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Extended Abstracts

Curated by Maja Gori
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"Resources in Societies" (ReSoc). An Introduction to the Leibniz Post-doctoral School in Bochum

Thomas Stöllner

Keywords
Resources, Premodern Economies, Social Transformation, Practice Theory

In today's political debate, raw materials and resources play an increasingly important role. It is a mostly highly economized debate that is conducted with regard to the accessibility and safeguarding of raw materials as well as the shareholder value of deposit assessments. This debate obscures the view that raw materials and resources deeply are thought in cultural categories. Their "use" results from needs and technical knowledge that people have acquired in dealing with their environment. Resources are therefore much more than useful raw materials; they reflect the social and cultural practice of people and are thus an expression of a multi-layered process of appropriation, which as such is embedded in various changes. These changes in the handling of resources and the changes that this handling has triggered in societies are an essential part of the "Resources in Societies" (ReSoc) project. ReSoc is a cooperation project between the Deutsches Bergbau-Museum Bochum (DBM), the Ruhr University of Bochum (RUB) and the FernUniversität in Hagen (FUH).

In particular, the "entanglement" of people with their environment and resources and the relationship between this "entanglement" and social change are still an important desideratum of theoretical approaches (see for archaeology e.g. Hodder, 2013; for anthropology: Ingold, 2000). ReSoc investigates such resource-based change processes on a theoretical and empirical basis. The Leibniz PostDoc School has proceeded from a practice-theoretical approach (based on the approaches of A. Giddens and P. Bourdieu: Giddens, 1984; Bourdieu, 1977). This should help to analyse the embedding of social institutions and their resource-controlled behaviour. In addition, current references to the materiality discourse in the social sciences and humanities are taken into account. Our approach aims at a multivocal perspective, in which the entanglement of humans with their materialized environment becomes apparent through various practices. This also includes how social institutions arise and change through such processes.

Humans' involvement in transformative processes is one of the most crucial aspects to our understanding of past and contemporary societies and their life-worlds (Husserl, 1913; Schütz and Luckmann, 1988; Habermas, 1981): transformations are omnipresent in history and the adaptation of peoples to and their impact on these processes is among the most relevant driving forces of human affairs. It is obvious that for many decisions we take as individuals, as societal groups, whole societies or political entities it is indispensable to understand these transformations. Within these processes resources play a decisive role: entangled in manifold ways in the practical and cognitive constructions of societies, they have to be regarded as important motivation. To put it in other terms: resources, their acquisition and social appropriation keep societies in action, no matter whether we consider them as preconditions like a "leaven in the dough" (Latour, 2005), in a broader sense as affordances (Gibson, 1977) within human practices, or as a projection screen for our desires and ideologies. Despite the topic's importance, it is surprising that these resources-related social transformations have rarely been considered within a broader theoretical approach that helps to understand these steadily ongoing processes.

Hence, the way resources are handled can be regarded as a vehicle to describe and study the manifold forms of transformations. It was therefore a broad element of scientific research within the last decades: however, to assess their role as social and cognitive constructions or as things interwoven with human practices, a reconsideration of the theoretical and methodological approach is necessary to frame the intended empirical studies. We often use resource-based supply and demand mechanisms in a very simplistic way to describe or explain social and economic changes: expressions like "structural change" or "transformation of structure" ("Strukturwandel") and their economic implications for societies and regions are widely accepted terms to describe a transformational process (Giddens, 1984). The political discussion of these developments has been simplified and not only expressed in economic vocabulary, but even reduced to its economic arguments. Mainstream economic theory that rests on the model of the perfectly rational and selfish "homo oeconomicus" abstracts away the embedding of social actors into institutional, political, and cultural contexts and has been criticized for quite some time not only by anthropologist, philosophers and sociologists, but also by behavioral economists, institutional economists, and others. The recent financial crisis made the short-comings of neoclassical economics with its rather mechanistic idea of the human actor apparent and led to some rethinking of economics (Holt et al., 2011) and our widely economic view of the world. For a better understanding of all reasons behind transformations we evidently need to draw our attention to the multi-variable entanglement of the human subject which requires a human-centred perspective on economy and social transformations and the way individuals and groups conceptualize and appropriate environmental and material factors.

It is interesting that economic growth and decline debates often result from a specific argumentative angle of World-System theories that came into discussion during the 1970s (Wallerstein, 1974; Costanza et al., 2007). The question of centres and periphery strongly influence structural concepts of the various branches in archaeology, technical and environmental history or economic theory since the 1940s (e.g. Polanyi, 1978). It was renewed and conventionalized in a broadened evolutionary concept of "adaptive systems" (Holling et al., 2002) and in structural actor-space concepts of macro-, meso- and micro-levels (König, 2009). It is therefore necessary to debate on their nowadays influential role in interpreting our data.

The complexity of such a discussion demands not only an interdisciplinary, but a transdisciplinary approach by a diverse association of scholars. Understanding humans within their social and environmental contexts, how they are embedded in social practices and landscapes, can be neither exclusively addressed by a positivistic method based on experiments and analyses nor by a solely constructivist approach. Rather, we have to act upon the assumption that humans are both committed to their individual and their society's conditionality, not only as objects of study. But also as researchers we have to reflect upon our own biases (Latour, 2005); a philosophical gap that is difficult to be overcome by different disciplines in their specific perspective. Humanities and social science have started to bridge these disciplinary gaps by describing new fields of common approaches for example by involving aspects of space and materiality in their studies. This "Practice Turn" (De Certeau, 1988, Schatzki et al., 2001) in social theory, which includes a turn to the space, the material things, and the human body, led to new levels of common understanding within the humanities and social sciences but also the natural sciences: It has opened common approaches to new horizons of understanding and discussion. Humanities and social sciences on the one hand and natural sciences on the other therefore need a holistic approach to gap this contraction, a chance that can only be achieved by transdisciplinary approaches which try to conflate the constructivist and positivist views in research.

Different transformation processes are examined from different scale perspectives. How did small-scale action processes of raw material appropriation initially develop into cultural constructs (e.g. through technical knowledge and learning processes; through the practice of extraction, etc.)? How are these processes reflected in the appropriation and construction of social spaces and ultimately in social transformation processes? Which interactions can be observed?

ReSoc has developed three research fields in which these questions are to be examined on a theoretical and empirical level. ReSoc is organically linked to main topics of the DBM research. The three research fields complement the research of the DBM, especially on a theoretical level. These are:

1. Appropriating (raw) material – converting to things. Resources and materials in practice

2. Spacing, making knowledge and innovation through resources and as resources

3. Transforming societies: actors in materialized asymmetries.

As part of the project, five postdoc projects in the fields of archaeology, economics, archaeometallurgy and mining archaeology were funded. As part of the project, the postdocs were able to choose different career paths and deepen them through their work at the DBM and the partner institutes. Many have chosen a career path in science. Following several Postdoc-positions (Mainz, Amsterdam, Heidelberg, Naples) during which she worked on different aspects of Balkan archaeology, Dr. Maja Gori started in Bochum her project on mobility and connectivity in the Central Mediterranean during the Early Bronze Age (Gori et al., 2018). In particular, she focused on the role of the Adriatic-Ionian region and the Balkans in the wide mobility pattern that can be traced in Europe during the 3rd millennium BC (Gori, 2020). In order to understand mechanisms behind migration, together with Dr. Frederik Schaff she applied Agent-based Modelling to the study of migration in the Adriatic Cetina phenomenon (Gori and Schaff, forthcoming). In 2019 she was appointed to the Institute of Heritage Science of the National Research Council of Italy (ISPC-CNR) as permanent researcher, and she continued her work within the ReSoc project as a research associate. Dr. Matteo Cantisani came to us from Nottingham as her successor in the middle of the corona pandemic and tries above all to look at the economic and social conditions of the 3rd millennium in Sicily. In the past few years, Dr. Peter Thomas has expanded his expertise in mining archaeology and carried out projects for knowledge transfer in the Bronze Age of Transylvania and the Carpathian Basin. In Bucium, the presumably Alburnus Minor, he developed a research project based on field archeology in the so-called Golden Square of Romania, which has now successfully completed its pilot phase (Thomas et al. in press 2020).

Dr. Yiu Kang Hsu came to us from the University of Oxford and its research focus there on metals from Eurasia and China (FLAME project). He was able to further expand his archaeometallurgical expertise and initiated projects in Mongolia and China (Hsu, Sabatini 2019). Due to the occupation with the Xiongnu temporal metals, the view into the different copper mining areas of China was necessary. Here Dr. Hsu, "Gary", will expand mainly on the Tang and Song temporal coinage. On a more theoretical and methodological level, the research of Dr. Frederick Schaff and Dr. Arne Windler stands. Both of them expanded the relationship to questions and methods of economics. For example, Frederick Schaff and his colleagues at the postdoc school advanced the use of agent-based modeling (Schaff 2020). To this end, he has carried out research on the Anasazi in the southwestern United States. The difficulty of simulating social practices came up again and again in our theoretical discourse. That was reason enough that Dr. Arne Windler entered into a theoretical debate about the conceptualization of the acting human being in archeology. Arne Windler was one of the few young scientists who took the path of museum curator and, especially in 2018/2019, got involved in the preparation of the special exhibition for the DBM exhibition "Death by Salt". In the meantime, Dr. Schaff and Dr. Windler left our postdoctoral school in order to open up new professional horizons in science coordination and in a commercial company.

That our postdocs would leave the DBM and its partner institutions is the expected course in a professional transition phase in which a research museum and its partner universities can act as sponsors and partners. As organizers, we are particularly pleased that our postdoctoral school is attractive enough that more postdocs have now come to the DBM with their projects. Supported by the Thyssen Foundation, Dr. Thomas Koch Waldner now works on the Bronze Age copper extraction in South Tyrol (Koch Waldner 2019), while Dr. Leandra Reitmaier-Naef looks at the metal supplies in Eastern Switzerland (Reitmaier-Naef et al. in press). Sharing the research questions posed at the beginning with our young scientists and developing them further together is an important goal of ReSoc. The final conference now at hand is thus the first section of the project. It is to be continued in a second phase within the framework of the Science Campus “Resources in Transformation” now granted by the Leibniz Association.

Finally, a few words of heartfelt thanks: The Principal Investigators, Prof. Dr. Michael Roos, apl.-Prof. Dr. Sabine Klein, Prof. Dr. Constance von Rüden for their constant cooperation and sympathy, our Advisory Board, Prof. Dr. Susan Pollock, Berlin, Prof. Dr. Roland Hardenberg, Frankfurt, Prof. Dr. Frank Hillebrandt, Hagen, and Prof. Dr. Mark Pearce, Nottingham, for their support and encouraging criticism. The thanks especially include Dr. Petra Eisenach, who takes on the administrative coordination of the project. And not to forget the Leibniz Association for the generous financial support and the employees of the office for the support in various places.

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Figure 1. Left to right, top to bottom: Peter Thomas, Yiu-Kang Hsu, Mark Pearce, Michail Roos, Frederik Schaff, Petra Eisenach, Frank Hillebrandt, Susan Pollock, Constance von Rüden, Thomas Stöllner and Maja Gori (Photo by P. Thomas).

SESSION 1 - Life Worlds in Resource Landscapes

Session Organisers

Thomas Stöllner, Yiu-Kang Hsu and Peter Thomas

Keynote Speakers

Timothy LeCain and Nils Anfinset

Keywords

Daily Practices and Routines in Landscapes, Life Worlds, Knowledge, Resources

What "resourcers" (resource-suppliers) perceived as relevant for their decisions is a key issue in understanding how resource-landscapes and specialized activities involving (mineral) resources has evolved in ancient societies. The decision - if a resource was worth exploiting, or if a landscape was considered appropriate to start an enterprise - has to do with the level of knowledge, world-views and expectations of the people involved. Normally the material evidence of production sites does not provide many clues about basic life-world-concepts.

However, we consider practices, which left their mark in the landscape, as one hint for the reconstruction of at least aspects of such basic perceptions, might they have been driven by social, economic or ritual/religious ideas and experiences. Ethnographic accounts tell us about the importance of experiences on structure and perceived causalities that decide the way of doing and constructing a life-practice. This session is dedicated to the discussion of such interdependencies on the basis of the theoretical models and special observations that ethnographers, archaeologists, sociologists made within their empirical studies, whose datasets often seemed illogical at first.

Resources as Life Worlds: How Do Material Resources Shape Lives and Minds?

Timothy J. LeCain

Keywords
Copper, Cognition, Extended Mind, Bronze Age

For an earlier generation of thinkers, the idea that a material resources like copper could fundamentally shape a society had seemed obvious. Archaeologists had often periodized the past in terms of the material things that they believed generated and sustained a certain type of society: the Stone Age gave way to the Bronze Age which in turn led to the Iron Age. Nineteenth century archaeologists took it as largely self-evident that the ability to smelt copper and make bronze tools marked a significant shift in the nature of a civilization, perhaps even establishing the pre-conditions for the rise of more complex societies and even writing. The Danish archaeologist Christian Jürgensen Thomsen formalized these ideas into the so-called three-age system of European antiquity in the 1830s. In more recent years, these concepts have persisted as rough markers of historical eras, the underlying assumption that a material thing like copper—since bronze is an alloy of copper and tin—persisted. However, the idea that stone, copper, or iron might be understand as a causal historical phenomenon fell out of favor. For post-modern historians with their focus on all things cultural, social, and discursive causalities, a Bronze Age seemed too simplistic and deterministic. Copper or material resources did not cause historical change, they argued, so much as it reflected previous changes in society. Following the rise of social and cultural construction, any such focus on material things seemed dangerously deterministic.

Which in many ways it was. However, in guarding against a simplistic determinism, the constructivist approach underestimated the many ways in which things like copper or other material resources shaped human culture in history in ways both subtle and profound. Part of the confusion here arises from a misleading model of human cognition that posits a brain that is largely abstracted and independent from the environment, as if a sheer act of intellectual imagination might easily enough shrug of the materialities that surround it to think in entirely novel ways. This is, perhaps, a theoretical possibility. Yet it seems obvious that someone who has only ever known the material possibilities of wood could somehow imagine a world where copper is ubiquitous. Their concept of what constitutes the concepts "hard", "malleable", "sharp" and so on, would be entirely encompassed by the properties of wood or stone that they have lived with for their entire existence. In this sense, the material world enters into our physiological and cognitive nature. The cultural becomes the biological.

These insights are supported by the recent development of neo-materialist theories through which we can begin to recognize how sociocultural phenomena themselves emerge from the ways human interact with non-human things, including the mineral resources they extract from the earth (LeCain, 2017). Indeed, a significant number of cognitive scientists and theorists now argue that even our much-vaunted human intelligence—presumably the first source of what we typically think of as culture—must also be understood as a material phenomenon. By this they mean not merely the largely undisputed point that all thought and consciousness emerge from entirely physical biochemical processes. Rather, some cognitive scientists and philosophers argue that the human mind is not confined to our skulls, or even our bodies, but is rather extensive with its surrounding environment.

Andy Clark, the most prominent advocate of this "extended mind" thesis, argues that human cognitive abilities can be distributed in a network of external props and aids like notes, maps, and files, aspects of our material surroundings without which some fundamental part of what we consider to be our intelligence would vanish. Obviously, many might object that these external material things are merely tools or scaffolding for an internal mind located solely in the brain. Yet Clark insists there are good reasons to embrace the idea that mind is literally extensive, as "it drives home the degree to which environmental engineering is also self-engineering." In changing our material physical environment, Clark suggests, we also reconfigure "our minds and our capacities of thought and reason" (Clark 2008: xxviii).

In a different though not altogether unrelated manner, the recent development of "neurohistory" also suggests the importance of considering cognition in our analysis of the past. Rather than pursuing the idea that the mind (in distinction to the brain) is extensive with the material environment, Daniel Lord Smail and other advocates of neurohistory focus more on the biological brain itself. Nonetheless, their concept of the brain is similarly linked to the material world. Drawing on recent insights from neuroscience, they point out that the brain is highly plastic, capable of both shaping and being shaped by its material environment. As humans use their intelligence and culture to change their material surroundings, Smail argues that they practice new patterns of behaviors that in turn "generate new neural configurations or alter brain-body states" (Smail 2008: 155).

As Clark, Smail, and other recent cognitive theorists suggest, our brains and minds are porous rather than bounded, plastic rather than fixed, and shaped by matter rather than merely a means of shaping it. Contemporary cognitive science and theory thus offers perhaps the most direct attack on the still dominant Cartesian and post-modernist idea of an abstract human mind—and thus culture and life worlds—that exists in isolation from its material environment. In sum, the new material turn might understand every aspect of human existence, from the most trivial to the broadest, as emerging from, evolving with, and being sustained by a dynamic material world.

The ways in which societies and individuals can think and act can be understood as emerging with the materiality of resources in at least two ways. First, as a material resource like copper or bronze sparks new ways of thinking and acting in the world. And second, as these new ways of thinking and acting become materially embedded in the society so that the environment itself carries the weight of their influence forward. Such an approach doesn't obviate the importance of cultural ideas and practices so much at it recognizes how these are embedded in and sustained by a non-human material environment. Put simply, in the Bronze Age the environment facilitates certain thoughts and practices that are distinctly different than those that would arise from a society based around stone or iron, or indeed wood and plastics.

With this in mind, the issue is not so much a matter of determinism, because this very idea posits an abstracted human intellect that exists outside of the environment that shaped, nurtured, and sustained it. By contrast, the neo-materialist approach argues that we are ourselves entirely material creatures emerging from a material world, and even our seemingly most abstracted thoughts and beliefs can never stray far beyond this world. This is not determinism but rather an embeddedness. Further, as we think and act within a particular environment of material resources, these patterns become ever more deeply engrained into who we are and how we understand the world.

This is the materialist meaning of a concept like the Bronze Age. Not that the availability of copper and tin determined the course of events. But rather, that once humans engaged with bronze they would henceforth think of the world and see possibilities for that world only as bronze people. Moreover, this would be a creative process, as humans used and pushed what bronze could do, new possibilities would emerge, new paths.

In sum, life ways were inextricably embedded in the material re-sources from which they emerged and were sustained. The material became the cultural.

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Relational Resources and Landscapes – Modes of Perception

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Keywords
Knowledge, Culture, Landscape

Over the past 150 years the discipline of archaeology has undergone substantial changes, from placing the object or artefact in focus, to analysis of larger contextual frames such as landscape and resources. At a time when aDNA, strontium isotopes and other analyses from the natural sciences are dominating interpretations of archaeological materials, we need theories and methods to takes us to the relationships between humans, things, landscapes and resources. The question is how we can understand parts of the prehistoric life-worlds? How did people conceptualize their landscape, knowledge and resources?

In this paper I will therefore approach a number of different themes connected to knowledge, culture and landscape with an emphasis on resources, using a number of cross-cultural examples especially connected to metals and mining. In order to build up this, I will especially draw on my own fieldwork from Nepal (Anfinset 2011), although this will be combined and broa-dened with additional studies from Africa, North America and Northern Europe, in order to better understand the knowledge of resources and technology in pre-modern societies. Here we see that there are a number of aspects that are connected to social-, economic and the religious life of those involved.

Today we often, but not always, regard resources as a way to exploit the natural environment in order to improve our conditions of living where the outcome is predictable. Resources are linked to technology and the ability to utilize both in a dynamic relationship and to capitalise the possibilities that develop through this interplay. However, resource extraction has implications on natural preservation and indigenous rights, bringing to the surface different knowledge systems and different ways to conceptualize the world. There is a dynamic interplay between resources and cultural values, or in other words between people, resources and landscape there exists a relation where the landscape express aspects of cultural identities, values and knowledge. This suggests that what we should not only understand as resources from a Western perspective where we often draw a clear distinction between landscapes, resources and humans.

Theoretically and methodologically these issues can be approached by relational thinking and cosmologies (e.g. Ingold 2000, 2011; Harvey 2005; Knappet and Malafouris, 2008; Olsen 2010; Brück 2019; Herva and Lahelma, 2020), which all have in common that non-human agencies are active features in the world and not only passive objects.

This aims at an interconnectedness between humans, landscape, and in this case resources, aiming at a broader understanding and ideas of how the world is shaped. This might be described as systems of knowledge, and ways of engaging with the world (Herva and Lahelma, 2020, p.6). Methodologically we may combine a number of disciplines such as archaeology, history, ethnography and folklore with a theoretical approach which comprises how people engage and perceive the world, and how this is related to the landscape. This means in other words how the environment and cosmology are perceived, including intangible and transcendental matters, and create a dialogue between different sources and materials. This has recently been known as relational thinking and epistemologies both within archaeology and anthropology, as systems of knowledge and ways to connect and engage with the world.

Therefore, using a relational ap-proach where materials and resources may have life or a spirit which are connected to a system of knowledge can give us further insight to the use of landscape and resources. The landscape may in fact play a significant part in the reciprocity of give and take, where there are no fixed borders, and engage with the environment. This demand in-depth studies of the social environment, not only observing, but also question how and why things happen.

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Caves and Rock Shelters, Burials and Smelting

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Keywords
Trentino, Northern Italy, Smelting, Caves, Ritual

At present, two separate phases of prehistoric smelting activity are recognised in the Italian Trentino - Alto Adige/Südtirol Region: the first in the later Copper Age and Early Bronze Age (Pearce, 2007, pp. 74-76), the second in the Middle, Recent and Final Bronze Age and Early Iron Age (Pearce, et al., 2020). They have very different characteristics. In the second phase of smelting, there are groups of stone-built open-air furnaces, sometimes in pairs with a roasting bed, and large heaps of slag (Cierny, 2008); production is on a large scale and would seem to have been highly visible in the landscape. Smelting mostly takes place in the areas where copper ore outcrops were mined (Preuschen, 1973). However, smelting in the first phase, the later Copper Age and Early Bronze Age, is entirely different and seems to have had a ritual connotation.

This can particularly be seen in the area close to the present-day city of Trento, where Copper Age and Early Bronze Age slag has been found at various rock shelters: Acquaviva (Besenello - TN), and Riparo Gaban, Romagnano Loch, La Vela di Valbusa and Riparo Marchi (Trento - TN). These are situated some distance from copper ore sources, at least 10 km as the crow flies (D'Amico, et al., 1998, p. 37); moreover, because of the mountainous Alpine terrain the actual distance travelled between the mine and the smelting place would have been greater and journey times long.

At Acquaviva, layers with a small furnace and slag heap overlie a female secondary burial (Angelini, et al., 1980, fig. 2) whose radiocarbon date of 3340-2900 cal BC[1] (bone sample, ETH-12497: 4410±70 BP; Pedrotti, 2001, pp. 202-203, 211-212, note 86 on p. 244) gives a *terminus post quem* for the metallurgical activity, though it is not clear how long a time elapsed between the burial and the smelting. Another furnace and an associated tuyère were also found at the site.

