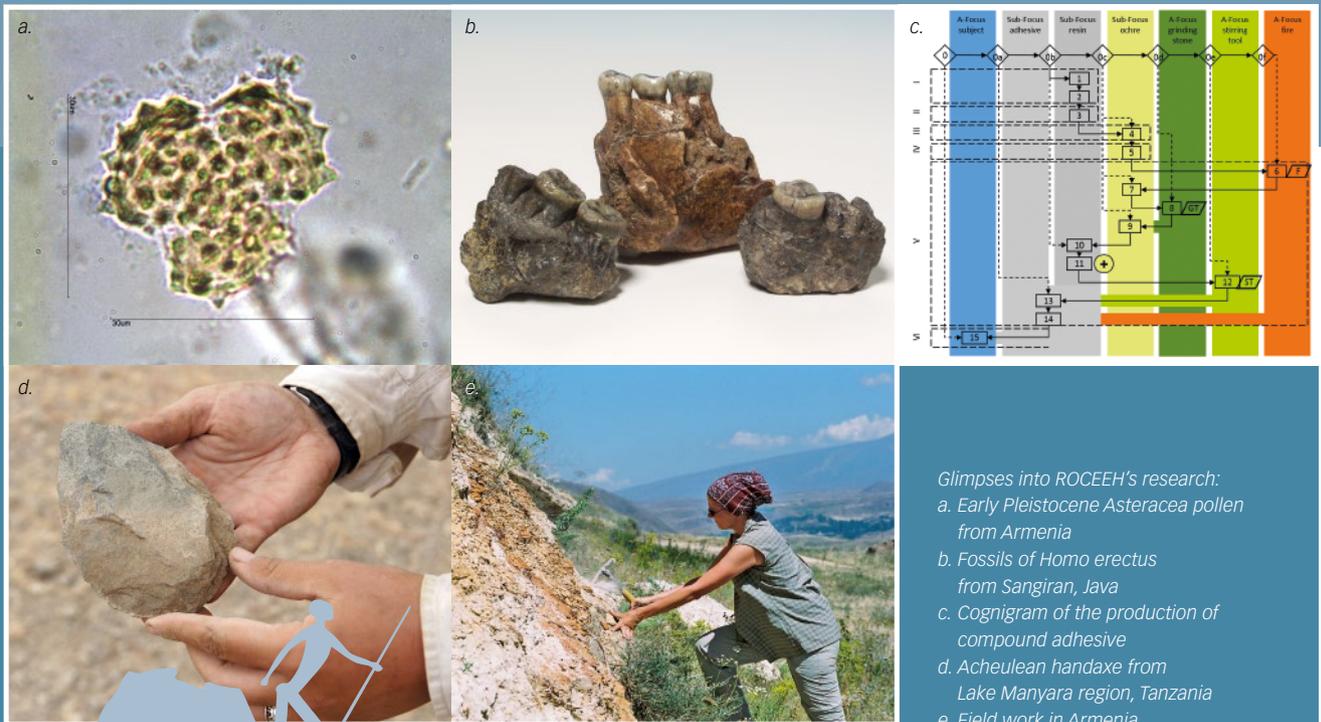


# The Role of Culture in Early Expansions of Humans (ROCEEH)





## THE ROLE OF CULTURE IN EARLY EXPANSIONS OF HUMANS

# Foreword

The research center “The Role of Culture in Early Expansions of Humans” (ROCEEH) is a long-term project of the Heidelberg Academy of Sciences and Humanities. ROCEEH aims to reconstruct the trajectory of human evolution in Africa and Eurasia between 3 million and 20,000 years before present. The project focuses on three different fields of expansion: the spatio-temporal and taxonomic expansion of the various hominin species, the expansion of the ecological environment and resource spaces, and most central, the expansion of hominin performances and cultural capacities (Fig. 1). An interdisciplinary team of archaeologists, paleoanthropologists, paleobiologists, geographers and database specialists addresses the dynamics and interactions of the different fields of expansions to gain a better understanding of the different roles of developing cultural capacities on the unique pathway towards “*becoming human*”. With workplaces at the Eberhard Karls University of Tübingen and the Senckenberg Research Institute in Frankfurt/Main, Germany, the research center will operate from 2008 until 2027. The evaluation of ROCEEH in 2016 provides good grounds to take preliminary stock of the current status of the project and its results.

## I. OBJECTIVES

When ROCEEH began its aim was “... to answer the question of when, where and in which form the interplay of changing climatic conditions, biological evolution and cultural development allowed the genus *Homo* to move beyond the behavioral niche of a large African ape and develop culturally defined niches outside of Africa. ... Through the investigation of early migrations in Africa and the subsequent settlement of first subtropical, then warm temperate, and finally cold temperate to polar regions of Eurasia, the project will follow the transformation of the human species from its biologically determined nature to a culturally driven organism. The history of human expansions opens up new perspectives on the temporal and spatial dimensions

of the increasing independence of the genus *Homo* from its purely biological limitations.” (ROCEEH report 2008)

As a result of theoretical debates and case studies performed over the last years, ROCEEH has developed new views on expansions, as well as on the dynamics and interactions of human evolution (Fig. 1). Expansions are a central concept not only for spatio-temporal dispersals in human evolution, but also for the understanding of hominin cultural capacities and the specific environment, the developmental forces and drivers in these fields, and the relationship between range, physical/mental/behavioral performances and the use of resources. Therefore, ROCEEH adjusted its objectives.

Instead of pursuing multidisciplinary causes-and-effects with the goal of finding developmental correlations among range expansion, environmental change and cultural innovations, ROCEEH opted for a true interdisciplinary, systemic approach to understand what “*becoming human*” really means. This unique approach integrates cultural, biological and environmental factors, and their changing forces and interactions. By gaining an increasing historical-social dimension of development and its cultural impact, hominins did not achieve increasing independence from biological limitations and environmental constraints. Enabled by their biological capabilities, hominins developed new relationships with existing environmental components and introduced new elements such as artifacts, thereby broadening their specific resource spaces and ranges, and intensifying their interconnectivity with the environment.

Accordingly, the structure of the research center has matured since the initial proposal of the project (Table 1). Each of the fields of expansion – range, ecospace/resource space, and performances – is now understood to represent a specific field of research. Research Unit RU1: Human Habitats was broadened to include human ecospace and resource spaces, as well as their interrelations. The formerly separate research units, RU2: Hominins and RU3: Cultural Evolution, are now merged into a comprehensive field of Hominin Performances with a focus on biological and cultural development of body, mind and behavior. Hominin ranges with spatial, chronological and taxonomic elements were identified as an additional research field. We integrated the three separate fields of expansion along disciplinary and interdisciplinary lines to formulate a better understanding of each individual field and their interconnections. A specific research field (formerly RU4: Integration) examines the broad picture of systemic evolution in

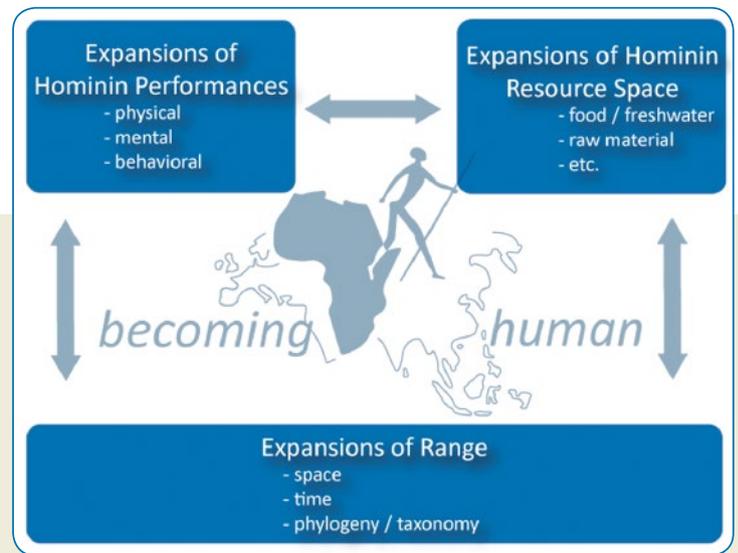


Fig. 1: System model of expansions in human evolution.

“*becoming human*”. A proposed spatiotemporal information system on human evolution will be realized in three parts: the growing ROCEEH Out-of-Africa Database (ROAD); the development of web-based toolboxes for the analysis of human expansions; and a web-based Virtual Atlas to integrate ROCEEH’s results at various levels of detail. Furthermore, the themes of modeling and the development of scenarios, as well as overarching theoretical issues and transdisciplinary discourse about ROCEEH concepts and results, are now consolidated into a single research field that examines systemic evolution along the path of “*becoming human*”.

Proposal – 2008	Current stand – 2016
Research Unit RU1: Human Habitats	Human Ecospaces / Resource Spaces
RU2: Hominins	Hominin Performances: body, mind, behavior – biological and cultural development
RU3: Cultural Evolution	
	Hominin ranges
RU4: Integration	Systemic evolution – Becoming human
a) Spatiotemporal information system on human evolution	a) Spatiotemporal information system on human evolution <ol style="list-style-type: none"> <li>1. ROAD – ROCEEH Out of Africa Database</li> <li>2. Toolboxes</li> <li>3. Virtual Atlas</li> </ol>
b) Models, scenarios – hominins in their environment	b) Models, scenarios – hominins in their environment
c) Theoretical issues, transdisciplinarity	c) Theoretical issues, transdisciplinarity

Table 1: Research structure as intended in the proposal (left) and adapted research structure as pursued in 2016 (right).

