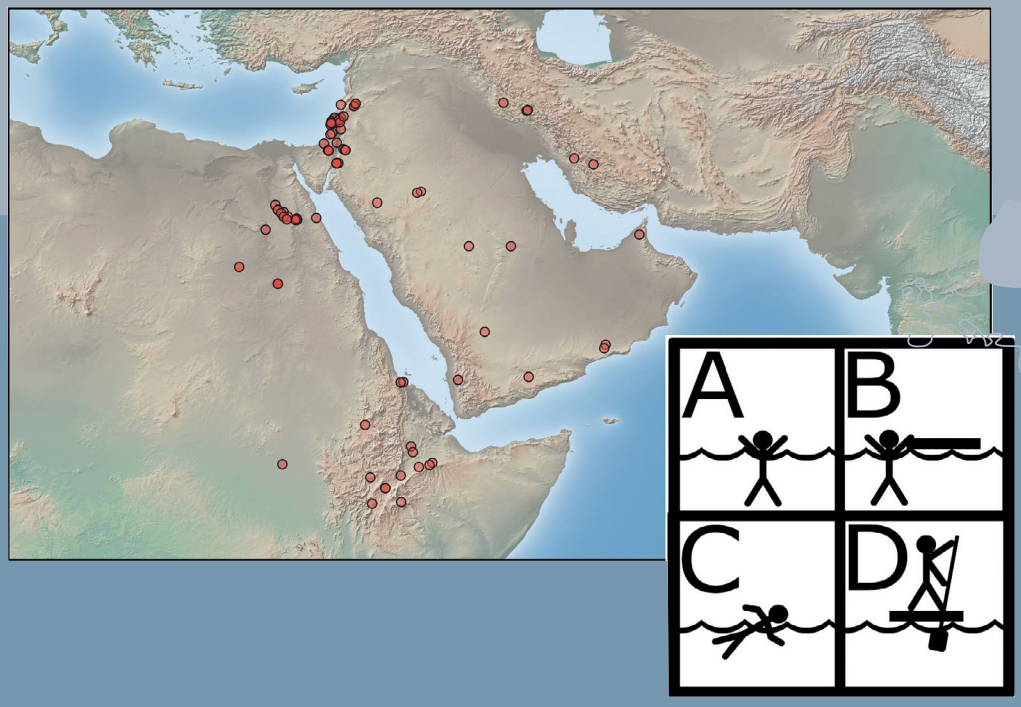
newsletter 24 | 2024

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



Evidence of human occupation on both sides of the Red Sea between 130,000 and 14,000 years ago, based on data from the ROAD database: An indicator for early human sea crossing? (Map: Cara-Maria Hirsch / Christine Hertler)

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

THE ROLE OF CULTURE IN EARLY EXPANSIONS OF HUMANS

Editorial

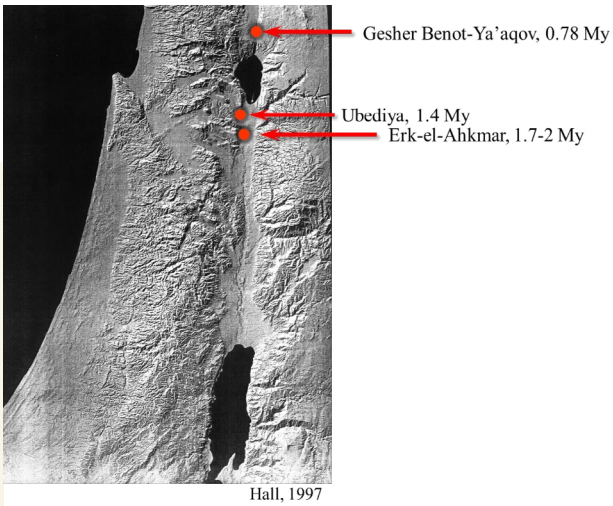
The 24th newsletter begins with the story of how ROCEEH began, describing the friendship and scientific circumstances that led to the project's conception. We then describe how ROCEEH applies agent-based models to examine whether early human expansions included the ability to cross sea straits. Next, we describe how ROCEEH's collaboration with international databases such as ARIADNE has impacted our own ROAD database. Finally, we report on ROCEEH's activities at the annual meeting of Computer Applications and Quantitative Methods in Archaeology in Auckland, New Zealand.