At Riparo Gaban, slag, tuyères, a crucible and a furnace were found (D'Amico, et al., 1998, p. 31, table 1) and a radiocarbon date of 2630-2300 cal BC (layer C5, Bln-1776: 3985±50 BP; Pedrotti, 2001, note 142 on p. 249) gives a *terminus ante quem* for the earliest smelting in layer C6.

At Romagnano Loch, the earliest evidence for metalworking, a crucible found in layer Q, sector III, is bracketed by radiocarbon dates (Alessio, et al., 1978, p. 80) - the layer below dates to 3710-3380 cal BC (layer R, R-775: 4810±50 BP) while the layer above dates to 2290-1960 cal BC (layer P, R-769: 3720±50 BP). There is also evidence for early Bronze Age metalworking. Smelting evidence includes slag, two tuyères and a fur-

[1] All radiocarbon dates are calibrated to 95.4% using OxCal v4.4.2 and the IntCal20 calibration curve: Bronk Ramsey, 2009; Reimer, et al., 2020.

nace. Burials are found in layer P of sector III (Perini, 1971, pp. 92-95; 1989; 1992, p. 53) and fragments of a crucible with traces of metal were found in the stone setting of tomb 12, which contained an adult whose bones were damaged by fire, probably as a result of later metalworking (Perini, 1975, pp. 300-301; Nicolis, 2001, p. 340). In sector IV, adjacent to sector III, slag associated with early Bronze Age pottery was found underlying a burial (Perini, 1971, p. 100).

At the Vela di Valbusa, a spread of slag, plus an area of baked clay and a furnace associated with a tuyère, was overlain by an Early Bronze Age tumulus and inhumation burial; a further two tuyères were also found at the rock shelter (Fasani, 1990).

At the Riparo Marchi, smelting can be dated to the end of the Copper and beginning of the Early Bronze Age (Mottes, et al., 2014); slag can be found in layers dating to the Early, Middle and final Middle-Recent Bronze Age of the nearby tumulus I at Gardolo di Mezzo (Mottes, et al., 2011; 2017).

Smelting slag has also been found at the Riparo di Monte Terlago rock shelter (Terlago TN), west of the Adige (Etsch) valley on the slopes of the Paganella massif, in layers dating to the Early and Middle Bronze Age (Dalmeri, et al., 2011).

It should be noted that smelting is also documented at open air sites (*pace* Dolfini, 2014, p. 497), for example a furnace and tuyères were found in a context with late Copper Age pottery at Tof de la Val, close to the Romagnano Loch rock shelter (Perini, 1973). Open air smelting sites are also known in the upper Adige valley e.g. at Bressanone/Brixen-circonvallazione ovest (BZ) and Gudon/Gufidaun-propr. Plank (Chiusa/Klausen - BZ) (Tecchiati, 2013, pp. 473-474), and at two hilltop settlements in the Fersina valley, close to copper ore outcrops of the Valsugana and Valle dei Mòcheni mining districts east of the Adige: Montesei di Serso and Croz del Cius (Pergine Valsugana - TN). A late Copper Age furnace was found at Montesei (Perini, 1978, pp. 10-25; Pedrotti, 2001, pp. 210-211), and a contemporary furnace and slag were found at Croz del Cius (Perini, 1989, figs 16-17). Likewise, not all Copper Age and Early Bronze burials in the region are associated with evidence for metallurgy (Perini, 1975, pp. 206-307; Nicolis, 2001) though burials are linked to rock shelters in the Adige valley south of Bolzano/Bozen (Tecchiati, 2013, pp. 457, 474, fig. 24).

The picture – at least as regards the Trento section of the Adige valley – seems to indicate a pattern of smelting in rock shelters and a strong association with places used also for burial (Pedrotti, 2001, p. 211; Nicolis, 2001, p. 356; Pearce, 2007, pp. 74-76). It is well known from ethnography that smelting, which sees the transformation of a powdered ore into a red liquid metal, has magical aspects (e.g. Budd and Taylor, 1995) and we might therefore argue that later Copper Age and Early Bronze Age copper smelting in this area was a secret activity; certainly we can say that it seems to have taken place in a ritualised context, perhaps as secret knowledge that had to be kept hidden both from the miners who extracted the ore and also those who cast and worked the copper and bronze metal, and protected by ritual (Forbes, 1950, pp, 79-91). Herbert (1993) has drawn attention to the numinous quality of slag in sub-Saharan Africa, and perhaps it is no accident that slag seems to have been included in multiple layers of tumulus I at Gardolo di Mezzo, as noted above. In Bolzano/Bozen province, in the upper Adige valley, slag seems to have been ritually buried along with tuyère fragments at the third millennium BC site of Millan/Milland-metanodotto SNAM (BZ; ETH-26698: 4090±50 BP, 2880-2480 cal BC; Tecchiati, 2013, pp. 465-467, fig. 17) and deposited in the tumuli at Velturno/Feldthurns-Tanzgasse (BZ; Dal Ri, et al., 2004, pp. 158, 162). However, Early Bronze Age metalworking (as opposed to smelting) is documented by crucibles at the Trentino lake villages (*palafitte*) of Ledro (Battaglia, 1943, pp. 40, 53-54, tav. XXVI.2; Rageth, 1974, pp.

175-176, taf. 89, 90: 1-4) and Fiavè-Carera (Perini, 1987, p. 34, fig. 14.1) and so it was arguably carried out openly within settlements, at least in the Valli Giudicarie of south-eastern Trentino.

This pattern would seem to present a different picture to Copper Age smelting elsewhere in modern-day Italy. For example, at Lovere (BG) on the shores of Lake Iseo in the Lombardy Alps, smelting seems to take place inside a settlement (Giardino, 2006; Poggiani Keller, 2000) and the same pattern is seen in central Italy, for example at San Carlo-Cava Solvay (San Vincenzo - LI) (Artioli, et al., 2016).

There does, however, seem to be a relationship between metalworking, caves and burials in central Italy later in the Bronze Age (Nicolis, 2001, note 80 on p. 364; Pacciarelli and Sassatelli, 1997, p. 16): for example, at the Grotta dei Baffoni (Genga - AN), in the Sentino gorge, in the Early or Middle Bronze Age (Lucentini, 1997, pp. 37-39) and at the Grotta a Male near Assergi (L'Aquila - AQ) in the Middle Bronze Age (d'Ercole, 1997, pp. 54-61). We may also note that there are Middle Bronze Age burials at the Grotta della Monaca (Sant'Agata d'Èsaro - CS), in Calabria, where copper minerals were likely mined for pigments in the third millennium BC. After the burial phase there was a new phase of mining at the end of the Middle Bronze Age in the cave (Larocca, 2001; Larocca, ed., 2005). This association between metalworking and caves may have been very long-lived: in Graeco-Roman mythology, the smith of the gods, Hephaistos/Vulcanus, worked underground in places with volcanic activity, such as the Aeolian islands (d'Ercole, 1997a, p. 57 - see for example Apollonius, *Argonautica*, 3, 41-42)2.

We can therefore see that in the later Copper Age and Early Bronze Age Trentino - Alto Adige / Südtirol the world view of copper smelters was different to that in the second phase of prehistoric smelting. In this first phase, smelting often takes place in caves and rock shelters, which were often also used for burials, and slag was incorporated in ritual monuments. The picture is of a craft that was secret and ritualised, rather than a 'rational' semi-industrial craft.

[2] For the ritual significance of caves in prehistoric Italy more generally, see Whitehouse (1992) and Pacciarelli (ed., 1997).

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Life and Work in the Ancient Iron Smelting Landscape of Elba Island

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Keywords
Elba Island, Iron Smelting, Alcohol Consumption, Night Work, Wage Labour

The Tuscan island of Elba was together with the city-state of Populonia the main centre of iron mining and smelting in *Italia* in antiquity (Figure 1). During more than 200 years of history of research, the focus was mainly on the identification and dating of sites. In the recent years, geoarchaeological and landscape archaeological studies offered new perspectives on human-environment interactions on Elba (Corretti, et al., 2014; Becker, et al., 2019a; 2020). In the current paper, we want to focus on the life world of the iron smelting landscape of Elba, a topic until now only rarely shed light on.

Economical imprinting phases of the iron smelting landscape Elba in antiquity

The chronology and economic development of both iron mining and iron smelting on Elba is well studied by now and can be divided into five imprinting phases (Eser and Becker, in prep.; Eser, 2020). The introduction of the iron mining and smelting technology falls into an anterior phase of predominantly copper-trade and possible copper-production between the 10th and 8th c. BC. After the iron deposits of Elba have been first mined in coastal opencasts in the 7th c. BC, Populonia turned its economic focus from copper to iron metallurgy (Corretti, 2017; Eser, 2020). The initial phase of ferrous metallurgy from the 7th to 5th c. BC is characterised by iron mining on Elba, the transport of Elban raw ore to different smelting sites on the Apennine peninsula—i.a. Populonia, Follonica, Genoa, Pisa and elsewhere (Manca, et al., 2018)—and the smelting of the ore at these continental sites (Eser and Becker, in prep.). The 4th c. BC marks the consolidation phase of both Elban and Populonian iron mining and smelting. Populonia increases her iron production by founding new iron smelting sites on Elba that are situated along the East-West-route connecting Populonia with Corsica, Sardinia, and other markets in the Western Mediterranean. Growing military pressure on Etruria probably fostered the demand for iron during that period (Eser, 2020). In the 3rd c. BC, the Romans take over control over the iron production in Populonia and Elba (Cambi, 2017). In the following two centuries, during the industrial phase, smelting sites are found all over Elba, predominantly at coastal locations with sandy beaches suitable for landing nearby well known anchorages, close to the mouth of creeks, and at the beginning of wider valleys with sufficient wood resources in the hinterland (Eser and Becker, in prep.; Corretti, 1988). The pattern (Figure 1) of these—sometimes large-scale—iron smelting sites (some over 10,000 tons of iron slag deposited) signifies the strategy of the fullest exploitation of secondary resources, including wood for charcoal production, and stone, sand, clay, and water for the construction of furnaces and tuyères (Eser and Becker, in prep.; Corretti, 2017; Eser, 2020). Rome's demand for iron was high between the 3rd and mid-1st c. BC as the Romans conquer one new province after another and, thus, gaining new markets for distributing their products. Besides the ongoing transport of Elban raw ore to the mainland the trade of Elban iron blooms is another remarkable feature of this period (Eser, 2020). In the second half of the 1st c. BC, the number of smelting sites on Elba and the intensity of smelting activities in Populonia clearly decreases (Cambi, 2017). The often claimed end of Elban iron smelting caused by fuel wood scarcity in the 1st c. BC is indefensible as smelting activities continued on smaller scale in 1st c. AD. Further, models concerning the fuel wood consumption show that it is unlikely that no sufficient fuel wood was available in the 1st c. BC

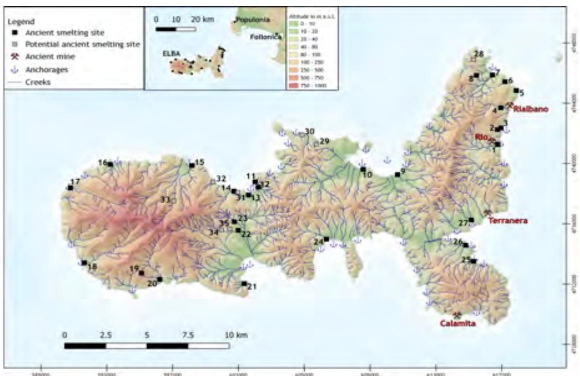

Figure 1. Map of Elba with ascertained and potential smelting sites. 1: Gli Spiazzi – 2: Vigneria – 3: Valle del Giove – 4: Fegatella – 5: Capo Pero – 6: Fornacelle – 7: San Bennato – 8: Ombria – 9: Magazzini – 10: San Giovanni – 11: La Guardiola – 12: Campo all'Aia – 13: Gnacchera – 14: Scoglio della Paolina – 15: Marciana Marina – 16: Sant'Andrea – 17: Patresi – 18: Pomonte – 19: Sughera – 20: Seccheto – 21: Galenzana – 22: Santa Lucia alla Pila – 23: Forcioni – 24: Fosso Stagnolo – 25: Ferrato – 26: Naregno – 27: Barbarossa – 28: Lentisco-Martella – 29: Seccione South – 30: Acquaviva West – 31: Spartaia – 32: Bagno – 33: Ponte di Rimercoio – 34: Fosso di Campotondo – 35: La Calcinaia. Credits: 1 R. A. Eser; data according to Nihlén 1958–59; Zecchini 1978; Corretti 1988; 1991; Pagliantini 2013/14; own observations; hillshade: Regione Toscana 2014

(Becker, et al., 2020). In addition, the old senate's decree to abolish mining in Italia reported by Pliny the Elder did not affect Elba (Camporeale, 2013; Eser, 2020). The phase of decline from the mid-1st c. BC to the late 1st c. AD is, therefore, rather marked by a creeping decline of iron smelting activities on Elba than by an abrupt end. Furthermore, there is indirect evidence for iron mining in the late 2nd c. AD by finds of Elban raw ore on the wreck of Procchio at the northern coast of Elba (Eser and Becker, in prep.; Eser, 2020). Except some literary evidence by grammarians and poets of the 5th c. AD concerning Elba's mines, there are no archaeological traces showing iron mining or smelting on Elba after the 2nd c. AD. Iron production starts again in the 11th c. AD under Pisan rule (Corretti, 1991; 2017; Manca, et al., 2018).

Alcohol for Elban iron smelters

Dealing with archaeometallurgical remains on Elba gains several problems. First, most of the ancient slag heaps are nowadays lost due to their excavation between the First and Second World War for re-smelting of the ancient iron slag (Pistolesi, 2013). Other smelting sites are overbuilt by modern tourist-infrastructure. Second, the archaeological traces found during these industrial excavations such as ceramics, coins, metal finds and so on gained—in opposite to Populonia's slag deposits (D'Achiardi, 1929; Minto, 1954; Fedeli, 1983; Chiarantini, et al., 2007)—little archaeological interest. Thus, recent archaeological research depends on the reports of former researchers such as Vincenzo Mellini (1879; Monaco and Mellini, 1965), Remigio Sabbadini (1919), and John Nihlén (1958/59). Besides these problems most of the ceramic remains one can find today on some of the former sites (Zecchini, 1978; Corretti, 1988; 1991; Eser, 2020) are often only undiagnostic body-sherds, giving only general datings like "ancient" or “roman”, if the remains show clear connections with metallurgy such as ferrous incrustations at all. Notwithstanding, the latest re-examination and re-evaluation of all dating materials of all known find spots of iron slag revealed that there are 27 ascertained and 8 potential ancient smelting sites on Elba (Eser, 2020), globally dating between the mid-4th c. BC and 1st c. AD which form the basis of the current paper (Figure 1).

Amphorae fragments of the 3rd c. BC to 1st c. AD were found in 27 out of 35 ancient smelting sites (Figure 2). On 19 of these 27 sites with amphorae sherds the amphorae ceramics are recognized as being Greco-italic, Dressel 1 or Dressel 2–4 forms, i.e. amphorae mainly used for containing Italian wine (Peacock and Williams, 1986; Sciallano and Sibella, 1991). In 15 out of 35 ancient smelting sites black-glazed ceramics have been discovered. In 10 of these 15 smelting sites, Campanian black-glazed ware is going hand in hand with wine amphorae fragments in the same context. Some of the Campanian black-glazed ceramics are recognisable as real drinking vessels such as a beaker Morel type 7221 b in Capo Pero (Morel, 1981; Corretti, 1988), a drinking bowl Morel form 6210/6220 in Gli Spiazzi (Monaco and Mellini, 1965; Morel, 1981), or a kantharos Morel type 3121a 2/3121f 1 in San Bennato (Morel, 1981; Firmati, Principe and Arrighi, 2006). The combination of ceramic ensembles of black-glazed drinking vessels and wine amphorae indicate the consumption of alcohol, foremost wine, which was one element of daily life at the smelting site. It is notable that the consumption of alcohol may here connected to the class of iron workers and not to the elites of society. The collective consumption of alcoholic drinks could be a form of identity-creating rite (Dietler, 2006) for the iron smelters with the side-effect that alcoholic beverages serve also as a high calorific intake for hard-working and sweating smelters at the furnace (Benquet, 2016).

At some smelting sites (Figure 2) other black-glazed ceramic vessels like flat bowls

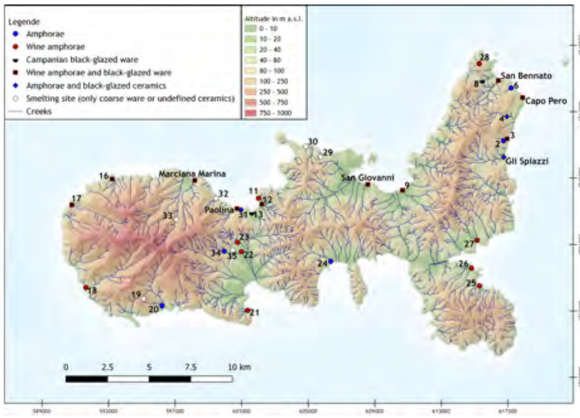

Figure 2. Map of Elba with ancient smelting sites containing finds of amphorae and black-glazed ceramics. For unnamed numbers see Caption of Figure 1. Credits 2 R. A. Eser; data according to Eser 2020; hillshade: Regione Toscana 2014

without handles and feet—so-called paterae (Morel, 1981) of different forms and types in Capo Pero, Scoglio della Paolina, San Bennato, Marciana Marina, and San Giovanni (Monaco and Mellini, 1965; Zecchini, 1978; Firmati, Principe and Arrighi, 2006; Pagliantini, 2013/14; Cambi, et al., 2018)—have been discovered that are normally connected with li bation. There the consumption of alcohol may have been part of a ritual scarifying alcohol at the furnace site for obtaining a good smelting result. Same can be seen nowadays in iron smelting rituals in southwest Ethiopia or Tanzania, where the offering of alcohol is still part of the smelting procedure (Haaland, Haaland and Dea, 2004; Schmidt, 2009). Finally, the ceramic ensembles of drinking vessels and wine amphorae could also point to the feasting of alcohol at workplaces as part of collective work events, a common practice of recompense in pre-modern societies (Dietler and Herbich, 2001; Dietler, 2006). For example, a big feast could mark the end of a smelting season that involved charcoal burners, mule transporters, smelters, co-workers and people from nearby settlements.

Light for Elban night workers in iron smelting

Oil lamps are common finds in ancient mining landscapes with deep mine workings. By current knowledge, there are no ancient traces—except one little short gallery in the Rio mine (Corretti, 2017)—left for deep mine working on Elba, thus, oil lamps were not much needed (cf. Stöllner, 2008). Maps, reports and sketches from the time before the beginning of industrial mining in 1850–80 show that there were in fact only opencast mines on Elba in antiquity (Eser and Becker, in prep.). But, a few finds of oil lamps—mostly the lamp type Dressel 2 of the late republican-early imperial period (Thöne, 2004)—have been discovered in 5 different smelting sites (Figure 3) out of 35 sites on the island (Monaco and Mellini, 1965; Vanagolli, 1971; Zecchini, 1978). As there are no signs for habitation directly at the smelting sites (settlements are located more inland) the lamp finds have to be connected with events that took place at these workplaces.

Smelting experiments have shown that the duration of successful iron reduction does not take always the same time span and is even longer when refining of iron bloom is following directly after smelting (see the durations of experiments by Crew, 1991; Nikulka, 1995; Fluzin, Ploquin and Dabosi, 2004). The duration of sunlight on Elba is changing from about 15 hours in summer to 12 hours in autumn (and spring) to only 9 hours in winter (Redazione di Comuni-Italiani.it, 2020). If we consider that the preparing acts of iron smelting such as crushing the ore and charcoal, firing of furnace structure, and implementing of tuyères took the whole morning and smelting started in the afternoon the whole production process could continue after the end of daylight. In such cases, the oil lamp finds can be an indicator for night work at the iron smelting sites. In fact, night work was especially an essential part of one of the supplementary works for iron smelting, namely charcoal burning (Holsten, et al., 1991; Radkau, 2018) which could have been taking place nearby the Elban iron smelting sites (but the data available today does not allow for any conclusions of the exact co-organization of charcoal burning and iron smelting on Elba). Nonetheless, night work should be considered as essential in the ancient operation mode of iron processing and is according to Julius Paulus (Sent. 2.18.1) often conducted by wage labourers, which may have been present at Elban smelting sites as well.

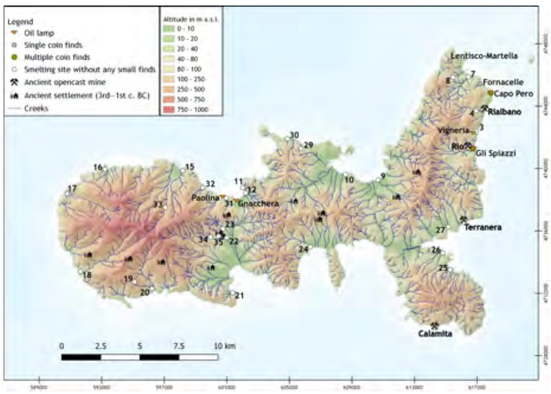

Figure. 3 Map of Elba with ancient smelting sites containing small finds like oil lamps and coins. For unnamed numbers see Caption of Figure 1. Credits: 3 R. A. Eser; data according to Eser 2020; hillshade: Regione Toscana 2014

Money for Elban iron and wage labourers

Another significant but often neglected feature of iron smelting sites on Elba are the finds of Roman coins made between the slags of different heaps. In 4 out of 35 sites, V. Mellini and R. Sabbadini discovered coins (Figure 3) in the time between 1877 and 1920 (Sabbadini, 1919; Monaco and Mellini, 1965). The coins are nearly all made up of bronze and are of two distinct time horizons: several roman-republican As—mostly the Janus-prow series (Thurlow and Vecchi, 1979)—from the late 3rd to the mid-1st c. BC in Gli Spiazzi, Capo Pero, and Lentisco-Martella and single Flavian (68–96 AD) sesterces in Gli Spiazzi and Fornacelle (Sabbadini, 1919; Monaco and Mellini, 1965; Eser, 2020). Besides the fact that somebody has lost his money at the different smelting sites the embodiment of the coins inside the slag heaps is a clear indication that money was needed at the workplaces. This is another remarkable feature as one would expect daily coin circulation in the settlements of the island where trade is taking place (Geneviève, 2016) but where coins are rarely found. This fact leads to three hypotheses:

Firstly, the coins were used for the trade of Elban iron products. This is clearly evidenced in a detailed text passage of Diodorus Siculus (5.13.2). After describing the different production steps of iron processing on Elba—from mining to crushing, preparing and smelting of iron blooms—Diodorus marks that the iron blooms (!) from Elba are changed against goods (μεταβάλλω) like eventually the wine amphorae and black-glazed ceramics and sold against money (συναγοράζω) to the seafaring traders. As most of the ancient smelting sites are situated at the coast in bays and good landing facilities, (Eser and Becker, in prep.), the seaborn trade of iron and goods was an important factor for running the different smelting sites.

