



Annual Report of the Research Center for 2020

The Role of Culture in Early Expansions of Humans (Frankfurt and Tübingen)

Human evolution is a story of expansions. During the last two million years the genus *Homo* spread from Africa into Asia and Europe in several waves of migration. New species developed and old groups became extinct (*range expansions*). As early as three million years ago, hominins had established new ways of dealing with their specific environment through culture. Stone tools produced with the help of another stone tool opened up access to new resources and activated changes in body, mind and behavior (*expansion of performances*). The ecospace of human species and their conspecifics changed the viability and development of potential resource spaces not only through natural processes, but also through changes in the distribution of a species and its behavior, which itself was increasingly shaped by culture (*expansions of resource space*).

ROCEEH's mission is to develop a systemic understanding of "becoming human", one which integrates these three types of expansion and how they interacted with each other. The project encompasses the time from three million to 20,000 years before present and spans from Africa to Eurasia. The project focuses particular attention on the development of the human capacity for cultural activities, as well as its background and characteristics.

At the core of the project is the multidisciplinary, web-based georelational database known as ROAD (ROCEEH Out-of-Africa Database) with its geographical information system (GIS) functionality. ROAD unifies geographical data about sites with additional information about the stratigraphical structure of layers and the archaeology those layers contain. In addition, ROAD assimilates information on human fossil history, fauna, flora and climate, information which can be used to model early human habitats. The results are integrated into a digital atlas detailing the development of humans and environment on the basis of GIS.

Started in 2008 and projected to run for 20 years, ROCEEH is a multidisciplinary research project situated at the interface between the cultural and natural sciences. This far-reaching, international effort is carried out by a team of cultural scientists, archaeologists, paleoanthropologists, paleobiologists, geographers and database specialists situated at the Senckenberg Research Institute in Frankfurt and the University of Tübingen.

Members of the Scientific Commission: regular members of the Academy, Barbara Beßlich (Heidelberg, until October 2020), Hermann H. Hahn (chairman, Karlsruhe), Thomas Holstein (Heidelberg, as of December 2020), Lothar Ledderose (Heidelberg), Irmgard Männlein-Robert (Tübingen), Claudia Maienborn (as of October 2020), Joseph Maran (Heidelberg), Ekkehard Ramm (Stuttgart); as well as Prof. Dr. Ofer Bar-Yosef (Harvard, passed away on 14 March 2020), Prof. Dr. Zvi Ben-Avraham (Tel Aviv), Prof. Dr. Manfred Ehlers (Osnabrück), Prof. Dr. Jürgen Richter (Köln), Prof. Dr. Wulf Schiefenhövel (Andechs), Prof. Dr. Marie Soressi (Leiden, as of October 2020), Prof. Dr. Mark Stoneking (Leipzig).

Heads of the Research Center: Nicholas Conard (speaker, Tübingen), Prof. Dr. Volker Hochschild (Tübingen), Volker Mosbrugger (Frankfurt/M.), Prof. Dr. Friedemann Schrenk (Frankfurt/M.).

Research Staff: in Frankfurt, Priv.-Doz. Dr. Angela Bruch, Claudia Growth (75%), Priv.-Doz. Dr. Miriam Haidle (scientific coordinator; 60%), Dr. Christine Hertler, Dipl.-Biol. Julia Hess (administrative coordinator; 50%); in Tübingen, apl. Prof. Dr. Michael Bolus (80%), Dipl.-Inf. Zara Kanaeva, Dr. Andrew Kandel, Maria Malina (75%), Christian Sommer, M.Sc. (75%)

Guests of the Research Center in 2020: Dr. Phil Glauberman (Yerevan, Armenia and Suzhou, China) visited ROCEEH/Tübingen from 14-20 January at its invitation. Dr. Mika Rizki Puspanigum (Bandung, Indonesien) researched in January and February within the framework of a Koenigswald Postdoctoral Fellowship at ROCEEH/Frankfurt. From 22 October until 6 December Dr. Alice J. Williams (Exeter, Great Britian) was guest of ROCEEH/Frankfurt. Since October 2018 Priv.-Doz Dr. Oliver Schlaudt (Heidelberg, Germany) is based at ROCEEH/Tübingen as a Heisenberg Fellow of the DFG.