How ROCEEH was initiated

The story of ROCEEH starts with Professor Karl Fuchs, who first visited Israel in 1977. He was part of a German-Israeli team of geophysicists who studied the crustal structure of the Jordan-Dead Sea rift (Ginzburg et al., 1979). Karl was at that time the director of the Geophysical Institute of Karlsruhe University—a post he was to hold for 30 years. We met during the survey and kept in touch from then on. We maintained a continuous correspondence about the structure of the Dead Sea rift and its similarity to the subsurface structure of the Rhine graben in Germany.

Karl nominated me to the Heidelberg Academy of Sciences, and I was elected as a Corresponding Member in 2000. On this occasion, he wrote to me that maybe the time had come to "connect" the Dead Sea rift with the Rhine graben, given the similarity of their subsurface geological structure. When I first came to Heidelberg in 2001, I was exposed to the finding of *Homo heidelbergensis*. It intrigued me because this hominid was discovered in a rift valley similar to the *Homo erectus* that was discovered in the Dead Sea rift valley (Figure 1).

In 2002, a symposium was held in Karlsruhe in honor of Karl's 70th birthday. A special volume of papers based on this meeting was published in the book *Perspectives in Modern Seismology* in 2005 and included my article "The Dead Sea Fault and its Effect on Civilization" (Ben-Avraham et al., 2005).



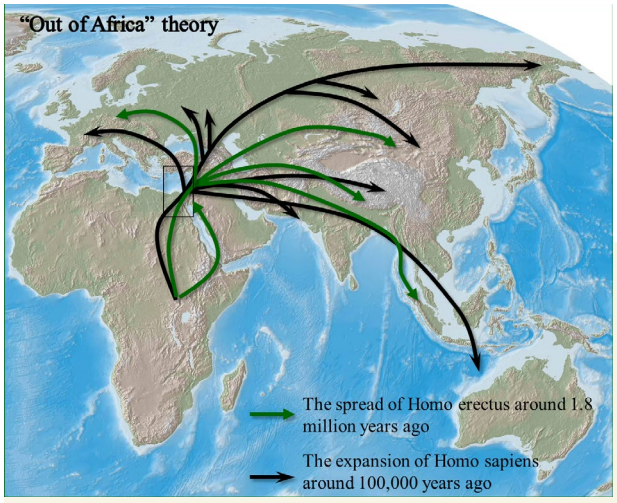
▶ Figure 1. Digital terrain model (after Hall, 1997) showing the Dead Sea in the south and the Sea of Galilee in the north. Red dots represent archaeological sites where remains of Homo erectus were found and their corresponding dates. Results of geological studies showed that the present-day deep topography of the Dead Sea rift valley, along which these sites lie, was formed some 2 million years ago and coincides with the first wave of hominids leaving Africa. As can be seen in the figure, some of the oldest sites correspond to the period after this time, leading to the question, "Was tectonics a driving force in human migration out of Africa"?

Since I was elected to the Heidelberg Academy of Sciences, I occasionally visited the Geophysical Institute at Karlsruhe University, which Karl headed. In 2004 I was awarded the L. Meitner-A. von Humboldt Research Award and was able to visit the University of Karlsruhe for several months every year. During this period, together with Prof. Karl Fuchs and Prof. Friedemann Wenzel, we discussed a possible research topic involving both the Heidelberg and Israeli Academies of Sciences to link the different disciplines relevant to the subject: geological sciences, biology, climatology, anthropology, and history. The title of the proposal was "Continental Rifting, Human Dispersals and Natural Hazards". The aim was to study the feedback mechanism at various temporal and spatial scales involved with geological processes, climate, biological evolution and development of human culture in graben systems.