Secondly, the coins were used to pay the iron smelters at smelting sites, so one can presume the application of wage labour on Elba. Especially, the money in some of the later on big slag heaps, e.g. Capo Pero or Gli Spiazzi, could be connected to wage labour as the big dimensions of these heaps—some over 10,000 tons—where eventually gained in big smelting campaigns during short time (cf. Geneviève, 2016). Such large-scale operations would have had a hierarchical organization in which one furnace master supervised several smelting teams of unskilled workers that were under contract by one entrepreneur. After they finished their contract by delivering a predetermined amount of iron, they were given the value of their labour as a wage in money (Mrozek, 1989). Such wage labour which could be also daily wage labour was practiced in antiquity, e.g. in mining, in transportation, in agriculture, in construction industry, and in more special cases such as the diving for pearls or conducting funerals (Mrozek, 1986; 1989).

Finally, the coins could have been also used for the remuneration of the supplementary industries, such as charcoal burning, transportation of goods, food production and so on (Geneviève, 2016; Eser, 2020). In that case, wage labour was possibly not only limited to iron smelters but included other professions as well.

Conclusions

After re-examining three different groups of findings from ancient iron smelting sites on Elba, we put forward three hypotheses concerning the life world of Elban iron smelters: (1) ceramic ensembles of wine amphorae and drinking-vessels (Campanian black-glazed ware) indicate the consumption of alcohol at smelting sites. This wine consumption could be due to nutritional, social, or religious reasons. (2) Several finds of oil lamps show the application of night work because furnace campaigns do not always take the same duration and can go beyond the end of daytime. (3) The discovery of bronze coins in slag heaps is surely connected to trade at the smelting sites and may point also to the application of wage labour on Elba which hints indirectly at the lower social status of these workers.

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Resource Landscapes of Sixteenth and Early Seventeenth-Century Mining

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Keywords
Workscape, Resourcescapes, Labour

The early modern German word for mine and landscape which is *Bergwerk* and *Landschaft* share the same meaning, of something that has been made or built, shaped or designed. Whereas the suffix *-werk* comes from the verb *wirken*, meaning to work or to make, the suffix *-schaft* is related to the verb *schaffen*, which means to create something by art or through craftsmanship.[1] Especially since the late fifteenth century mining became a very prominent site of technological innovation and application. The invention of increasingly complex ventilation systems, or new pumping and ore processing technologies transformed remote places into technical landscapes. These landscapes reflected a dynamic system shaped by the interplay of mineral matter, human and mechanical labor, as well as natural processes.

My analytical take on the topic of "life worlds in resource landscapes" promotes a perspective of how nature, miners, and mechanical arts created "landscapes" of multilayered relationships between mineral matter, physical labour, the miner's bodies, infrastructures, experiences and beliefs, through which the miners understood and made sense of their world. With their work, machines and infrastructure humans changed nature and are being changed themselves. Next to many other concepts (older and more recent) I'm inspired by Thomas G. Andrews' concept of "workscape", which reveals how nature shaped the lived experience, identity, and politics of mine workers. Andrews defines the workscape as interplay of human labor and natural processes. It implies a "constellation of unruly and ever-unfolding relationships—not simply land, but also air and water, bodies and organisms, as well as the language people use to understand the world, and the lens of culture through which they make sense of and act on their surroundings" (Andrews, 200, p. 125). However, Andrews' concept of "workscape" is based on a distinction from the concept of "landscape", which he understands only superficially as a two-dimensional space. He underestimates the dynamic and multi-layered dimensions of landscape while reducing it to a static artistic representation of a "particular stretch of ground" (Andrews, 2008, 125). But landscape is more than that. In Cosgrove's understanding, "it points to a particular spatiality in which a geographical area and its

[1] Lemma 'bauen', in *Deutsches Wörterbuch von Jacob und Wilhelm Grimm*, Vol. 1 (Leipzig, 1854), 1171-1175; Lemma 'schaffen', in *Deutsches Wörterbuch von Jacob und Wilhelm Grimm*, Vol. 14, (Leipzig, 1893), 2017–2032; Lemma 'Werk', in *Deutsches Wörterbuch von Jacob und Wilhelm Grimm*, Vol. 28, (Leipzig, 1955), 328–347.

material appearance are constituted through social practice" (Cosgrove, 2004, p. 61). In a word, landscape is best understood as a relational space determined by the performative relation between nature and human making, thinking and experiencing. It connects nature, culture and imagination as a spatial actor. In the following I prefer to direct our attention from workscapes to *resource landscapes*, or *resourcescapes*.

The etymological roots of "Ressource" in the German speaking context date back to the eighteenth century (according to Kluge), where it (already) denoted the stock of natural and financial resources. Originally, the term was borrowed from the French *resoudre*, which in turn was derived from the Latin *surgere* (to rise) and *regere* (to lead, to govern). Therefore, the term resource is conceptually intertwined with lifted materials (*surgere*) and politics (*regere*) (see H-Soz-u-Kult Debatte 2012, n.p.). Although sixteenth century did not yet use the term resource it nonetheless is important to apply it as an analytical concept.

My analytical take on resource landscapes takes into account the material culture of substances (most notably: Espahangizi and Orland, 2014; Miller, 2005; Soentgen 2007; Mintz 1985) and goes beyond a static understanding of both landscape and resources. According to the classical study of the resource economist Erich Zimmermann (1933) resources are made through processes of appraisal and human labor. Zimmermann understands resources not simply as fixed and finite, but as constantly in the making. Resources are not, but "they become", as he puts it (Zimmermann 1933, p.3). He proposed a functional and relational notion of resources, which depend of people's wants and their appropriation of their environment. However, understanding resources as entirely social and depending of human control and human wants neglects the uses and possibilities that matter affords to humans. In a recent article, the anthropologists Tanya Richardson and Gisa Weszkalnys draw their attention to resource making not only as social but also as material process. They start from an understanding of resources as "relational phenomena" of *resource materialities* (2014). The latter involve "the combined examination of the matters, knowledges, infrastructures, and experiences that come together in the appreciation, extraction, processing and consumption of natural resources" (Richards and Weszkalnys, 2014, p. 8). In line with these recent conceptual approaches to a broader understanding of resources, especially from anthropologists and geographers, I argue for a dynamic and more holistic approach to resources as socio-natural entities consisting of material, symbolic, epistemic, political, and discursive dimensions.

Figure 1. Mining landscape with miner's at work. After: Georgius Agricola, *De re metallica*, Basel: Froben, 1556, p. 72.

Mechanized extraction technologies, division of labor, official administration and wage labor were characteristic for the mining industry since the sixteenth century.

Family businesses, small-scale technology and cooperative associations were gradually replaced by models with decidedly capitalist features: the practice of silent partners became a dominant business model, which was necessary due to the high investment costs involved in opening up new mines and in pumping, extracting and smelting facilities (see esp. Bartels, 1992; Bartels and Slotta 2012; Asmussen and Long 2020 with further literature). Moreover, the machines became increasingly complex and expensive, they also enabled the expansion into deeper layers of rock. Going deeper underground made mining not only more expensive, but also more dangerous for the miners. As Pamela Smith has shown, the entanglement of the miners' bodies with matter was particularly evident. The miners' specific manual labor influenced their musculature and posture, and the matter on which they worked also marked their bodies with distinctive diseases (Smith, 2015; 2017). All interventions to nature led to numerous consequences or side effects and formed an ongoing cycle of production and decay. Humans not only produced, manufactured, exchanged or consumed resources and transformed landscapes they also became increasingly entangled with and dependent on them through their bodily and mechanical work and maintenance (on the aspect of human-thing entanglement see Hodder 2012). This new form of human-technology-nature entanglement in the context of the proto-industrial mining economy has been reflected and addressed by authors with both scholarly and artisanal backgrounds such as Georg Agricola (1494–1555) or Paracelsus (1493/1494–1541) and his followers.

The illustrations in Georg Agricola's renowned book on mining *De re metallica* (1556) depict an environment that has been visibly and fundamentally transformed (Figure 1): They show a largely deforested mining landscape, perforated throughout with pits and shafts. The miners are represented as diligent and hard-working, who can be seen operating machines or working in the shafts and tunnels. They wear their traditional garb, the miner's hood, and are equipped with tools essential to their given work: hammer, pick, and lamp. Agricola's woodcuts show how nature is converted into a productive resource through mechanical and bodily labor.

De re metallica has been generally interpreted as evidence of a new understanding of human domination of nature which evolved during the sixteenth and seventeenth century. The entanglement of the human body with nature stands in opposition to the mainstream narrative of Western culture that has propelled science, technology, and capitalism's effort to "master" nature; or the destruction of nature by mechanistic science and technology that began in the late sixteenth and early seventeenth century. This narrative builds on the fundamental dichotomy between technology and nature, or culture and nature (see esp. Latour 1991; Bennett 2001; Chakrabarti 2009; Pritchard and Zeller 2010; LeCain 2017).

A closer look to Agricola's text shows that his depiction of the miners' the hard work combined with technical inventiveness is not narrated as a story of working against nature but as a mode of co-*laboration* where nature itself had a particular form of agency: Sixteenth-century mining literature was heavily indebted to an organic perception of nature (Merchant 1983, pp. 99–126). In his earlier book on mining *Bermannus, sive de re metallica* (1530) Agricola uses a vocabulary of generation and growth when discussing the occurrence of silver in the Bohemian mining area of St Joachimstal: "This silver ore can also be found in very different forms. There are, so to speak, surprisingly large masses in the side cords of the ore veins, where it is found in formal nests. Moreover, it can be found like buds sprouting from flowers"[2]

[2] "Invenitur & hoc varia ratione. Interdum enim massæ magnitudinis cannalibus venarum, tanquam in nido quodam reperiuntur. Interdum ut gemmæ ex arboribus pullulascunt..."

(Agricola 1530, p. 73). Agricola's theory of mineral generation, which he formulated elaborately in his later works *De ortu et causis subterraneorum* libri V (Basel, 1544) and *De natura fossilium* (Basel, 1546) was based on mineral juices that he sees in analogy to the humors of ancient physiology: various types of water and juices in the Earth are generated by their innate warmth just like the humors are generated in the bodies of animals (Hirai 2005, p. 119–120; Norris 2007 and 2006).[3] This makes clear that for Agricola the mineral realm was not a separate domain, rather it is connected to animal and vegetable bodies through the principle of humors. This perception also becomes visible in terms of utility: in the first book of *De re metallica* (Agricola 1557, pp. i–xxi) Agricola defends mining against critics, who consider it as the downside – in a literal and moral sense – of praiseworthy, noble and fertile agriculture. He argues that just as the soil the underground has to be cultivated in order to bring rewards.

The idea of perceiving the mineral realm in analogy to the animal and the vegetable was discussed by Pliny, Strabo and Albert the Great and received much interest among neoplatonist thinkers such as Henricus C. Agrippa von Nettesheim, Paracelsus, Girolamo Cardano, Bernardino Telesio, Francesco Patrizi and Giordano Bruno to Tommaso Campanella, the Rosicrucians and Robert Fludd (Merchant 1983, pp. 99–126; Oldroyd 1974). Among practitioners, miners and alchemists the writings and ideas of Paracelsus (1493/94–1541) gained a considerable influence (Smith 2004, pp. 82–94 and 155–ff.). On his numerous journeys Paracelsus visited all important mining regions in Saxony, Bohemia, Slovakia, Transylvania and Slovenia. In these places he received a broad range of knowledge about minerals and metals from miners, assayers, smelters, alchemists, mint masters and other practitioners. Especially during his stay in Schwatz in 1522/23 he learned about the effects of chemical substances on the health of the people (Soukup 2004, pp. 195–248). His philosophy of nature was based on the correspondence between the world (macrocosm), and the human being (microcosm) (Gantenbein 2000). Paracelsus adopted the concepts of "seeds" that was developed in Renaissance neoplatonism and alchemy and placed it at the core of his natural philosophy and theology, seeing God as the primordial seed of everything. (Hirai 2005, pp. 179–215; Hirai 2020). For Paracelsus only experience and manual labor enable knowledge of nature. Understanding and experiencing nature was for him a "form of worship, giving

Figure 2. Speculum metallorum, fol. 20r, 1575, Vienna, ÖNB, Codex 11 134

[3] He explicitly distanced himself from Albertus, who wrote in his *De mineralibus* that the growth of different minerals is to be attributed to the power of the stars (Agricola 1956, p. 133, 180). Further he opposed theories that perceived sulfur and mercurius as compositional principles of all metals, which is most prominently articulated in the work of Paracelsus (Agricola 1956, pp. 166-169; Norris 2007, pp. 73–76).

humans an understanding of God's creation" (Smith 2004, p. 84). In accordance with other authors of mining books such as Ulrich Rülein von Calw (1465–1523) he promoted an organic conceptualization of ores that is articulated in terms of procreation and giving birth.[4] The bohemian metallurgist Nicolaus Solea (n.d.), heavily indebted to Paracelsus' ideas, gives detailed information about the entire lifecycle of metals: In his *Büchlein von dem Bergwergk* [Booklet on mining, 1600] he describes the generation or "semen" of metals (pp. 4–8), their food (pp. 8–11) or their inhalation (pp. 26–29) and exhalation i.e. dying (pp. 29–33). Within this organic perception of the mineral domain the process of growth and refinement of metals is described as a "workplace that resembles a church" in which the metallic spirits eat, rest and work (*De officina metallorum*, pp. 11–14). Soleas makes thus particularly clear that hard work was the basic principle of all life on earth on every level of creation.

Nevertheless, human labor in the mine and nature's labor underground was engaged with vital matter: In contrast to our modern belief, metals were perceived as animated, changeable, renewable, and some even thought they were able to regenerate when the mines were abandoned by the miners. The latter was formulated by the Lutheran priest and pastor of the mining town of St Joachimsthal Johannes Mathesius (1504–1565) in his printed collection of mining sermons *Sarepta oder Bergpostilla* (1562, esp. Third Sermon, pp. XXXVIII–LVII).[5] He further stated that metals would develop very slowly from base metals to precious metals: "So arises the common occurrence among our miners that when they strike a nice bismuth, they say they came too early; by which they mean that if the ore had only sat longer in the mountain fire, it would have become silver"(Mathesius 1562, p. L).

In all these texts from authors with medical, alchemical or theological background mining is characterized as an economic, laborious, empirical and spiritual undertaking: Solea described the mine as a workplace and underground church (Solea 1600, p.12), Mathesius depicted it as God's metallurgical laboratory (Mathesius 1562, p. XLI) and Paracelsus regularly drew analogies from his medical or metallurgical practice to the Christian doctrine of salvation. For example, when the distillation and the removal of slag during the refining of metals is seen as a metaphor for the resurrection of Christ (Gantenbein 2000, p. 20).

A significant image illustrating this divine geological agency is found in the manuscript *Speculum metallorum* [*Mirror of the metals*], which contains alchemical sections by Martin Stürz, a descendant of a Saxon mining family (Stürtz, Basel Codex 1597, pp. 5r–8r; Kirnbauer 1961). The visualization of the generation of metals connects metallurgical knowledge with theological interpretation.

Behind a crucified Christ seven ribbons are depicted that represent the seven metals with their corresponding planetary sign and colors: lead (Saturn, black), tin (Jupiter, blue), iron (Mars, red/brown), gold (Sun, gold), copper (Venus, green), mercury (Mercury, red) and silver (Moon, silver/grey). In this illustration an analogy is created between the suffering, death and salvation of Christ and the generation of mineral matter (Vienna Codex 1575, fol. 20r.; Kirnbauer, 1961, p. 22). Horst Bredekamp argued, that a mine run by virtuous miners was thus not only a form of work which appealed to God, but also became a symbol of the redemption of matter and humans at the same time (Bredekamp, 1981, p. 17). Therefore, not only with regards to the practices (and consequences) and benefits of mining but also with regards to the theories of metallogenesis (generation of metals) we see that labor is considered as an essential factor, which

[4] "Item in der vormischung ader voreynigung des quecksilbers und schweffels im ertz helt sich der schweffel als der menlych som undd daß quecksilber als der weiblich som in der geberung ader entpfahung eynes kindes Rülein." 1518 [orig. 1500], n.p.

[5] "Hierher gehört nun das gemeine zugnuß unser Bergkleut/ wenn sie einen schönen Wißmat erschlagen/ pflegen sie zu reden/ wir sind zu frü kommen/ damit sie bekennen/ wenn diese bergart lenger im bergfewer gestanden/ so were gut silber drauß worden. "

determines and enables resource production. We thus should not restrict labor solely to the domains of economy, industry and production. For a broader understanding of the early modern resource economies of mining it is essential to connect the economic implications of labor with its natural philosophical and spiritual meanings.

Summary

The literary and visual culture of mining proves to be a fruitful ground to historicize the interplay between the multiple semantics and meanings of natural resources, labor and technology, which together form a resource landscape: with the aid of mining tools, pumping, digging, and ventilation machines, the natural limits of labor are pushed further into the subterranean realm. The co-*laboration* between nature, bodily work and machine power brought labor deeper into the rock which also increased pain, danger, and risk to human life. The ingenious innovations that created new working conditions and dangers are mostly investigated with a focus on technological innovation, human mastery over nature or economic efficiency. But to understand human relation to the underground and its resources only in terms innovation and mastery means to ignore the many different layers of human-nature entanglement in resource landscapes.

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Knowing Stones. Handling Deposits 1000 to 1500 – Reflections on a History of Knowledge of Mineable Georesources

Lena Asrih

Keywords
Medieval Mining, Georesources, History of Knowledge, Interdisciplinarity, Methodical Approaches

Decisions on whether or not to start a mining operation are and have always been, based on knowledge and priorities derived from it; but how did that knowledge look like, before geology and chemistry developed as sciences and mining developed its own specialist literature? How did people handle that knowledge? In this paper, I refer to the concept of a history of knowledge of mineable georesources from 1000 to 1500. As historian, my primary focus is on written sources and their potential of giving us information on what societies knew about deposits and their use and how they dealt with that knowledge. Obvious sources like mining administrative texts or alchemical and mineralogical texts can build the basis of such an analysis. Besides that, literature, religious writings, or texts of arts and crafts are worth considering. There are many ways to write such a history of knowledge. It could, for example, either concentrate on a *specific resource (1)*, *type of source (2)*, or *mining product (3)*.

Archaeological and historical research document mining activities in different times and spaces. Therefore, we know about medieval mining regions and settlements, the mines, the tools, about working organisation, living environments and trade. These activities are literally and figuratively based on deposits. Most of the known medieval mining activities concern silver, copper and lead. Those metals were important for minting and they were object of royal interest and claim. The latter explains some of the desiderata in research. The focus of many mining history works lays on mining administrative records like contracts, accounts, directories of fees, or law texts. Whereas mining on iron, building stone, gemstone, or coal, for example, seldom occur in such written sources and therefore are less represented in research (see Bartels and Klappauf, 2012, pp.112-119). It is necessary to widen the view and to preferably use various source types of materials and texts (primary and secondary sources) to see if there are references to mining or especially to metals, minerals and stones, their deposits and/or their use. Furthermore, interdisciplinary perspectives have to supplement the historical research.

Oral traditions and tacit knowledge are not reflected in written sources – unless indirectly. Images and objects bear information, which art historians, archaeologists or geologists can decode.

Preserved material culture (*mining products, 1*) – like secular and sacral stone buildings, manuscripts elaborately decorated with gemstones, iron tools from artisans and farmers, bronze weapons and bells – can be the starting point of where or what to search for. Are there for example artisans' descriptions, building plans, lists of goods or other documents, which inform about the provenance of the used resources and about knowledge stocks related to that? Another possibility to write a history of knowledge of mineable georesources is to select a *type of source (2)*, for example literature, and to analyse it in regard to mining. Honemann (2004) did that – rather cursory – for mining of medieval and early modern times. Possible questions to selected sources can aim at what and how authors refer to mining, deposits or to relevant knowledge stocks. Focussing on a *specific resource (3)* is the third proposed way to address the issue. Vogel wrote a history of knowledge of salt (Vogel, 2008) – concentrating on the 18th and 19th century and on some Prussian and Austrian case studies. The challenge of writing a history of knowledge of mineable georesources from 1000 to 1500 will be to decide on an investigation area and to find suitable sources. For all mentioned approaches, an essential task is to identify the "relevant knowledge stocks" as such. Finally, it is also clear that the approaches overlap.

Referring to the concept of a history of knowledge there is not one history to tell but many (Östling, 2018, p.13 following Burke, 2016). As a general history of knowledge of mineable georesources from 1000 to 1500 would be overly broad, it has to focus on either one of the proposed approaches or must be limited in other ways. The latter is particularly relevant, as the necessary interdisciplinary work and the view beyond the horizon of European interpretation frames, again widens the perspectives. The intended histories tie in with the vivid developments of history of knowledge (summarizing Östling, et al., 2020; with focus on material world Espahangizi and Orland, 2014) and therefore promise inspiration to mining history research.

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SESSION 2 - Skill, Embodiment and the Growth of Knowledge

Session Organisers

Constance von Rüden and Maja Gori

Keynote Speakers

Trevor Marchand and Maikel Kuijpers

Keywords

Caft, Embodiment, Skill, Technical Practices, Resources

If we understand resources as socially produced constructs, knowledge and its transmission represent a key aspect in approaching the relationship between resources and societies. Indeed, knowledge is relevant in almost every aspect of a community: it is not only central for its subsistence economy and the appropriation of raw materials and thus for the survival of the community, it is also necessary for their contestant social cohesion. Of course, many aspects of a group's knowledge are not visible in the archaeological record, but the knowledge inherent in crafts is well-reflected thorough its materiality. Raw materials, tools, unfinished and finished goods allow insights into the skill of a craftsperson. They reflect his or her choices and social needs, as well as the habitualized activities guided by tacit knowledge. Beyond this, learning or the appropriation of techniques and their involved skills from one generation to the next or from one group to another is a crucial aspect for the spread of such resource knowledge. Next to embodiment and the materiality of the things involved, this spread of knowledge is also driven by cultural choices and the people's socio-cultural identity.

The session aims to bring together researchers interested in the reconstruction of the resource "technical knowledge" by material remains and aims to address how such a resource can be spatially and temporally spread.

Boat-building, Experimental Archaeology and the Indispensability of Hands-on Know-how

Trevor Marchand

Keywords
Anthropology, Problem Solving, Craftwork, Apprenticeship, Yemen, Oman, Magan, Bronze Age

Abstract

The objective of this essay is to promote the role of hands-on learning in the disciplines of archaeology and anthropology as a field method for better understanding human skill, problem solving activities, tools and materials in relation to given cultural and environmental contexts. Examples are taken from my anthropological research with contemporary craftspeople in Yemen and from an "experimental archaeology" headed by Maurizio Tosi and Gregory Possehl on the east coast of Oman.