Key Aspects

The 13th year of the ROCEEH research center was affected by the COVID-19 pandemic, in terms of both organization and content. Planned introductory workshops in Frankfurt and Leiden about how to use the ROCEEH Out of Africa Database (ROAD) were postponed indefinitely. On account of travel restrictions, field work was curtailed and fewer guests could be received by the research center. Since the middle of March, 2020 the team has met online weekly via Skype or Zoom, instead of its monthly meeting in person (Fig. 1).



Fig. 1. The ROCEEH team during its weekly online meeting

A planned two-day retreat in April to compare the behavior of Neanderthals during a cold and warm phase (Marine Isotope Stages 6 and 5e) was reorganized as a one-week online meeting. The team met for two hours every morning and then worked on the themes of the day in the afternoon; on the next day, results of the previous session were visualized in Mindmaps (Fig. 2).

The experience gained through the retreat was helpful in restructuring the international ROCEEH conference “Human Origins – Digital Future” from a planned three-day meeting in Frankfurt to an online event. By distributing the sessions over five afternoons, recording the talks, and presenting the results of the previous session in Mindmaps, the team succeeded in integrating participants from Japan to the West Coast of the USA who could participate live or watch pre-recorded talks¹.

¹ Haidle, M.N., Bolus, M., Bruch, A.A., Hertler, C., Hochschild, V., Kanaeva, Z., Sommer, C. & A.W. Kandel (2020). Human Origins – Digital Future, an international conference about the future of archaeological and paleoanthropological databases. *Evolutionary Anthropology* 29, 289-292.

