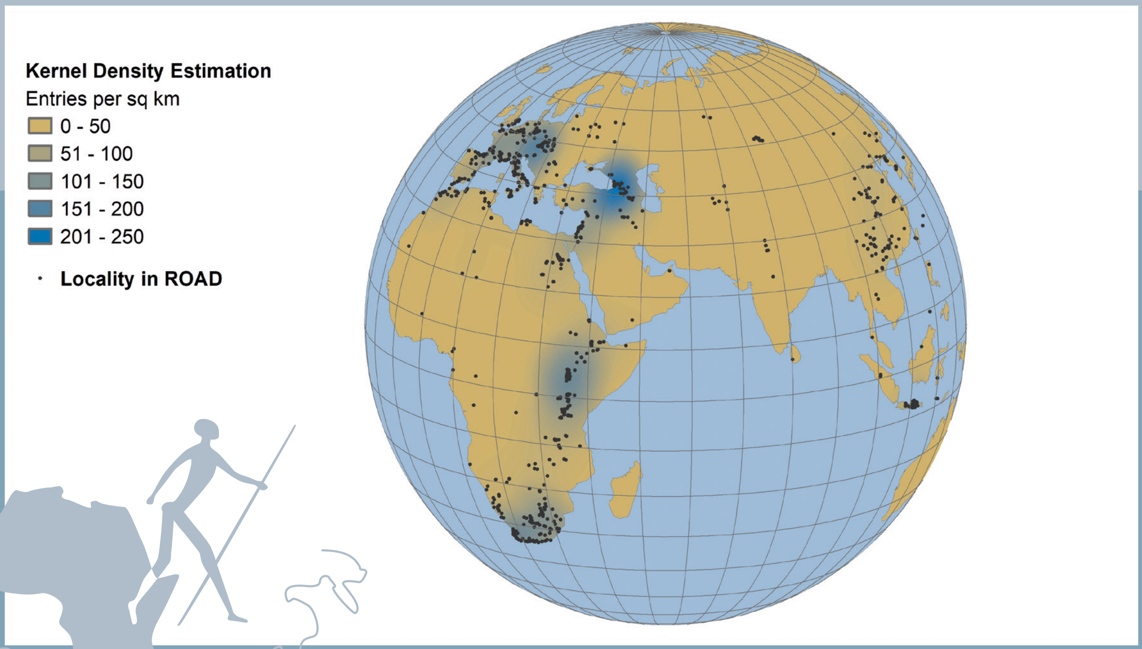
ROCEEH Out of Africa Database (ROAD) – Applications



This view of Africa and Eurasia depicts the density of data stored in ROAD as of Feb. 2018. The map shows where ROCEEH has focused its energy entering data. (Map: C. Sommer)

HEIDELBERGER AKADEMIE DER WISSENSCHAFTEN
Akademie der Wissenschaften des Landes Baden-Württemberg

THE ROLE OF CULTURE IN EARLY EXPANSIONS OF HUMANS

Foreword

In its first brochure about ROAD, the ROCEEH research team described the technical aspects of its large-scale, multidisciplinary database which contains data about the last three million years of human history. In this second brochure, we follow up by focusing on the practical applications that ROAD offers its users. ROAD provides a synopsis of prehistoric sites and cultures, opening up the deep past of humankind to further exploration. ROAD allows its users to compare, combine, analyze and visualize information about archaeological and paleoanthropological sites. We hope that ROAD will help scientists and the general public to better understand the wide spectrum of our cultural heritage.

A brief overview of ROAD

The volume of data published about human evolution and allied scientific disciplines has increased exponentially during the past 25 years. To make this information more accessible, ROCEEH developed a database called "ROAD" and created applications for its use. ROAD facilitates the study of human evolution by synthesizing evidence gathered from more than 1,600 localities and 7,600 associated assemblages (as of Feb. 2018). The localities include African and Eurasian sites dated between three million and 20,000 years ago. ROAD is a web-based relational database combining archaeological, paleoanthropological, paleontological, paleobotanical, geographical and bibliographical information in a logical and well-structured manner.

Of the sites already entered, many are of global significance. They include world heritage sites such as the Ice Age caves of the Swabian Jura in Germany, well-known for mobile art and musical instruments, as well as the famous hominin-bearing deposits of Olduvai Gorge in Tanzania. Other sites are less well-known, but just as important for studying the origins of our ancestors and their behavior. Since 2008 the ROCEEH research center systematically collects data relevant to understanding the early expansions of humans. Most of the data stored in ROAD comes from published scientific literature. A smaller portion stems from ROCEEH's own research and unpublished results of ROAD users. Along with the scientific details entered into ROAD, the bibliographic source of every dataset is recorded.

ROCEEH defines expansions as the "spatiotemporally organized distribution patterns" of hominins and artifacts, including correlations between those datasets and changes observed through time. We proposed three different types of expansion: 1) expansion of range; 2) expansion of hominin resource space; and 3) expansion of hominin performances. By considering three modes of expansion, ROCEEH has broadened the typical scientific perspective used for studying our human ancestors. However, our method does not restrict us to the mere analysis of "spatiotemporally organized distribution patterns." Rather, it allows us to examine the specific distribution of human behavioral patterns expressed through artifacts, their relationship to the environment, and their specific ecological configurations.