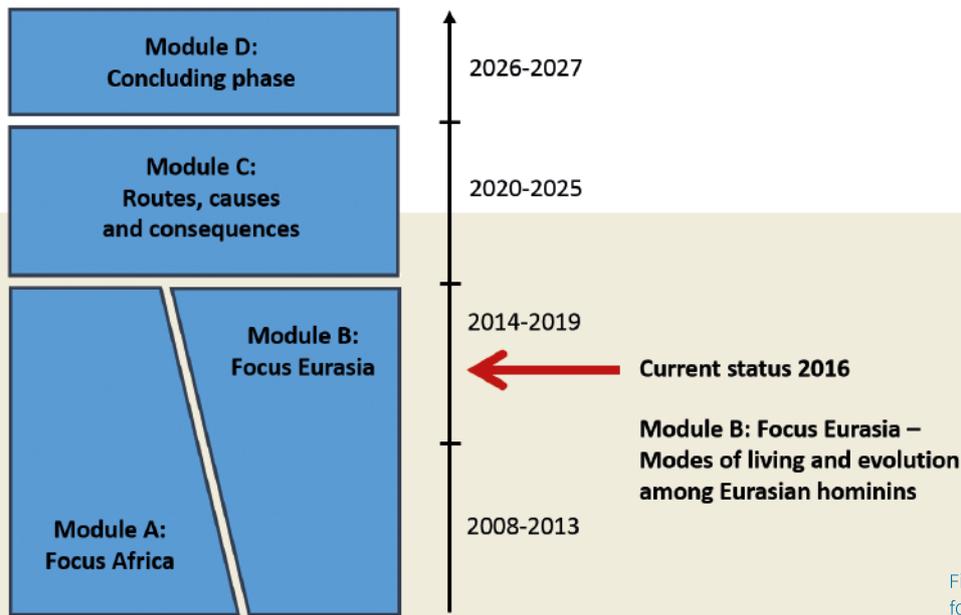


Fig. 2: Schedule of work modules for the ROCEEH research center.

ROCEEH's research is structured into four modules (Fig. 2). Module A, with its focus on Africa, and Module B, with its focus on Eurasia, are both dedicated to the development of theoretical concepts, research structures and data compilation in ROAD. (Modules C and D will begin later in the project and are aimed at analysis and conclusions.) Pilot studies have helped test the theoretical concepts and database structures, as well as issues of quality control and data sustainability. The African continent was emphasized as a core area during the first six years of the project; since 2014 the focus shifted to exploring the Eurasian data pool. Data compilation, the development of new analytical methods, case studies and networking continue to be core responsibilities of the involved disciplines. Furthermore, a significant part of ROCEEH's activities revolve around interdisciplinary issues, such as the conceptual integration

of disciplinary approaches into theories; overarching case studies on human evolution; and the discussion of integrative approaches and results and their transmission to broader networks. The dissemination of ROCEEH concepts into the transdisciplinary discourse on "*becoming human*" started with the participation of external research groups working on the development of the concept of supply systems and on embodiment as a paradigm for an evolutionary cultural anthropology. By publishing in a broad spectrum of scientific journals, edited volumes and popular papers and by participating in conferences, thematic sessions and workshops, ROCEEH strives to lead the way in disciplinary, interdisciplinary and transdisciplinary discussions on human evolution, human expansions, and the cultural impact that these processes bring about.

## II. RESULTS

The following compilation gives an overview of ROCEEH's results in several different research areas: theoretical concepts, methodological developments, data generation and compilation, the ROCEEH Out-of-Africa Database (ROAD), and case studies. Here, we present a general overview by selecting certain highlights. You can find more detailed information at [www.roceeh.net](http://www.roceeh.net) where you can browse the lists of publications and field projects, or read about current ROCEEH activities in our biannual Newsletters.

**A) Theoretical concepts:** An important part of ROCEEH's work has involved the development of theoretical concepts central to the question of the *role of culture in early expansions of humans*. These theoretical concepts are the outcomes of and form the backbone for the reflection and integration of the case studies.

– **Expansions:** In ROCEEH's sense, hominin expansions are more than just simple dispersal events (Fig. 1). Beyond

spatial, chronological, and taxonomic *expansions of range* (Hertler et al. 2013; Bolus 2015) human evolution is also characterized by *expansions of physical, mental and behavioral performance*, from which the expansion of *cultural capacities* can be deduced. In addition to the *expansion of ecospace*, the natural habitat with its intrinsic parameters of climate, vegetation, fauna and landscape correlated to human range expansions, *expansions of resource space* can be identified. The broadening of the resource spectrum, as well as the altering of relationships with specific resources for sustenance, raw material and artifacts, reflects a human characteristic closely interrelated with the expansion of cultural performances and capacities. These varied expansions interact with one another and increasingly affect each other's development, thus circumscribing a changing path on the way to "becoming human".

- Cultural development:** The *model for the evolution and expansion of cultural capacities* (EECC) (Haidle et al. 2015) emphasizes the fact that cultural performances possess three dimensions of development, as opposed to other organismic performances (Fig. 3). Besides evolutionary-biological and ontogenetic-individual dimensions effective in all forms of organismic performances, an additional historical-social dimension of development is a characteristic of cultural performances. 1) The *evolutionary-biological dimension* affects possibilities and constraints set in genes and gene expressions and is expressed in basic anatomy and physiological standards of a group of organisms. Developments in this dimension enable or hamper a performance, either by directly affecting its emergence, or by indirectly constraining developmental possibilities. 2) The *ontogenetic-individual dimension* refers to individual agency and experiences in dealing with the environment and pertains to the potential and constraints of an individual organism. 3) The *historical-social dimension* of development narrows and at the same time broadens the path of individual agency and experience. Historically and socially derived cues open potential scenarios or raise constraints. Cultural performances are grounded in factors developed by evolutionary-biological processes and achieved and executed in individual ways. A learning path, however, is also provided by the behavior of the social group to which an individual belongs. This social learning path is determined by traditions and innovations as antagonist mechanisms of development; it is created and functions within a historical time frame. The significance of the historical-social dimension increases over the course of human evolution, as it is self-enhancing.

- Expansion of cultural capacities:** Changes in biological, historical-social or individual factors do not produce "culture" in a single creative event. If chimpanzees possess a capacity for culture, this does not imply that theirs exists in the same form as ours. Rather, a range of fac-

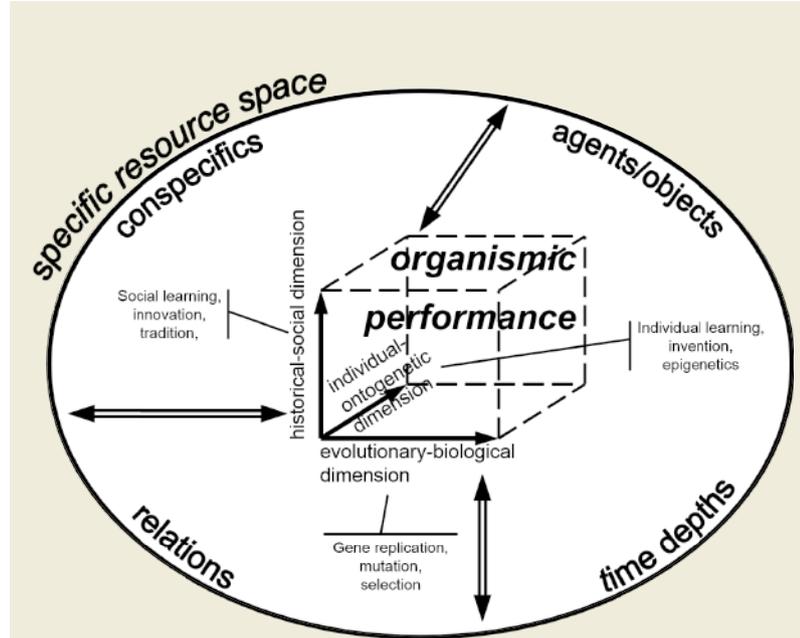


Fig. 3: Three developmental dimensions of human performances interact with the specific resource space (Haidle et al. 2015).

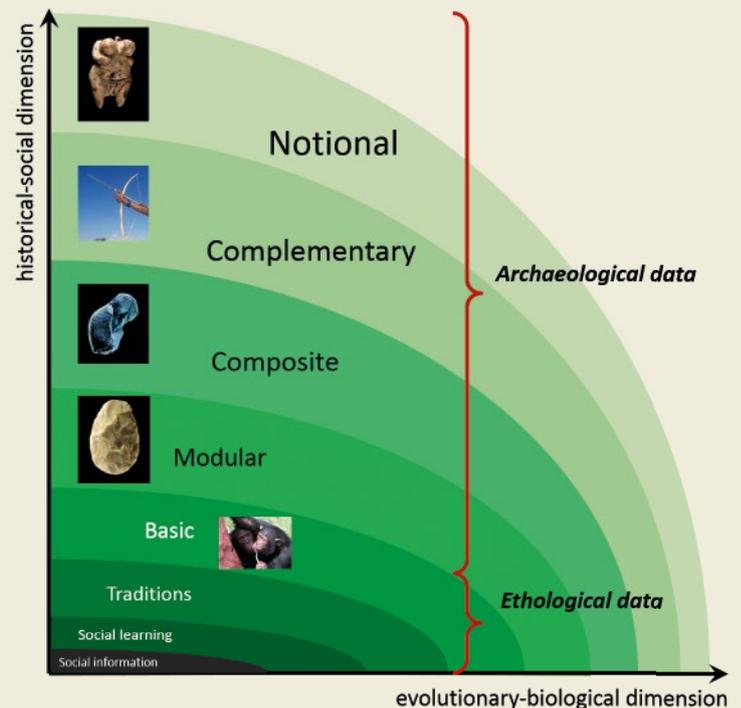


Fig. 4: The model of the evolution and expansion of cultural capacities (EECC model): eight grades of cultural capacities referring to different socially transmitted information have been identified in ethological and archaeological data (Haidle et al. 2015).