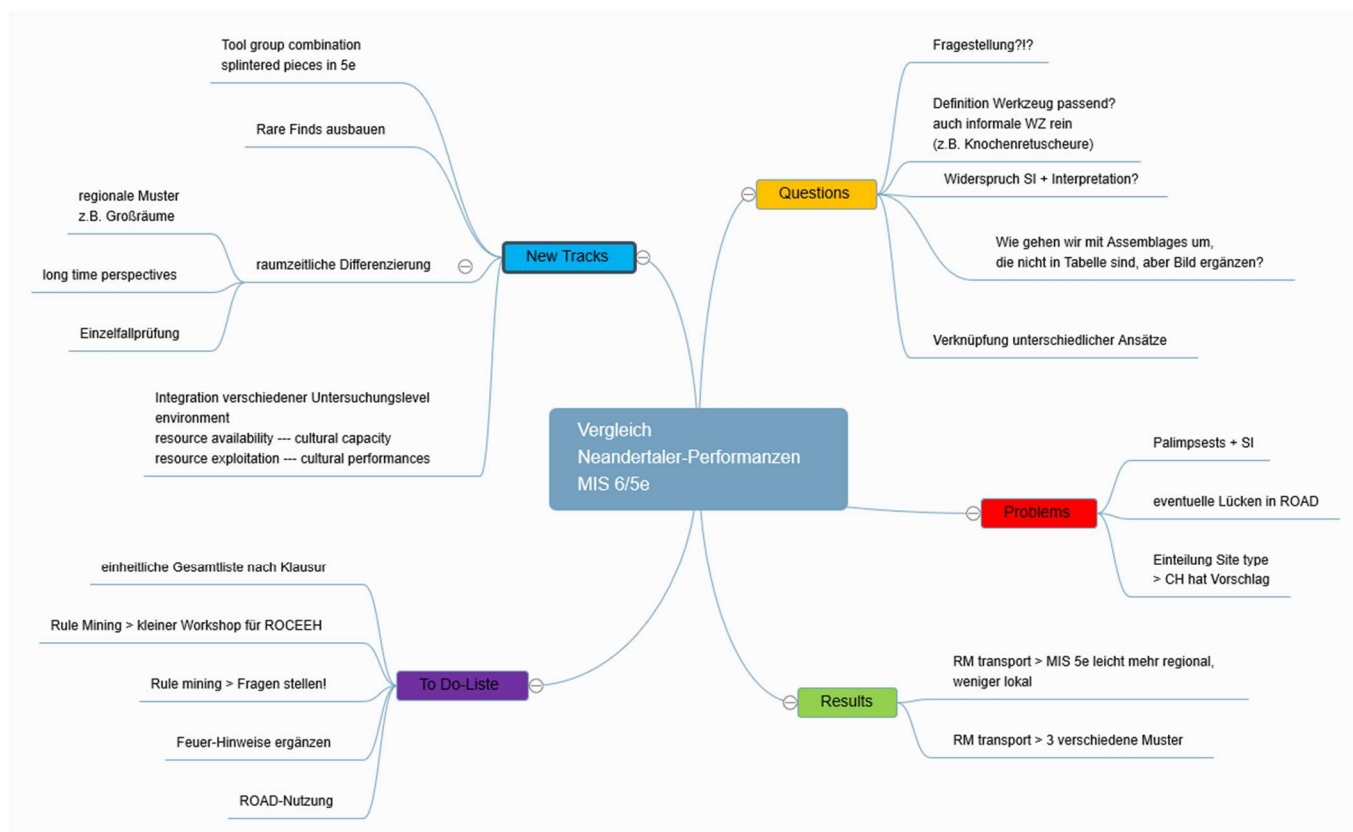


Fig. 2. Mindmap presenting the results of Day 3 of the 2020 ROCEEH retreat

The pandemic-related cancellation of an exhibition at the Archaeological Museum of Frankfurt allowed ROCEEH to fast-track its own exhibition entitled, “Becoming Human // The Origins of Our Culture” which was originally scheduled to open in 2022. Working together with the staff of the museum, the ROCEEH team designed the exhibition remotely during the pandemic and worked towards its full implementation. The exhibition focuses on when and where the process of becoming human became evident and also examines which early junctures led humans to become who and what they are today. During the design phase, it was important to portray the beginnings of human development as a process in which biological, historical-social and ecological steps interact, yet are mutually dependent. The earliest phase of cultural development of humans in Africa, from about 3.3 to 1 million years ago, stands as the focal point of the exhibit. The oldest stone tools known from humanity come from the region of Lake Turkana in Kenya, as does the earliest evidence for the use of fire. This period offers the first fossil evidence of our own genus *Homo* dated to around 2.8 million years ago. Furthermore, during this time the first culture of stone tools, known as the Oldowan, became established in Africa. In Eurasia, several sites allow us to detect the first

phase of human expansion, known as Out-of-Africa, which started about 2 million years ago. At the same time, another cultural phenomenon known as the Acheulean expanded from Africa into Europe and Asia. The Acheulean is the technology of handaxes which, despite its continual development, lasted for more than a million years. The exhibition embeds current knowledge about the fundamental cornerstones of the early history of humanity into discourse about the meaning of the term “culture” within this ancient context. Human development is also compared to the culture of chimpanzees, highlighting social learning in its various forms as a key to culture and tracing the parallel developments of thought and actions. The exhibition is scheduled to open on May 14 and run through October 31, with the goal of illustrating the deep cultural history of humanity. The exhibition will make clear how over the course of millions of years many different developments have contributed to making us a diverse species that now populates the entire planet.

In 2020 ROCEEH became a partner of the Coalition for Archaeological Synthesis (CfAS, <http://archsynth.org>), a group of individuals and institutions aiming to promote the expansion of knowledge about the past to help address current and future social issues. CfAS consists of over 50 international partners from scientific and professional associations, digital infrastructure providers, NGOs, academic institutions and cultural heritage management firms. ROCEEH brings experience in its exploration of the deep past of human history and its expertise in managing a large interdisciplinary database (ROAD). ROCEEH was also chosen from over 50 applicants to participate in a 15-person working group whose goal was to understand the ubiquitous phenomenon of human migration from a long-term perspective and, in this regard, to develop successful plans of action. In 2020, three scientific research proposals and a joint position paper² resulted from the first workshop held in late 2019.