Such a comprehensive view of early hominin expansions requires the structured organization of data about artifacts and human behavioral patterns, as well as environmental and ecological data. Every site in ROAD has distinct geographic coordinates. Each site has its own geological stratigraphy which

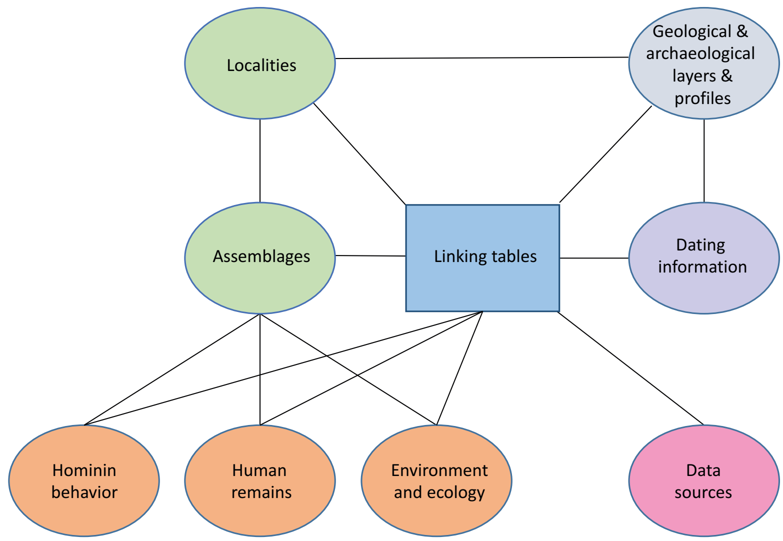


Fig. 1: A schematic depiction of the logical structure of ROAD. The colored ovals represent generalized themes contained in the database, while the central rectangle and the lines connecting it to the themes show the network of relationships.

contains layers, and each layer includes information about its age. Assemblages entered into ROAD belong within a specific layer. In this way, ROAD effectively integrates the following themes (Fig. 1):

1) Localities and assemblages: Includes spatial information about localities (sites) and details about the assemblages (collections of finds) they contain. The assemblages may stem from archaeological, paleoanthropological, paleontological and paleobotanical investigations.

2) Layers, profiles and dating information: Combines stratigraphic information and age determinations of geological layers and profiles, archaeological layers and profiles, and assemblages of different types of finds. This theme considers both absolute (radiometric) and relative dating methods to estimate the minimum and maximum age of each layer.

3) Hominin behavior: Comprises archaeological data about stone artifacts; tools made of organic materials such as bone, ivory or shell; symbolic artifacts such as art, musical instruments or ornaments; miscellaneous finds including ocher; and non-portable finds known as features.

4) Human remains: Records data on hominin fossils, anatomy, sex, and age of the individual. Varying taxonomies are collected in separate tables, a method which allows us to associate more than one taxonomic interpretation to hominin specimens and/or a group of human fossils.

5) Environment and ecology: Compiles data about the fauna and flora associated with cultural remains and hominin finds. Further information can be derived from these data, for instance, climate, vegetation, biomes and ecology.

6) Data sources: Cites bibliographic information linking publications to localities, layers, ages, and assemblages. Other references can be added, for example, the names and institutions of researchers who store data in ROAD which are not yet published.

ROAD was designed to address the specific needs of a diverse range of potential user groups. Its hierarchical user management system allows for different levels of access. Some levels can be viewed without logging in, while others require registration and login details. Scientists may wish to study and analyze different hypotheses about patterns of early human expansions. Researchers benefit from the comprehensive scope of ROAD which allows them to store their own datasets and link them to larger sets of published data. While individual data are protected, they can be made available to other ROAD users when desired. ROAD is made freely available to a wider audience beyond the realm of scientists. Public users can explore different aspects of the database by using ROADweb, and in the future, they will be able to create fact sheets about specific localities and search the Virtual Atlas. We purposely built this degree of flexibility into ROAD to make it appealing to all users.

Practical applications of ROAD

In the following sections we describe some of the practical applications of ROAD. The application methods include the following examples: simple SQL queries; a sequential analysis using our time slice tool; a practical application for our age slider tool and an associated scenario toolbox which allows users the ability to select alternative identifications of hominin taxa; enhanced mapping tools such as GeoNetwork; and an agent-based model that simulates expansions of hominin groups across the landscape. By providing these examples we hope to illustrate the diverse possibilities that ROAD offers its users. In the coming years, we plan to expand these capabilities and attract more users.

ROAD for archaeologists

We consider ROAD to be an invaluable tool for archaeologists. Not only does it store a vast amount of data about the cultural innovations of humans across a broad swathe of time and space, it offers analytical tools and other functions to query, analyze and map these large datasets within ROAD. The datasets can also be exported from ROAD and used by other programs that perform further statistical and geographical analyses, as well as modeling and simulation. In Boxes 1 and 2 we present examples of recent applications. Box 1 discusses how we queried data in ROAD to understand the increasing cognitive complexity associated with the Middle Stone Age of southern Africa. Box 2 highlights how we study patterns of the data in ROAD to better understand the emergence of ocher use in Africa.