For the first stage, we proposed a joint workshop, also called "Continental Rifting, Human Dispersals and Natural Hazards", to discuss the development of topography and environmental conditions that led to the hominin dispersal out of Africa through the Dead Sea rift valley (Figure 2). The invited scientists came from different disciplines and various countries. We suggested a workshop at the Heidelberg Academy of Sciences on July 15-18, 2004 to promote an international cross-disciplinary task group. The idea was to invite prominent scientists from Germany, Israel and elsewhere to discuss the unique issues of graben systems, how they affect the evolution of mankind and to develop the research agenda mentioned above.

The workshop itself was attended by 30 scientists from 8 countries and 5 different disciplines. The initial attempt made at the conference to link the different disciplines was met with enthusiasm. The first day was dedicated to keynote lectures, one in each of the core topics relevant to the project. Three working groups (time scales, links and locations) were formed and, at the end of the second day, as a result of these discussions, the first contours of a scientific plan were formulated, which was developed into a full draft on the third day.
There were indications that the Union of German Academies could provide such an infrastructure through three Academies which had already pledged support: Heidelberg (State: Baden-Württemberg), Mainz (State: Rheinland-Pfalz), Berlin-Brandenburg (State of Brandenburg and City of Berlin). Heidelberg agreed to be the Academy in charge (*federführend*). As a result, we wrote a core proposal involving several research institutions.

After the meeting, I returned to Israel. Since human migration was not part of a research topic at the Institute of Geophysics in Karlsruhe University, we considered some of the people whom we met at the workshop. Therefore, we visited the University of Tübingen in 2005 and offered Volker Mosbrugger to take the lead in the project. After a long meeting he agreed to be in charge of submitting the proposal to the Union of German Academies. Volker and his colleagues changed the emphasis of the proposal to "The Role of Culture in Early Expansion of Humans", which is how ROCEEH was created. Fortunately, the proposal was a big success and received funding starting in 2008.



▲ Figure 2. Hominid expansion out of Africa via the Dead Sea rift valley. Green arrows represent the first wave that occurred around 1.8 million years ago, while the black arrows show the modern wave about 100,000 years ago.

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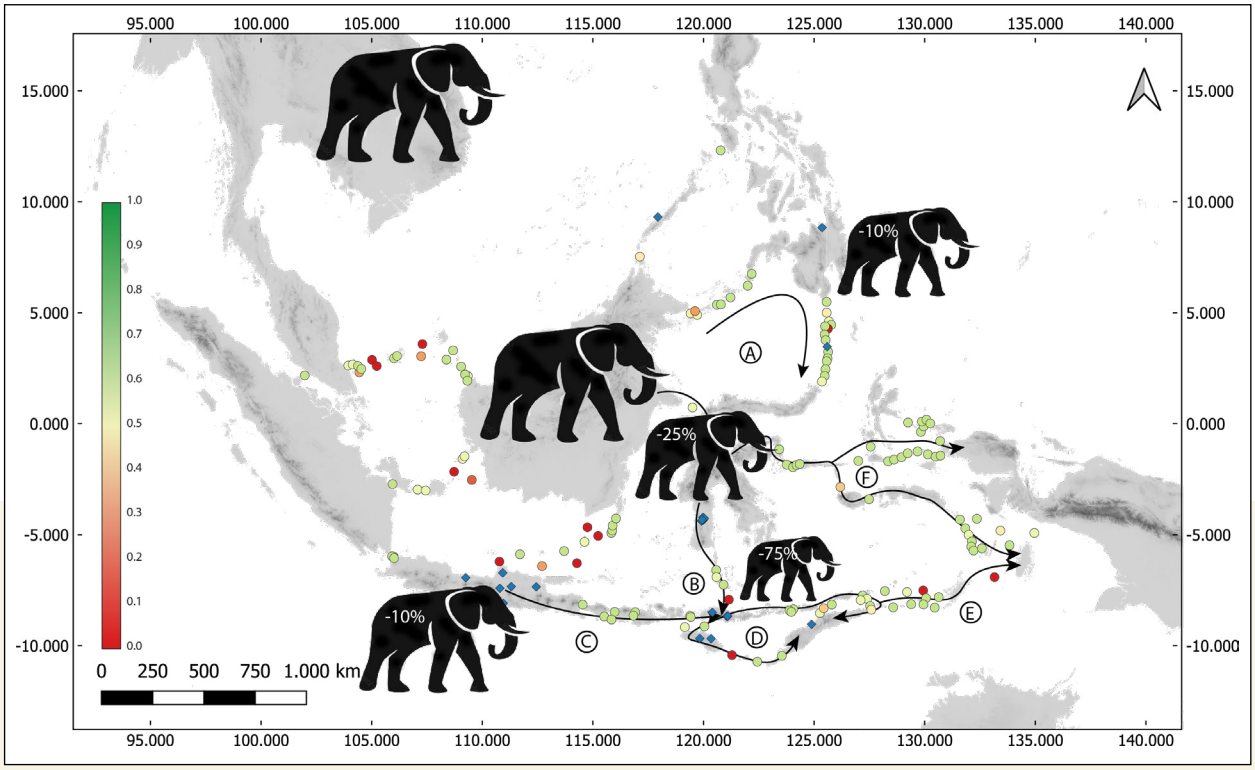
Zvi Ben-Avraham