Apprenticeship as Method

I came to social anthropology as a trained architect with considerable experience of monitoring building sites. The move to anthropology was driven by a desire to better understand the nature of skill learning and traditional building-craft knowledge. My journey in the anthropology of craftwork took me first to Northern Nigeria (1992-3), then Yemen (1995-7), Mali (2000-5) and, more recently to London's East End (2005-7 & 2012-13), where I trained fulltime for two years as a fine woodworker and furniture maker. For the first decade and longer, my fieldwork focussed on masons operating in cultural contexts where they were popularly acknowledged to be "master builders" (i.e. *magina*, *ūsta*, *mallam*). This means that they were responsible for both the design and construction, and they typically operated without the use of measured architectural drawings or reliance on professional engineers. Their learning was grounded entirely in practical, site-based apprenticeships in difference to a formalised qualifications-based training that most building craftspeople in Western Europe undergo. The masons with whom I worked in West Africa and Arabia were highly practised in the vernacular styles of architecture that have historically characterised their towns or cities, employing either mud brick or kiln-baked clay brick and indigenous, manual building technologies to create distinctive building forms and decorative elements.

In fieldwork, I use an apprentice-style method. I train and labour over long periods with communities of craftspeople with whom I establish a solid rapport. In this exchange of "toil for ethnographic knowledge", my physical contribution of labour offers me privileged access to practices and various expressions of expertise. A regular schedule of long hours, and engagement in what are often repetitive manual tasks permits repeated observation and more detailed understandings of artisanal techniques, and of the modes of communication used by craftspeople and their apprentices in teaching and learning skills.

"Apprenticing" as a technique of anthropological inquiry is well suited to the study of learning and knowing in practice-based contexts where talking is upstaged by doing. It also equips anthropologists with first-hand experience and possibly some level of expertise in the practices that they theorise and write about. At a personal level, while apprenticing and training in craftwork, I could pursue the pleasure that I experience in collectively making things with others while indulging my curiosity about the ways that we, as humans, think, calculate, communicate and create. In the process, I gained greater confidence in my own abilities to problem solve in the flow of the task.

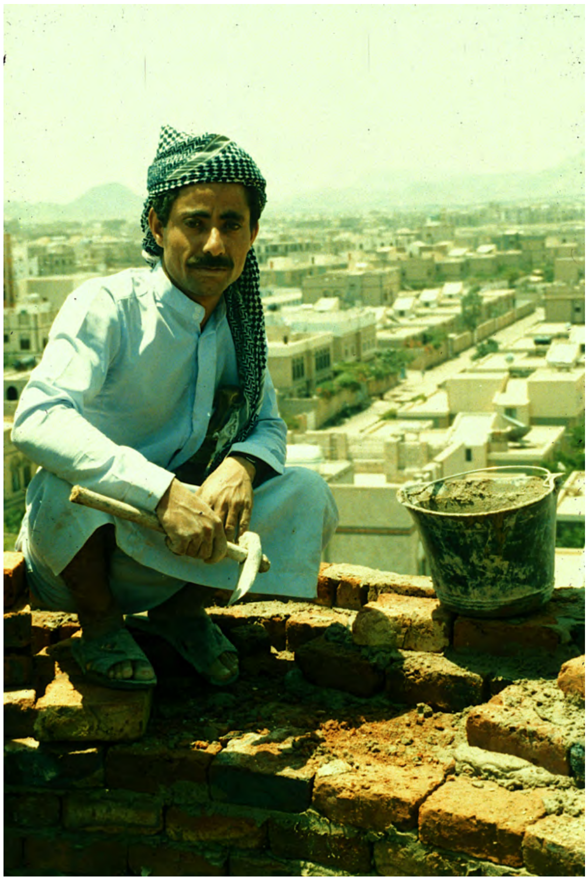

Figure 1. Minaret building in Sanaa, Yemen. A mason laying bricks at the top of the tower. Photograph by T. Marchand.

Minaret Building in Yemen

To illustrate, I offer a brief overview of my fieldwork with a specialised team of traditional minaret builders in Yemen's capital, Sanaa. By the time I came to work for the al-Maswari family of masons, they were at the forefront of a renaissance of minaret-building activity that was being financed by a surge in private wealth and affluence.

One of the first things I learned on site was that minarets in Sanaa are constructed from the inside-out, so to speak, without the use of external scaffolding. Materials are transported by hand along the internal spiral staircase to where masons lay kiln-baked bricks in beds of mortar, while perched precariously on top of walls rising more than fifty meters in the air. Their work provides a popular spectacle for the gatherings of passers-by who watch from the streets below. The various radii that compose the tower's dimensions are measured and checked with a nylon cord, knotted at fixed intervals and fastened to an axial steel post. The threaded metal post is embedded at the core of a central masonry column, and is incrementally extended through the entire height of the tower. The central column, the spiral staircase and the exterior circular wall are raised in tandem, and the whole structure is supported on deep foundations of black basalt stone.

Members of the al-Maswari family confided that before embarking on their first commission for what was to be a relatively small minaret, they carefully surveyed one of Sanaa's ancient landmarks to better understand the principles of its construction, thereby conducting their own kind of "experimental archaeology". In conversation with members of the public, however, the al-Maswari masons denied any such preparatory study and instead claimed that, as Yemeni builders, their know-how was intuitive. They did not produce drawings, nor did they use mathematical ratios to gauge the proportions and dimensions of the vertically-stacked components of their minarets. Instead the master mason, or *ūsta*, judged the proportions to be correct when they 'filled his eye.' Such claims served to reinforce commonly-held beliefs that skills are innate to master masons and that the city's building tradition is somehow conserved in the mental templates of such experts. When asked to explain the skilled know-how they possess, spoken language quickly met its limits and the masons resorted to practical demonstration.

The making of a mason was not merely a feat of attaining technical proficiency. On minaret-building sites, for instance, the master mason's engagement with his clients and his labourers was typically informed by popular conceptions of Islamic piety and moral conduct. Discourse was regularly punctuated by Qur'anic verse and religious expressions, and work was scheduled to observe midday prayer and the daytime fast during Ramadan. A large brass insignia reading *ma sha'Allah* ('What God Wills') was suspended from an iron chain above the ground-level doorway to the minaret, offering God's protection for the workers during the erection of these towering edifices. Young tradesmen were strictly disciplined with a reverence for authoritarian hierarchy, and every member played his part in the machine-like assembly of routine activities and was responsible for plying endless loads of building materials up and down his designated territory of the spiralling stairwell.

In Sanaa, the apprentice's position within the chain of command was tenuous, and if he dared to transgress the rules of comportment he was speedily replaced and distanced from his privileged position. It was from that coveted spot, working next to the mason, that an apprentice effectively "stole" techniques through patient and careful observation. Apprenticeship training lasted over a period of five years and longer, and during that time young Yemeni men gradually gained the necessary know-how and the correct attitudes for organising projects and commandeering their own future building sites and work teams. Once a man was declared a mason, his mentoring continued under the yoke of senior masters and he was slowly delegated more autonomy until he establishes his own clientele and position within the highly competitive trade.

Shortly after completing my fieldwork in Sanaa, the political situation and security in Yemen deteriorated, pre-empting the current civil war that erupted in 2015, and which menaces the future survival of the people and their once-spectacular cultural and architectural heritage.

Oman & the Boats of Magan

In 2000, I began visiting Oman on a regular basis: not for fieldwork but rather as a lecturer on the country's rich archaeology, traditional architecture and culture. It was during these stays in Oman that I began visiting the country's sole remaining operational wooden-boat-building yard, located in the historic coastal town of Sur and not far from the important Bronze Age archaeological sites of Ra's al-Jinz and Ra's al-Hadd. I therefore turn now to a documented case study of experimental archaeology that illustrates the importance for archaeologists, too, in adopting a hands-on approach to learning about human skill and ingenuity and about the properties and performance of materials that were used by our human ancestors in making their everyday objects.

Oman's geographic location and the predictable cycle of the Monsoon weather system are key to understanding the close relationship between the peoples of the southeastern Arabian Peninsula and the sea. Sailors of the Gulf and Western Indian Ocean have practiced navigation for thousands of years, making contact and forging trade relations with the civilisations of Mesopotamia and the Indus Valley. They progressively established trading networks with India, China, East Africa, the eastern Mediterranean world and, by the 19th century, with the United States of America and England.

There is ample archaeological evidence of trade in the Persian Gulf and the Gulf of Oman during the 3rd millennium BCE between Sumer (in Mespotamia), Dilmun (in the Persian Gulf, centred on Bahrain, Kuwait and Qatar and eastern Saudi Arabia), Meluhha (the Sumerian name for a location likely corresponding to the Indus Valley) and Magan, which corresponds roughly with eastern Oman. Ra's al-Jinz and Ra's al-Hadd were thriving seasonal fishing and trade villages at that time. They were two of many settlements in the eastern Arabian Peninsula where a new social and economic order developed, characterised by expansion of trade as well as extensive tomb construction. Settlements at the coastal sites were constructed of stone and mud brick. Buildings were typically rectangular in plan, with multiple rooms and courtyards with ovens or fireplaces for food preparation.

The inhabitants of these settlements had shifted from a hunting-gathering existence to fish processing (drying, salting), shell jewellery production, boat building, rope making, basketry and local and international trading. Growth in agricultural production resulted in food surplus, which was stored or exchanged. Metal from inland mines became available for the production of tools, weapons and ornaments. Goods and wares imported to Ra's al-Jinz included storage jars and, notably, bitumen from Mesopotamia, ceramic vessels from the Indus Valley, and soft-stone vessels from Iran and Baluchistan. The oldest known frankincense burner, dating to ca. 2500 - 2000 BCE, was found at Ra's al-Jinz, confirming local use of frankincense. It also prompts speculation that this precious resin, harvested from the Boswellia sacra tree in remote regions of Dhofar in southern Oman, may have been exported already at this early date.

Figure 2. Replica of a hypothetical Bronze Age boat of Magan, in the National Museum of Oman (Muscat). Photograph by T. Marchand.

Figure 3. A boat builder's set of basic tools, Zanzibar. Photograph by T. Marchand.

Mesopotamia imported large quantities of copper for manufacturing agricultural tools, weapons and instruments. Bun-shaped copper ingots came mainly from Magan, smelted in the Sohar region (northern coastal Oman), and transported by caravan to Dilmu n where they were loaded onto ships for Mesopotamia. Vessels sailed along the gulf and up the Euphrates, as far as Mari (in present-day Syria). Along with copper ingots, gabbro played a major role in trading relations between Magan and Mesopotamia. This hard igneous stone – formed from the slow cooling of magnesium-rich and iron-rich magma, and often found in ophiolite complexes – was used for making copper mining tools in Magan. In Mesopotamia, gabbro was used by Sumerian sculptors to carve royal statues (e.g. Gudea, King of Lagash, 2144-2124 BC, on whose dress it is written in cuneiform: "From the country of Magan, he [Gudea] ordered black stone and he had it sculpted in the shape of his statue").

The people of Magan were exporting and importing goods not only by caravan, but also by boat. But, what did these boats look like? From what materials were they made? And, how were they constructed? From 1985, remarkable findings of bitumen slabs and fragments at Bronze Age coastal settlements, such as Ra's al-Jinz and Ra's al-Hadd, provided clues to these questions. Prior to the bitumen discoveries, historians and archaeologists had relied mainly on cursory information gleaned from cuneiform tablets, iconography and ethnographic documentation of traditional sailing vessels to hypothesise the nature of Magan boats.

Lashed timber construction has been proposed for these vessels. It is believed that this method was used in Arabia as early as the mid 3rd millennium BCE. Lashed construction entails tying planks together with rope made probably from date palm fibre, which is arranged transversely across the boat's hull. The holes made for passing the fibre rope are plugged with wood to keep the lashings tight. An economic use of scarce timber is achieved by fitting shaped planks together like a three-dimensional jigsaw puzzle. This also helps to restrict their movement. Hull framing is largely or entirely absent, but through-beams supply an important structural element.

During the Bronze Age, imported bitumen from Mesopotamia (where it occurs in natural deposits) was applied to keep the seams watertight.

The most spectacular example of a Bronze Age boat of lashed construction is the Khufu boat (or Solar barge), built for Cheops (second Egyptian Pharaoh of the fourth dynasty of the Old Kingdom) and discovered at Giza in 1954. It took years to skilfully reassemble this masterpiece of wooden boatbuilding, measuring nearly 44 metres in length and nearly 6 metres wide. Built mainly of Lebanon cedar planking, it displays a "shell-first" construction technique, using unpegged wooden tenons (*Paliarus spina-christi*). The ship was built with a flat bottom composed of several planks, but no actual keel, and the planks and frames were lashed together with Halfah grass.

An alternative prototype for the Magan boats, however, was one made of bundles of reed lashed together, like the solar barge of the Akkadian Sun God, Utu, depicted on a cylindrical seal (ca. 2200 BCE, Tell Asmar, Iraq). A 3rd millennium cuneiform tablet from Mesopotamia (now in the British Museum) lists materials ordered for a shipyard. In addition to several varieties of timber, it names different vegetal fibres and goats hair for making rope, copious supplies of reeds, huge quantities of fish oil, ox hides and purified bitumen, which was 'for making watertight the Magan-boats.'

In 1985, archaeologists led by Maurizio Tosi and Serge Cleuziou discovered slabs and fragments of bitumen with impressions at Ra's al-Jinz. The impressions were of woven reed matting, bundles of reeds, rope or string, and barnacles, indicating the surfaces of seagoing vessels. The bitumen itself was chemically matched to sources in northern Iraq. In 1999, with funding from the Omani government, Tosi and Gregory Possehl headed an experimental project to reconstruct a hypothetical Magan boat.

In addition to the available iconography and direct evidence supplied by the bitumen slabs, background research was also made into the construction of reed boats/rafts built by the "Marsh Arabs" of Iraq as well as of various types of traditional fishing and sailing vessels that were made during recent centuries along the Omani coast. One of these is the shashah, assembled from the midribs of date-palm fronds and still used today, but for inshore fishing only. Logically, as a seagoing cargo-carrying vessel, a Magan boat would have been significantly larger and necessarily more robust. Naval architecture software was therefore used by the archaeological team to create and assess possible designs of a vessel made principally from reed bundles that was capable of carrying a substantial cargo and of sailing into the Arabian Gulf or across the western Indian Ocean.

According to Tom Vosmer, an "experimental archaeology" approach was adopted by the project, importantly allowing the team to gain further understanding of the materials and to explore the crafting and assembly processes. The objective was not to reproduce the definitive "Black Boat of Magan", but rather to enable the archaeologists to pose new and better-informed questions.

The skills involved in boat construction in Eastern Arabia are thousands of years old. Techniques would have evolved in response to locally available materials and would have possibly adopted methods imported from the Indus Valley and Mesopotamia. The original tools used for making the Magan boat would likely have been axes and adzes, chisels, wooden mallets, and spikes and needles made of wood, bone or copper.

Guided by the listing of materials on the cuneiform tablet, the approximately 12 metre-long hull of the hypothetical Magan boat was constructed with bundles of reeds (*Phragmites autralis*) lashed together, onto which an exterior covering of reed matting was "quilted". The team produced handmade rope from Carex fibre and used Omani sources of Acacia and Ziziphus spina-cristi timber. Bitumen was imported from Iraq and its properties were adjusted with additions of lime for improving dimensional stability and fish oil for enhancing the bonding quality. The vessel was coated inside and out with that mixture, and the exterior was then smeared with mud. The gunwales were covered with hides, fixed in place with wooden nails, to protect the reed hull from abrasion.

On 7 September 2005, the Magan boat's maiden voyage was launched from Sur, in the hope of sailing nearly 1000 kilometres across the Indian Ocean to the historic Indian port of Mandvi. Not 30 minutes into the voyage and just tens of kilometres from shore, the boat sank. The boat was lost to the Arabian Sea but much valuable learning by the researchers had been gained about material properties, craftwork, boat building and sailing a bundle-reed vessel.

As an anthropologist, an ethnographic approach to understanding how things are (or were) made appeals most strongly. In pondering how our Bronze Age and Iron Age ancestors made things, there is a great deal of readily available information to garner from the ways that people are still making things with natural materials and straightforward mechanical technologies that are moderated by the craftsperson's body and guided by their perceptual senses and experiential knowledge.

In the Gulf and around the Indian Ocean, the basic kit of boat-building tools has remained mostly unchanged for centuries, and likely millennia. In addition to the conjectured axes, adzes, chisels and mallets used by the Bronze Age ship builders, their contemporary counterparts in Sur, as well as in distant Zanzibar (which had been part of Oman's empire), use handsaws, pitsaws, and pull saws; wood planes, bow drills, nail pullers and caulking irons; as well as a variety of measuring tools and plumb lines. I offer below some illustrated examples of these straightforward manual tools.

For measuring angles, a protractor made of wood with a weighted string attached satisfies the task; and, for fitting irregular edges of planks together (in the manner described earlier for Bronze Age boat building), a

Figure 4: A boat builder working on the hull of a new sailing vessel, Sur, Oman. Photograph by T. Marchand.

Figure 5: Boat builders using caulking irons and wooden mallets to fill the seams between planks with cotton soaked in shark oil, Zanzibar. Photograph by T. Marchand.

simple marking gauge is used. Caulking irons and mallets are employed to tightly fit cotton thread or coconut fibre (or other fibrous materials) between the seams. The fibres are impregnated with fish oil or other waterproof substances. Some kinds of boats are still built "plank first", meaning that the hull is assembled first and th e framing fitted afterwards. Nails holding frames to planks are clenched on the inside, over the frames. In some places in the Western Indian Ocean, such as Zanzibar, the carbon steel nails and spikes, as well as many of the carpenters' basic tools, are made by local blacksmiths.

Planks are shaped by a kind of "steam bending" method that involves bracing the ends of the planks to a stake and twisting them with torque created by tying them to poles. The "steam" needed for shaping the planks is created by using slow burning low-heat charcoal and periodically dousing the planks with water. The charcoaled surface of the timber also improves water and rot resistance. Alternatively, planks may be shaped with an adze, requiring considerable hand skill and perceptual judgment. Boles and boughs of trees are carefully selected for their curved and V-shaped geometries, as well as for their grain pattern, and then further shaped with the axe and adze to produce the framing that is fitted into the plank hull. A manually-operated bow-drill is used for pre-drilling holes in the planks and the framing elements through which the nails are driven. Using a mallet and caulking iron, the joints between planks and the individual nail holes are tightly packed with cotton soaked in shark oil.

Embracing Mistakes

At the heart of boat building, like any craft, is problem solving. Problem solving activities are involved at every stage of creative design and making, including, for example, calculating quantities, weights and dimensions; intuitively engineering structures; configuring geometries, proportion and scale; choosing or producing colours, glazes or mixtures (like the bitumen coating on Magan boats); selecting and evaluating materials (like the reeds, fibrous threads and leather hides); and choosing, setting-up, and possibly modifying tools for the tasks of making and assembling. While physically engaged in designing and making, the body of the craftsperson has its own challenges to overcome. At a motor level, they must resolve how to take-up good postures, form correct grasps, coordinate bi-manual practices, exert appropriate pressures, and perform fluid, rhythmic and economic movements. They must also resolve how to continue working when confronted with limitations or failure of their body caused by injury, illness or ageing. The nature of all such challenges and the search for their solutions are timeless, shared equally by our Bronze Age ancestors and future generations of craftspeople.

Paired with problem solving is making mistakes. Making mistakes offers the starting point for learning and improving, as I came to understand as an apprentice on building sites and as a trainee in the carpentry shop; and as both the original Magan boat builders and the members of the experimental archaeology project will have experienced. Learning arises in identifying that a mistake has been made, understanding it as a problem for which a strategy to remove or resolve the problem can be devised, formulating a set of corresponding activities, and testing those activities in real practice. Notably, these procedures of learning do not necessarily unfold in the neat linear manner described, or as discrete events. The physical activity of putting something right, for instance, might alter one's understanding of the nature of the mistake, or lead to identifying further mistakes as the problem source. The process is dialogic.

The relevant point here for archaeologists (and for anthropologists of material culture) is that learning and discovery are not confined to abstract thinking about the problem, one step removed from the physical activities of implementing a solution. Instead, learning – whether it is in craftwork, anthropology or archaeology – demands situated perceptual experience and physical activity, as well as emotional engagement when confronted by a challenging problem and while working a way through it. Perceiving, doing, and feeling are part and parcel of the same cognitive matrix for problem solving that also includes producing inner dialogue or interactive dialogue with fellow craftspeople about findings, procedures and results. Importantly, the cognitive matrix also includes the imagination. In relation to boat building, the maker's act of imagining extends beyond his/her "picturing" what the vessel will look like to include imagining how it will relate to the bodies of its sailors, to its cargo, to changing conditions of the sea and to sometimes treacherous shorelines; as well as how it will be interacted with, moved over land, launched, sailed, navigated and moored. These ways of knowing and imagining constitute an abundant, overlapping exchange of information in the proactive search for potential problems and their solutions.

In summary, if discovering a mistake or identifying a challenge offers a starting point for learning, it then follows that the process of learning through exploration, experimentation and reflection brings about new knowledge or new ways of getting to know something. Like the original boat builders of Ra's al-Jinz, the archaeologists of the Magan boat project will have discovered this. Experimenting with hypothetical reconstructions of long-lost objects offers a unique and valuable window for sharing, at some level, the conceptual, perceptual and emotional experiences of our ancestors. It also allows researchers to attain a richer understanding of what it is to be human.

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Materials and Skills in the History of Knowledge – a Bronze Age example

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The following text is an adapted excerpt from Kuijpers 2019

Materials and skills in the history of knowledge – a Bronze Age example

Any reconstruction of the resource "technical knowledge" requires that we first define what we mean when we talk about 'knowledge', and how we can access this knowledge through material remains. I will do this by means of a Bronze Age example. Exploring the knowledge and skills of prehistoric metalworkers—through their objects—forced me to think about the different characteristics of two types of knowledge identities: those of craft and of science.

Studying the manner in which metals are worked I struggled to harmonize skill with the data that the archaeometallurgical discourse was producing. This gap between the social archaeologists' interpretations of metalworking technology and the material scientists' body of factual data has long been recognized. Some authors have built a career on stressing the differences and this has led to an entrenchment on either side of the debate. Recently, there have been pleas to combine the two, but *how* to do so remains the central issue. Here I present an attempt at reconciling these supposedly opposing approaches.