² Altschul, J.H., K.W. Kintigh, M. Aldenderfer, E. Alonzi, I. Armit, J.A. Barceló, C.S. Beekman, P. Bickle, D.W. Bird, S.E. Ingram, E. Isayev, A.W. Kandel, R. Kiddey, H.T. Kienon-Kaboré, F. Niccolucci, C.S. Ragsdale, B.K. Scaffidi & S.G. Ortman (2020). Opinion: To understand how migrations affect human securities, look to the past. *Proceedings of the National Academy of Sciences* 117 (34), 20342-20345.

Field Work

In 2020 the staff of the Research Center conducted or participated in three field projects:

Africa

- South Africa: Sibudu Cave and Umbeli belli Rock Shelter. Excavation and analysis of finds (Conard, N., Bader, G., Will, M., 6 weeks)

Europe

- Germany: Hohle Fels in Schelklingen and Lonetal. Excavation and analysis of finds (Conard, N.J., Janas, A., 9 weeks)
- Germany: Schöningen. Excavation and analysis of finds (Conard, N.J., Serangeli, J., 40 weeks)

ROCEEH Out-of-Africa Database (ROAD) and ROADWeb

Interdisciplinary work is an outstanding feature of the ROCEEH research center, and this is also reflected in the data model of the ROAD database. Database models in science can be understood as the logical, structural implementation of the mental concepts of a discipline. Accordingly, ROAD enables the various specialized information from the fields of archeology, anthropology, paleo-environment and geography to be integrated and evaluated in an interconnected way. The development of the ROAD database structure was pioneering work that can only be accomplished by such a long-term project. The conceptual basis of the database follows *Domain Driven Design*, which places the *domain*, in this case the above-mentioned scientific disciplines, and its *subject matter*, i.e. the subject-specific concepts, in the foreground³. Thus, further development of the database model was checked and implemented, taking into account the area of tension between technical correctness and necessity on the one hand, and possible links to neighboring domains on the other. This high horizontal integration across multiple domains sets ROAD apart from similar databases and aims to answer the overarching research question: What was the role of culture in early human expansions?

Since the research center began in 2008, an overall change in science has paralleled the targeted development of the ROAD database structure and its content. The current trend is aimed at increased interdisciplinary cooperation, accessibility of research data and reproducibility of

³ Evans, E. (2003). *Domain-driven design: tackling complexity in the heart of software*. Boston: Addison-Wesley.

analyses, as reflected in concepts such as *Open Science*^{4,5} and the *FAIR Principles*⁶ – which stands for Findable, Accessible, Interoperable, Reusable. The increased culture of scientific cooperation can be seen, for example, in the growing number of ROAD users, scientific publications related to ROAD and the demand for workshops ("ROAD shows"), in which interested parties are instructed in how to use the database. In addition, a number of measures have been initiated since 2019 to further increase the availability and networking of ROAD. This includes the development of new products and licensing as well as additional, standardized data structures which allow links to external databases. These measures are briefly explained in the following text while considering the FAIR Principles.

In order to make research data *Findable*, it should be available on the Internet in a way that goes beyond a simple text-based search using conventional search engines. For this purpose, ROAD was registered as a data repository at re3data.org (a registry of research data repositories), which maintains extensive metadata on content, research centers and the licensing of scientific databases. The metadata are provided with a *Digital Object Identifier* (e.g. ROAD's DOI is 10.17616/R31NJMUJ), which acts as a permanent reference for the database. Through the DOI, research data can be indexed in other data collections, such as the Open Science Infrastructure of the European Commission *OpenAIRE* (www.openaire.eu) or special data search engines such as *ThroughputDB.com*, *Repositoryfinder* (repositoryfinder.datacite.org) and *Google Dataset Search* (datasetsearch.research.google.com). In the future, the research center aims to offer ROAD content at a higher level of detail, for example at the assemblage level (i.e. a summary of find categories in a layer of a locality).

The principle of *Accessibility* means both the authorization of legal access and its practical implementation by means of interfaces and graphic surfaces. Both meanings have always been

⁴ Molloy, J. C. 2011. The open knowledge foundation: open data means better science. *PLOS Biology* 9, e1001195.