Modeling expansions

Modeling plays an important role in ROCEEH projects. We model environments, shifts and changes both in space and time, the exploitation of resources, as well as hominin behavior including subsistence patterns, learning, and cooperation within groups. While environmental patterns and dynamics are amenable to modeling using probabilistic models and/or numerical simulations, behavioral patterns of hominins are not directly determined by a limited number of factors. Although the environment represents a relevant context for their behavior, hominins frequently have the choice among several options how to act in a particular situation. How hominins behave in a particular situation may be directed by intentions, experiences they made in similar situations, and/or the behavior of other group members. The complexity and, to some extent, unpredictability of hominin behavior does not, however, mean that it cannot be modeled at all. In fact, agent-based modeling offers the option to account for exactly such situations.

Agent-based modeling is an approach which allows us to simulate particular challenges in order to determine the outcome. As a simulation-based procedure, it allows us to model systems which cannot be observed directly, because they do not exist anymore or because their pace is too slow. This is exactly the kind of problems we are frequently dealing with in archaeology and paleontology, for instance in modeling hominin expansions.

We apply tailor-made models to monitor the dispersal of hominins, when routes require the crossing of sea straits, for instance. In this example, crossing success depends on features of the sea strait, for example the speed and direction of the current, water temperature, or width. Yet, hominins may choose among several ways to cross a sea strait. They may drift without further support, cling to a natural raft, swim in a basic style, or use an artificial raft, when they manage maritime travel. The scenarios are illustrated in the figure on the title page. Crossing success may increase, when they consider the experiences of others, who already managed crossings. We designed the hominin water crossing ABM 'HoWCrossing' to experiment with crossing attempts across diverse sea straits in the Mediterranean and Red Sea, and compared the outcome in glacial and interglacial settings on a quantitative basis. Crossings in the Mediterranean are unsuccessful without an artificial raft, either because currents are too strong, water temperature too low, or the distance simply too far. Crossing the Red Sea at Bab-al-Mandab on the other hand is achieved by all means, and even passive drifting scenarios are successful during glacial conditions. HoWCrossing provides an experimental context applicable to other sea straits by adjusting the environment accordingly. The figure on the title page of this issue shows Late Pleistocene localities in ROAD on either side of the Red Sea. Data provided by HoWCrossing help us to understand the connections between eastern Africa and the Arabian Peninsula.