Box 1:
Increasing behavioral flexibility? An integrative macro-scale approach to understanding the Middle Stone Age of southern Africa (Kandel et al., 2016)

The Middle Stone Age (MSA) of southern Africa represents a period during which anatomically modern humans adopted a series of diverse cultural innovations. Researchers generally attribute these behavioral changes to environmental, neurological, or demographic causes, but none of these alone offers a satisfactory explanation. Even as patterns at the site level come into focus, large-scale trends in cultural expansions remain poorly understood. ROCEEH conducted this study to review diachronic datasets from localities in southern Africa and test hypotheses of cultural and environmental causality (Fig. 2). We queried the contents of ROAD and analyzed the data to gain an understanding of large-scale variability. We designed queries to evaluate the diversity of stone tool assemblages to model site use, examine transport distances of lithic raw materials to understand patterns of movement, and assess the cultural capacities required to manufacture and use different sets of tools. We also applied stochastic models on the queried data to examine the geographic distribution of sites and reconstructed biome classes and climatic constraints.

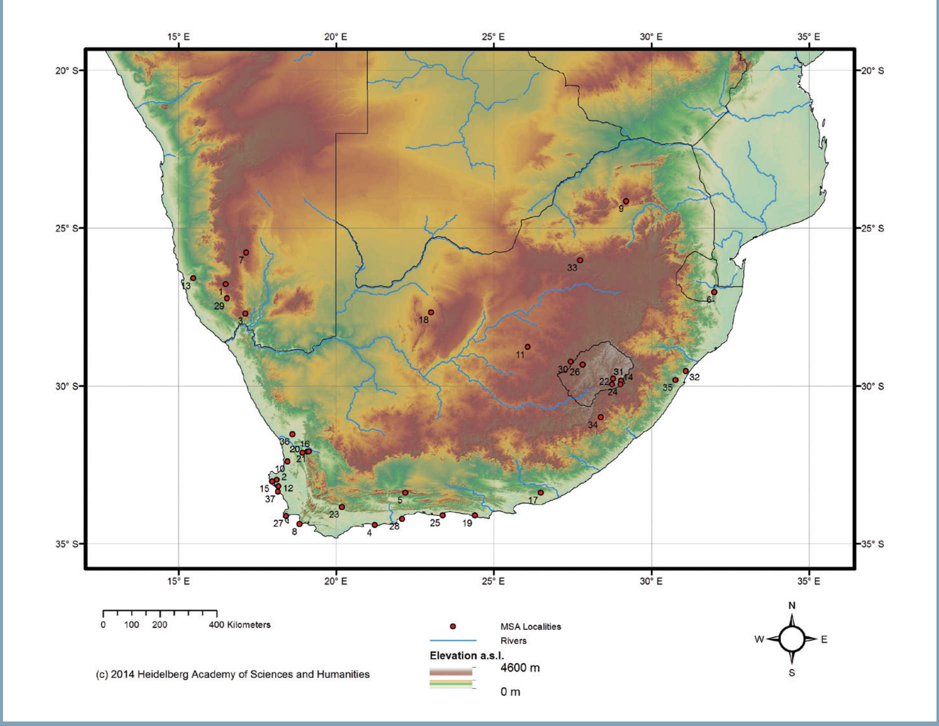


Fig. 2: Map of southern Africa showing the distribution of MSA localities investigated in this study. (Map: M. Märker)

This large-scale analysis allowed ROCEEH to integrate various datasets and gain an overview of diachronic behavioral and climatic trends. Foremost, we were able to demonstrate that the range of cultural capacities expanded during the MSA. We define cultural capacity as the behavioral potential of a group expressed through the problem-solution distance required to manufacture and use tools. Our analysis also showed that the behavior exhibited by MSA people as expressed in the archaeological record (i.e., their cultural performance) is not equivalent to their cultural capacity. In other words, although MSA people had the cognitive capacity to choose from a wide array of possible behaviors, other factors influenced their actual choices.

Box 2:
The emergence of habitual ochre use in Africa and its significance for the development of ritual behavior during the Middle Stone Age (Dapschauskas & Kandel, in prep)

ROCEEH uses the data in ROAD to study how the use of red ocher expanded across Africa during the MSA. Our study aims to understand how this behavior emerged and developed over time. We chose ocher because this material is often well-preserved at African archaeological sites (Fig. 3). Archaeologists have different opinions about the significance of ocher use. One group recognizes ocher as a practical material used for hafting stone artifacts with compound adhesives, as an abrasive material for smoothing, or for its physical and chemical properties as a sunscreen or insect repellent. The other group interprets ocher as a purely symbolic medium used for burials, personal decoration or ritualistic behavior. ROCEEH espouses both viewpoints and sees ocher as an indication of both possibilities; we assume that prehistoric people did not distinguish ocher's functional uses from its symbolic ones.