⁵ Murray-Rust, P., Neylon, C., Pollock, R. & Wilbanks, J. 2010. Panton principles – principles for open data in science [online]. Available: <https://pantonprinciples.org/> [accessed 2020-02-02].

⁶ Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J., Appleton, G., Axton, M., Baak, A., Blomberg, N., Boiten, J.-W., Da Silva Santos, L. B., Bourne, P. E., Bouwman, J., Brookes, A. J., Clark, T., Crosas, M., Dillo, I., Dumon, O., Edmunds, S., Evelo, C. T., Finkers, R., Gonzalez-Beltran, A., Gray, A. J. G., Groth, P., Goble, C., Grethe, J. S., Heringa, J., 'T Hoen, P. A. C., Hooft, R., Kuhn, T., Kok, R., Kok, J., Lusher, S. J., Martone, M. E., Mons, A., Packer, A. L., Persson, B., Rocca-Serra, P., Roos, M., Van Schaik, R., Sansone, S.-A., Schultes, E., Sengstag, T., Slater, T., Strawn, G., Swertz, M. A., Thompson, M., Van Der Lei, J., Van Mulligen, E., Velterop, J., Waagmeester, A., Wittenburg, P., Wolstencroft, K., Zhao, J. & Mons, B. 2016. The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data* 3, 160018.

promoted in ROAD. The authorization of access takes place through a four-layered user management system, and access to the data is secured with the *QueryTool* and the geographic information system *ROADWeb*. The existing offer was expanded in 2020 by joining ARIADNEplus (ariadne-infrastructure.eu). This project unifies and assimilates governmental and scientific data collections to integrate archaeological data across countries and times. ROAD is positioned within the context of other high-quality, extensive repositories, thus increasing the accessibility, range and visibility of both the database and the research center.

Since the FAIR principles are clearly situated within the digital realm, *Accessibility* also means access to digital data. However, as it turns out, there is still demand for analog content, provided that the information is structured and graphically appealing. This was achieved through the *ROAD Summary Data Sheets*⁷, which makes it possible to extract data about individual sites in a summarized form as a PDF. One success of this measure can be seen in feedback received from external specialists, who help point out errors and thus contribute to the validation of the database and improved data integrity.

Data correspond to the principle of *Interoperability* if they are machine-readable and have a standardized structure allowing them to be linked to external sources. As mentioned above, the structure of ROAD already takes the concept of individual disciplines into account. In some disciplines, standardization could be easily achieved because community standards or even ISO standards were readily available. This applies especially to geodata, for which the *Open Geospatial Consortium* has a central authority to issue guidelines, due to the economic relevance of this type of data. In other domains that are more strongly influenced by research, such standardization is not currently the norm, but a number of community standards are developing. One such community standard for archeology is the *AO-Cat* model, which was developed by the ARIADNEplus network and is now being implemented by ROCEEH as an additional exchange format. The data model is currently used by over 40 institutional partners. Thus, it has a critical mass that we anticipate will allow it to establish itself as the *de facto* standard over the long-term. In addition, A0-Cat is composed of widely used individual standards such as CIDOC-CRM and Dublin-CORE, which ensure interoperability beyond

⁷ Bolus, M., A. Bruch, M. Haidle, C. Hertler, J. Heß, Z. Kanaeva, A. Kandel, M. Malina, C. Sommer 2021. Durch die Menschheitsgeschichte mit dem neuen ROAD Summary Data Sheet. Archäologische Informationen 43, Early View, published online 7 October 2020.

Bolus, M., A. Bruch, M. Haidle, C. Hertler, J. Heß, Z. Kanaeva, A. Kandel, M. Malina, C. Sommer 2021. Explore the history of humanity with the new ROAD Summary Data Sheet. Archäologische Informationen 43, Early View, published online 7 October 2020.

archeology. However, it is clear that such standards do not reflect the depth of content implemented in ROAD, as the database was created to answer specific research questions. Therefore, ROCEEH offers the best practice of static APIs for exchanging specialized data requests.