▲ Figure 3. Crossing success rates of stegodons undergoing island dwarfing while they migrate from mainland Southeast Asia towards Papua New Guinea along various routes (A-F). (Figure: C. Hertler)

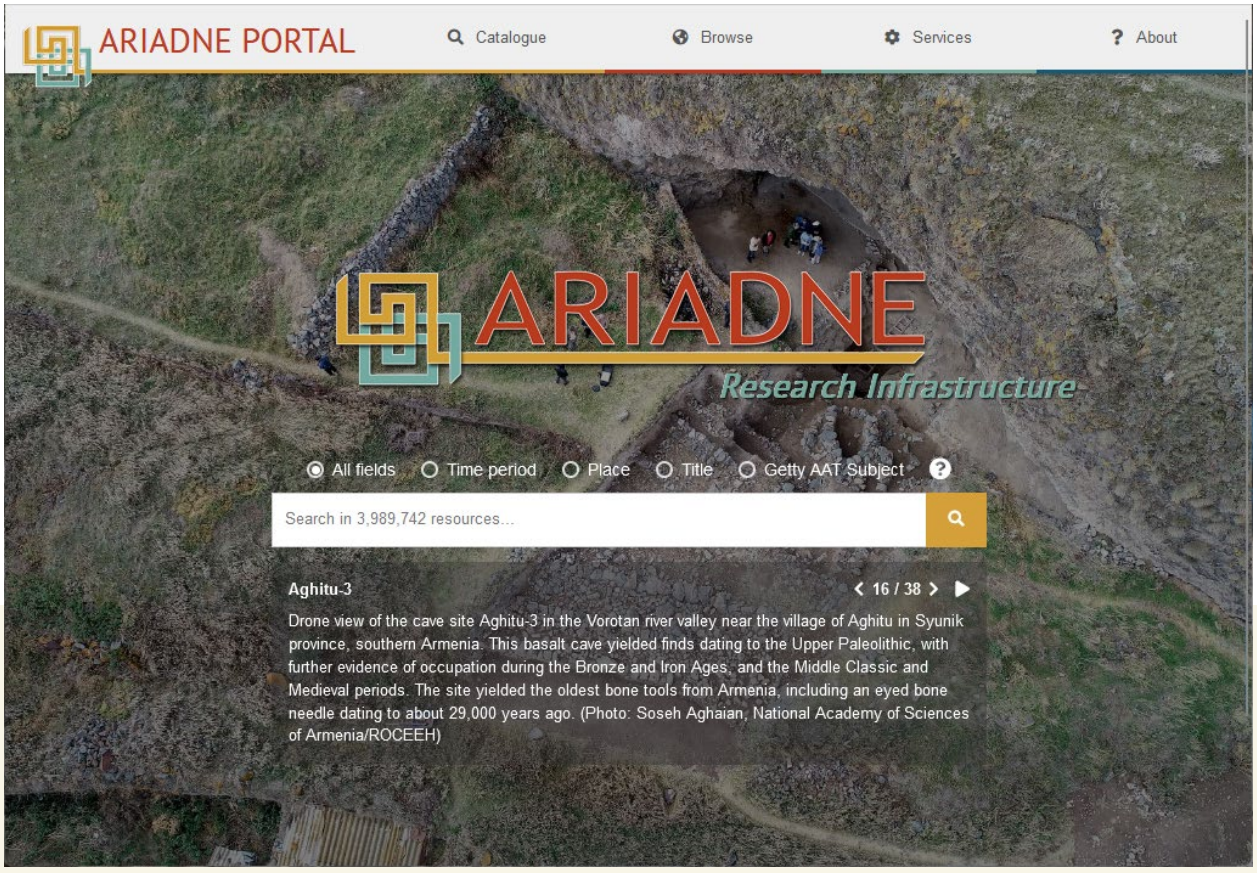
In a simplified version of HoWCrossing named SEAcross ABM, we restricted the crossing option to just active swimming, but implemented a swimming style which is managed by all terrestrial mammals, namely quadrupedal paddling. Movement in modern human swimming styles like breaststroke or crawl are optimized for speed, but we cannot assume that early humans or even hominins were capable of performing such strokes. While quadrupedal paddling is less efficient, all terrestrial mammals can do it. In this case, swimming speed and endurance depend on body size and available energy deposits. We applied this model in a series of experiments, in which we tested crossing success across the islands of Wallacea linking Southeast Asia with Australasia. One fossil family of proboscideans, the Stegodontidae, managed such crossings in the Pleistocene. The fossil record of stegodons illustrates in addition, that they underwent island dwarfing. Of course, changes in body size will in turn influence crossing success. SEAcross allows us to quantify and monitor such coupled processes. The results of our study are displayed in Fig. 3. Critical bottlenecks occur, but due to seasonally changing currents, many of them are restricted to particular parts of the year. Data resulting from our study also permits us to focus on particular routes and understand the sequence of settlements on islands in which the fossil record implies repeated migrations.