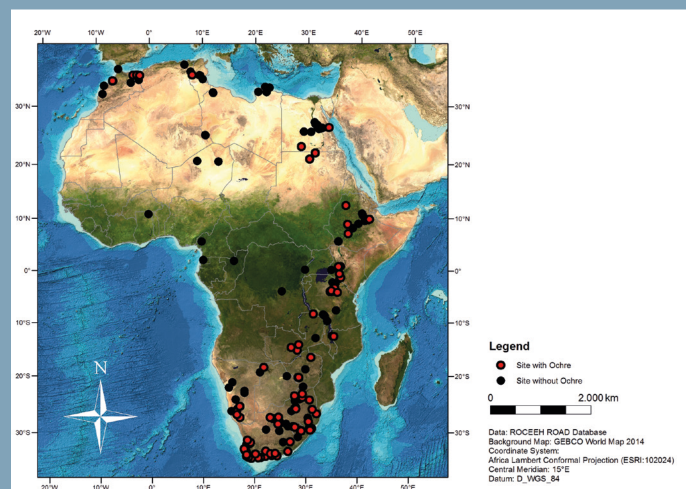


Fig. 3: Map of Africa showing distribution of sites with and without ocher which are entered in ROAD. (Map: C. Sommer)

We studied the African archaeological record contained in ROAD for indications of when and where ocher became an important part of the behavioral repertoire of archaic and modern humans. We queried ROAD to examine African sites dated between 500,000 and 30,000 years which contain ocher in their assemblages. To further analyze the data, we developed a "time slice tool" to examine large-scale patterns over different windows of time. We also varied the sampling interval to see if this would affect the results. Regardless of the time scales selected, we noted stepwise increases in the use of ocher at certain points in time. During the initial phase of ocher use starting about 500,000 years ago, ocher was present at about 10% of all sites. However, by about 100,000 years ago, ocher was present at almost half of all archaeological sites. We are currently analyzing the data to ascertain if these changes might indicate the behavior of different species of humans, different cultural preferences, human responses to climatic variability, or geographic differences.

ROAD for paleoanthropologists

ROAD also contains information about human fossils. Each hominin specimen is considered to be its own assemblage, except in cases where several bones or bone fragments unequivocally belong to the same individual. Information about a fossil may include its taxonomic designation, anatomical identification, sex and age of the individual.

We developed an application in the MapModule called the "age slider". With this tool a user can specify a time range of interest. For example, if you are interested in studying the distribution of a specific hominin taxon, you can perform a query to obtain a list of localities where this group of hominins is known to have occurred and plot their spatial extent on a map. By applying the age slider, users can examine changing distribution patterns of hominin taxa over specified intervals of time.

In the field of paleoanthropology, however, fewer things are as hotly debated as the taxonomic classification of individual hominin specimens. In ROAD users can apply their own concepts about human evolution and play with alternative scenarios. In conjunction with the age slider tool, users can test their own scenarios about hominin expansion. Thus, the user can visualize the spatiotemporal shifts in distribution patterns of hominins on a map. This method allows a user to display, examine, compare and discuss the consequences of taxonomic assignments. It also allows us to test the impact of various assumptions on expansion patterns in an intuitive way and use these data for modeling expansions.

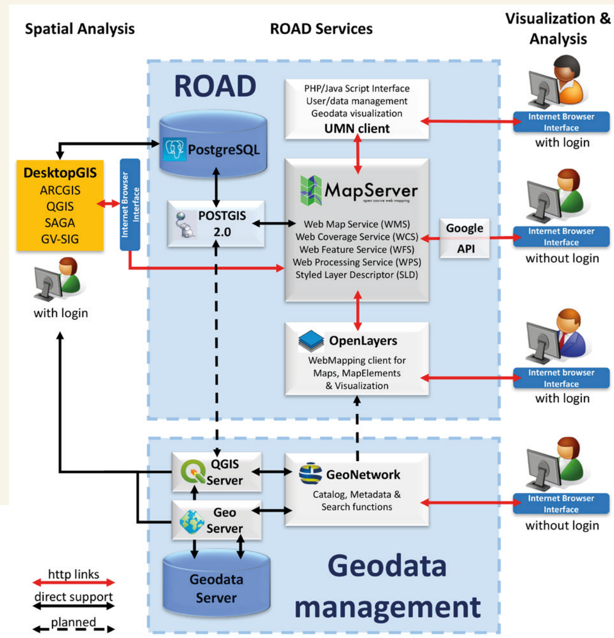


Fig. 4: ROAD infrastructure showing a variety of installed software packages for geodata management.

ROAD for geographers

In addition to the archaeological and paleoanthropological data described above, ROAD contains a vast store of geodata (Fig. 4) provided as map layers and related information (metadata). Geodata can be vector or raster data which can be arranged in composed maps and visualized using GeoNetwork, the MapModule in ROADweb, or other web mapping tools. The geodata contain basic geographic information, such as point type locations, boundaries, rivers and lakes. They can describe data about soils, geology, biomes, temperature, precipitation, ice coverage and other physiographic, climatic or cultural aspects. Similar to archaeological and paleoanthropological data, geodata are also stored in ROAD and additionally in the file system. Geodata are provided to ROAD users through the MapServer and GeoNetwork.

ROCEEH uses GeoNetwork as a management system to store metadata that describe the properties of geospatial datasets stored in ROAD. The capabilities of GeoNetwork include extended search functions which allow a user to find geodata with regard to semantic, spatial and temporal content. The GeoNetwork Catalog Service helps a user to integrate externally stored data. GeoNetwork has its own user management system to regulate different levels of access. Registered users can export geodata to their own desktop systems.

The most valuable feature of the ROAD GeoNetwork is its search function. The search function enables users to look up titles, keywords and text strings. The spatial filter allows users to select an area of interest on a map and then search for results that intersect with the spatial extent chosen. The temporal filter is useful for finding a specified time slice, such as a cultural entity or a geological epoch. Filtering for a specific resource or a given spatial or temporal scale guarantees the efficient selection of data. The search results show the selected title of the geodata, a short description of its contents, and a preview image. Furthermore, a user can visualize the selected datasets as a Web Map Service (wms) and create new WebMaps by combining further datasets.