Reconciling opposing sides

My starting point is that to distinguish between scientific knowledge and craft knowledge, and stress their differences, is unhelpful. As archaeologists our concern lies with the development of human cognition and the formulation of knowledge over time. One of the main ways for archaeologists to gather information on these topics is from the scientific analyses of prehistoric artefacts. Using the example of Bronze Age metalworking, these would be compositional analyses and metallography of metal artefacts. This means that we need to assess the connections – not the differences – between craft, science, and technology, which I will do so using the notion of skill.

Both scientific and craft knowledge are types of material knowledge. To a craftsperson, it is not a necessity to precisely understand what causes a raw material to perform in a certain manner and why. What matters is that they recognize the relevant changes and act upon them, and they do so through their sensory modalities. This is a small but important nuance, one that takes into account the properties of materials in knowledge production, and which allows archaeologists to look for skilled behaviour without presupposing conceptual knowledge. This is crucial, because practice reached far beyond conceptual knowledge (i.e. theory) during many periods in the past. But how does engagement with a material, through the senses, lead to knowledge about that material?

A sensory approach: perceptive categories

In addition to the two knowledge frameworks mentioned above I propose adding a third one: the psychophysical framework. This framework operates at the intersection of cognition and materiality. Lacking other more precise tools, it is through the body that prehistoric metalworkers would have learned and categorized their materials. A sensorial categorization of material is distinct from the scientific one but not separate from it. After all, the qualities and behaviour of a material are a sensorial reading of the properties from which they stem. Hence, I am *not* arguing that scientific analyses are incapable of shedding light on questions about prehistoric craft and skill. But one needs to look at them where, quite literally, they make sense.

To operationalize this perspective, I make use of *perceptive categories*. This methodology works with data provided by material sciences, but the thresholds with regard to the categorization and analysis of this data are based on the human senses and thus on metalworking as a craft. Perceptive categories emphasize the qualities, behaviour, and performance of materials that are recognizable and relevant to craftspeople and attempts to associate these with the properties and processes for which scientific measurements are available. In short, this method aims to organize the data into categories attuned to the aspects of the materials that matter to craftspeople. This is a pragmatic attempt to work with the data we have in an empirical manner, without violating either our epistemology (scientific knowledge) or the prehistoric epistemology we are trying to uncover (craft knowledge). Let me explain this by example of composition and colour.

What prehistoric knowledge looks like; colour is composition

The amount of tin in a bronze is a property that the material scientist can measure in percentages; for the metalworker, however, it equals the quality of colour. Colour plays an important role because it provides the metalworker with a perceivable quality of the material that allows for differentiating between copper-compositions.

The recognition that colour must have been important in the development of metalworking skills led some research to quantify the relationship between composition and colour (Mödlinger et al., 2017; Radivojević et al., 2018; Wunderlich et al., 2019). But, whereas to the scientist this accuracy and precision matters, a craftsperson approximates. This is why we need the perceptive categories. Bringing into focus the properties that are perceivable, these categories are scientifically less accurate yet meaningful and relevant to metalworkers. At the same time, these categories are substantiated through scientific measurements and as such are a helpful analytical tool through which scientific techniques can be integrated into archaeological interpretation. A quantitative phenomenology so to speak.

I argue for six different perceptive categories of copper-composition that might have been relevant to metalworkers of Early Bronze Age Europe. With the help of a *chaîne opératoire* that incorporates these categories it is demonstrated that indeed these were recognized and worked differently from each other (Kuijpers, 2018a,b). Confirming the existence of such categorization in prehistory also—importantly—gives us insight into what prehistoric knowledge looked like.

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Knowledge, Skill and Senses

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Introduction

There is not one knowledge. There are different dimensions of knowledge and each of them has its own relationship with skill and sensory perception. Due to their intangible part it is difficult to recognise sensory perception, knowledge and skill in a fruitful way for archaeological research despite the fact that all three fields were and are omnipresent in human life.

Starting with knowledge we could say that one part of it has a cognitive nature and is mainly structured and transferred through language. Another part of knowledge is embodied. Skill again is the result of knowledge embodiment as Figueiredo and Ipiranga (2015, p. 350) state. The part of knowledge which can be "translated" linguistically is obviously much more represented in theoretical discussions. We are able to describe the material outputs of knowledge and skill like handcrafted objects or the necessary gestures we perform to produce these things. But when it comes to intangible fields of skill and knowledge like technical choices or other inner processes like the perception of matter and linked emotions or values, we quickly feel awkwardly lost in subjectivity.

Even so Budden (2008) as well as later on Botwid (2013; 2017) could grasp the two kinds of knowledge by focussing on cultural learning in crafts. They described a discursive and a non-discursive part with the simple but precise categories "what to do" and "how to do". This concept is able to respect the highly cognitive level of crafts and to give room for the mentioned intangible aspects, their cultural interpretation and their primordial trigger – the sensory perception.

A similar approach was presented in other disciplines with important impact on archaeology, e.g. in neuroanthropology. How the appropriation of (motor) skills is shaping the neuronal system was generally demonstrated by Downey and Lende (2014) or by Pettinen (2014) regarding habit formation in Taijutsu practice. As skill is part of cultural expression the learning process inscribes cultural values not only into our thinking but also directly into our body, body memory and habit. Taken all together skill gains an anatomical dimension.

The modern relation to skills

Coming to the significance of sensory perception and how we interpret it within our cultural system, we may draw on studies created since the 1990s under the name of sensory archaeology (e.g. Skeates and Day, 2020; Hamilakis, Pluciennik and Tarlow, 2002). The traditional model of five senses was extended and the interplay between senses gained importance for an understanding of the genesis of cultural habits. The nature of the senses was described as "affective and mnemonic" (Hamilakis, 2013, p.14) matching the observations of neuroanthropology. But as our world looks like we were trained to see it, an excursus into early childhood development may be of interest. Regarding a single sense, the visual sense, Miller (2000, pp. 19-20) described the development of children's perception and how it is influenced, nay created, by culture: for example, with the help of teachers who correct children's drawings to become more and more anatomic instead of a rendered mixture of multi-sensual impressions.

Figure 1: Copying experiment with an apprentice of pottery.

After this reflection, what is our current relationship with things? Which role do skills and senses play in production and use of objects? Has the nature of our cultural knowledge changed? And is there an influence on archaeological research?

An example of zeitgeist in archaeological methodology can be seen in the concept of the chaîne opèratoire (e.g. Leroi-Gourhan, 1964) which – although it is a powerful tool and therefore in wide use – expresses our modern understanding of technical knowledge, when applied without the above-mentioned implicit aspects. Today we are so used to "instruction manuals" with described or illustrated operational steps, that we forget how young this linguistic category is and how it still epitomises the socialisation of technologies since the 1950s (Nickl, 2001, p.7). Manuals connect the amateur with the professional, serving our desire for independence. They also had an evident impact on our everyday language (Nickl, 2001, p.9), which shows only more the role of Zeitgeist.

A connected phenomenon can be seen in the American Do-it-yourself movement of the last century which arrived in the 1960s in Germany supported by the pioneer warehouse companies OBI and Hornbach (Voges, 2014). By democratising fields of expertise, a new market niche was discovered: prefabricated components for the private handyman. With the slogan "Kein Mann von Fach und trotzdem Fachmann" the TESA company got to the very heart of the trend. A superficial understanding in favour of fast and successful "crafting" was offered to replace an intensive but sometimes tedious comprehension which goes with sensory education and motor practice.

Parallel to the development of manuals (since 2012 an official part of technical language with a European Norm code EN 82079-1) in modern industry, which includes studies of human behaviour and motor memory (Fahlbuch, Meyer and Dubiel, 2008), a shift in archaeological methodology can be recognised. The diverse and sometimes complement interpretations of the concept of the chaîne opératoire show the search for a more holistic perspective of actions instead of operations (Martinón-Torres, 2002).

Case study

Linking the above-mentioned thoughts with an archaeological example we may look at Roman Provincial pottery: A special set of skills was trained for wheel-thrown conical bowls in the space between Lake Neuchâtel and Lake Constance (Melko, 2017, pp.217-218): a special set of skills was trained for wheel-thrown Roman conical bowls in the space between Lake Neuchâtel and Lake

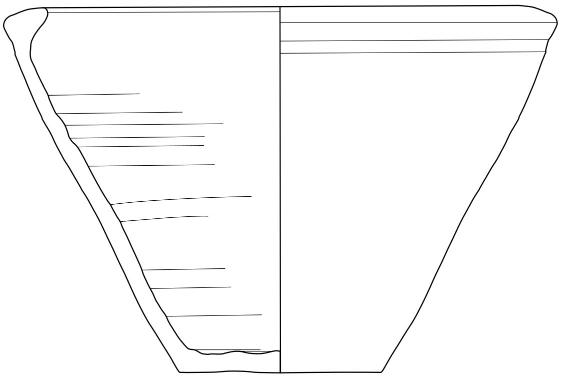

Figure 2: Roman bowl type, which was used in the region between Lake Neuchâtel and Lake Constance.

Constance (Melko, 2017, pp.217-218). This set aims to shape a thick rim which protrudes inwards. While the general form does not need more than basic throwing skills – regarding the bowl's wall thickness, the proportion of diameters and size – the additional thickened rim requires a very farsighted management of mass distribution and well-centred working. Remarkably these bowls were not exclusively made by experts, but also by advanced beginners with general abilities needed for wheel throwing but still struggling with an evenness of the walls, air pockets and a proper mass distribution at the junction between bottom and wall. Therefore, both hands have to move independently and steady in speed, pressure and direction – a skill which is only gained through time-intensive training. It seems that it was set much value upon mastering the thickened rim, so it was trained together with the first basic gestures.

After analysing the "what" and "how" of the production we may step over to social values connected with the customer's embodied knowledge about things. The bowls, in fact, provoke a distinctive range of gestures while using them in everyday life. Our fingers clasp comfortably around the rim, so that we soon carry also the bigger ones one-handed without much care. Liquids don't tend to slop over, so we handle sauces and stews less tentatively after becoming used to the new shape. While putting them into cupboards or piling them, they won't break easily if they bump together with their strong rims. All in all, these bowls prompt a rough and vibrant interaction between human and thing.

If we are aware of our modern imprints and apply both perception-based and process-oriented analyses, new possibilities open up for us to explore the skills and knowledge stored in archaeological objects.

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Knowledge is a Scarce Resource: a Comparative Exploration of Communities of Practice and the Transmission of Knowledge Amongst Small-scale Stone and Gem Workers in the Bronze Age Aegean and Idar-Oberstein, Germany, from Early Modern Times until the Present Day

Sarah Finlayson and Julia Wild

Keywords
Knowledge Transmission, Embodied Knowledge, Gemstone Processing, Small-Scale Stone-working, Workshops, Trade, Migration, Bronze Age Aegean, Idar-Oberstein

Seals were used very widely in the Bronze Age Aegean (roughly 3000 to 1000 BCE) as markers of identity and status, as personal adornment, and in formal administrative processes. Our evidence for their manufacture and use is scattered and fragmentary; there are the seals themselves, their impressions on clay sealings, and a very small amount of workshop evidence, both structures and contents (for an overview of the evidence, see Krzyskowska, 2005). From these disparate sources, we try to reconstruct the lifecycles of these objects, from manufacture to deposition, and the lived experiences of the people who made, used and valued them.

The sociopolitical and economic contexts in which seals were made and used changed radically through the course of this period, from the small-scale farming communities of the very early Bronze Age, who made simple handmade soft-stone seals for their domestic sealing activity (for example, the Cretan prepalatial site of Myrtos *Fournou Koriphi*, Warren, 1972), up to the complex redistributive systems of the Minoan and Mycenaean palaces of the Middle and Late Bronze Age, in which exquisite gold signet rings and hard-stone seals were used in complex administrative procedures (Krzyskowska, 2005; Panagiotopoulos, 2014). The nature of craft activity, the individuals involved, and how they learnt and taught their skills, must have evolved considerably - and, at some point, there was the highly significant transition from independence to elite or palatially-controlled workshops (for example, Poursat, 1996; Younger, 1979).

It is possible to define particular kinds of knowledge that would need to be transmitted; the techniques used to create different shapes, for example, or the significance of motifs, seal forms and script signs and how to manipulate them in socially-meaningful designs. We can also posit the existence of overlapping or intersecting communities of practice - those who engraved seals, those who consumed them, and those who created and perpetuated the administrative processes in which the seals were used. What we cannot easily reconstruct is how the necessary knowledge was shared or controlled, and what happened at the intersections of each of these groups.

In this paper, we explore the Aegean evidence through the lens of the community of small-scale stone workers at Idar-Oberstein, Germany. Here, historical records and surviving workplaces and equipment capture the lives, working conditions and embodied experiences of craftsmen from the 16th century ACE onwards. The Idar-Oberstein craft community was based on a cottage industry, in which work was carried out in a very traditional and closed family environment for centuries, and in some cases, technical processes were handed down that are very close to those of historical societies. At the same time, trade relations and migration to and from Idar-Oberstein have influenced the way gemstones were and are processed (Kraus, 2016; Hisserich, 1890).

Figure. 1 Stone engraver at his workplace in Idar, circa 1900. Courtesy: Private Archive Dieter Jerusalem.

Working through this comparison, we can begin to develop a model of the flows of information within craft communities, to help to fill in the gaps for time periods or geographical regions, such as the Aegean, for which we have considerably less evidence. These historical comparanda do not, of course, provide an exact parallel or any easy answers, and a key part of our discussion reflects on the most appropriate and nuanced use of historical or ethnographic data.

Particularly powerful factors we consider include the importance of families or other closed groups for creating a path of knowledge transfer, but also potentially restricting the spread of information and fostering secrecy; the formalisation or codification of knowledge into ‘the right way of doing things’; the role of apprentices and how learning-through-doing enables deep levels of embodied knowledge, while also sometimes acting to restrict personal and social mobility; and the small-scale, very local possibilities for preferential access to resources, raw materials or tools.

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Figure 2. Exterior view of the agate grindery "Doktorschleife" in Idar, circa 1900. Courtesy: Private Archive Dieter Jerusalem.

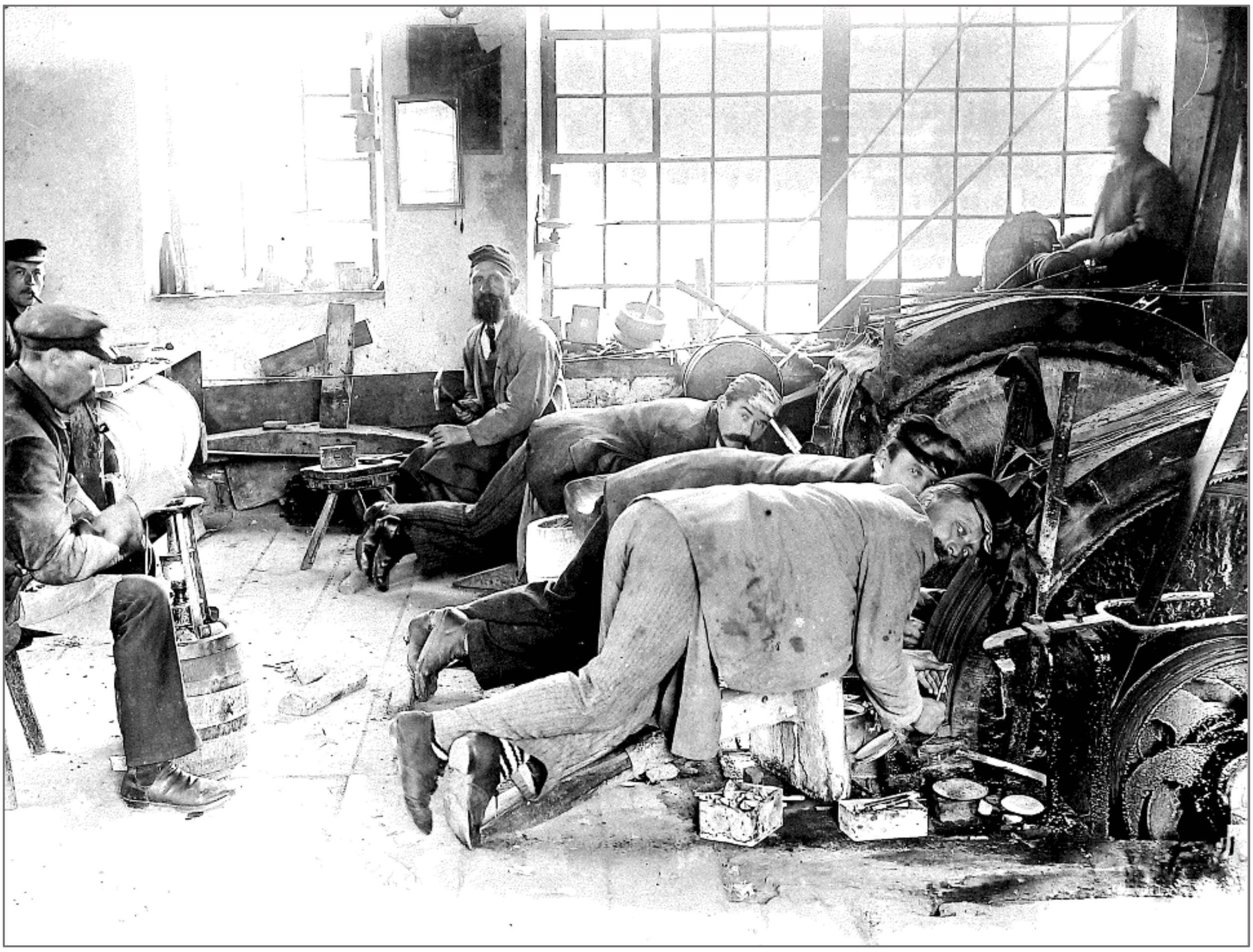

Figure 3. Interior view of the agate grindery “Doktorschleife” in Idar, circa 1900. Courtesy: Private Archive Dieter Jerusalem.

Innovation and the Relational Aspects of Skill

Nikolas Papadimitriou and Akis Goumas

Keywords
Skill, Technical Affordances, Relational Habitus, Mycenaean Gold-working

Discussion about technical knowledge revolves around the notion of "skill". The term itself is rather vaguely defined: some scholars use it in plural ("skills") to describe a number of manual competences, while others prefer the singular to denote the competitive advantages that distinguish "skillful" from "less skilled" craftsmen.

In general, skill is treated as a self-contained (i.e. context-free) entity, a standard set of dexterities, which can be acquired with varying degree of success by different craftspersons. In this paper we argue that this is valid only (or mainly) in the learning stages of a craft – when apprentices are trained in the proper use of tools, the tolerance of materials, and the basic principles of composition. When it comes to creative work, skill becomes a more fluid notion. In contexts that favor innovation, craftsmen tend to experiment with novel techniques, new combinations of materials and even new tool-types. Such innovations create new *technical affordances*, which open previously unimaginable paths of work and may make earlier methods look insufficient. This suggests that skill has a strong *relational element*, which needs to be explored. It also raises interesting questions about the very nature of skill: is the craftsman who makes an innovation "more skillful" than before? If yes, where does skill lie? In the mental capacity, the manual dexterity or the new technical affordance?

Approaches to Skill

Almost 60 years ago, W.M. Macqueen described craft skill as "a complex of mental and physical achievements, in which manual skill plays only a part" (1951, p.34). He stressed that during training (and sometimes during production) "complex operations [are broken] into simple units" to facilitate learning. He also emphasized that a craftsperson encounters continuously new situations and challenges. To respond to these challenges, he has to acquire "a propensity for meeting changing situations adequately, … the power to translate ideas into…own manual expression, and … the ability to apprehend the different elements which combine to make up the total of his skills" (Macqueen 1951, p.36).

More recent research has paid less attention to the close interweaving of mental and physical qualities in craft-working. Scholars are mostly interested in making as *practice*, laying emphasis on the habitual or "embodied" elements of skill and the non-conscious sides of craft knowledge (the "motor know-how" of Pelegrin 1991; 1993). This has illuminated the non-cognitive aspects of knowledge acquisition but, at the at the same time it has created a kind of split between the mental and the manual. Ingold has described this split as a "reduction of the technical to the mechanical" (Ingold 2001, p.21; 2018) and urged for exploring anew the inherent structural relation of mind and body in craft-working. Kuijpers has also argued against a dichotomy between discursive and non-discursive knowledge in crafting (2012, p.138-139; 2017, p.81-82).

In that direction, we believe that a relational approach can be helpful. While acknowledging the importance of habitual learning in craftwork (and the associated function of habitual memory, as described in Apel 2006, p.214-218), we would like to introduce the notion of "relational habitus", originally developed in the realm of educational psychology. "Relational habitus" is defined as an "ensemble consisting of individuals linked with tools, tasks and others", who interact through repeated embodied actions in the service of a goal-directed activity, generating "intersubjective processes of meaning making" (Stone et al. 2012, p. 72). In these intersubjective processes, "tools are not simply given but take on meaning in the context of relationships with others as part of routine practices and this meaning continually develops" (Stone et al. 2012, p.74). In other words, habitus depends directly on – and is signified by – the *context of interaction*.

In the following section, we will explore how these ideas can be applied to Aegean archaeology. We will present "training pieces" and technically-advance artefacts, and suggest that the meaning of skill varied significantly according to the context of work.

Case-Studies

Apprenticeship and training

Training pieces are difficult to identify in the archaeological record, not the least because in certain crafts (e.g. metallurgy) they were probably recycled. But crafts like stone-working offer good examples. In a late Hellenistic/Roman marble workshop discovered at Aphrodisias, excavators found sculptures at various stages of the carving process (van Voorhis, 2018). Some of them were interpreted as training pieces, because the tool-traces observed on their surfaces varied considerably, not conforming to a given stage of the marble-carving chaîne opératoire. Instead, they looked like the work of apprentices, who tested techniques and tools with varying success. Tool-marks ran in different directions and were randomly placed on the surface. A statue was found to have two right feet, suggesting a curious insistence in the correct execution of this particular feature. More examples of training pieces are known from Hellenistic Delos.

In such cases, the artistic result was of little importance; what mattered was the acquisition of technical competence in the handling of tools. This was achieved through repetitive trial-and-error actions, probably under the close supervision of masters. Repetition is crucial in training; it is through continuous practice that external knowledge (i.e. what apprentices are told and shown by their teachers) can turn into embodied experience. This involves what psychologists term 'non-declarative' or 'procedural-/habitual memory', i.e. the gradual development of automized movements, which can be performed without conscious reflection – although perceptual processes, like priming are also involved (e.g. Squire et al., 1993, p.275-278; Baddeley, 1999, p.16-19, p.81-85; see also Apel, 2006).