In order to do justice to the principle of *Reusability*, individual products such as the *ROAD Summary Data Sheets* are published under an open Creative Commons license. Furthermore, the research center strives to expand current practice with individual access to the database through an open license in order to make the exchange of data as transparent as possible. In addition to these specific measures, the research center now benefits from increased organizational networking that has arisen over the course of the orientation towards the FAIR Principles and Open Science. ROCEEH is involved in the Coalition for Archaeological Synthesis, the ARIADNEplus network and the National Research Data Infrastructure (NFDI4Objects, www.nfdi4objects.net). The project is actively involved in the development of community standards for archaeological data, above all based on its many years of experience in the interdisciplinary integration of various scientific disciplines.

As in previous years, the ROAD application (ROADWeb) was upgraded in 2020 and its usability improved. For example, we updated the SVG graphics for the global chronostratigraphic correlation table for the last 2.7 million years, which is used in several places in ROADWeb for queries, as well as the programming associated with it. The documentation of the ROAD application has been updated, especially for data import. The implementation of the new query management from 2019 has been improved in part to meet user requirements. Currently, researchers cooperating with ROCEEH cannot write complex queries (such as nested SQL SELECT queries) themselves with the query tool in ROADWeb. Instead, we formulate php scripts for the desired queries and outputs and compile these on a page in ROADWeb. Data entry into ROAD continued in 2020 and as of January 7, 2021, ROAD contained 1,979 localities and 11,973 assemblages.

Project relevant conference contributions and lectures by research staff

The staff of the Research Center organized one conference and two workshops. They participated in two online conferences and were lead or contributing authors in nine lectures and presented four posters. They also presented the project or their own research ten times at work meetings, lecture series and colloquia.

Third Party Funding

To complement the financing provided by the Academy, the team sought additional funds for methodological development, case studies and visits from guest researchers and young academics. ROCEEH received additional support from the The Digital Archaeological Record (tDAR) and ARIADNE. One doctoral candidate received a fellowship from the Gerda Henkel Foundation.

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 postgraduate students in their qualifications:

- Lectures and seminars at the University of Frankfurt/Main: Angela Bruch, Christine Hertler, Ericson Hölzchen
- Lectures and seminars at the University of Tübingen: Michael Bolus, Angela Bruch, Miriam Haidle, Christian Sommer
- Supervision of Master's, Diploma and Doctoral theses: Michael Bolus, Angela Bruch, Miriam Haidle, Christine Hertler, Andrew Kandel
- Supervision of archaeotechnical trainees: Maria Malina

Project relevant publications by research staff and principal investigators

A total of 27 project relevant publications appeared in 2019 in which the principal investigators and staff of the Research Center played a leading or contributing role:

ISI-listed publications: 17

1. Altolaguirre, Y., **Bruch, A.A.** & Gibert, L. (2020): A long Early Pleistocene pollen record from Baza Basin (SE Spain): Major contributions to the palaeoclimate and palaeovegetation of Southern Europe. *Quaternary Science Reviews* 231, 106199. DOI: 10.1016/j.quascirev.2020.106199
2. Altschul, J.H., Kintigh, K.W., Aldenderfer, M., Alonzi, E., Armit, I., Barceló, J.A., Beekman, C.S., Bickle, P., Bird, D.W., Ingram, S.E., Isayev, E., **Kandel, A.W.**, Kiddey, R., Kienon-Kaboré, H.T., Niccolucci, F., Ragsdale, C.S., Scaffidi, B.K. & Ortman, S.G. (2020): Opinion: To understand how migrations affect human securities, look to the past. *PNAS* 117(34), 20342-20345. DOI: 10.1073/pnas.2015146117