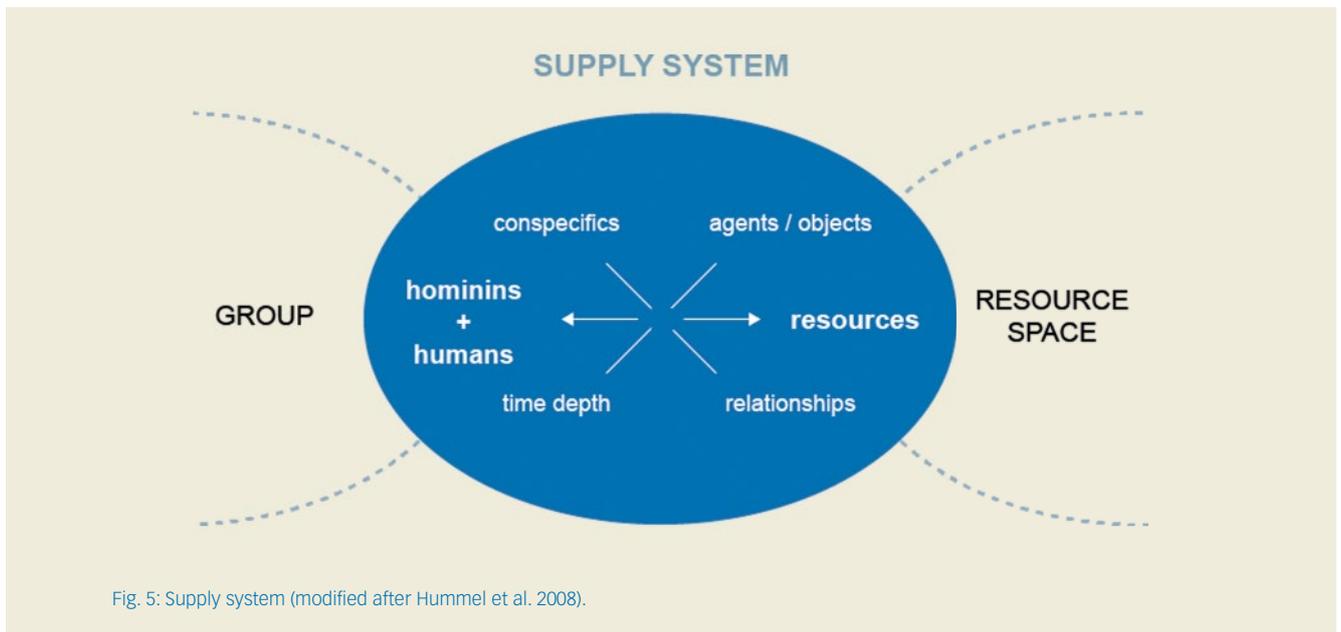


Fig. 5: Supply system (modified after Hummel et al. 2008).

tors generates different cultural capacities with specific requirements and possibilities of expression. The concept of different and developing *cultural capacities* is a more appropriate approach for studying the evolution of cultural behavior than a simple assessment for the presence or absence of “culture” in certain living and extinct species. The EEE model (Haidle et al. 2015) offers a differentiated analysis of cultural evolution based on socially transmitted information, as observed in animals such as other primates, in comparison with the cultural remains of hominins. The model comprises eight grades (Fig. 4), but does not imply a progressive ladder, the climbing of which leaves lower steps behind. Rather it focuses on the expansion of cultural capacities which extends the behavioral options and repertoire, while retaining the possibilities of earlier grades.

- **Ecospace/Resource Space:** Hominins selected specific environments according to resource availability and their capabilities of accessing and extracting resources. Such environments can be characterized in several steps. The ecospace describes a sphere of coexistences; the parameters of climate, vegetation, fauna and landscape forms correlate with spatio-temporal ranges occupied by hominins (Bruch et al. 2015). Their impact may have been immediate, coarse or indirect. The resource space comprises a selection of elements acting as agents or objects, such as competitors or predators, food or raw material, tools or symbionts, parasites or hosts (Haidle et al. 2015). The specific resource space may change by altering existing relationships or establishing interactions with new natural or human-made elements, and acts as a gateway for increasing cultural impact.

- **Supply systems:** Hominin groups operate various supply systems which describe systems of interactions of a group with the specific resource space (Hummel et al. 2008). ROCEEH adapted the concept with respect to the question of the *role of culture in early expansions of humans*. Supply systems are sets of elements (conspicifics, agents, objects) with specific relationships linked to specific fields of tasks such as nutrition, mobility, defense and shelter (Fig. 5). In the course of human evolution, the scope of existing supply systems increased by adding new elements (e.g., new prey species, new tools), forming new relationships to known elements (e.g., shift from prey to competitor among other predators), or exploiting relationships to elements in growing time depth (e.g., delayed access to raw material). The spectrum of supply systems broadened with artifact production and maintenance, external energy supply, and transmission of information and communication. The scope and spectrum of supply systems are dynamic with regard to human evolution. They are shaped and controlled by the expansion of cultural performances and capacities and serve as scaffolds for cultural development. In fact, as the number of components increased, relationships became more versatile and intensive, and the time depth expanded dramatically, reaching from the past and into the future.
- B) Development of methods:** To answer different questions raised by the ROCEEH project, the team developed a set of new methods above and beyond conventional procedures.
- **Cognigrams and effective chains:** By systematically reconstructing and coding attention foci, as well as actions

(*chaînes opératoires*) and effects between foci, cognigrams enable the comparison of behavior from diverse contexts (Fig. 6). This makes it possible to contrast the performances of living animals and different hominin species, analyze innovations, observe stagnation or expansion of behavioral concepts beyond the adoption of new artifact assemblages (Haidle 2012; Lombard & Haidle 2012), and evaluate cultural expansion on different levels.

- **Analysis of cultural innovations:** A better understanding of innovative processes, their origin and implementation is based on a better understanding of the novel elements within an innovation. A scheme has been developed to analyze innovative performances for novelties in form, function, material, technology of production, technology of use, and overall concept (Haidle & Bräuer 2011).
- **Bridging theory/holistic mapping:** Archaeological and paleontological sources represent fragments, or fragmentary products, of human performances. However, because they are constrained by processes of formation, preservation and eventual discovery, they represent only a fraction of the original performances in a limited form. The sources cannot speak for themselves, but rather require the reconstruction of performances and the physical, mental and behavioral characteristics involved in the different steps of interpretation. An example is shown by bridging arguments for reconstructing causal cognition (Fig. 7) (Haidle 2014). *Holistic mapping* represents an epistemological method for joining the characteristics of specific artifacts with higher ranking cognitive abilities and neuronal structures (Garofoli & Haidle 2014).
- **Tool specialization index:** To assess whether diachronic trends observed in assemblages of stone tools indicate large-scale changes in behavioral flexibility, ROCEEH applied a mathematical approach to determine the degree of specialization of tools and tool groups in a given lithic assemblage. Modifying Simpson’s diversity index, which ecologists use to calculate the natural diversity of com-

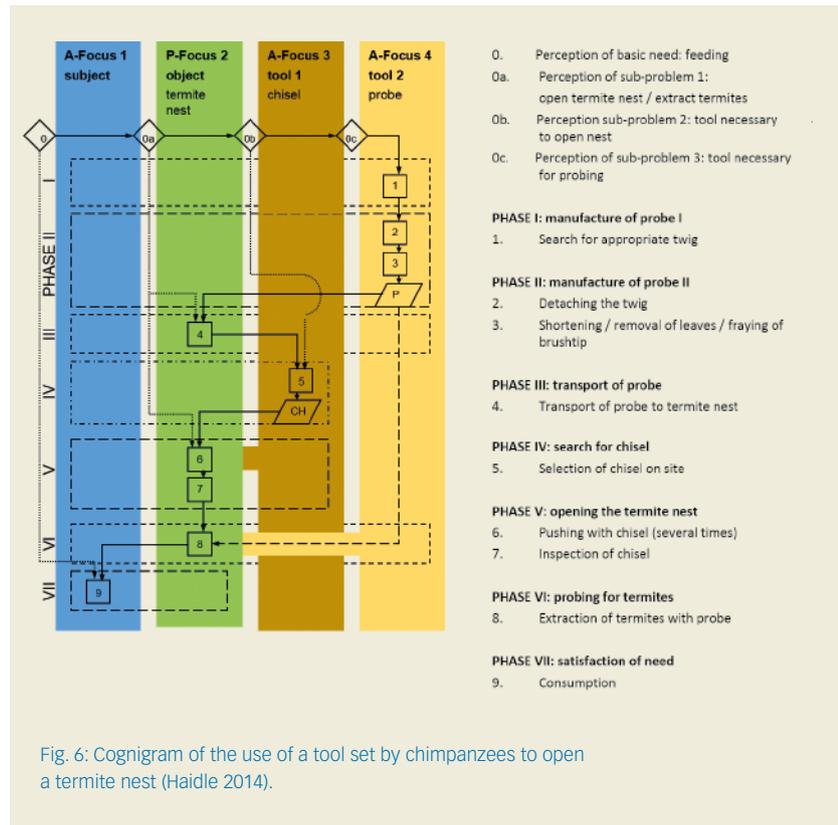


Fig. 6: Cognigram of the use of a tool set by chimpanzees to open a termite nest (Haidle 2014).

munities, we developed a method to compare the degree of specialization among different cultural complexes and evaluate the length of stay. If the calculated diversity index reflects the duration of stay at a locality, changes in the relative frequency of sites featuring low and high degrees of diversity can be interpreted as changes in land use patterns (Kandel et al. 2015).

- **Climate quantification based on small mammal assemblages:** The quantification of climate from archaeological sites has mainly been based on the analyses of plant remains with problems arising from limited preservation.

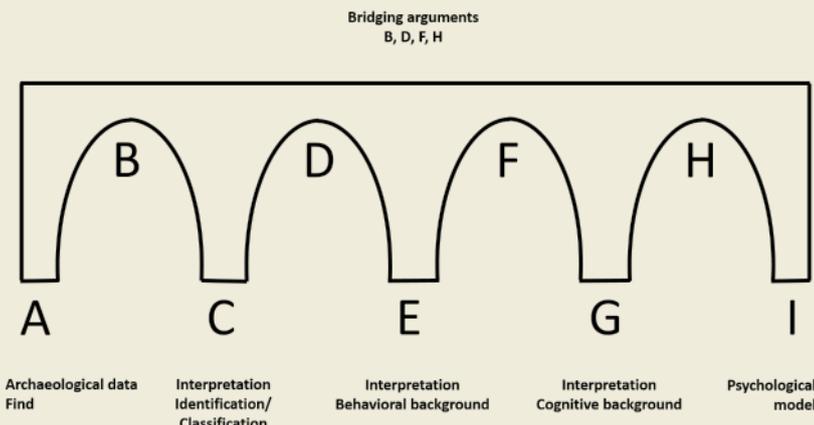


Fig. 7: Bridging arguments: from archaeological data to psychological models (Haidle 2014).

The Coexistence Approach normally used to infer paleoclimate from the bioclimatic distribution of extant plant species has now been applied to small mammal assemblages (Maul et al. 2015; Fig. 8). By combing data from plant remains with data from small mammals, we will be able to cross-validate results, obtain multi-proxy datasets and increase data coverage.

- **Quantitative vegetation analysis based on herbivore communities:** Large mammalian herbivore communities depend directly on vegetation and thus indirectly on climate parameters. Thus, the functional structure of these herbivore communities may be used to infer vegetation density and primary productivity (Kandel et al. 2015). This approach is applied to characterize various hominin environments.
- **Scenario-based approaches:** The study of specific dispersal events often does not result in the identification of a single testable hypothesis, but instead yields a series of interrelated alternative explanations (Gutmann et al. 2010). Such alternatives can be summarized and integrated in scenarios allowing for the integration of several hypotheses with differential emphasis. From the viewpoint of methodology, such scenario-based approaches are underrepresented, and many studies still search for single explanations. While such attempts result in undesirable

simplification, scenario-based approaches as developed in ROCEEH offer a sophisticated alternative.