One of the advantages of the GeoNetwork system is that metadata are stored in a standardized Extensible Markup Language (xml) file. The xml files are compatible with ISO 19115, ISO 19119 and ISO 19110 standards for spatial resources, as well as the Dublin Core standard. This ensures that users can select metadata from the ROAD GeoNetwork and then integrate them easily into their own standardized catalog. Users of ROAD benefit from the ability to integrate external datasets, such as the paleoenvironmental datasets collected by the National Oceanic and Atmospheric Administration, the Food and Agriculture Organization of the United Nations, and the European Space Agency, among other resources. In summary, the GeoServer framework allows users the ability to link geospatial data to the various datasets stored in ROAD and combine them with the powerful storage and search capabilities of GeoNetwork.

ROAD for modeling and simulation

Results queried in ROAD can be easily exported in the form of tables. These datasheets can be used to derive models or run simulations. ROAD contains viable information for different stages of modeling development. These include data for the conceptualization, implementation, parametrization and validation of simulation models. ROAD serves as a valuable source of environmental data, agent attributes and validation criteria. This information is required to conduct spatial simulation experiments, such as in agent-based modeling.

The environmental data include topographic, climatic and vegetation information. ROAD stores these maps from various sources. They include global and regional data, as well as data from various time periods. These maps can be downloaded as raster data and then implemented into a variety of agent-based simulation platforms, such as NetLogo or Repast. These are the agent-based modeling environments upon which the agents move, disperse or interact in different ways.

The agents are the acting entities and represent the organisms under study. For example, these could be hominin groups of Early and Classic Neanderthals (Box 3), fauna or plant species. The archaeological and taxonomical information in ROAD allows for the characterization of these agents by providing information about the artifacts associated with a certain locality at a particular time, a species type, or surrounding prey.

For the design of simulation experiments, we use the locality information stored in ROAD to serve as "checkpoints" for specific simulation runs, for example, to examine under what conditions hominin agents starting at locality A will reach locality B, or whether they select a certain route.

Finally, simulation results can be compared with the empirical evidence from ROAD which indicate hominin presence at a particular place at a specific time. Therefore, ROAD can be used to validate or revise simulation models. Accordingly, ROAD data can be used for other modeling approaches such as equation-based modeling, statistical modeling or least-cost path analyses.

Box 3
Modeling spatial behavior and landscape preferences of Neanderthals

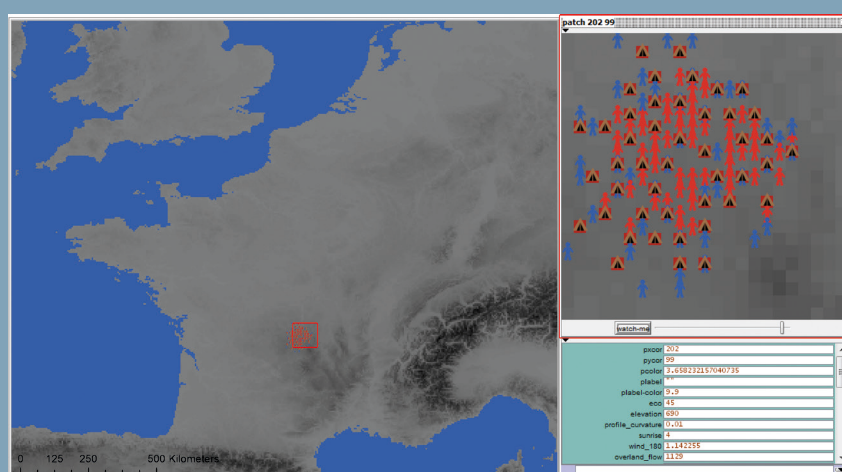


Fig. 5: NetLogo visualization of an agent-based model of Neanderthal mobility. The agents represent Neanderthal groups migrating across a topographic landscape model of France (left). Red agents move with a degree of randomness defined in the initial settings, while blue agents migrate around permanent residences, as represented by tents (upper right). Agents migrate according to topographic preference, but are constrained by their home range. Selected parameters (lower right) represent attributes of the patch (upper right). In addition to the standard NetLogo parameters which define position, coloring and labeling of the patches, the parameters show values of topographic indices, such as elevation, profile curvature, wind direction, sunrise and overland flow distance. The agents decide where to migrate based on these parameters.

The reasons for the disappearance of the Neanderthals starting about 40,000 years ago remain debated. Explanations for their demise include climatic or demographic changes, competition with *Homo sapiens* or evolutionary constraints. The degree to which the Neanderthals were affected by these factors depends on their geographic distribution, which resulted from their patterns of migration. To evaluate these hypotheses, it is necessary to study how they moved through the landscape. Because the process of migration is dependent upon space and time, we apply an approach that makes use of dynamic simulations.

We use agent-based modeling to simulate the migration of Neanderthals during different time periods and across space. An agent-based model consists of agents, an environment and rules which define the agents' behavior in the environment. In our model, the agents represent Neanderthal groups. The environment consists of grid cells, each of which has a degree of favorability related to the agents' topographic preferences based on climatic, strategic and water-related criteria. Our statistical analysis incorporates information about each fossil locality. The agents in the model migrate across the landscape according to these preferences. Furthermore, a randomness parameter may be set to prevent agents from getting stuck at places where favorability is very low.