3. Baumann, C., Bocherens, H., Drucker, D.G. & **Conard, N.J.** (2020): Fox dietary ecology as a tracer of human impact on Pleistocene ecosystems. PLoS ONE 15(7), e0235692. DOI: 10.1371/journal.pone.0235692
4. **Conard, N.J.**, Schmid, V.C., **Bolus, M.** & Will, M. (2020): Lithic assemblages from the Middle Paleolithic of Geißenklösterle Cave provide insights on Neanderthal behavior in the Swabian Jura. Quartär 66/2019, 51-80. DOI: 10.7485/QU66_3
5. **Conard, N.J.**, Serangeli, J., Bigga, G. & Rots, V. (2020): A 300,000-year-old throwing stick from Schöningen, northern Germany, documents the evolution of human hunting. Nature Ecology & Evolution 4, 690–693. DOI: 10.1038/s41559-020-1139-0
6. Falcucci, A., **Conard, N.J.** & Peresani, M. (2020): Breaking through the Aquitaine frame: A re-evaluation on the significance of regional variants during the Aurignacian as seen from a key record in southern Europe. Journal of Anthropological Sciences 98, 99-140. DOI: 10.4436/JASS.98021
7. **Fuentes, R.**, Ono, R., Carlos, J., Kerfant, C., Sriwigati, T.M., Aziz, N., Sofian, H.O. & Pawlik, A. (2020): Stuck within notches: Direct evidence of plant processing during the last glacial maximum to Holocene in North Sulawesi. Journal of Archaeological Science: Reports 30, 102207. DOI: 10.1016/j.jasrep.2020.102207
8. **Haidle, M.N.**, **Bolus, M.**, **Bruch, A.A.**, **Hertler, C.**, **Hochschild, V.**, **Kanaeva, Z.**, **Sommer, C.** & **Kandel, A.W.** (2020): Human Origins – Digital Future, an international conference about the future of archaeological and paleoanthropological databases. Evolutionary Anthropology 29, 289-292. DOI: 10.1002/evan.21870
9. **Haidle, M.N.** & **Schlaudt, O.** (2020): Where does cumulative culture begin? A plea for a sociologically informed perspective. Biological Theory 15, 161-174. DOI: 10.1007/s13752-020-00351-w
10. Hayrapetyan, A. & **Bruch, A.A.** (2020): Pollen morphology of some species of the genus *Quercus* L. (Fagaceae) in the Southern Caucasus and adjacent areas. Acta Paleobotanica 60(1), 1-42. DOI: 10.35535/acpa-2020-0001
11. Kitagawa, K. & **Conard, N.J.** (2020): Split-based points from the Swabian Jura highlight Aurignacian regional signatures. PlosOne 15(11), e0239865. DOI: 10.1371/journal.pone.0239865
12. Moncel, M.-H., Biddittu, I., Manzi, G., Saracino, B., Pereira, A., Nomade, S., **Hertler, C.**, Voinchet, P. & Bahain, J.-J. (2020): Emergence of regional cultural traditions during the Lower Palaeolithic: the case of Frosinone-Ceprano basin (Central Italy) at the MIS 11–10

transition. *Archaeological and Anthropological Sciences* 12, 185. DOI: 10.1007/s12520-020-01150-x

13. Ono, R., **Fuentes, R.**, Pawlik, A., Sofian, H.O., Sriwigati, Aziz, N., Alamsyah, N. & Yoneda, M. (2020): Island migration and foraging behaviour by anatomically modern humans during the late pleistocene to Holocene in Wallacea: New evidence from Central Sulawesi, Indonesia. *Quaternary International* 554, 90-106. DOI: 10.1016/j.quaint.2020.03.054
14. **Schlaudt, O.** (2020): Type and token in the prehistoric origins of numbers. *Cambridge Archaeological Journal* 30(4), 629-646. DOI: 10.1017/S0959774320000165
15. Schmidt, P., Stynder, D., **Conard, N.J.** & Parkington, J.E. (2000): When was silcrete heat treatment invented in South Africa? *Palgrave Communications* 6, 73. DOI: 10.1057/s41599-020-0454-z
16. Will, M. & **Conard, N.J.** (2020): Regional patterns of diachronic technological change in the Howiesons Poort of southern Africa. *PLoS ONE* 15(9), e0239195. DOI: 10.1371/journal.pone.0239195
17. Zanolli, C., Schillinger, B., Kullmer, O., **Schrenk, F.**, Kelley, J., Rössner, E. & Macchiarelli, R. (2020): When x-rays do not work. Characterizing the internal structure of fossil hominid dentognathic remains using high-resolution neutron microtomographic imaging. *Frontiers Ecology and Evolution* 8, 42. DOI: 10.3389/fevo.2020.00042