It is thus clear that in training contexts, skill is a 'closed system' defined by instructors/masters. It has specific *standards*, which need to be attained by apprentices. These are primarily manual (i.e. the proper handling of tools and execution of techniques) and secondarily conceptual (how to use tools to create a design). Apprentices have to achieve those standards in order to be accepted as craftspersons. Therefore, the inter-subjective relation among masters and apprentices is biased, if not uni-directional. This might help to explain how artistic 'traditions' emerge. Apprentices spent so much time and effort trying to adjust their bodily postures and movements according to their masters' instructions that it is very difficult later to diverge from this way of "doing things".

Creative work and innovation

When it comes to innovative work, however, things function differently. We understood that when we studied (together with Dr. Eleni Konstantinidi) one of the most demanding metal-working techniques performed in ancient Greece, i.e. the so-called "gold-embroidery" (Konstantinidi, et al., 2014, p.341-343). This was a method of decorating the hilts and pommels of prestigious weapons with gold elements. The technique consisted in the application of minute L-shaped gold bars (less that 0.2 mm) on the surface of the hilt, in order to create a kind of gold 'plateau', which was then decorated with engraved motifs (Figures 1-3). The surface was so carefully burnished that, when finished, it actually resembled gold leaf, and only a very experienced eye could understand the difference.

The technique is encountered almost exclusively in "royal" graves of Early Mycenaean Greece (17th to 15th c. BC). Its rarity, and the overall homogeneity of known pieces, suggest that it was performed by very few artists, probably in one or two workshops at the site of Mycenae. Despite of that, there are clear signs of evolution and technical advances.

Figure 1. Minute L-shaped gold bars used in the gold-embroidery technique from Dendra, 15th c. BC (National Archaeological Museum, Athens, P 7349). Photo taken by the authors, with the kind permission of the National Archaeological Museum of Athens.

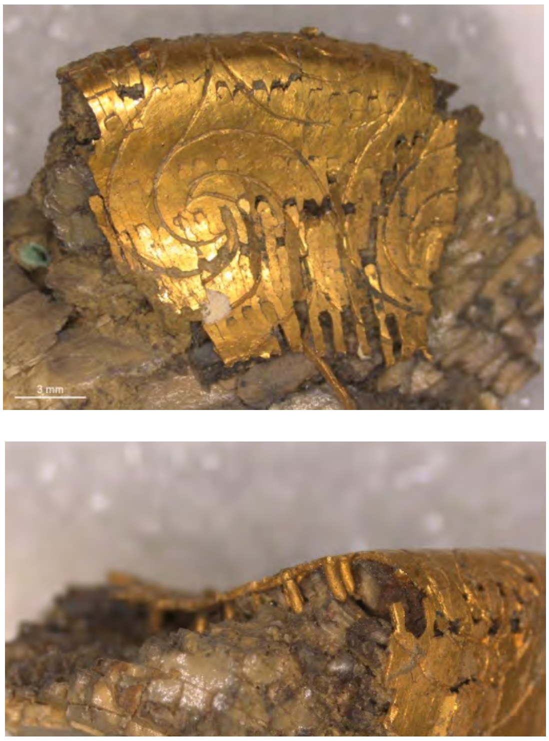

Figure 2. Part of the ivory pommel of a bronze dagger decorated with gold embroidery, from Dendra, 15th c. BC (National Archaeological Museum, Athens, P 7362). Photos taken by the authors, with the kind permission of the National Archaeological Museum of Athens.

What motivated these advances – especially since the details of the technique were almost invisible to the naked eye? Competition among craftsmen is a possibility, although in our view even more important was *competition with tradition* – i.e. the need of a skilled artist to test his/her own limits and surpass the work of predecessors. And what exactly was improved each time? The technical capacity of the craftsman or another – perhaps cognitive or sensorial – element?

To explore the last question and understand the challenges faced by the craftsmen, we attempted experimental reconstructions of the technique at various stages of its evolution. The experiments were conducted by A. Goumas, an accomplished professional goldsmith. The details will be presented in the conference.

Here we summarize the basic results:

a) Manual abilities were refined with time but this was not the most crucial point.
b) What increased substantially with each effort was the artist's visual perception; with practice Mr Goumas could see in far greater detail the surface of the object.
c) Technical advances required the creation of *new tools* – that was a crucial element.
d) His work was governed by the desire to solve problems observed in earlier pieces or encountered in earlier efforts.

Increased visibility and *refined tools* proved to be the most essential parts of innovation. The process was governed by a *problem-solving mentality*; but the notions of 'problem' and 'solution' *changed* together with tools and visibility. Each advance created new *technical affordances*, which opened new paths of work, and made previous methods look inadequate.

This case suggests that skill at the highest level of craftsmanship relates closely to *innovation*. But innovation is by definition relational, as it is based on a dialogue with tradition. This relational-dialogic process has a profoundly cognitive/conceptual character. Automized movements and sensorial perception are of course important. Yet what blends these elements together is the desire of the artist to solve what he perceives as a "problem". This justifies Macqueen's thesis that craft skill is "a complex of mental and physical achievements, in which manual skill plays only a part" (1951, 34) and suggests that skill in archaeology can only be fully understood if grounded in sound contextual analyses.

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The Wooden Structures of The Neolithic Wetland Habitation Anarghiri Ixb (Western Macedonia, Greece): Ways to do, Ways to be

Tryfon Giagkoulis

Keywords
Northwestern Greece, Neolithic Wetland, Trackways, Fences, Raw Material Exploitation, Craft Specialization, Social Integrity

"A building is not just a place to be but a way to be"
Frank Lloyd Wright

The perishable nature of the materials used for the construction of space in prehistoric settlements, together with the impact of various depositional and post-depositional factors, ordinarily result rather fragmentary and confusing excavational images regarding the general outline of the habitations or the special characteristics of the residential or other structures. Therefore, beyond the apparent difficulties to reconstruct the size and the form of the built entities, certain aspects of architectural activities, as for example the specific building practices employed or the exact physical and technical attributes of raw materials used, remain more or less obscure.

Nevertheless, the extraordinary state of preservation of organic structural elements found in the excavations of prehistoric wetlands - particularly in central and northern Europe - offer the opportunity to specialists to approach quantitative and qualitative parameters of architecture that usually remain archaeologically undetectable. Similarly, favourable study conditions were only recently formed for Greek prehistoric research in Amindeon basin (Western Macedonia, Greece), where several sites were endangered by the intensive lignite-mining activities of Greek Public Power Corporation S.A.-Hellas. The realization by the Greek Ministry of Culture and Sports (Ephorate of Antiquities of Florina) of an extended Rescue Excavations Project (2003-2017) in the Lignite Mining Zone (survey, trial-trenching and rage-scale rescue excavations) covering an area of approximately 550 hectares resulted the discovery and documentation of 54 new archaeological sites dating from the Early Neolithic to the Late Bronze Age (late-7th - late-2nd mill. BC) (Chrysostomou, Giagkoulis and Mäder, 2015; Chrysostomou and Giagkoulis, 2016). There are indications that among those habitations, 19 Neolithic settlements were established in the surroundings of the prehistoric wetland, with their residential or other structures influenced at least periodically by water fluctuations (lakeshore habitations), while another 8 occupations were characterized as “typical lakeside pile-dwellings”, located mainly on the northern shore of Lake Chimaditis.

One of the most prominent prehistoric settlements of Amindeon Basin was Anarghiri IXb, a habitation located at the north-eastern edges of Lake Chimaditis in an area that until the 1960’s was covered by shallow-water marshes (Figure 1). The rescue excavation of the settlement (2013-2016) was certainly the most challenging endeavour of Amindeon Rescue Excavations Project due to its scale and operating staff involved (more than 800 archaeologists and workers). The outcome of this highly-demanding task realized literally at the edge of the lignite mining zone was the investigation to the natural soil of approximately 1.2ha on the periphery of the prehistoric habitation of 2.8ha

Figure 1.a. The Region of Western Macedonia in Greece b. The Neolithic lakeside settlement Anarghiri IXb in Amindeon Basin and the Four Lakes region c. The excavation of Anarghiri IXb (2015 campaign) on the edge of the lignite mining zone (Courtesy: Florina Ephorate of Antiquities).

of the total occupation's area, as well as the selective investigation of another 0.8ha in the central habitation zone, focused on the uppermost anthropogenic deposits. According to approximately 80 ^{14}C dates of structural wooden elements and other carbonized organic materials analysed by the Laboratory for the Analysis of Radiocarbon with AMS of the University of Bern, the earliest habitation was established during the Late Neolithic I period (approx. 5400 cal BC), with continuous human presence until the beginning of Final Neolithic period (approx. 4200 cal BC), whereupon the settlement was probably abandoned (Giagkoulis, 2019). The outstanding amount of complete coarse and decorated clay-vessels, stone (Papadopoulou, 2020), bone, antler (Arampatzis, 2019), clay and wooden tools, jewellery, anthropomorphic and zoomorphic figurines etc discovered, documented and preserved by the project's scientific team reflect a wide range of productive and socio-ideological activities of a flourishing Neolithic community.

Nevertheless, the excavation of the settlement's periphery revealed a general picture unique for south-east European wetland archaeology, namely the Anarghiri IXb pile-field consisting of more than 3600 wooden elements (Fig. 2, 3a and b). Most of these are roundwood vertical posts (78.7%), with lengths varying usually from 0.5 to 1.20m and diameters ranging from 9 to 12cm; however, the stratigraphic and spatial distribution of some posts of exceptional length (>2m) and diameter (>25cm) could be related to special load-bearing parts of the wooden structures. In most of the cases the bottom end of the piles was worked to become pointed or wedge-shape with visible tool marks indicative for the implementation of different woodworking techniques. Considerably fewer (12.8%) are worked and unworked wooden elements deposited horizontally in the lowest layers of the habitation; yet, their original place and function as structural parts of the prehistoric buildings are difficult to conclude, since there is no secure evidence about their stratigraphic correlation to the neighbouring vertical posts. Similar constraints exist also regarding the extraction of usable information from the examination of a relatively small number of thin twigs and small branches (3.15%), while one last category of material is the woodchips found scattered all over the excavation area (5.35%).

The sampling of structural wood realised during the last excavation campaigns resulted more than 1000 samples, constituting the first wood-assemblage deriving from a Balkan prehistoric wetland. The preliminary microscopic examination of 805 samples provided useful indications about the preferences of the Neolithic builders in the use of raw material. According to the results of the species identification, most of the sampled elements (80%) are oaks (Quercus sp.). One second distinguishable group of trees' stems belong to various conifers (18.5%). There is also a small percentage of samples (1.5%) belonging to deciduous trees' species.

The systematic documentation and study of the spatial arrangement and characteristics of those findings led to the identification of some clearly recognizable accessing and enclosing wooden structures on the marginal zone of Anarghiri IXb (Giagkoulis, 2020) (Figure 2). Accordingly, **Trackway 2** was an elongated alignment of more than 500 posts measuring approximately 85m, which led from the probable core of the habitation space to the settlement's edges. The structure showed a noticeable variety regarding the exploitation of roundwood and splits and the adoption of woodworking techniques by the prehistoric builders. The calibrated measurements of ten ^{14}C-dated posts from Trackway 2 ranging from 5308-4988 cal BC indicate that the trackway was evidently in use for nearly 250-300 years, being at the same time the earliest known wooden accessing structure in Neolithic Europe. **Trackway 3** consisted of more than 540 posts covering a distance of approximately 122m and connected Anarghiri IXb with the opposite dry-land, where the settlement Anarghiri XI was excavated, with several Early Neolithic to Early Bronze Age occupation phases (Chrysostomou and Giagkoulis, 2018). According to its dating ranging from 5020-4799 cal BC, it is quite probable that Trackway 3 was built probably after the abandonment (or destruction) of Trackway 2. Two similar, but partially investigated double posts' row alignments at the Southern Sector of the excavated area were characterized with some reservations as **Trackway 3a(?)** (approx. 4836-4723 cal BC) and **Trackway 3b(?)** (approx. 5208-4800 cal BC), without excluding the possibility that they constituted structural parts or successive repairs of Trackway 3 or some other accessing structure.

Although the arrangement of the vertical structural elements and the lack of horizontal wood do not facilitate the exact reconstruction of the two trackways' form, their comparison to similar structures discovered in European wetlands led to the supposition that they were ground-level features comprising a walking surface of horizontal elements retained and supported by vertical posts.

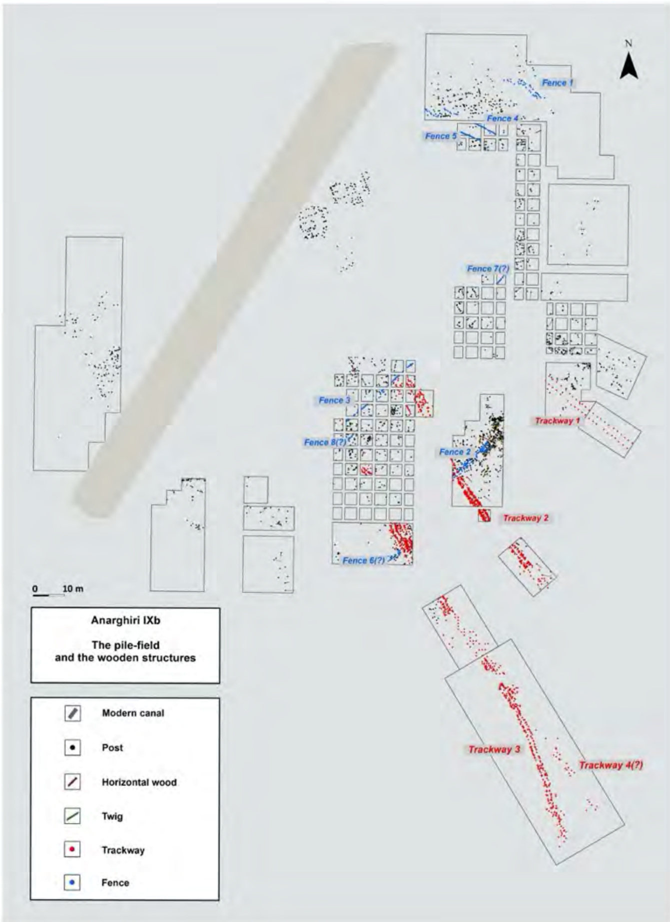

Figure 2. Anarghiri IXb pile-field and the accessing and enclosing wooden structures (Digital plan: T. Giagkoulis).

Trackway 1 is the most clearly recognizable wooden feature on the eastern edge of Anarghiri IXb comprising a 35m long and 2.5m wide double row of 45 oaken posts (Fig. 3c). The dating of the structure in the Early Bronze Age (approx. 2577-2469 cal BC) most probably explains its obvious structural differences compared to the earliest features, namely the elaborately processed vertical posts arranged rather regularly to form a bridge-like crossing to the opposite dryland. This feature, together with the slightly earlier remains of the fragmentary double posts' row characterized as **Trackway 4(?)** (approx. 2862-2581 cal BC) constitute for now the only securely dated evidence for some human activity during Early Bronze Age in Anarghiri IXb.

Apart from the trackways that provided access to the settlement from and to the opposite lakeshore, some other distinguishable posts' alignments were unearthed on Anarghiri IXb periphery, possibly related to the organization and/or delimitation of space and activities. On the northeastern edge of the occupation, a 13m long double posts' row named **Fence 1** (approx. 5209-4984 cal BC) could be used as a boundary between the marginal area with very limited anthropogenic activity at northeast and the denser built area at southwest. Some few meters to the south of Fence 1, another two linear posts' alignments measuring approximately 20m **(Fence 4)** and 22m **(Fence 5)** were unearthed. The dated wooden elements sampled from Fence 4 and 5 (5208-5002 cal BC and 5212-5051 cal BC respectively) make quite plausible the suggestion that these two synchronous features were probably parts of bigger structures built as means for arranging space or even enclosing the habitation or one specific area.

At the southeastern edge of the settlement the 15m long **Fence 2** (5299-5076 cal BC) apparently intersected Trackway 2 and constituted of a single row of posts directed from SW-NE for approximately 10m and ended up in two shorter in length double posts' rows, forming a denser entity, which was probably supported by some of the numerous horizontal wooden elements found **Fence 3**, a continuous single posts' row measuring approx. 30m discovered some 40m to the northwest of Fence 2 towards the central habitation zone, seems to be constructed later than any other Neolithic feature documented (approx. 4668-4464 cal BC). The feature is probably combined with the adjacent **Fence 8(?)** (approx. 4668-4404 cal BC) constituting of 16 vertical posts with curved top part probably for carrying horizontal elements. Lastly, the fragmentarily excavated alignments characterized as **Fence 6(?)** and **Fence 7(?)** could be either parts of larger continuous entities or were connected with some of the more securely documented structures; still, these suppositions are hardly controllable due to the lack of dateable samples from these two last posts' rows.

Since the remains of buildings - most probably of residential function - in the central part of the Late Neolithic habitation were either not excavated or they were scarce and fragmented, the trackways and the fences on the periphery of Anarghiri IXb constitute the only clearly recognizable architectural features that could lead to interpretative notions beyond their form. Accordingly, apart from cross-referencing of the similar wooden trackways of various types unearthed in European wetlands (Hayen, 1957, p.171; Hafner, 2002; Brunning, 2007, pp.188-230; Heumüller, 2016), the attempt to test some plausible suggestions concerning their function(s) on the edge of the prehistoric begins from their obvious use as crossings, joining the main habitation space of Anarghiri IXb with the opposite dryland exploited as multivariate productive space, being at the same time part of a broader communication network between Late Neolithic settlements within Lake Chimaditis wetland. Although direct indications in Anarghiri IXb material are missing and the dates of the trackways are early enough, it would be intriguing to introduce the discussion that correlates the construction of some central European wooden trackways dating back to the late-4th mill. BC with animal traction and the use of wheeled vehicles (Schlichtherle, 2002; Pétrequin, et al., 2006).

It is also argued that the deposition of "special" artefacts or groups of materials in the wet surroundings of trackways is sometimes deliberate and should be associated with symbolic actions performed by the prehistoric communities (Coles, Hibbert and Orme, 1973; O'Sullivan and Van de Noort, 2007; Brunning and McDermott, 2013, pp.368-370).

The remains of wooden fences on the settlement's periphery are fragmented and non-continuous and their function is open to interpretations such as those proposed for enclosing structures in prehistoric wetlands, i.e. means to reduce impacts from waving water and wind, structures to separate building and/or productive activities' spaces or to control movement of people and livestock from/towards the main occupations' areas (Hasenfratz and Gross-Klee, 1995, p.222; Bauer, 2009, p.191; Bleicher and Burger, 2015, pp.121-138). The most controversial suggestions which associate this kind of structures to defensive purposes are citing variable indications in the archaeological record related to phenomena of violence or warfare even during the Neolithic (Pétrequin and Bailly, 2004, pp.39-40; Torke, 2009, p.264-269; Viellet, 2009, p.285; Hafner, 2010, p.359-360). In an interpretative direction that considers the enclosing structures as socially significant for the formation and reproduction of communal identities between the inhabitants of a Neolithic settlement, it is further claimed that these works being

Figure 3. a and b. Vertical posts extracted from the lowest wet layers of the habitation; c. The Early Bronze Age Trackway 1 ; d. Oaken posts from Trackway 1; e. Detail of the lowest part of post with tool marks (Courtesy: Florina Ephorate of Antiquities).

established at the peripheral zones of the residential space were also functioning as physical or even symbolic delimitations of the communities' boundaries signalizing specific messages to neighbouring groups. These would have been related to some kind of "legal establishment" of the community's "rights" on land and recourses in the surroundings of the habitation (Meyer, 2002, p.70; Chapman and Gaydarska, 2006, pp.20-21; Neustupný, 2007, p.3). Moreover, some more recent views relate the establishment of enclosing structures with the need of the Neolithic communities to protect and even defend rights or access to natural resources and raw materials declaring at the same time power and control (Alušík, 2017, p.195).

Moreover, it would be interesting to integrate the findings from Anarghiri IXb into the discussion in Greek prehistoric research concerning the purposes of encircling Neolithic settlements by their inhabitants through various structural interventions (ditches, walls, palisades, pits etc). The corresponding interpretative alternatives refer to planning and spatial arrangement of buildings and activity areas (Hourmouziadis, 1979), increasing antagonism and conflicts among Neolithic communities (Kokkinidou and Nikolaidou, 2004; Runnels, et al., 2009) or demarcation of the settlement's, as well as community's boundaries in a symbolic - together with the practical - level (Pappa, 2007; Kotsakis, 2009).

Focusing again on Anarghiri IXb accessing and enclosing structures, it could be claimed that those were literally defining in a considerable degree the "scene" for the development of fundamental socioeconomic and ideological activities of the local community especially during the Late Neolithic period. Consequently, their construction constituted one advantageous field for the organized procurement, management and exploitation of raw materials, for the implementation of innovative technical solutions, as well as for the possible growth of personal competences. Even rather imperceptible for the time being, some of these aspects of the building processes could be approached by the comparative observation of the trackways' structural attributes. For example, according to the spatial distribution of the vertical retaining posts that form the two parallel alignments of Trackway 2, the average distance between them is estimated to be approx. 2m. Measuring the same attribute of Trackway 3 an average distance of 1.60m between the two posts' rows is recorded. Moreover, most of the posts comprised Trackway 2 - evidently their preserved part - were 51-70cm long (with some noticeable exceptions that are bigger than 1m), deriving from trees' stems with a diameter ranging between 9-12cm. In contrast, the vertical elements discovered across the course of the later Trackway 3 are smaller, usually preserved in a length of 31-50cm and deriving from stems 5-8cm in diameter. Comparing these specific characteristics of the two features, it could be claimed that Trackway 2 was probably a more solid and load-bearing structure than Trackway 3, though both could be reconstructed as features build on the marshy area between Anarghiri XI and Anarghiri IXb sites. Although the observed structural differences could be explained as the outcome of changes in spatial organization or the impact of environmental factors, the use of trees' stems of variable physical properties could reflect changes regarding the availability of raw materials or different practices for wood procurement or woodland management implemented by the Late Neolithic community.

The bridge-like Trackway 1 was constructed and used in the quite different chronological and sociocultural context of the Early Bronze Age (mid-3rd mill. BC), of which no usable data from the excavated part of Anarghiri IXb are available so far. Therefore, the exclusive use of oaken roundwood posts, bigger (average length approx. 110cm) and older (stems with more than 30 annual growth rings) than those usually documented in Anarghiri IXb Neolithic wood assemblage could be considered as evidence of well-organized and targeted exploitation of the available resources. On the other hand, the regular placement of the vertical posts that supported the substructure for the horizontal walking surface and the elaborately processed lowest part of all 45 vertical posts indicate an advanced familiarization with the physical attributes of the raw material and an evidently effective application of technical solutions that would ensure the stability of the bridge-like feature in the wet or marshy ground on the settlement's surroundings (Fig. 3d and e). Classifying the posts according to the marks on their lowest parts, namely the number, size and form of the facets produced by the use of cutting or processing tools, the obvious similarities observed could lead to rather intriguing thoughts, similar to those expressed by the excavators of the Iron Age wooden trackway in Bad Buchau-Wuhrstraße in Lake Federsee, which claim that in the regularity of the processing marks the "handwriting" of the prehistoric builder could be in some degree recognized (Heumüller and Million, 2013, p.132).