The result is an agent-based model implemented in NetLogo. The model enables the quantitative evaluation of hypotheses about the migration of Neanderthals. For example, different starting locations and demographic scenarios can be compared in dynamic simulations. In summary, the model functions as a tool with which we can test hypotheses about the migration of Neanderthals in a controlled setting. On the basis of the results of the simulation, we can validate, neglect or revise hypotheses.

ROAD for all scientists

ROAD as data storage

Some of our colleagues have chosen to take advantage of the functionality offered by the structure of ROAD to store their own data. Especially for paleontological and paleobotanical datasets, ROAD ensures the long-term storage and easy accessibility of one's own data. ROAD offers its users the possibility of creating individual queries for conducting one's own analyses, applying the various tools provided, and assessing the spatial patterns of those data on maps. Therefore, ROAD adds value to the data stored, especially in combination with the many layers of background information provided by the database. Furthermore, information stored in ROAD can serve as basic data to conduct more derived analyses, such as climate and vegetation reconstructions, which contribute to a better understanding of early human environments.

The MapModule: Linking ROAD with external databases

ROAD represents an ambitious effort to collect and link data from a variety of disciplines with the aim of reconstructing early human expansions. We recognize that there are other ongoing efforts to collect data relevant to human expansions and that these projects often overlap with ROCEEH's scope. To avoid redundancy, we designed the MapModule to link external databases to ROAD. The MapModule provides a map interface in which query results from multiple databases can be joined and displayed (Fig. 6). This can be achieved either graphically on its map surface or as a series of tables which can be downloaded and subjected to further analysis, modeling or simulation. Individual queries are imported as separate layers, so that information about the source of data is preserved and recognizable for the user. Furthermore, the MapModule allows the application of toolboxes developed specifically for ROAD. External databases currently provide additional geographical and chronological background information about human groups, artifacts or environmental features. The sharing policies of each database are respected. If required, access to remote databases can be protected by user logins which are administered by the owners of the data. Examples of databases currently linked to ROAD include the Neotoma Paleoecology Database, the Neogene Quaternary Mammals Database, and the Collaborative Research Center, "Our Way to Europe" (SFB 806).

Fig. 6: This view combines Middle Pleistocene (130-780 ka) hominin and faunal data from ROAD with Middle Pleistocene faunal data from the Neogene Quaternary Mammals Database (NQMDB).

The future of ROAD

Locality fact sheets

To make the information stored in ROAD more accessible to the general public, ROCEEH will prepare a printable datasheet summarizing each locality. These fact sheets will provide an overview of each locality, including data about its location, layers, profiles, ages, assemblages and publication sources. To learn more about the sites entered in ROAD, public users can download a single fact sheet about a given site or even the entire volume in pdf format.

ROCEEH's Virtual Atlas

As a complement to the ROAD database and the fact sheets, ROCEEH will establish a Virtual Atlas. The Virtual Atlas is a work product that will provide details about our methodological approaches and presents results to the general public. The Virtual Atlas is an essential part of ROCEEH's vision for sustainability, allowing results to be accessed beyond the projected end of the project in 2027. The Virtual Atlas will be structured around four main topics including: 1) theoretical background; 2) methodological foundations; 3) research foci and questions; and 4) alternate scenarios of expansion. The Virtual Atlas will provide this information to the general public, as well as students and specialists, allowing its readers to keep track of ROCEEH's progress. Readers can stay in touch with the scientific state-of-the-art as content is added, refined and improved.

The Virtual Atlas will be web-based, consisting of text, figures, links to original publications and maps generated though ROAD. It will allow for different ways of accessing the respective information, for example systematically based on main research topics, thematically through a search function, geographically and chronologically. The Virtual Atlas will be flexible because of its ability to be expanded in any direction, adjusted at any stage of the work, and updated as long as the research center exists.

How to access ROAD

Exploring the system

By entering http://www.roceeh.uni-tuebingen.de/roadweb/smarty_road_simple_search.php into a browser, anyone can experiment with ROADweb (Fig. 7). Access is also possible through ROCEEH's homepage (www.roceeh.net) by selecting the tab entitled "ROAD" and proceeding to the database. By clicking on "Search" in the lower left, a public user can gain an overview of data contained in ROAD without having to log in. When activated, the map on this page shows localities and assemblages currently entered in the database. The interface allows a user to select specific localities and assemblages, different categories of assemblages, and the desired range of ages.