Agent-based models like HoWCrossing and SEAcross are specifically designed to integrate environmental and behavioral factors, and to show how they interact in the process of dispersal. Agent-based modeling is an extremely versatile and adaptive method, which can be used to integrate data stored in ROAD. In addition to spatial expansions such as dispersals, we also design models focusing on the relationship between subsistence behavior and patterns of mobility. We will introduce these models on another occasion. Conceptual models help us to identify relevant factors and are embedded in model design. The integrative power of well-designed agent-based models provide ROCEEH with a valuable toolbox to examine specific questions in the process of becoming human.

Christine Hertler

A short history of ROCEEH's cooperation with ARIADNE

The interoperability of databases is one of the essential building blocks of the FAIR principles, which state that all research data should be Findable, Accessible, Interoperable and Reusable. These four steps help ensure that the results of research are not lost forever and improves the ability of researchers to make use of previously obtained data. One of the largest database



▶ Figure 4. Homepage of the ARIADNE Portal (https://portal.ariadne-infrastructure.eu/). This image shows a drone view of Aghitu-3 Cave in southern Armenia, where since 2009, ROCEEH has been conducting excavations and research about the first modern humans in Armenia.

infrastructures that compiles heritage data is spearheaded by a European initiative now known as the ARIADNE Research Infrastructure (https://www.ariadne-research-infrastructure.eu/). This large-scale database platform was funded by the Horizon Programme of the European Union from 2012-2016 (first as the ARIADNE Integrating Activity) and again from 2018-2022 (as ARIADNEplus). By consolidating vast amounts of archaeological data in a single online storehouse, the ARIADNE Portal makes its data freely available to everyone. Users can search for subjects of interest, as well as periods, cultures and regions, to learn what resources are available and which agency is responsible for them. Thus, it has become an essential research tool for archaeologists and the general public.

ARIADNE now contains almost 4 million datasets covering a broad spectrum of subjects ranging from shipwrecks and Roman coins all the way back to prehistoric settlements. ARIADNE's established Linked Open Data triple store allows data providers like ROCEEH to map their datasets in a standardized way to match the required formats of ARIADNE. Through the mapping process, ARIADNE is able to aggregate data from other databases, allowing ARIADNE to understand what these data represent and present them in a user-friendly, searchable interface. During its lifespan, ARIADNE has spun off projects which aim to conserve data for the future, such as SEADDA (Saving European Archaeology from the Digital Dark Age, 2019-2023) and SHADE (Sharing Heritage and Archaeological Data Effectively, 2023-2024).

ROCEEH began its collaboration with ARIADNE in early 2020, when the two teams met in Prato, Italy. After the meeting, ROCEEH's first task was to learn how to use the pipeline which ARIADNE developed to prepare data for integration within its framework. This process entailed mapping ROAD data to standardized ontologies and applying thesauri developed and used by ARIADNE. Simply put, mapping allowed data from ROAD to be translated and understood by ARIADNE. Once ROCEEH decided which of its own data to contribute and implemented the mapping, integration became a straightforward task. After three successful transfers of data, ROAD is now a major contributor of prehistoric data contained in ARIADNE with almost 8600 entries and growing. A workshop sponsored by SHADE held in Heraklion, Crete from 17-21 June 2024 helped data providers like ROCEEH to optimize their use of ARIADNE. The concepts learned at the workshop will be applied to future transfers of data so that ROCEEH can independently add and update its own datasets.