- **Analysis of hominin dispersal based on agent-based modeling:** Hominin dispersal is directly driven and constrained by climatically induced shifts in the environment (Rodriguez et al. 2014). Agent-based modeling is an ideal tool to characterize, examine and integrate diverse hypotheses on individual expansion events (Hözlchen et al. 2015).
- **Paleo-landscape reconstruction:** Different methodological approaches emphasizing remote sensing were utilized to contribute to the understanding of the paleo-landscape development. The complex lacustrine development of Lake Manyara and its paleo-stages were investigated by delineating the extent of paleolake sediments older than 0.633 Ma with multispectral ASTER data (Bachofer et al. 2015a). In addition, lake terraces and shorelines on different levels up to 80 m above today's lake level and an outlet to the neighboring Engaruka basin were detected by analyzing the backscatter intensity of TerraSAR-X data (Bachofer et al. 2014). The distribution of topsoil (Bachofer et al. 2015b), identified from multisensoral remote sensing datasets indicates soil formation, as well as erosional and depositional processes. The methodology was also successfully adapted for sites in Ethiopia (Melka

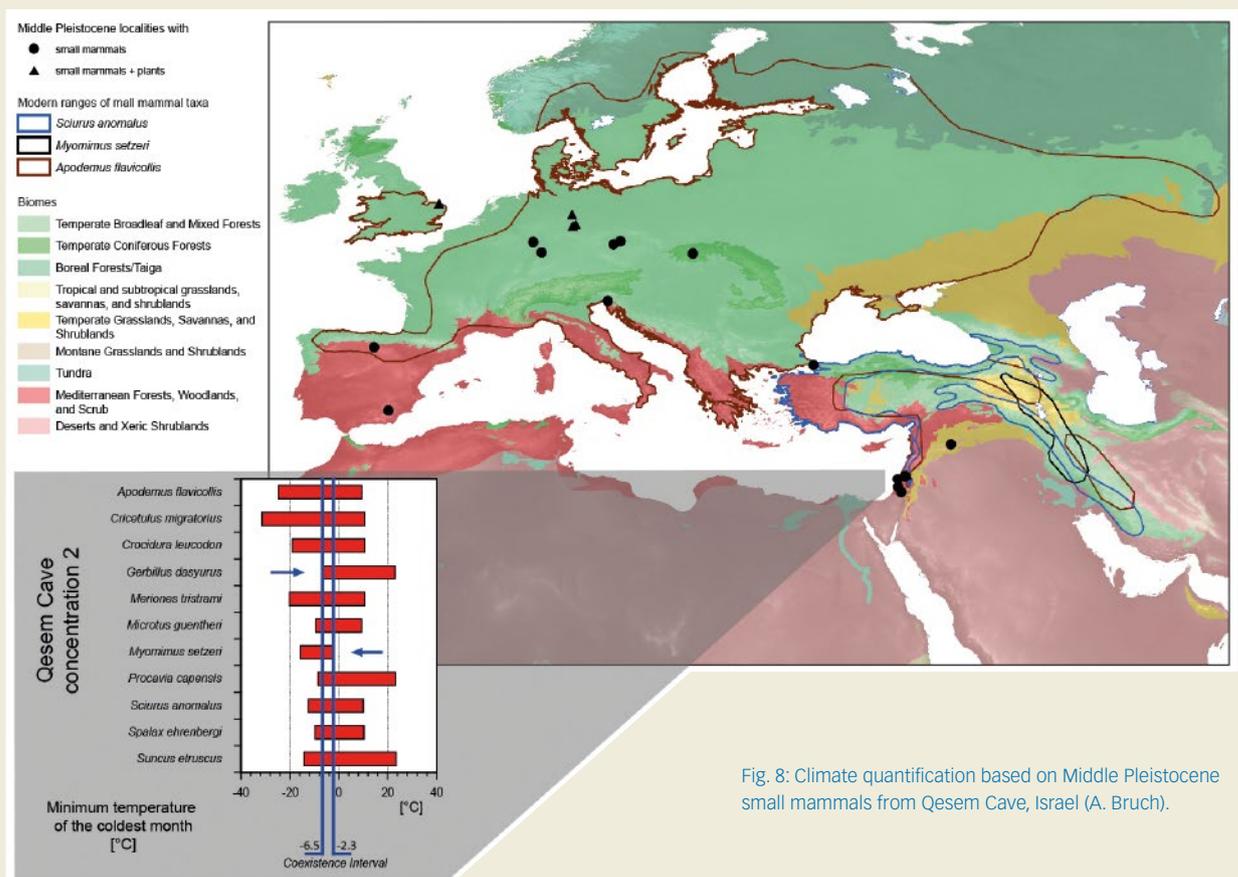


Fig. 8: Climate quantification based on Middle Pleistocene small mammals from Qesem Cave, Israel (A. Bruch).

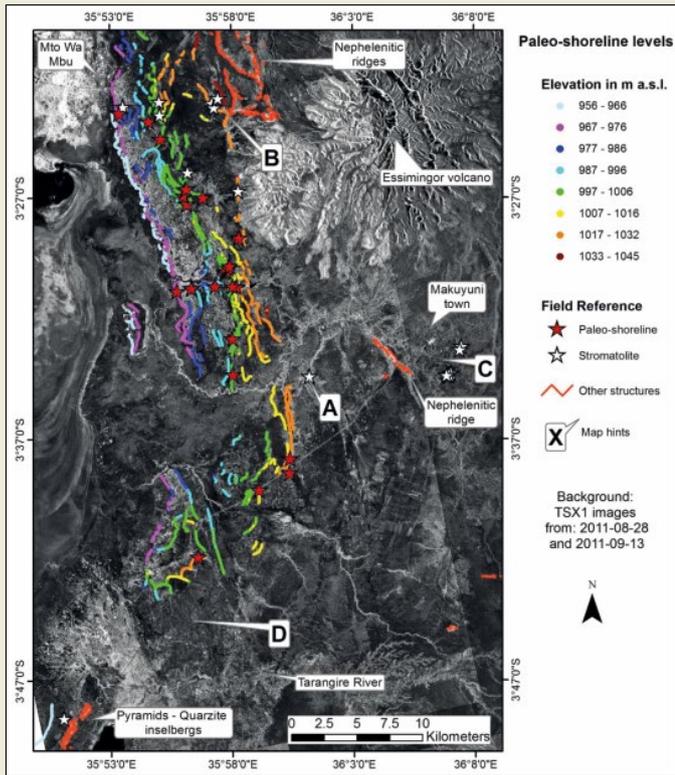


Fig. 9: Identified levels of paleo-shorelines east of Lake Manyara, Tanzania (Bachofer et al. 2014).

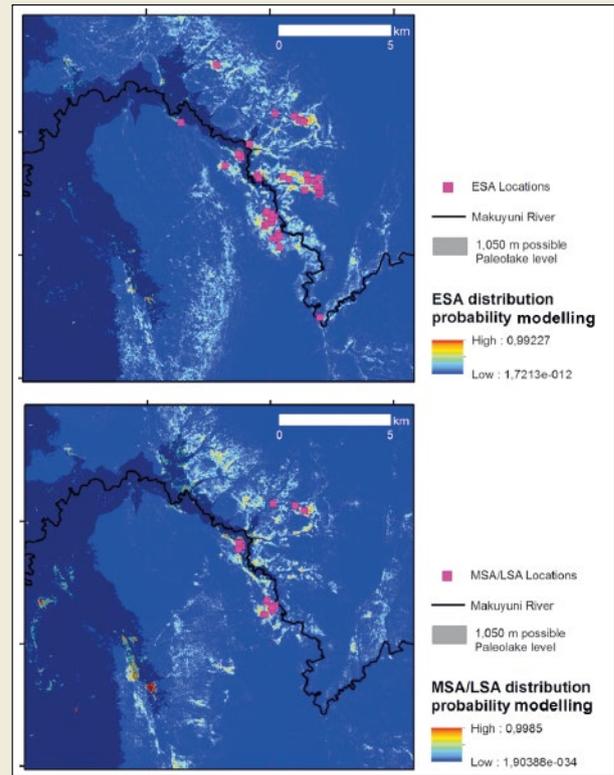


Fig. 10: Probability modelling of the distribution of ESA and MSA/LSA sites in the Makuyuni area, Tanzania (G. Quéhéhérvé).

Kunture), the United Arab Emirates (Jebel Faya) and southern Africa (Fig. 9).

- **Archeological site prediction:** Fossils and artifact find locations were characterized using high resolution DEM information (e.g., ALOS PRISM and SRTM-X) and multi-spectral data derived from ASTER images as predictor variables. Subsequently, different stochastic and machine based learning algorithms were tested, such as support vector machines, boosted regression trees and statistical mechanics approaches (Maxent). Study cases of early hominids sites in Tanzania (Fig. 10), South Africa, Iran, Ethiopia, as well as for Neanderthals in Europe, show the potential of this methodology (Märker et al. 2010; Märker et al. 2011; Kandel et al. 2015). Site predictions allow for a better organization of fieldwork and enable the development of new hypothesis for understanding the spatial expansion of early hominids.

**C) Data generation and compilation:** ROCEEH pursues four types of data acquisition.

- **Fieldwork:** Surveys and excavations at selected locations yield primary data. Although this time consuming work offers just a small glimpse of the entire picture, direct

engagement in the field provides us the opportunity to keep up with developments of field methods essential to evaluate data, generate new ideas for analyses, and establish contacts with other researchers. We select research areas based on their potential to deliver important new findings that will help us answer questions about the origins and interactions of cultures. By contributing primary data, ROCEEH's field projects allow firsthand interpretations of evidence that expands our understanding of the *role of culture in early expansions of humans*. The following paragraphs summarize some of our key findings.