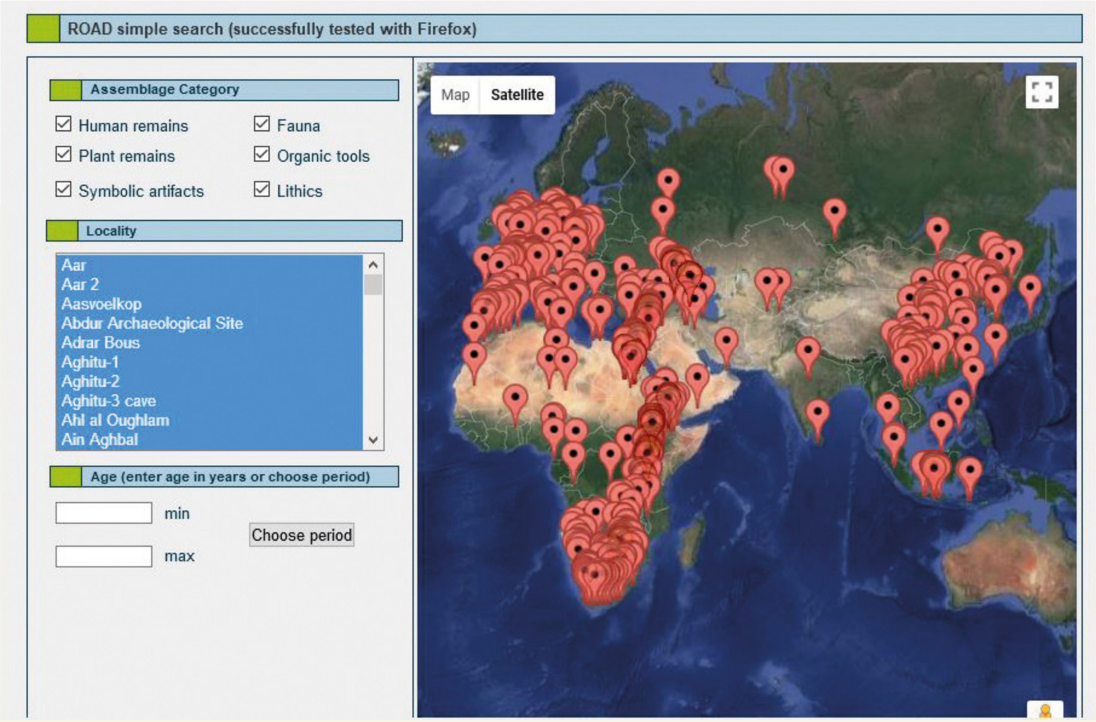
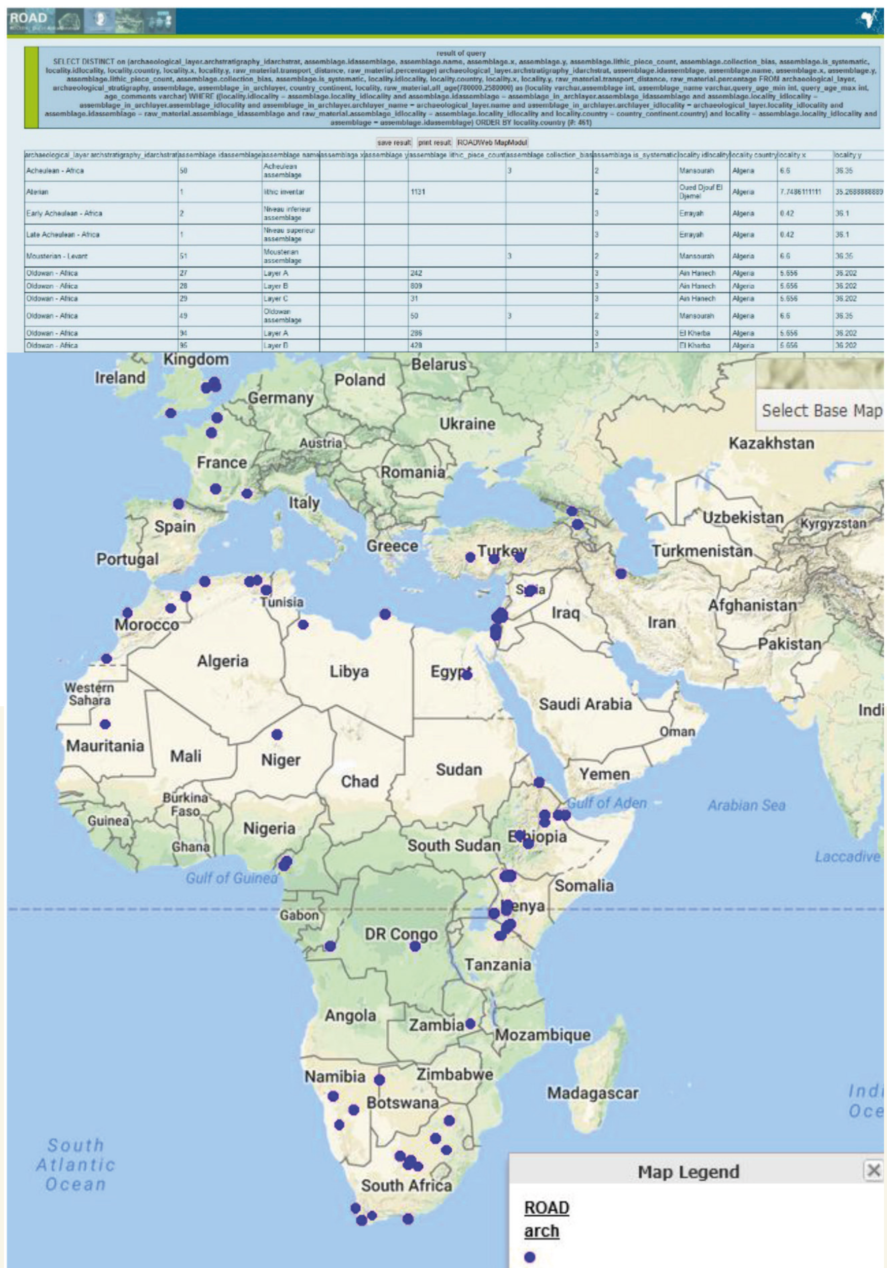


Fig. 7: This map displays all localities currently entered in ROAD. The ROADweb portal invites public users without a login to access basic services such as mapping localities and assemblages, selecting different categories of assemblages, and specifying a time period.