Taking the aforementioned observations into account, it could be suggested that the general planning, building, as well as maintenance or repair of Anarghiri IXb accessing and enclosing structures most probably constituted communal labour-intensive endeavours. Therefore, being works of some extraordinary scale - compared to the construction of residential or other architectural units of smaller dimensions - they might require a higher degree of accurate decision-making in respect of adequacy in raw materials provenance and management, tasks' organization and collaborative implementation. In consequence, it would be plausible that all these different parameters that formulated the framework for the successful realization of the structures' building projects could have played some role in the development of dynamic relationships between the members of the Neolithic community of Anarghiri IXb. Subsequently, it should not be excluded that some inhabitants would have been familiarized with the management of the local woodland, wood species' exploitation for specific purposes or particular technical tasks regarding the structures' building.

In conclusion, within the framework of a multi-levelled study of Anarghiri IXb material culture it could be further explored whether these developing personal skills gradually led to some degree of craft specialization or to what degree personal competences and building skills constituted not only some kind of "social capital" appropriated for the successful realization of specific construction projects, but were also transmittable knowledge, a factor that would reinforce the community's integrity.

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SESSION 3

Resources and Complex Systems

Session organisers
Michael Roos, Frank Hillebrandt and Frederik Schaff

Keynote Speakers
Iza Romanowska and Angelos Chliaoutakis

Keywords
Complexity, Resources, Modelling

In this session, we want to explore methodological approaches that deal with the complexity of high-level archaeological questions by taking a resource-based view. Under a high-level question, we understand a question that deals most comprehensively with human behaviour in its specific spatiotemporal context. More concretely, we do not want to focus on a single aspect of the archaeological record for a given region and time, but want to understand the dynamics of the past society in a given geographical area over a long time span (typically several hundred years).

A particularly interesting approach to such issues is to build formal, data calibrated simulation models with artificial societies populating an artificial world. However, inevitably one encounters a huge 'lack of data', especially when it comes to modelling human behaviour. Hence, ethnographic and anthropological work that aims at detailed descriptions of daily life and decision processes in past societies, likely providing more than one hypothesis, is a crucial part of such a discussion.

Furthermore, we recognise that the availability of resources, be it material or culturally produced and accumulated, is an important aspect when trying to understand such higher order questions. The distribution and availability of resources (including, e.g., knowledge) structures and limits the potential activities of the humans that lived in the specific spatiotemporal con-text. Taking a resource-based view is thus most helpful in selecting the elements in the model or making inevitable assumptions on past human societies, be it individual behaviour or social processes.

Agent-based modelling as a paradigm shift in archaeological research

Iza Romanowska

Keywords
Agent-based modelling, simulation, complexity science, digital archaeology

The fundamental difficulty in (almost) all archaeological inquiry is that the primary objects of our study are long dead. Trying to reconstruct the lives of past peoples based on the few bits and bobs they left behind is challenging. However, contrary to the widely held belief that archaeological data is somehow special in its 'badness', we are not the only discipline studying an inherently inaccessible system. A barrage of methods exists to deal with this problem, first and foremost among them: simulation modelling.

The task might look daunting. How do we go from three hundred thousand pieces of Palaeolithic lithic debitage or 500kg of Roman pot to an understanding of the complex network of relationships between individuals, groups, and their environment that we know make human societies? Agent-based modelling (ABM) provides a method for unravelling some of these complex interactions and uncovering the dynamic processes that have driven societies in the past. ABM is a popular simulation technique used across social, life and physical sciences. It is also becoming the go-to type of simulation in archaeology. In this talk, I will ground modelling methods in the epistemological framework of the scientific process and showcase the innovative ways in which we can use simulation and other formal model-building techniques to understand the interactions between individuals and their social and natural environments. I will discuss the potential and limitations of computational modelling in humanities at large and highlight the range of possible applications.

Why Simulation?

It is easy to regard ABM as yet another hype in archaeological computing. This is not the first time that a group of archaeologists figures out how to use particular software and a wave of papers appears heralding the "solution" to all archaeological problems. Here, I will argue that this is more than a new algorithm, or a fancy statistical technique – simulation is a fundamental way of doing science. Axelrod (1997) calls it a "new way of conducting scientific research". One that marries induction, i.e., describing the world by looking for patterns in data with deduction, i.e., describing the mechanisms that could give rise to these patterns. Simulation formalises deductive reasoning, such as conceptual models - hypotheses, and contrasts their predictions with patterns revealed by the induction type of research. In simple terms, simulation is a formal representation of our ideas of how the world functions that allows us to see how likely these ideas are given the data. It can be used in a range of applications: to test hypotheses, check data coherence or even as a theory-building tool. Although most modelling techniques can be used to contrast conceptual hypotheses with data, simulation is the only one that can handle complex dynamic and non-linear systems, such as social and socio-natural systems that our discipline is most concerned with.

There is nothing inherently better about agent-based modelling compared to other simulation techniques. If anything it is more cumbersome to develop and analyse, less tractable and significantly more computationally expensive. However, it has a significant advantage for those involved in archaeological research in that it can repre-sent the world from the bottom-up.

The world from the bottom up

There are two major scales of archaeological data and theory. One scale is that of individual people and their behaviour: the makers and users of the pots and lithics, the pedestrians in the streets of ancient cities and the traders exchanging goods. Data patterns that we commonly detect in the archaeological record are a result of individual human behaviours. However, they are highly aggregated into population-level patterns: changes in the frequency of particular pottery decoration, a network of streets, or the percentage of "exotic" products on an archaeological site. Thus, we think of the past in the familiar terms of people's behaviour but need to analyse it on the level of large-scale group dynamics. This is not an easy task as proven by the existence of social sciences, which do exactly that but for the present times and with significantly more and better data.

ABM is specifically designed to cross these two scales. Agents can represent individuals or small social units and follow easy to interpret behavioural rules, e.g., "buy a new pot when the old one breaks". ABM can even incorporate individual agency and the inherent unpredictability of human life - factors humanities researchers hold particularly dear. Contrast it with equation-based representation where the characteristics of the system are described top-down, e.g., "rate of pottery replacement". Such high-level indicators of the population-level dynamics are not easy to derive from archaeological data, which may to some extent explain the long delay in the adoption of simulation by researchers working on past societies. The bottom-up approach is a source of some unique capabilities of ABM.

Three agent-based modelling superpowers

First, the definition of ABM models is very natural. In the process, known as ontology building, the modeller develops a framework of what the agents are and how they behave. As mentioned, the definition of these rules is easy as they mirror our everyday experiences. For the same reason, the assumptions and reasoning involved in the model are transparent and easy to understand thus facilitating model testing and critique by others.

Second, a particular feature of complex systems is that simple rules can lead to unexpected consequences. Sometimes this is because the interactions between the elements of the system are non-linear and difficult to predict. Two people walking down a street have a different dynamic that a crowd of two hundred. In other cases, a particular context makes the outcome of an event different than the one that would normally occur. The bankruptcy of one company can trigger a deep economic crisis if the system is already on edge, even though similar events caused no serious repercussions for decades before. This kind of mechanisms can rarely be conceived by just thinking about them, formal computational methods are often the only way to uncover them.

The individual agency, the uniqueness of each agent's situation and their ability to dynamically adapt to the changing circumstances make ABM among the closes possible representations of human experience. There is nothing that humans can do but the agents cannot, which means that the choice of modelling topics is also limitless. Any process that can be codified as a behavioural rule, including personal preferences, particular life experiences and character features, irrational decisions or sheer luck can be part of an ABM. This opens up archaeological investigations to topics that until now were not operationalized and therefore often ignored in our explanations.

Simulation, such as ABM, may be a new way of doing science and its superpowers are great but, most certainly, it is not the only or even the best way of doing science in all circumstances. There are clear limitations to the scope of what one can do with ABM.

Three agent-based modelling fallacies

Simulation and ABM do not replace the need for induction and deduction type work. A model can help in finding the most likely mechanism that created the data pattern but if no data pattern is available it is limited to giving an answer to what-if types of questions. In most cases, a lot of data goes into the simulation parameters and even more is used to calibrate and validate it. In simple terms, more data and better data translate into more and better models. Similarly, conceptual deductive models are the very basis of simulation ontologies and if it was not for researchers coming up with new and insightful hypotheses there would be little to test.

Second, the fact that ABM models are developed in a computing environment and ultimately are, admittedly quite complicated, an expression of a series of simple mathematical operations does not make them more likely to be true than any other type of a model, conceptual models included. If not compared with data they remain a thought experiment and cannot be used to "prove" anything. However, they do hold a persistent advantage over theories defined verbally: formalism facilitates scientific transparency and scrutiny because the definition of all terms is complete. In short, putting a theory into a computer does not make it any more likely to be true but it does make it easier to test it.

Finally, there is a widespread perception that the more data one puts into the model and the better quality and resolution of it, the better the model. In a similar vein, more realistic models are often perceived as better ones. This is a particularly slippery slope for ABMs where including additional variables, behaviours, conditions, etc. is relatively easy to do. However, the explanatory power of simulation comes not from the detail it includes but its ability to simplify the system to the bare minimum and still get an answer. By definition models are always simplified versions of reality and what we decide to include or omit is arbitrary. This is why, just like we have many different theoretical frameworks, we also need many different models to investigate the same phenomena.

The future

Many disciplines have experienced or are experiencing a shift from predominantly data collection and analysis based research to more computer modelling type of research. And although it is unimaginable that any field will give up on collecting data or conjuring theories all together simulation is here to stay. Humanities-based disciplines are one of the last ones to hold on but with the potential that these techniques bring, it is a powerful tool that can change how we do archaeology all together.

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Methodological Approaches Towards Simulation and Modeling Social Organization of Past Societies

Angelos Chliaoutakis

Keywords
Agent-based Modeling, Multi-agent Systems, Geographical Information Science, Social Organization, Archaeology

Abstract

Some of the most interesting questions one may ask about early societies are about people and their relations, and the nature and scale of their organization. As an attempt to answer - or better provide insights on - such questions, I would like to present you in this talk with an agent-based simulation model incorporating different methodological approaches, spanning from multi-agent systems and game theory to network theory and spatial modeling. As a case study, we employ the model to evaluate the impact of different social organization paradigms and interaction mechanisms on an artificial Bronze Age "Minoan" society, located at different geographical parts of the island of Crete (Greece), based on available archaeological resources.

Introduction

Archaeologists seek to interpret human history by providing theories about the interactions between societies and their natural environment, grounded on archaeological evidence. Archaeological theories, however, are based on data that is static. What I mean, is that it might reflect the results of the dynamic interactions among people, materials, landscapes, and the inhabited environment in general, but not these dynamics themselves, thus having a difficulty linking cause and effect in the past. An alternative way to reason about historical and past actions and events from observed data, is to transform theoretical questions and hypotheses into computational terms. Towards this end, computational modeling and simulation can assist archaeologists on expressing individual or collective entities, relationships between them or phenomena, allowing them to explore and test theories against observed data, to conduct plausibility (or improbability) tests, and experiment with different sets of initial conditions and scenarios to explain particular sequences of cause and effect.

In particular, agent-based modeling (ABM[1]) (Wilensky and Rand, 2015) is a field research methodology originally developed as part of computational modeling, but widely used by other disciplines, from life and physical sciences to environmental and

[1] I will be using the acronym ABM to refer to both "agent-based modeling" and "agent-based model(s)"

social sciences. ABM is quite effective in representing the interactions among acting entities (agents), that may represent individuals, and groups, since these entities can be represented directly and can possess internal state(s), and a set of behaviours or rules that determine how the agent's state is updated from one time step to the next. Scholars argue, however, that most agent-based simulation models used in archaeology and beyond, simply do not define truly autonomous agents (Drogoul, Vanbergue and Meurisse, 2003), and ideas and notions from the Multi-Agent Systems (MAS) community and related principles should be followed in the design of the respective ABMs. This is something I have attempted to do in my thesis, and that I will also try to make apparent in this talk.

Methodological Approaches

In my thesis, we examined how methods and techniques from multiple computer science fields can be combined to deliver an augmented ABM to be effectively utilized in the archaeological domain. In order to establish an ABM that would actually simulate an artificial past society in a realistic landscape environment, one should examine many aspects, and most probably be called to utilize solutions from various fields of computer science or even other scientific fields. The core of our approach is to formally describe and improve agent-model design, as a means for developing simulations which can lead us to better understand emergent phenomena associated with the evolution of complex systems, such as artificial past societies organization. This is achieved by properly introducing and incorporating MAS ideas and techniques towards enhancing agent sophistication in organizational design.

Specifically, we provided a modeling approach that employs autonomous, *utility-based* agents (rational utility-maximizers) for modeling their intra-community interactions (Chliaoutakis and Chalkiadakis, 2016); *utility* refers to some ranking or scale of the subjective welfare an agent. We also incorporated in our ABM a number of different social organization paradigms (e.g., independent, egalitarian-like, hierarchical) and subsistence regimes (e.g., cultivation systems), aiming to assess the influence of social organization on agents' population growth, agent community numbers, sizes and distribution. Importantly, we adopt and adapt a "self-organized" agent organization paradigm that builds on MAS work for problem-solving in modern agent organizations (Kota, 2009). Agents are autonomously organized into a dynamic "stratified" social structure (peer and authority relations exist between them), by continuously re-adapting the emergent structure, if required, based on exchanged resources. As a case study, we employ our ABM to assess the intra-

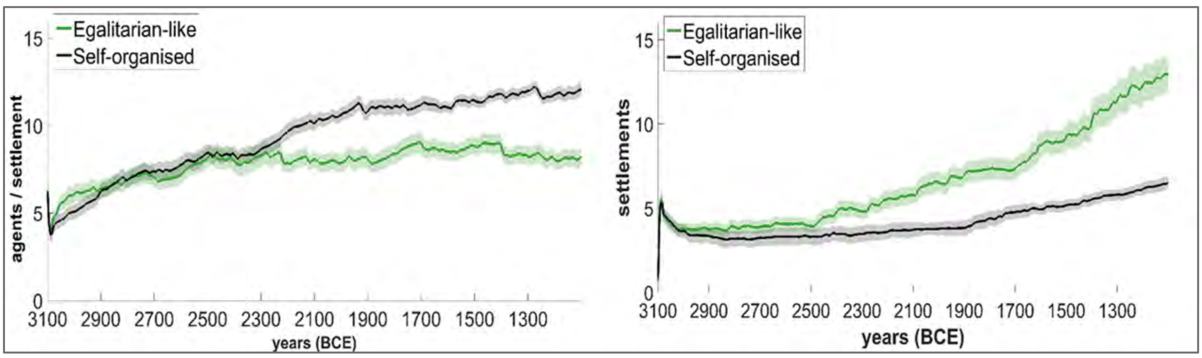

Figure 1. Number of agents per settlement group (left) and settlements (right) over 2,000 (annual) time steps with respect to intensive agricultural practice and without a requirement for settling near an aquifer. Shading areas indicate 95% confidence intervals.

settlement organization of "Minoan" agents affected by their interactions, based on archaeological resources about the Minoan civilization (Bintliff, 1982). Agents represent "households", residing in an actual environmental landscape (Digital Elevation Model) at the wider area of Malia (20 x 25 km, 1 ha cell size) at the island of Crete during the Bronze Age (temporal scale of each simulation is 2,000 annual time-steps). Simulation results show that when agents adopt an "egalitarian" social organization behaviour, a settlement pattern of many "small-size" settlements is emerged, while when the self-organization social paradigm is adopted, a "heterarchical" social structure emerges, giving rise to fewer but larger settlements during the Middle – Late Minoan period (Figure 1). This fact is in line with archaeological evidence for larger settlements (towns and palaces) eventually coming to existence during the Middle – Late Minoan period, where a more varied and dynamic social structure is now suggested (Driessen and Langohr, 2014).

The various social organization paradigms explored, assume a cooperative attitude on behalf of the agents. Specifically, agents were assumed to be willing to provide resources out of their stock in order to help agents in need. However, if one is to model societal transformation accurately, agent behaviour has to be analyzed from a strategic perspective as well. Therefore, we blended *evolutionary game theory* with multi-agent systems' self-organization for modeling the evolution of social behaviours in a population of strategically interacting agents (Chliaoutakis and Chalkiadakis, 2017). Specifically, we provide a novel evolutionary self-organization algorithm by simulating repeated "stage games" played by pairs of strategic agents, i.e. cooperative, defective and equivalent retaliation (tit-for-tat), by means of which they exchange utility (corresponding to resources) with others. The results of the games contribute to both the continuous re-organization of the social structure, and the progressive adoption of the most successful agent strategies. We conducted a systematic evaluation of the performance of various agent strategies, assuming several variations in the way agent and agent organization *fitness* are defined, as well as in the way agents adopt new strategies (i.e. deterministic or stochastic), for studying the evolution and adaptation of strategic behaviours of agents, and the effect these have on the artificial Minoan communities. Simulation results show that scenarios that are better in sustaining higher agent population sizes are when agent performance is compared to that of its immediate community (settlement), against agents adopting the same strategy and the adoption of an alternative strategy is stochastic. Interestingly, in

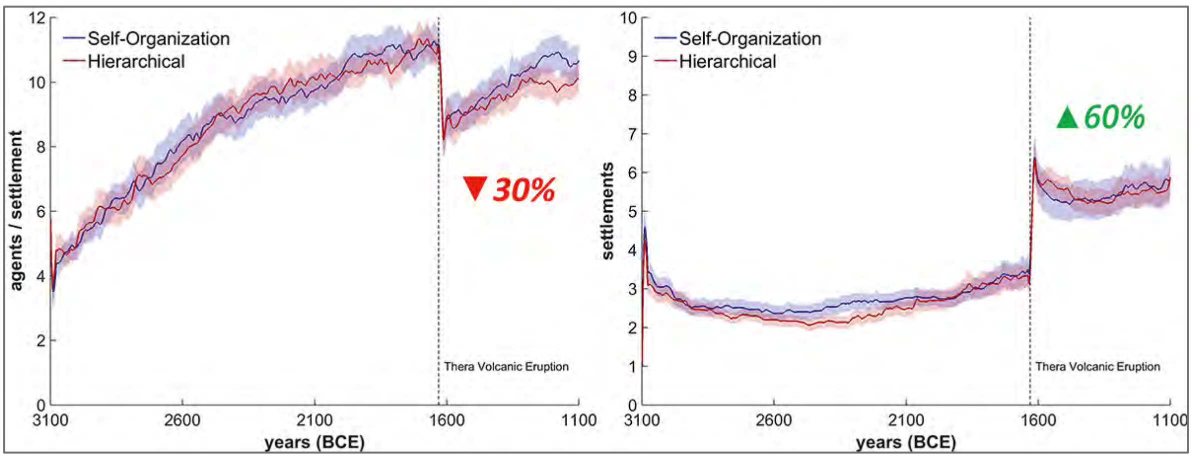

Figure 2. Number of agents per settlement group (left) and settlements (right) over 2,000 (annual) time steps, considering a volcanic eruption scenario. Shading areas indicate 95% confidence intervals.

these scenarios agent populations mostly adopt cooperative strategies, in contrast to the stage game equilibrium (mutual defection). We further embodied approaches and techniques from *geographical information systems* (GIS), not-only to properly capture spatial aspects of agent environment, but also agent-agent and agent-environment interactions. Specifically, we Incorporate *spatial analysis techniques* (i.e. map algebra, cost distance/allocation), towards the development of a simple natural disaster model representing a volcanic eruption, in order to assess the imminent social crisis in terms of agents' social organization, before and after the natural catastrophe event (Chliaoutakis, Chalkiadakis and Sarris, 2018). We also conducted a systematic evaluation on social change, based on archaeological resources on the environmental and human impact of the mid-2nd millennium BCE Santorini eruption to the Minoan civilization (Driessen, 2018). The change observed in the distribution of settlements (including high mobility patterns), with higher number of "small-size" settlements at the end of the LM period (Figure 2), provide support to hypotheses suggesting that the Theran eruption led to a clear breakdown of the Minoan socio-economic system.

Furthermore, we also model agent *inter-community* interactions, by providing a novel trading module that readily incorporates various *spatial interaction models* to simulate exchange and distribution across household agent communities, in order to explore the resulting trading network's efficiency and its evolution at different points in time (Chliaoutakis and Chalkiadakis, 2020). Thus, our ABM is now able to study of the settlements' trading ability and power, given their geo-location and their position within the trading network, and the structural properties of the network itself. As a case study we use the Minoan society during the Bronze Age, in the wider area of "Knossos" (40 x 30 km, 1 ha cell size) at the island of Crete, Greece. We instantiate two well-known spatial interaction models, *XTENT* and *Gravity*, and conduct a systematic evaluation of the dynamic trading network that is formed over time. Simulations assess the sustainability of the artificial Minoan society in terms of population size, number and distribution of agent communities, with respect to available archaeological resources (Driessen, 2020) and spatial interaction model employed. We further utilize ideas from *graph theory* to analyze the trading network's structure (centrality, clustering, etc.) and how it affects inter-community organization, providing in the process insights and/or support to archaeological hypotheses regarding the settlement organization in place at the time.

In simulation scenarios where settlement "importance" is based on archaeological evidence about the settlement type at any given

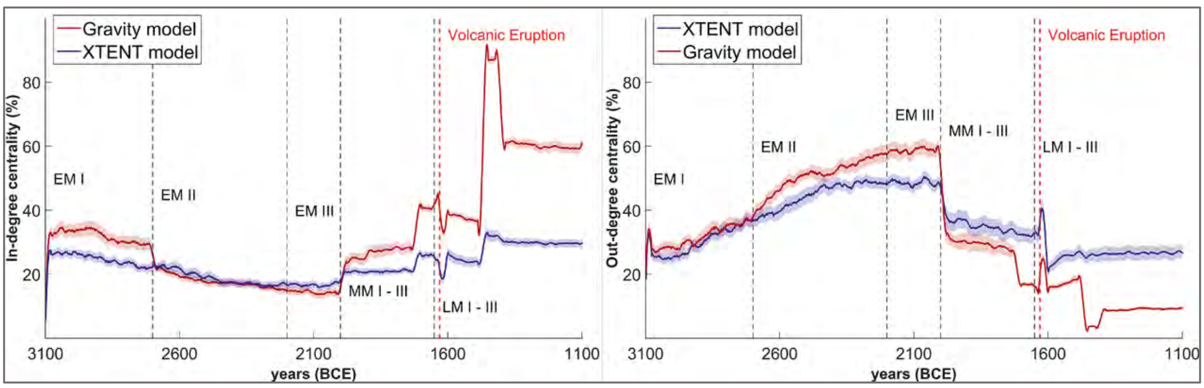

Figure 3. Relative in-degree (left) and relative out-degree (right) graph centrality indexes of the trading network over 2,000 annual time steps (Minoan period), considering known archaeological site locations and types. Shading areas indicate 95% confidence intervals.

time step and geographic location, the Gravity model was able to better capture the trend in settlement numbers that exist in the archaeological record. In these scenarios we also observe that the respective model exhibits a high relative out-degree centrality during the end of the Early Minoan period, suggesting that a small number of "influential" centers could have existed, linked to a settlement hierarchy where resources are distributed by these centers to others in the network; but there are no clearly prominent centers to which resources are directed (Figure 3, right). By contrast, a high relative in-degree graph centrality after the volcanic eruption and during the Late Minoan period, suggests that there are certain "prominent" settlements in the trading network (Figure 3, left). Therefore, the network's structure and interaction patterns are to an extent reversed after the Theran eruption, and one could assume that a settlement hierarchy where resources are traded towards the (few) most important settlements in the trading network is implied during the Late Minoan period.