- **Middle Stone Age Culture in Southern Africa:** Southern Africa represents a key region of ROCEEH's field work because of its critical importance in understanding the adaptations and expansions of modern humans during the Middle to Late Pleistocene. Field seasons included regional landscape surveys and geomorphological reconnaissance, prospection for new potential sites, archaeological excavations, and multidisciplinary analysis of a variety of faunal and botanical remains, geological materials and archaeological finds. Work at Sibudu (KwaZulu-Natal), for example, inspired studies on the quantification of climate, short-term behavioral change in the MSA, and MSA lithic technology (Bruch



Fig. 11: Fieldwork at Hoedjiespunt, South Africa (photo: M. Ecker).

et al. 2012; Will et al. 2014; Conard & Will 2015); excavations at Hoedjiespunt (Western Cape) (Fig. 11) led to examinations of early coastal adaptations (Will et al. 2013; Kyriacou et al. 2015).

- The Rift Valley as a Dispersal Corridor (Early and Middle Pleistocene of East Africa):** Eastern Africa represents a core region of ROCEEH's field work to assess the ecospace of early hominins. The target areas for fieldwork are linked by the eastern arm of the East African Rift System. The sites studied by ROCEEH members are late Early and early Middle Pleistocene



Fig. 12: ROCEEH field school sieving for fossils in a gully system of the Lake Manyara region, Tanzania (photo: A. Gonschior).

in age. The array of methods and approaches includes archaeology, paleoanthropology, paleontology, paleoecology, and reconstruction of paleo-environments and paleo-landscapes. A focus lies on understanding the interdependencies of human presence and the development of lakeshore environments during the Middle Pleistocene of the Lake Manyara region in Tanzania (Fig. 12) (Kaiser et al. 2010; Frost et al. 2012; Bachofer et al. 2015a; Flores-Prieto et al. 2015; Giemsch 2015). Current geographical fieldwork at Melka Kunture, Ethiopia supports the understanding of Pleistocene landscape development by flooding, soil erosion, sediment transport and deposition, volcanism and tectonics.

- Early Pleistocene – Caucasus, Iran and the Western Mediterranean:** The Caucasus represents another key region for ROCEEH's field work and aids our understanding of the environmental context of early humans during the Early Pleistocene Out-of-Africa expansions. Besides a strong focus on paleobotanical and palynological research (Fig. 13), archaeology, large mammal paleontology and paleogeography are also examined to provide an overview of the environmental history of the region. All field seasons included survey for new potential sites in adjacent areas. The comparison with data from the Western Mediterranean (southern Spain) will shed light on potential corridors of early human expansions into Europe. Environmental reconstructions resulting from this field research help us to better understand the landscape near Dmanisi as the global climate changed (Scharrer 2013; Bruch et al. 2014; Kirscher et al. 2014).
- Middle to Upper Paleolithic Transition in Southwest Asia:** Southwest Asia, including the Caucasus, the Levant and Arabia, constitutes another core region of ROCEEH's field work. This region is critical to



Fig. 13: Examination of Early Pleistocene stratigraphy in Armenia (photo: A. Gonschior).



Fig. 14: Early evidence for the production of clothing: a fragment of an eyed needle from early Upper Paleolithic layers at Aghitu-3 Cave, Armenia (photo: D. Arakelyan).



Fig. 15: The skull of a wolf found at Aghitu-3 Cave, Armenia. The mandible, seen in the lower portion of the photo, showed cut marks, clear evidence that humans impacted this find (photo: A. Taller).

understanding the adaptations of Neanderthals and the expansion of modern humans during the Late Pleistocene. Field seasons included regional landscape surveys and geomorphological reconnaissance, prospection for potential new sites, archaeological excavations and multidisciplinary analysis of a variety of finds such as stone artifacts, faunal and botanical remains, bone tools, shell beads, pigments and geological materials. Current research focuses on Sefunim Cave in Israel, with a large assemblage of shell ornaments, on Jebel Faya (UAE), with its well-stratified archaeological sequence and detailed environmental contexts (Bretzke et al. 2013), and Suhailah (UAE), with evidence for Middle Pleistocene occupation. Another focus is on Aghitu-3 Cave in Armenia, a site which yielded evidence for the early manufacture of complex clothing (Fig. 14) and an early Upper Paleolithic relationship with wolves that we tested by means of morphometric, genetic and isotopic studies (Fig. 15) (Kandel et al. 2012; Gasparyan et al. 2014; Kandel et al. 2014).

■ **Middle to Upper Paleolithic Transition in Europe:** Europe is an important region for ROCEEH's field work. Europe is the stage for different range expansions and cultural developments of both Neanderthals and modern humans during the Middle and Late Pleistocene. Cave sites of the Lone and Ach valleys in the Swabian Jura, Southern Germany are emphasized as research areas yielding the earliest evidence of mobile art (Fig. 16) and musical instruments (Conard 2009; Conard et al. 2009; Conard & Malina 2015). Annual field seasons with excavations at Hohle Fels and other cave sites also include regional landscape surveys and geomorphological reconnaissance, geophysical investigations and prospection for new potential sites. Additional field

work around Mugello, Italy provides data on landscape evolution and attempts to link landscape genesis with Middle Paleolithic archaeological evidence.

■ **Hominid expansions across the Sunda Shelf and into Wallacea:** Mainland and insular Southeast Asia represent core regions for the study of the hominin expansion processes. Hominins dispersed from the Southeast Asian mainland across the Sunda Shelf and into Wallacea several times. Various hominin species accomplished such dispersals at different points in time throughout the Pleistocene. Examining the ecological framework of such expansions permits the comparison of behavioral constraints of various hominin taxa and increases the understanding of the behavioral capacities at different

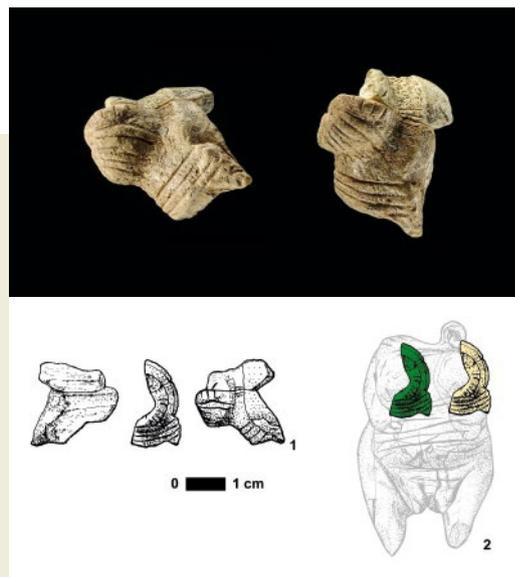


Fig. 16: Fragment of an ivory figurine from Hohle Fels, Germany, and the reconstruction indicating the presence of a second Venus (photo: J. Lipták; reconstruction: M. Malina).

times. Field work has started at Sangiran, Java and at Majalengka, a late Early Pleistocene locality in West Java.

- **Examination of assemblages in collections:** Additional data is obtained by the analyses of botanical, faunal and archaeological remains from other projects and of assemblages in collections, for example at the University of Tübingen, the Senckenberg Research Institute, the Georgian National Museum in Tblisi, Iziko South African Museum in Cape Town, the National Museum of Kenya in Nairobi, the National Museum of Tanzania in Dar es Salaam, the Geological Research and Development Centre in Bandung, the Paleontological Department of the Bandung Institute of Technology, and the Dubois Collection at Naturalis in Leiden.
- **Literature research:** The broad spectrum of ROCEEH's research on early human expansions in different fields spanning from more than 3 million until 20,000 years ago in Africa and Eurasia necessitates that we devote considerable resources to literature research. Reviews of range expansions (Hertler et al. 2013; Bolus 2015) form a background to integrate more specific studies. A major amount of the data used by ROCEEH especially for supra-regional, diachronic and large-scale interdisciplinary studies stems from literature and is systematically collected to complete the ROCEEH Out-of-Africa Database (ROAD, see below). By the end of 2015, datasets that incorporate geographical, stratigraphical, archaeological, paleoanthropological, paleoecological and bibliographical information were entered into ROAD from 5209 assemblages at 1508 localities.
- **Cooperation with existing databases:** ROCEEH attempts to link the ROAD database with databases of other large

projects. The aim is to connect data collections with differing areas of interest and thus expand the range of possible interdisciplinary and large-scale approaches. So far, cooperation with two external databases, the NEOTOMA Paleocology Database and the Neogene-Quaternary Mammals Database (NQMDB) have been established.

- D) **ROCEEH Out-of-Africa Database (ROAD):** Since ROCEEH required a specific data infrastructure to store, manage, manipulate and visualize different data types and formats, we developed ROAD as our own central, web-based georelational database. The database integrates geographical, stratigraphical, archaeological, paleoecological, paleoanthropological and bibliographical information on archaeological and paleontological sites in Africa and Eurasia from 3 million to 20,000 years before present. ROAD allows for the assessment of prehistoric habitats, as well as the dynamics of early human expansions, from archaeological and paleoanthropological perspectives. ROAD enables the various disciplines to access and query all data and visualize them in a geographical framework. With its GIS functionalities, ROAD is an essential prerequisite for illustrating spatio-temporal information at different scales, leading to the visualization of complex expansion dynamics. ROAD is currently available to the public with limited user rights through the project website ([www.roceeh.net](http://www.roceeh.net)). Associated researchers can access selected parts of ROAD in order to enter, query, visualize and analyze data within the framework of their research questions; however, for now full access to ROAD is restricted to the ROCEEH team. ROAD is intended to provide open access to closed datasets of published research questions for further analyses. For technical details of ROAD see the ROAD Brochure (2015) on [www.roceeh.net](http://www.roceeh.net).



Fig. 17: Archaeological survey in the Geelbek Dunes (photo: L. Giemsch).

**Quality control** is a major issue in the maintenance of ROAD. Regular checks for inconsistencies in data entry are conducted. An important module for data control e.g. allows geological profiles to be depicted as interactive graphics with detailed information about the individual geological layers, while simultaneously showing the correlated archaeological profile. Differing attributions, e.g. of hominin fossils to taxa, are recorded; some data is completed by comments about the rating of reliability and integrity. Multiple entries of different quality, e.g. about the dating of an assemblage, are included to reflect the ambiguity of the data and to enable individual interpretations. Therefore, it is often not possible to get easy answers to “simple” questions just by querying the database. ROAD is a **tool for research**, and the results of queries have to be critically reviewed to match with the individual research question. The growing data set is the basis of many of ROCEEH’s case studies, but it is also open to research questions of other researchers. Additionally, ROAD can be used as an interface to link data collections from other projects and make them available to the international research community. The connection of the Neogene–Quaternary Mammals Database to a user surface in ROAD shows how ROAD can be used as a meta-database to meaningfully evaluate external data without the owners of the data giving up their rights and without duplicating data collection. Thus, ROAD is also a **tool for networking**. In future, it is intended to intensify the cooperation with other large database projects such as the Collaborative Research Center SFB 806 “Our Way to Europe”.