Customized ROAD training events

If a user requires advanced services, a personalized login is necessary. Registered ROAD users must consent to ROCEEH's data sharing policy. Advanced services might include performing data entry, writing SQL queries, or conducting detailed analyses of stored data. We offer customized ROAD training events to familiarize potential users with the intricacies of the system. In groups of five to ten people, scientists learn how they can benefit from the ROAD system. The training provides an in-depth presentation of the structure of ROAD, and allows participants to practice writing and running specifically designed queries. While ROAD itself offers users a list of prepared SQL queries, most scientists have their own questions to answer and will want to design their own queries. The results of such a query can be plotted on a map in ROADweb and exported (Fig. 8). The thematic focus of a training event, whether on archaeology, paleoanthropology, paleoenvironmental studies or paleogeography, depends on the requirements of each individual. If you are interested in attending or hosting a ROAD training event, please contact us at road@roceeh.net.



archaeological_layer.archstratigraphy_idarchstrat	assemblage.idassemblage	assemblage.name	assemblage.x	assemblage.y	assemblage.lithic_piece_count	assemblage.collection_bias	assemblage.is_systematic	locality.idlocality	locality.country	locality.x	locality.y
Acheulean - Africa	50	Acheulean assemblage				3	2	Mansourah	Algeria	6.6	36.35
Aterian	1	lithic inventar			1131		2	Oued Djouf El Djemel	Algeria	7.7486111111	35.2688888889
Early Acheulean - Africa	2	Niveau inferieur assemblage					3	Errayah	Algeria	0.42	36.1
Late Acheulean - Africa	1	Niveau superieur assemblage					3	Errayah	Algeria	0.42	36.1
Mousterian - Levant	51	Mousterian assemblage				3	2	Mansourah	Algeria	6.6	36.35
Oldowan - Africa	27	Layer A			242		3	Ain Hanech	Algeria	5.656	36.202
Oldowan - Africa	28	Layer B			809		3	Ain Hanech	Algeria	5.656	36.202
Oldowan - Africa	29	Layer C			31		3	Ain Hanech	Algeria	5.656	36.202
Oldowan - Africa	49	Oldowan assemblage			50	3	2	Mansourah	Algeria	6.6	36.35
Oldowan - Africa	94	Layer A			286		3	El Kherba	Algeria	5.656	36.202
Oldowan - Africa	95	Layer B			428		3	El Kherba	Algeria	5.656	36.202

Fig. 8: Results of a query for Early Pleistocene (0.78-2.58 Ma) archaeological finds stored in ROAD, presented in tabular format (top) and as a map in the MapModule (bottom).

Who's Who?

ROCEEH is a multidisciplinary research center sponsored by the Heidelberg Academy of Sciences and Humanities. The research center is based at the University of Tübingen and the Senckenberg Research Institute in Frankfurt/Main. ROCEEH's expertise comes from a team of cultural and natural scientists trained in the disciplines of archaeology, paleoanthropology, paleontology, paleobotany, geography and computer science (Fig. 9).

Fig. 9: Members of the ROCEEH team (from left to right and top to bottom): Prof. Nicholas J. Conard Ph.D. (speaker); Prof. Dr. Volker Hochschild; Prof. Dr. Volker Mosbrugger; Prof. Dr. Friedemann Schrenk; apl. Prof. Dr. Michael Bolus; Priv.-Doz. Dr. Angela A. Bruch; Claudia Groth; Priv.-Doz. Dr. Miriam N. Haidle (scientific coordinator); Dr. Christine Hertler; Dipl. Biol. Julia Heß; Dipl. Inf. Zara Kanaeva; Dr. Andrew W. Kandel; Priv.-Doz. Dr. Michael Märker; Maria Malina; and Christian Sommer, M.Sc. The ROAD network includes Master's and doctoral candidates, as well as post-doctoral and affiliated researchers.

Resources:

ROCEEH Homepage: http://www.roceeh.net/home/
ROADweb: http://www.roceeh.uni-tuebingen.de/roadweb/smarty_road_simple_search.php
Status Report 2016: http://www.roceeh.net/network/newsletter/
ROAD Brochure 1-2015: http://www.roceeh.net/road/roceeh-out-of-africa-database/
Dapschauskas, R. & Kandel, A.W. (in prep). The emergence of habitual ochre use in Africa and its significance for the development of ritual behavior during the Stone Age.
Kandel, A.W., Bolus, M., Bretzke, K., Bruch, A.A., Haidle, M.N., Hertler, C. & Märker, M. (2016). Increasing behavioral flexibility? An integrative macro-scale approach to understanding the Middle Stone Age of southern Africa. Journal of Archaeological Method and Theory 23, 623-668.

EDITORIAL Priv-Doz. Miriam Haidle and Dr. Andrew Kandel

CONTACT
ROCEEH Research Center Tübingen
Rümelinstr. 23,
D –72070 Tübingen, Germany
www.roceeh.net
road@roceeh.net

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
DER DEUTSCHEN AKADEMIEN
DER WISSENSCHAFTEN

March 2018