Other peer reviewed publications: 4

1. Gasparyan, B., Adler, D.S., Wilkinson, K.N., Nahapetyan, S., Egeland, C.P., Glauberman, P.J., Malinsky-Buller, A., Arakelyan, D., Arimura, M., Dan, R., Frahm, E., Haydosyan, H., Azizbekyan, H., Petrosyan, A. & **Kandel, A.W.** (2020): Study of the Stone Age in the Republic of Armenia (Part 1 – Lower Paleolithic). *ARAMAZD: Armenian Journal of Near Eastern Studies* 10(1-2), 1-60.
2. **Haidle, M. N.**, & **R. Stolarczyk** (2020): Thinking tools. With cognigrams from reconstructions and interpretations to models about tool behavior. *Intellectica* 73, 107-132
3. Martinetto, E., Bertini, A., Bhandari, S., **Bruch, A.A.**, Cerilli, E., Cherin, M., Field, J.H., Gabrielyan, I., Gianotti, F., Kern, A.K., Kienast, F., Lindsey, E.L., Momohara, A., Ravazzi, C. & Thomas, E.R. (2020): The last three millions of unequal spring thaws. In: Martinetto, E., Tschopp, E. & Gastaldo, R. (Eds.). *Nature through time. Virtual field trips through the nature of the past*. Cham: Springer, 1-54. ISBN 978-3-030-35058-1
4. Willmes, C., Niedziółka, K., Serbe, B., Grimm, S.B., Groß, D., Miebach, A., Märker, M., Henselowsky, F., Gamisch, A., Rostami, M., Mateos, A., Rodríguez, J., Limberg, H.,

Schmidt, I., Müller, M., **Hölzchen, E.**, Holthausen, M., Klein, K., Wegener, C., Weninger, B., Kellberg Nielsen, T., Otto, T., Weniger, G.C., Bubenzer, O. & Bareth, G. (2020): State of the art in paleoenvironment mapping for modeling applications in archaeology - summary, conclusions, and future directions from the PaleoMaps Workshop. *Quaternary* 3(2), 13. DOI: 10.3390/quat3020013

Publications without peer review: 4

1. **Bolus, M.** (2020): Seit mehr als drei Millionen Jahren: Gestaltungsfähigkeit altsteinzeitlicher Menschen. In: U. Lüke und G. Souvignier (Hrsg.). *Der Mensch – ein Tier! Und sonst? Interdisziplinäre Annäherungen. Quaestiones Disputatae* 307. Freiburg/Basel/Wien: Herder, 69-98.
2. **Haidle, M.N.** (2020): Laudatio: Dr. Andrew Sorensen, Twentyfirst Recipient of the Tübingen Prize for Early Prehistory and Quaternary Ecology. *Mitteilungen der GfU* 28, 7-10.
3. Hayrapetyan, N., Kvavadze, E., Shatilova, I., Gabrielyan, I., **Bruch, A.A.** (2020): Subfossil palynological spectra from the surroundings of the village Tsovinar (Lake Sevan, Armenia). *Biological Journal of Armenia* 72(3), 52-58.
4. Marjanyan, M.A., Harutyunyan, R.G., **Bruch, A.A.**, Gabrielyan, I.G., (2020): To the knowledge of the paleofauna of the subfamily Lixinae (Coleoptera, Curculionidae) of Sisian Suite (Southern Armenia, Early Pleistocene). *Biological Journal of Armenia* 72(1-2), 110-114.

Popular publications: 2

1. **Conard, N.J. & Malina, M.** (2020): Fortsetzung der Ausgrabungen am Hohle Fels und neue aurignacienzeitliche Werkzeuge aus Mammutelfenbein. *Archäologische Ausgrabungen in Baden-Württemberg 2019 (2020)*, 47-51.
2. **Haidle, M.N.** (2020): Anfänge menschlicher Kultur. *zur debatte* 2/2020, 35-37.

Miriam Haidle, Julia Heß, Andrew Kandel, Christian Sommer and the ROCEEH Team