**E) Selected case studies:** Case studies in ROCEEH’s research range from micro-scale studies of specific archaeological or paleoenvironmental assemblages or specific problems of various kinds of hominins in a certain region to their integration in broader frames. Macro-scale approaches represent a growing focus tracking developmental dynamics of single fields of expansions, interactions between them, and dynamics of these interactions. Here, only some examples can be presented. For more detailed information please go to [www.roceeh.net](http://www.roceeh.net) to browse the lists of publications and of field projects, or to explore current ROCEEH activities in our Newsletters.

– **MSA in Southern Africa:** Site specific or regional studies such as those on assemblages from Hoedjiespunt (Will et al. 2013; Kyriacou et al. 2015), Geelbek Dunes (Fig. 17) (Fuchs et al. 2008; Kandel et al. 2013), Langebaan Lagoon (Kandel & Conard 2012), or Sibudu (Bruch et al. 2012; Will et al. 2014; Conard & Will 2015) contribute to an increase in basic knowledge. Summarizing studies such as that on variation in human hunting strategy and diet breadth during the MSA of Southern Africa (Clark & Kandel 2013) provide insight into the broader context, in this case, into human resource space and the supply



Fig. 18: Wooden spear VII from Schöningen, Lower Saxony, in situ – a starting point for considerations about the development of human cognition (photo: P. Pfarr, Niedersächsisches Landesamt für Denkmalpflege, CC BY-SA 3.0 de).

system of nutrition. The example of a macro-scale approach applied to the Middle Stone Age of southern Africa (Kandel et al. 2015) integrates several archaeological and paleoenvironmental lines of research. Evidence of expansion of cultural performances and also of cultural capacity without a significant expansion in either range or ecospace, and with only a slight expansion of resource space indicate increased variability in behavior. This finding initiated the development of the concept of behavioral hyperplasticity as a framework for examining cultural change during the Middle Stone Age. This framework contrasts with existing models of cultural modernity and will be further advanced in the coming years.

– **Expansion of cultural performances/capacities:** Different from the MSA focus with its bottom-up approach, this aspect of ROCEEH’s research follows a top-down development. The concept of evolving cultural capacities was first introduced in 2011 at the ROCEEH symposium on “The Nature of Culture”. Thus began an interdisciplinary discussion that resulted in a conceptual paper by several of the participants (Haidle et al. 2015). The model of the evolution and expansion of cultural capacities (EECC)

has since been applied and discussed in several case studies, such as the evolution of causal cognition (Haidle 2014), a re-interpretation of the cultural development in pre-colonial Tasmania (Haidle 2016), and contributions by several authors to the conference proceedings (Haidle et al. 2016). The model also inspired ideas for future ROCEEH research on cumulative culture and the expansion of composite technologies.

- **Cognitive evolution:** While physical and behavioral developments can be at least partially inferred from the fossil and archaeological records, cognitive evolution represents a sort of black box: theories about the development of thinking are not easily tested. With the method of holistic mapping and plausibility selection of competing approaches (Garofoli & Haidle 2014), this epistemological problem can be controlled. The systematic reconstruction and coding of activities and attention foci from archaeological remains in cognigrams, combined with bridging theory and an embodiment perspective, form the basis for ROCEEH's approach to cognitive evolution. The analysis of bow-and-arrow production and use (Lombard & Haidle 2012) gave rise to the examination of possible cognitive implications using bridging theory

(Coolidge et al. 2016). A radical embodied approach has been applied to Lower Paleolithic spear manufacture (Fig. 18) and leads to a deeper understanding of the necessary cognitive capabilities behind this behavior (Garofoli 2015a).

- **Characterization of Neanderthals:** Regional studies focusing on the Swabian Jura examined the land use patterns and spatial organization of Neanderthals (Conard et al. 2012) and discussed the demise of their cultural niche with the arrival of anatomically modern humans (Conard 2011). A broader view is offered by tracking Neanderthal dispersals out of Europe (Serangeli & Bolus 2008). The analyses of different landscape parameters of all known Neanderthal fossil sites based on stochastic modeling gives insight into the differences in site preferences of Early and Classic Neanderthals (Fig. 19) (Märker & Bolus, under review). Comparative studies on molar macrowear revealed strong eco-geographic dietary variation independent of taxonomic affinities (Fiorenza et al. 2011). An embodied approach to examine personal ornaments, for example, helps to discuss the question of Neanderthal cognitive equivalence (Garofoli 2015b). A recently started interdisciplinary comparison of the relationship between

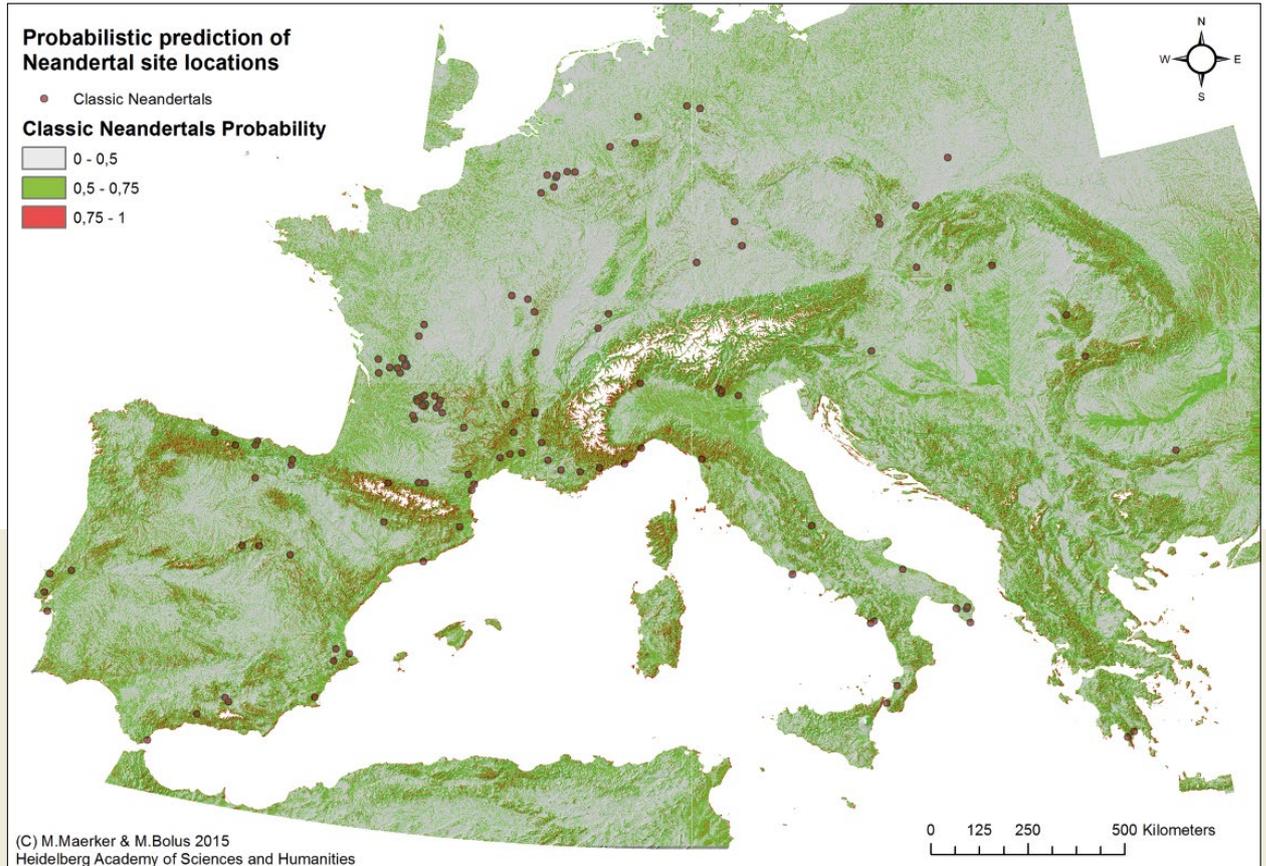


Fig. 19: Probabilistic prediction of site locations based on landscape parameters of fossil sites of Classic Neanderthals (Märker & Bolus, under review).

Fig. 20: Competitors of *Homo erectus* in Java: from top to bottom, fossils of tiger, short-faced hyena, Trinil dog and comparable living species (photos: fossils (left) – R. Volmer, animals (right) – J. Scholz).



humans and the environment in Europe from MIS 6 to MIS 5e will emphasize different adaptations to glacial and interglacial conditions.

- **Hominin meat eating and the effects of competition:** A shift to a higher proportion of meat in the diet represents one of the key events in the early evolution of hominins. We set up a functional model which permits the examination of the relationship between prey and predator communities in various ecosystems. This model analyses shifts in the predator guild as a function of competition (Volmer et al. 2016) and characterizes the role of hominins in carnivore guilds (Fig. 20).
- **Hominin dispersal events and their relationship to habitat selection:** Hominins did not arbitrarily inhabit just any kind of environment; instead, they selected specific habitats according to their performances and the resource

equipment accessible to them. We examine such relationships in various case studies, for instance along the Rift Valley in East Africa (Kaiser et al. 2010; Bachofer et al. 2014), in the Caucasus and the Middle East (Bruch et al. 2014; Maul et al. 2015) and Southeast Asia (Hertler et al. 2013).

### III. SCIENTIFIC SERVICES, INTERACTION AND PUBLIC OUTREACH

ROCEEH is a long-term project that can reach its objectives only through continuous exchange of ideas, methods and data. In addition to cooperation with specialists working on similar questions, ROCEEH addresses scientists with transdisciplinary perspectives on the question of “becoming human”, trains students in adjacent fields of research and informs the general public. To support the transmission of knowledge we follow several tracks (Table 2):

**A. Linkage of ROCEEH with other projects (ROAD and other databases):** In the last years we established close ties with NECLIME, an international open network of paleobotanists, the Neotoma Paleocology Database, the INQUA project “Modelling human settlement, fauna and flora

dynamics in Europe during the Mid-Pleistocene Revolution (1.2–0.4 Ma)”, the Neogene–Quaternary Mammals Database, and the Collaborative Research Center SFB 806 “Our Way to Europe”.