Andrew Kandel

Publication: "The ROCEEH Out of Africa Database (ROAD): An indispensable research tool for human evolutionary studies"

At this year's CAA (Computer Applications and Quantitative Methods in Archaeology) conference in Auckland, New Zealand, ROCEEH was represented by Prof. Dr. Volker Hochschild (University of Tübingen) and Jan-Olaf Reschke (Senckenberg Frankfurt). Both officiated as chairmen of the session "Data Sources and Data Integration for Macroscale Archaeology". During the session the presentation about the ROCEEH Out of Africa Database (ROAD) ignited lively debate, since the audience already knew ROAD from previous CAA conferences and was curious to learn about new developments. Especially, the implementation of a new tool called "Ask ROAD" (https://www.roceeh.uni-tuebingen.de/askROAD/) , which is available without logging in, simplifies querying of the database for external users.

Two further presentations were given, one by Jan-Olaf on the subject "How much data is enough? Modelling the earliest occupations of Western Europe" and the other by Volker on "Computational geomorphic research and its use for landscape archaeology: Examples from South Africa". In the first talk, Jan-Olaf's results of agent-based modeling received great encouragement, while the second presentation on geomorphological landscape reconstruction in South Africa by Volker produced much interest as well.

The ROCEEH team will certainly be represented at the 2025 CAA meeting in Athens.

▲ Figure 5. CAA 2024 venue at the University of Auckland (Photo: V. Hochschild)

Who's who?

This issue: Zvi Ben-Avraham and Jan-Olaf Reschke

Zvi Ben Avraham has been Professor of Geophysics at Tel Aviv University in Israel since 1982. Between 1982-1989 he also held a professorial position at Stanford University. Since 1989 and until 2007, he additionally held the Max Sonnenberg Professorship of Marine Geosciences at the University of Cape Town in South Africa. In 2007, he was appointed founding director of the Charney School of Marine Sciences at the University of Haifa in Israel as well as founding director of the Israel Centre for Mediterranean Sea Research (MERCI). Among other things, his research focuses on the geophysics of the Mediterranean Sea and the Dead Sea Transform fault system. He is a member of the Israeli Academy of Sciences, the Heidelberg Academy of Sciences, the Academia Europaea, the Royal Dutch Academy of Sciences, the Russian Academy of Sciences and the Georgian Academy of Sciences. He holds the Israel Prize. Together with Heidelberg Academy members Prof. Karl Fuchs and Prof. Friedemann Wenzel, he developed the idea of a research center on human expansions, which was eventually realized as ROCEEH. Since the center's inception in 2008, Zvi Ben Avraham has been a member of ROCEEH's scientific advisory board.

Jan-Olaf Reschke completed his academic training as a paleobiologist at the Goethe University in Frankfurt am Main. In his doctoral studies he focuses on studying early hominin subsistence strategies by means of modeling. He simulates potential hunting and gathering strategies employed by early hominins and recent hunter-gatherers using agent-based modeling. In past projects he started to develop a new agent-based model which allows the study of how environmental conditions and the available behavioral strategies of hominin foragers result in specific mobility patterns. Currently, Jan-Olaf is also part of an ERC Project and plans to use his model to identify which environmental and behavioral aspects played an important role during the first early hominin occupation of Europe.

Forthcoming

- NECLIME annual conference 2024

8-15 September 2024, Almaty, Kazakhstan

Focusing on Cenozoic climate and ecosystem evolution in Central Asia, especially in extreme environments. You can find more details here: https://www.neclime.de/conferences.html

- NECLIME workshop of the working group on palynology

23-26 October 2024, Krakow, Poland

You can find more details here: https://www.neclime.de/workshops.html

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