- B. Compilation of data:** ROCEEH integrates data from smaller projects into ROAD to complement its own data collection, as well as secure accessibility and increase visibility and use of other datasets. Additionally, the ROAD database is used as a source and for storage of data by other projects.
- C. Open access to closed data sets:** In the near future ROCEEH intends to provide open access to closed datasets of published studies for further analyses.

Year	Publications				Cita- tions (ISI)	Conference contributions			Graduates			Third party funding
	ISI- listed	peer	non- peer	popu- lar		ROCEEH conferences	workshops/ sessions	talks	BA	MA	PhD	
2015	40	10	8	6	602	1	0/5	34	3	2	2	255
2014	15	3	10	14	435	–	1/10	41	2	3	–	345
2013	18	7	8	8	360	–	2/4	38	1	5	5	460
2012	29	4	14	11	294	–	3/1	50	2	5	3	250
2011	21	13	6	11	198	1	1/2	24	–	1	1	160
2010	11	13	8	8	132	–	2/1	27	1	3	2	–
2009	11	13	6	26	44	1	–	23	–	2	–	–
2008	14	11	7	12	8	–	2/1	28	–	1	–	–
<b>Sum</b>	<b>160</b>	<b>74</b>	<b>67</b>	<b>96</b>	<b>2073</b>	<b>3</b>	<b>11/24</b>	<b>265</b>	<b>9</b>	<b>22</b>	<b>13</b>	<b>1470 k€</b>

Table 2: ROCEEH's output by number.

**D. Publications:** To reach a broad audience the ROCEEH team presents its results in different ways: as printed publications in ISI-listed and other journals, edited volumes and popular magazines, in conference contributions and radio talks, and in scientific advisory boards for museum exhibitions. Our aim is to increase the accessibility of ROCEEH publications by presenting our reference list on the homepage, sharing papers via Research Gate, Academia.edu or upon request, and increase the number of open access publications. The newsletters on [www.rocee.net](http://www.rocee.net) provide information on current research subjects and activities of ROCEEH. In the future a Virtual Atlas is planned for the comprehensive presentation of different ROCEEH results.



Fig. 21: Interdisciplinary discussions at the Expansions2015 conference in Frankfurt/Main (photo: J. Heß).

**E. ROCEEH conferences:** To disseminate and discuss ROCEEH approaches and results, the team of the research center organized three conferences. The first ROCEEH conference on “Human Expansions and Global Change in the Pleistocene – Problems and Methods” was held 2009 at Frankfurt/Main in cooperation with the BiK-F. The second ROCEEH conference 2011 in Tübingen focused on “The Nature of Culture” (Haidle & Conard 2011). Products of this symposium were a joint article of several participants introducing the EECC model of evolution and expansion of cultural capacities (Haidle et al. 2015) and conference proceedings discussing the issues from primatological, archaeological and paleoanthropological perspectives (Haidle et al. 2016). In 2015 the ROCEEH Conference “Expansions 2015” assembled an international group of archaeologists, paleoenvironmentalists, and modelers in Frankfurt/Main to integrate various approaches examining expansions in human evolution (Steigerwald et al. 2015) (Fig. 21). Additionally, workshops on more restricted topics with regional or thematic focus convene specialists to share ideas and data. So far, meetings have been organized in ROCEEH's offices and also in specific areas where we conduct research, for example, Johannesburg and Cape Town, South Africa, Addis Ababa, Ethiopia, and Tbilisi, Georgia (Bruch et al. 2014).

**F. Conference contributions:** ROCEEH has regularly hosted sessions at international meetings. The work of ROCEEH is presented in numerous talks and posters every year addressing a scientific audience at national and international conferences, but also in public lectures.

**G. ROCEEH teaching:** In addition to their research activities, the staff strive to impart students with the benefits and results of their work and support graduate and post-graduate students in their qualifications. Team members teach regularly at Eberhard Karls University of Tübingen and Goethe University Frankfurt/Main. They supervise Bachelor, Master, Diploma and Doctoral theses as well as archaeotechnical trainees. Graduates share their approaches and integrate their results in the ROCEEH Graduate Network. They profit from a broader referential context for their specific research questions, contacts to international specialists and participation in conferences. ROCEEH stays in close contact with former graduates in its Alumni Network.

**H. ROCEEH guest network:** At both of its offices in Frankfurt/Main and Tübingen, as well as in the field, ROCEEH regularly welcomes guests from various disciplines for short periods of some days up to research stays of several months' duration. The guests come to familiarize themselves with methods developed in the ROCEEH network, share ideas and data, analyze material, prepare publications with team members, and find an inspiring research environment. Representatives of the ROCEEH guest network include Humboldt Prize winner Prof. David Lordkipanidze and fellows of the Humboldt Foundation, Dr. Hanneke Meijer and Prof. Martin Porr. A complete list of guests is provided on [www.roceeh.net/networks/visitors](http://www.roceeh.net/networks/visitors).

## IV. ROCEEH OUTLOOK

In the coming years the project will continue to collect data, evaluate discipline-specific data, and integrate its analyses in focused case studies. While the first six years centered on Africa, the focus until 2019 remains on Eurasia. The schedule for the coming years includes data collection (Research Unit RU4a) with an emphasis on Eurasia. The same geographical focus applies to field work (RU1, RU2, RU3), with new projects planned in India, Southeast Asia, and China. From 2020 onwards, research will focus on the identification and integration of dynamics, interactions, and dynamics of interactions on the way to “*becoming human*”, modeling, and the construction of scenarios. Different from the initial proposal, research unit RU1: Human Habitat will explore the distinction between ecospace and resource space to forge a better understanding of the interrelation between environments and hominins. RU2: Hominins and RU3: Cultural Evolution have merged to better integrate physical, cognitive and behavioral aspects related to understanding the development of hominin performances and cultural capacities. Additional emphasis will be placed on spatio-temporal and taxonomic expansions of range as a distinct research topic, with increasing evidence provided from the field of genetics on the split, coevolution, movement and admixture of hominin populations over the last 400,000 years (Fig. 22).

ROCEEH gathers information on genetic evidence of hominin range expansions from the literature and also cooperates with scientists working on population genetics and ancient DNA, including Dr. Mark Stoneking from the Max Planck Institute of Evolutionary Anthropology in Leipzig and Prof. Johannes Krause from the Max Planck Institute for the Science of Human History in Jena. In dealing with genetic evidence, ROCEEH will emphasize its unique potential to set the identified range expansions in a large-scale framework of environmental and cultural factors and identify the interrelations. Several research questions are

raised, for example, by the genetic identification of the Denisovans in Siberia and their common ancestry and partial coexistence with Neanderthals. Another issue concerns their admixture with anatomically modern humans, genetic traces of which are mainly found in modern populations of New Guinea. Questions specific to ROCEEH cover the environmental conditions and timing of potential corridors of dispersal, traces of associated cultural change or continuity, and the implications for cultural capacities of the different kinds of hominins.

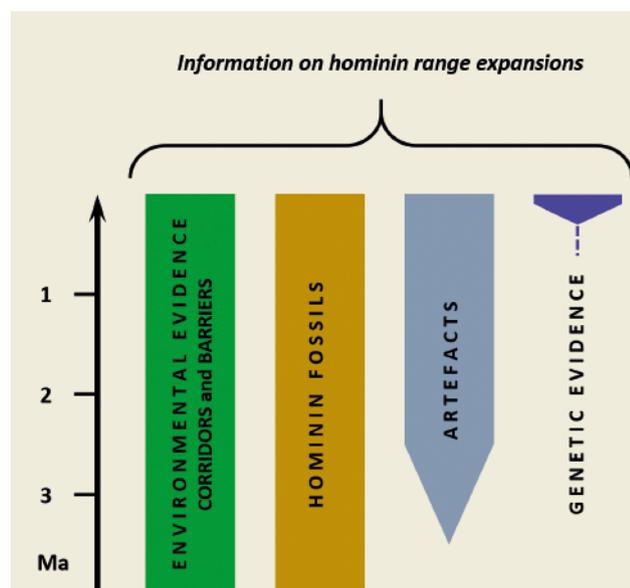


Fig. 22: Information on hominin range expansions is derived mainly from morphology and morphometric analyses of hominin fossils, from artifacts and, for the last 400,000 years, from genetics. Environmental data provide additional information about the conditions of range expansions.

Until the end of Module B “Focus Eurasia” in 2019, the research fields Hominin Ecospaces/Resource Spaces, Hominin Performances, and Hominin Ranges will emphasize specific theoretical concepts, develop and improve its methodology, and conduct selected case studies, as described below.

**A. Hominin Ecospaces/Resource Spaces:** A main theoretical issue in this research field will be the distinction of ecospace and resource space with regard to parameters, drivers and their interrelations with the expansion of hominin performances, cultural capacities and range. In this context, a focus on methodology and case studies will examine the quantification of elements within the resource space. A case study on plant resources in the Lower Paleolithic aims to develop and apply a method to quantify their availability in a specific environment on the basis of the well-studied fossil assemblages from the Early Pleistocene of the southern Caucasus (Fig. 23). The environmental conditions associated with early hominin range expansions will be central to two other case studies. First, high-resolution analysis of the Early Pleistocene regional environment before, during and after the first expansion of early *Homo* into southern Spain will help clarify the mechanisms of climatic forcing on regional vegetation. This is crucial to quantify how rapid and severe environmental change has been in this region, and if there was a fundamental change in the environmental setting that might have triggered the first occupations. The examination of links between ecospace and dispersal of early *Homo* into and within Europe will continue with ROCEEH’s participation in the INQUA International Focus Group “*METHOD: Modelling Environmental dynamics and Hominin Dispersals around the Mid-Pleistocene Revolution*”. Second, a comparative study of the ecospace of *Homo erectus* and *Homo sapiens* in Southeast Asia will provide insight into the different conditions that allowed the dispersal of these hominin groups across

the Sunda Shelf and into Wallacea. Field work in Java at Majalengka (Fig. 24) will support the case study with primary data. Faunal and botanical investigations are planned to characterize the physiography of the find locations. In Africa, physiographic studies at Melka Kunture, Ethiopia and the application of remote sensing and physical models to assess landscape stability and instability around Sibudu Cave, South Africa, and Makuyuni, Tanzania, will complete the suite of environmental studies.

**B. Hominin performances:** In the coming years, the theoretical focus of this research field will be targeted towards the characterization of interrelations in the development of body, mind and behavior, and the impact of the historical-social dimension. Thoughts on this matter will be applied, for example, in a case study examining archaeological evidence for cumulative culture. The original concept is based on shared intentionality documented in human children, but not great apes. Until now, researchers have pursued a presence-absence approach; linkage to material evidence of cultural development is sparse. In contrast, ROCEEH proposes a gradual approach based on the EECC model of the evolution and expansion of cultural capacities. Three grades of cumulative culture are proposed with increasing cumulative effects and an accelerating speed of development. The rise of composite technologies probably associated with simple donated culture represents a case study related to the model of increasing cumulative effects in cultural development. Increasing evidence of composite technology is associated with at least three hominin (sub)-species during the Paleolithic, specifically with regard to the hafting of tools, but also to compound materials such as adhesive or paint. Currently, little is known about the range of expressions and complexity, the development of these ranges throughout the Paleolithic, or the development of frequency and distribution of expressions of the concept.



Fig. 23: Fossil leaf from Early Pleistocene formations of the Vorotan Basin in southern Armenia (photo: A. Gonschior).



Fig. 24: The Early to Middle Pleistocene site MJK1a at Majalengka, Java (photo: C. Hertler).



Fig. 25: a) Grinding stone from Mumba Rockshelter, Tanzania, used to pulverize ochre (photo: Y. Hilbert).



b) map derived from ROAD data showing finds of pigments in MSA contexts in Africa (A. Kandel).

Different cognitive processes commonly associated with the ‘modern human mind’ are considered to be prerequisites for the development of composite technology. The proposed study will provide new perspectives about composite tools by integrating behavioral, cultural and cognitive analyses. Whether an increase of behavioral complexity and cognitive capacity was necessary for the development of percussive technologies in stone tool production will be explored with the help of cognigrams.

The habitual use of ochre during the MSA and Middle Paleolithic of Africa, its possible advantages, cultural associations and related demographic patterns are the center of another case study in the research field of hominin performances (Fig. 25).

**C. Hominin Ranges:** The emphasis of this research field will be on the compilation of hominin expansions of spatio-temporal and taxonomic ranges, as proposed in the literature. The aim is to develop different scenarios out of complementary or conflicting evidence to serve as the basis for further studies in Module C (scheduled from 2020–2025). A significant part of the work in this research field will be used as a starting point for integrative studies, as introduced below. Regarding the integration of genetic information, see above.

**D. Integration in the research field “becoming human”:** The theoretical and methodological discussion in this research field will focus on the dynamics of interactions, with special emphasis on the development of supply systems which link hominin groups and their specific resource

spaces. An analytical approach is taken by the development of baskets of goods. Central questions evaluate the possibilities of managing the resource supply in various ecosystems and the impact on expansions. An advanced approach of *Homo sapiens* to cope with different and changing environments can be seen in the concept of hyperplasticity, a potential substitute for the concept of “cultural modernity”. We assume that modern humans did not differ so much from other hominins in certain cultural performances, but rather in their greatly increased behavioral plasticity and flexibility, strengthened social differentiation, specialization, advanced forms of cultural transmission (donated culture), and the adoption of notional performances. The connection of these behavioral developments to other mental and physical aspects will be explored. Dynamics of interactions will also be emphasized in a comparative case study about the impact of a marked change of the ecospace triggered by global warming. The development of the relationship between ecospace, resource space, hominin performances and range in Europe from MIS 6 to MIS 5e will be explored while searching for possible special conditions in the transition from a glacial episode to an interglacial phase. The continuing study of differences in site preferences of Early and Classic Neanderthals will be expanded to include the site preferences of anatomically modern humans between 200,000 and 50,000 years ago for comparison. The testing of quantitative and conceptual approaches in modeling will be a crucial issue in the coming years of the project. This will allow for an improved understanding of the dynamics of interactions and the critical examination of advantages and constraints.

– **Spatiotemporal information system on human evolution:**

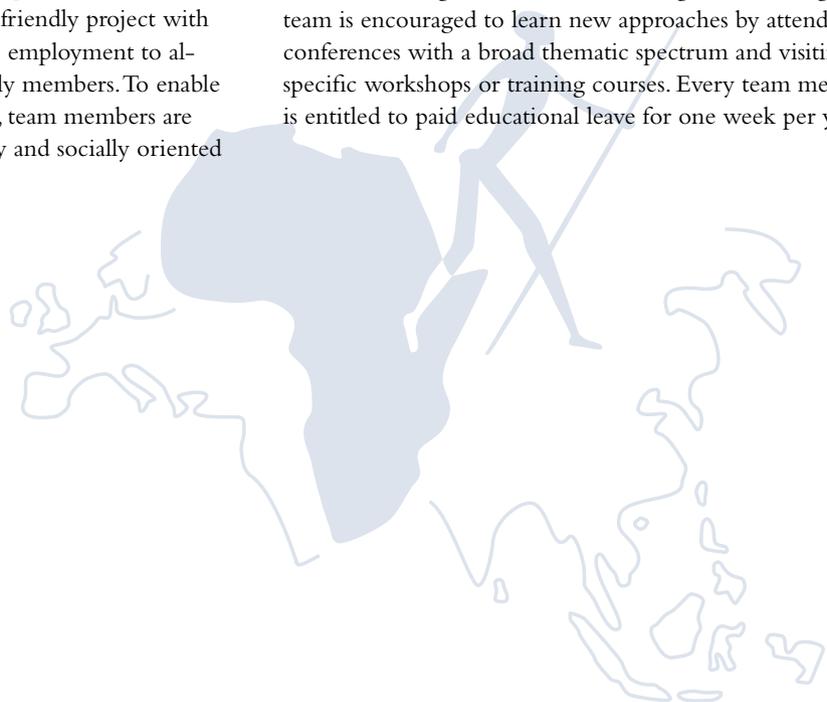
The development in this work field is projected to occur in three spheres of activity. First, the ROCEEH Out-of-Africa Database (ROAD) will focus on continuing data entry of assemblages from Eurasian localities and updating the existing data collection based on current publications. An intensification of existing cooperation and negotiation of new partnerships with other databases will be crucial for broadening the data coverage of ROAD and fostering its use beyond the ROCEEH project. Aims for the coming years include user-friendly operation with more options to work with ROAD at different user levels, enhancing search and query possibilities, and visualizing results. Web services will be improved to simplify the retrieval of specific data from ROAD, as well as the ability to perform additional operations on the data, such as summarization or statistical computation. A second sphere of activity in the coming years will be to develop web-based toolboxes for the analysis of human expansions, including GIS procedures, scenario tools, and agent-based modeling. These toolboxes can also be used by projects with a different spatial, temporal or thematic

focus. The third sphere of activity will implement a new format for the presentation of ROCEEH's approaches and results. The Virtual Atlas will introduce the theoretical background, methodological basis, and case studies, presented as small bites and organized in a hierarchical structure. Several access levels will briefly introduce ROCEEH's research questions and present results to the general public, providing an overview of the overarching concepts, methods used, sites explored, problems examined, with outcomes introduced as short summaries. The Virtual Atlas will allow a user to access further information about a desired subject in the form of pdfs or links to other publications. Links between the pages will enable a user to encounter the different research fields of ROCEEH on an individually selected path appropriate to the specific level of interest. The Virtual Atlas will combine short texts with figures, tables, and static and semi-static maps. The flexible structure of the Virtual Atlas will allow its contents to be continually adapted to the progress of ROCEEH and the current state of knowledge as data are updated, refined and corrected.

## V. ROCEEH SOCIAL COMMITMENT

ROCEEH adheres to the guidelines set by the DFG for equal opportunity employment – to achieve gender balance in the research system and make a scientific career compatible with family commitments – and these aims are pursued by the Heidelberg Academy of Sciences and Humanities, as well as both hosting institutions, Eberhard Karls University of Tübingen and the Senckenberg Research Institute. ROCEEH defines itself as a family-friendly project with flexible arrangements and part-time employment to allow care of children and other family members. To enable continuous individual development, team members are invited to participate in scientifically and socially oriented

advanced training. Situated within a broad interdisciplinary and transdisciplinary network, ROCEEH encourages its team members to develop new research fields, to raise third-party funding and to organize their own workgroups with graduates. The scientific and technical personnel maintain close contact with universities and other research institutions to exchange ideas and methodological knowledge. The team is encouraged to learn new approaches by attending conferences with a broad thematic spectrum and visiting specific workshops or training courses. Every team member is entitled to paid educational leave for one week per year.

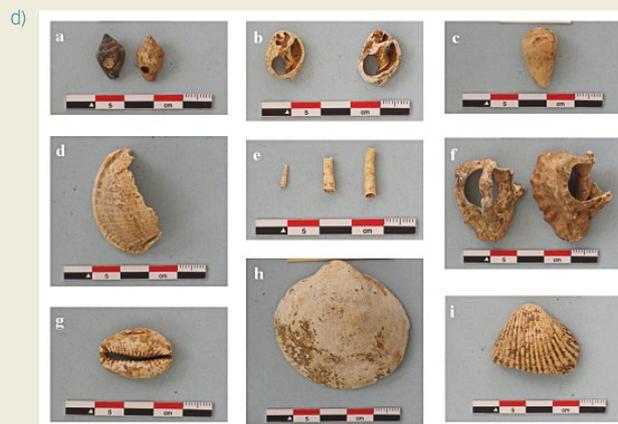
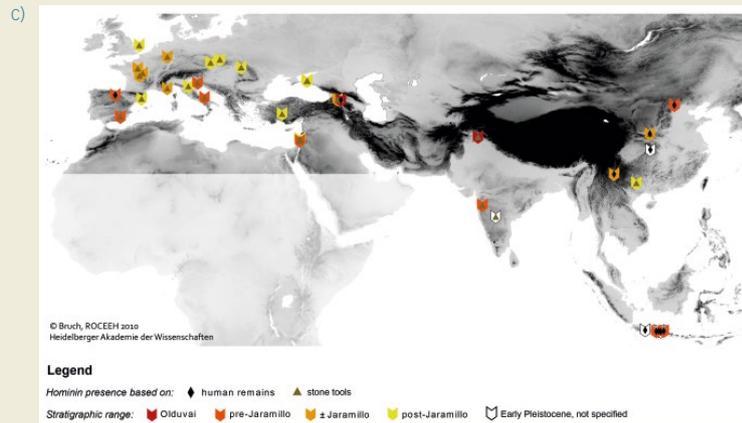


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Glimpses into ROCEEH's research  
a) Examining South African gully systems  
b) Excavation at Hohle Fels, southern Germany  
c) Early Pleistocene presence of Homo in Europe  
d) Shells from Sefunim Cave, Israel

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