Conclusions

I hope that you now have some idea on various methodological approaches that can be integrated into an ABM, for structuring and assessing different hypotheses on an artificial society. In my case study, these hypotheses are about the social organization of an Early Bronze Age "Minoan" society, located at different geographical parts of the island of Crete, Greece. Indeed, model parameter choices are based on available archaeological resources, but are not biased towards any specific assumption. To sum up, results over a number of different simulation scenarios demonstrate better sustainability for settlements consisting of and adopting a socio-economic organization model based on self-organization, where a "heterarchical" social structure emerges. Simulation results also demonstrate that successful agent societies adopt an evolutionary approach where co-operation is an emergent strategic behaviour. In simulation scenarios where a simple natural disaster model was enabled, we observe noticeable changes in the settlements' distribution, relating to significantly higher migration rates immediately after the modeled Theran eruption, suggesting that the volcanic eruption led to a clear breakdown of the Minoan socio-economic system. Moreover, we observe that modeling a trading network that favours settlements' importance (Gravity) rather than distance (XTENT) between settlement locations, can produce settlement patterns similar to the one that exist in archaeological record, and further insights regarding the settlement organization in place at the time.

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Simulating Resource Exploitation Strategies in Iron Age to Hellenistic Communities in Southwest Anatolia

Dries Daems and Stef Boogers

Keywords
Anatolia, Resource Exploitation, Energetic Returns, Social-Environmental Systems, Agent-Based Modelling

Introduction

People have always needed to interact with their environment, collecting foodstuffs, hunting animals, working the land, and exploiting resources. All human societies need energy and resources in order to sustain themselves. As a result, people also have a profound impact on their environment when exploiting these resources. All of the goals and practices of a society to track and collect resources can be subsumed under the moniker of resource exploitation strategies. In order for societies to be resilient over longer periods of time, these strategies need to be sustainable. That is, a balanced interaction between society and nature is needed in which the social consumption of resources does not exceed their availability and/or regeneration rate.

In this paper, we will explore human-environment interactions in the area of Sagalassos (southwest Turkey) from Iron Age to early Hellenistic times (1000-200 BCE). Over the last three decades, the Sagalassos Archaeological Research Project has been conducting interdisciplinary research, resulting in extensive archaeological and environmental datasets.

Geomorphological data and simulations of patterns of erosion and sedimentation for the Gravgaz valley, one of the better studied catchments in the area, have suggested a significant human impact on the environment – expressed through changes in vegetation cover and soil thickness – from the 9th c. BCE onwards (Van Loo, et al., 2017). This primary phase of human impact can be associated with the onset of the so-called Beyşehir Occupation Phase, characterised by warmer and more humid circumstances that favoured agricultural and arboricultural production at higher altitudes, resulting in the increased appearance of cultivated tree species in the pollen record (Bottema and Woldring, 1984; Kaniewski, et al., 2007).

The aim of this paper is to shed light onto the underlying mechanisms and strategies of resource exploitation in Iron Age to Hellenistic sites in the area of Sagalassos in southwest Turkey. We wish to test the hypothesis that hilltop sites can be considered major drivers of environmental change in the area during the Iron Age to Hellenistic period. By building an agent-based model of subsistence and resource exploitation, we explore a novel avenue for hypothesis testing in interdisciplinary archaeological research in the Sagalassos Project.

Methods and materials

This paper integrates archaeological and environmental data in an agent-based modelling approach to study human-environment interactions in the area of Sagalassos (southwest Turkey) from Iron Age to early Hellenistic times (1000-200 BCE). The area discussed here is part of the 1200 km² study area of the Sagalassos Project. Data is derived from excavations, intensive and extensive archaeological surveys, geophysical studies, pollen cores, chemical analysis and model simulations.

Archaeological data for this period indicates the emergence of a number of extensive, fortified hilltop sites from the ninth century BCE onwards, particularly in the eastern part of the study area. These hilltop sites were strategically located, having good visibility over the surrounding valleys and access to a sufficient amount of arable land in their direct vicinity. It has been suggested that each of these sites exercised a certain degree of control over the valley(s) in their immediate surroundings (Vanhaverbeke, et al., 2011). Besides fortified hilltop sites, a series of agricultural hamlets and villages has been attested in the Burdur Plain, one of the most fertile areas in the region (Kaptijn, et al., 2012). These sites could perhaps be linked to Düver Yarımada, which was suggested to have been a religious complex and central place at that time (Kahya, 2015; Talloen, et al., 2006). A series of smaller sites were also found in the recent Dereköy Highland survey in the eastern parts of the study area (Vandam, Willett and Poblome, 2017). Hilltop sites constituted the apex of the local settlement pattern in most of the area, serving as foci of population congregation.

Archaeological excavations, geophysical surveys and extensive material studies at one of these sites - Düzen Tepe - have suggested that these were agricultural communities with a locally-oriented productive landscape, focusing strongly on the immediate environment for their main subsistence and resource procurement (Cleymans, Daems and Broothaerts, in Preparation; Daems and Poblome, 2016; Vanhaverbeke, et al., 2010). Düzen Tepe was a fairly sizeable settlement, with a settlement nucleus of about 15 ha and structures spread across the entire 60 ha plateau overlooking the Ağlasun valley. Recent calculations based on house counts and the area of habitation have estimated a population size of about 1000 people for Düzen Tepe (Cleymans, Daems and Broothaerts, in preparation).[1]

Archaeobotanical data indicates a variety of crops were produced, including wheat and barley, as well as various pulses. Faunal data of Düzen Tepe also suggests that goat and sheep herding constituted an important economic activity for daily subsistence (De Cupere, et al., 2017b). Analysis of stable nitrogen and carbon isotope signatures (δ13C and δ15N) indicated that animals were likely herded together or kept in enclosures in the vicinity of the site and fed a nearly identical diet (Fuller, et al., 2012).

The intensity of exploitation of their immediate surroundings meant that hilltop sites such as Düzen Tepe were likely major drivers of environmental change in the local landscape (Daems, et al., in press). Pollen data from the study area of Sagalassos do indeed show a significant human impact associated with the emergence of hilltop sites in the region (De Cupere, et al., 2017a). However, despite past efforts, our knowledge of how these communities operated, the nature of their resource exploitation strategies, and subsequently, their impact on the environment, remains limited as it is based only on this single proxy. The more intricate coupling of social and ecological spheres on the micro level elsewhere in the study area of the Sagalassos Project remains understudied. Unfortunately, most of these sites are located on private lands, which, under the current regulations, impedes future excavations and

[1] The Gaussian distribution of all applied estimation methods resulted in a 1 sigma range (68.2%) of 958 ± 504 inhabitants.

sampling. So far, it has proven impossible to conduct more traditional archaeological research on these sites.

The observed dynamics also need to be considered in light of climatic and environmental changes, most notably as part of the Beyşehir Occupation Phase (BOP). The onset of the BOP is defined solely by indications of human impact (Eastwood, Roberts and Lamb, 1998), resulting in differential timing between areas (Kaniewski, et al., 2007). The interpretation of this period in light of climatic changes only came about after this delineation. Local increases in moisture availability have been demonstrated during the Iron Age for the Sagalassos territory (Bakker, et al., 2012), but they may very well only have constituted a small release from a relatively dry period for the entirety of southern Anatolia (Finné, et al., 2011; Woodbridge, et al., 2019). Likewise, the shift to a more "Atlantic" climate in southwestern Turkey (Bottema, 1993) was not necessarily characterized by significantly warmer temperatures (Finné, et al., 2011). The widespread archaeological evidence of the BOP in the face of such uncertainties inherent to the paleoclimatic record emphasizes the importance of studying the aforementioned social aspect. So far, the integration of social and environmental data proxies has only been successful on a coarse-grained scale with limited chronological resolution. This has impeded a good understanding of human-environment interactions for this period. With our model, we hope to bring these social and environmental spheres together and assess their interaction on the local level.

Simulating the past

The discussion above shows that a lot of the detailed human-environment interactions in the area of Sagalassos are still left to be explored. However, due to the limitations of the available data, the Sagalassos Project is increasingly turning towards the potential of simulation models to fill in the gaps. For this paper, we wish to test our hypothesis that the Iron Age hilltop sites in the area of Sagalassos can be considered the main drivers of environmental change, as observed in the Gravgaz data. We are building an agent-based model to explore subsistence and resource exploitation strategies for these small-scale agricultural communities.[2]

In our model, we use a semi-realistic GIS environment, plotting known sites in a simplified landscape with properties such as altitude, forest yield potential, fertility and resource availability. We simulate three general types of resources across the landscape: agricultural products (subsistence: renewable), clay (production: non-renewable), and wood (fuel for subsistence and production: renewable). All resources have two main properties: quality and distance to the settlements. These properties have been cross-culturally observed to generate feedback mechanisms and trade-offs resulting in profitable and non-profitable zones of exploitation for different types of resources (Arnold, 1985). We will simulate different resource exploitation strategies by exploring the energetic returns to investment of agents from each site when looking for each resource under different parameters. To validate our model, we will compare simulated patterns of exploitation and human impact with those of the environmental data from the Gravgaz valley.

Discussion

Recent studies have suggested that hilltop sites in the area of Sagalassos had a significant impact on their environment. These nucleated settlements with relatively high population densities were characterised by locally-oriented strategies of subsistence and

[2] Coded with the NetLogo software. See https://github.com/driesdaems10/Resoc for source code and ODD documentation of the model.

resource exploitation which likely required extensive energy and resources from the immediate environment. Possible indications of this process, resulting in decrease of soil depths on the slopes as well as increased soil depths and fertility in the lower valley, can be found in the study of sedimentation rates at Gravgaz (Van Loo, et al., 2017). As a result, agricultural potential of the higher areas may have decreased, but simultaneously, the potential for habitation in the lower areas would have markedly increased as well.

With the development of an agent-based model, we hope to uncover the drivers behind the diversification of settlement locations within the landscape and elucidate whether the observed environmental changes can be linked to resource exploitation strategies. Such strategies are built on trade-offs between quality and distance of resources in light of their energetic returns. The highly dynamic nature of this process is ideally suited to be captured by an agent-based model.

The agent-based modelling approach presented in this paper is intended to show the great potential of simulations in studying human-environment interactions in the past. Even though simulations have been applied in archaeology for several decades, many research avenues remain unexplored. Deepening the consilience between the historical and natural sciences through such simulation efforts will hopefully continue to yield promising results in understanding environmental change and its effects on human societies in the past, as well as in the present (Haldon, et al., 2018).

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A Replication of a Resource-Based Model of the Emergence of the State

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Keywords
Emergence of the State, Economic Relation, Hierarchies

Introduction

Archaeological simulation models provide a means to explain historical records by investigating generative mechanisms. Thus, they contribute to the analysis of social mechanisms. A replication of a systems-dynamics model of the emergence of the state is presented that relies on a theory of power based on mechanisms of the distribution and redistribution of surplus, generated from the acquisition of resources. The model investigates the process of the self-organisation of the establishment of social positions, denoted as Power Territories (PT), modelled as an ideal type (Weber, 1968) of a strict hierarchy. The model calculates the evolution of the number of positions in these Power Territories, based on the available resources, regardless of how the resources are utilised, i.e. for agricultural investments or for warfare, for example. The Process of distribution and redistribution is the independent variable, the process of generating position in Power Territories is the dependent variable. The original model has been replicated and reduced to a kernel model that exhibits the same dynamics regarding the emergence of positions.

Since the mechanisms on which archaeological modelling is based cannot be observed, archaeological modelling has to rely on assumptions that are merely based on its plausibility. Therefore, at the example of a model of the emergence of the state, an exploration of its parameter uncertainty is undertaken. This is done by a sensitivity analysis. In fact, the model behaviour is sensitive to a variation of the values of most of the parameters under consideration. This opens a way to link the exploration of the model with empirical investigations and in turn to an exploration of the theoretical plausibility of the assumed mechanisms.

Brief exposition of the model

There are numerous theories of the origin of the state. Nevertheless, they have the one task in common that along with the establishment of the state centralised institutions were developed and a social differentiation took place, releasing a social class from direct agricultural production. This point is in the centre of the model. the model is solely a model of distribution and redistribution of surplus. Thus, first the production volume has to be calculated. This is done by multiplying the workforce by the labour productivity. Then access priorities to the produced values are formulated for three classes of the

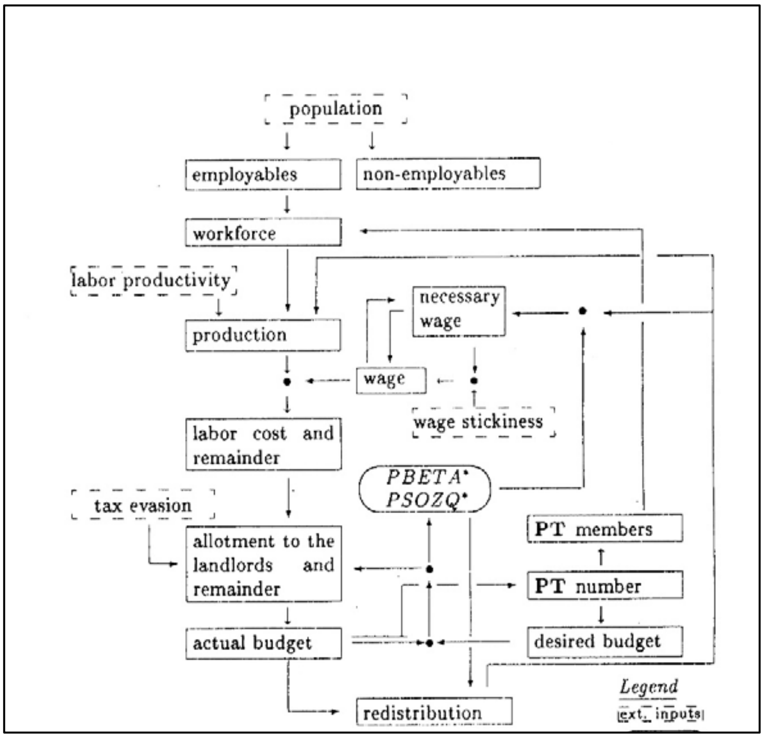

Figure 1. Central dynamics of the model.

social unit: the working class, the landlords as the economic elite, and the PT system.

After this process the remaining surplus is open for redistribution performed by the PT. Redistribution is governed by two variables reflecting two strategies of securing power: Both variables react to a comparison of the actual with the desired budget. But one strategy, denoted as PBETA, is to enhance the revenues by expanding the territory of the PT under consideration in the case of budget shortening while the other, denoted as PSOZQ, is to save expenditure in the case of budget shortening. Yet, they are dialectically opposed, leading to a nonlinear dynamic. The causal structure is given in Figure 1: The simulation run starts roughly at the historical time when archaeological artefacts indicate first settlements. This is calibrated at 6000 BC. At this time, the number of PTR positions remains a sleeping variable. However, at 1500 BC the model shows a rapid growth of the number of PTR positions, as displayed in Figure 2. This is interpreted as the emergence of the state, containing centralised institutions with a bureaucratic structure.

Simulation experiments

The possibility of a critical examination and discussion of the assumed mechanisms implied in the model would enhance its theoretical legitimacy. Theories which are open for rational discussion enhance the chances of theoretical progress. Methodologically, a fundamental advantage of theory formulation with simulation models can be seen in the fact that they allow for the possibility of an experimental investigation of the theory. They provide a framework for a rational discussion. Yet, let's keep on talking: To understand the dynamics of the model the mechanisms will be investigated which generate these positions. As it is indicated by the causal diagram above (Figure 1), the model is primarily concerned with the process of distribution and redistribution. Therefore, a close examination of these processes will be undertaken with regard to the question of how the emergence of the state is affected by them.

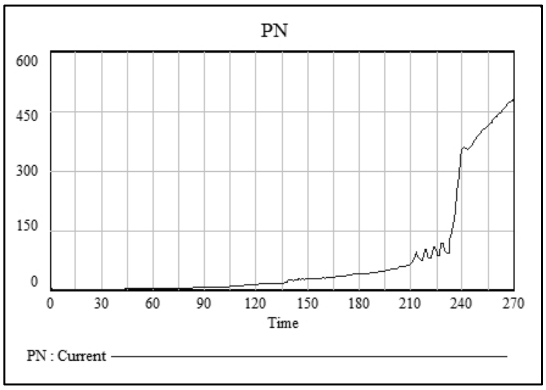

Figure 2. Evolution of the number of PT positions.

The strength of the influence of the redistribution strategies PBETA and PSOZQ can be estimated by a sensitivity analysis. In particular, the hypothesis has to be tested, that the model behaviour is determined by their nonlinear dialectic. Yet, the question remains, what would happen, if they would work in the same direction. This is tested in both ways: Firstly, the direction of PBETA is changed and secondly the direction of PSOZQ is changed the other way round.

PBETA	0,13/0,44/1	1/0,44/0,13
PN	480	252

PSOZQ	1/0,5/0,1	0,1/0,5/1
PN	480	258

Table 1: Experimenting with redistribution mechanisms

It can be seen that, in fact, the model behaviour is dependent on the nonlinear dynamic of the opposing direction of these variables. It doesn't matter which variable is changed, but the dynamics is considerably slower if the variables are not opposing.

The working class has the first access priority to the generated surplus. It is a plausible assumption that what the working class gets is dependent on their bargaining power. In the model this is specified as a constant added to the term by which GTETAV is calculated. Its value is GWPOWC = .857. Obvio usly, this is not an empirical value. Yet, to investigate the model robustness, it has to be investigated inasmuch the model results depend on the arbitrariness of this assumption. The causal power of this assumption on the model results is analysed by a very simple sensitivity analysis. GWPOWC is a factor, regulating what is really handed out to the working class from the maximum possible amount. Yet, its value can vary between 1 and 0. In the following, the results at the end of the run time of the model will be presented. The dynamics is neglected, simply because of lack of space. Yet, only the final number PN of PTRs in comparison to the independent variable under investigation is displayed. The model results show a high sensitivity to this variable.

GWPO WC	1,00	0,9	0,857	0,7	0,5	0,3	0
PN	2,75	65	480	481	562	703	703

Table 2: Experimenting with the bargaining power of the working class.

It is highly plausible and supported by historical evidence, that a distribution struggle took place between the economical and political elite. This is modelled as a conflict between the landlords and the state. The conflict is described as the degree by which the state has access to the budget of the landlords.

PNMXQ	1	0,9	0,8	0,75	0,5	0,25	0,1	0
PN	145	180	223	478	479	480	479	480

Table 3: Experimenting with power struggle between economic and political elites.

This is dependent on a variable denoted as GPOLWW. This variable is calculated endogenously, dependent on the desired budget of the state. Its demand is calculated by the demand for the alimentation of its subordinates. A crucial term, however, that can be varied, is a variable called PNMXQ. It denotes the propensity to realise the budgetary maximum number of PTRs together with their personnel. In the standard scenario its value is chosen as 0,25.

The sensitivity analysis shows that the self-organising capacity of state formation is highly dependent on the power relation between the economic and political elite. This seems plausible.

Conclusion

The central results can be summarised in the following way: With respect to the working class, the emergence of the state is highly dependent on their bargaining power. Also, it depends on the power relations between the political and economic elite. Furthermore, they depend on the strategies of how redistribution is performed. The question, called a test of sufficiency for social mechanisms, was, whether the qualitative model behaviour is robust within a degree of tolerance prescribed by the common-sense knowledge. This will be briefly discussed.

– The strategies of redistribution proved to be effective. Even though the model is even more sensitive to the variation of other variables, the opposing direction of the redistribution strategies is important for the model result. A sociologically surprising effect of the experiment was, that it doesn't matter which variable is changed: The model result is more or less identical if both variables PBETA and PSOZQ act to enhance the competence field or if they both react with saving strategies in the case of budget shortening. One could guess that the dynamics of state formation would even be stronger if in both variables a drive to enlarge the competence field is implemented. This is not the case. Yet, the computational effects of their nonlinear interaction are important for the model behaviour.

– The high sensitivity with regard to the bargaining power seems to be plausible: it is known that there are societies without any state even though the level of productivity would allow for it. The emergence of the state is not a necessary consequence of rising productivity. It follows, however, that it has to be explained, why in some societies the so-called bargaining power of the working class is high, while in others it is low. Carneiro, for example, offers such an explanation by arguing that in the Amazon jungle people could easily flee from conquerors which was impossible in the Andes region. This can be interpreted as examples of different bargaining power of the working class. This, however, relies on material assumptions about the social reality. Yet, the self-organising capacity of a hierarchy dynamics is not sufficient to distinguish between societies with and without an emerging state. Yet, a simple uncertainty analysis sheds light on complex theoretical issues.

– According to common sense knowledge, there is no doubt, that power relations between political and economic elite are highly important. Globalisation is just an actual example.

I'm looking forward to continuing the discussion at the conference.

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The Role of Agropastoralism in Ancient Pergamon – An Agent-based Modelling Approach

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Keywords
Agropastoralism, Multi-agent-Simulation, Pergamon, Land

Introduction

This study uses archaeological information about agropastoralist societies in the Chora of Pergamon to develop an agent-based model (ABM), which aims to provide insights into ancient agropastoralist land-use practices of animal husbandry and olive plantation. Agropastoralism is the most common form of pastoralism and combines animal husbandry practices with farming as well as hunting, gathering, and fishing (Chang 2015). In this context, it is hypothesized, that the environs of the study area are suitable for the simulated agropastoralist practices, which in turn are sufficient for providing the simulated settlement's limited growing population with goods.

The ancient city Pergamon and its micro region serve as study area. It is located in the western part of the fertile Bakırçay valley in western Anatolia. Pergamon became the region's most powerful city in early Hellenistic times with an assumed population peaking at ca. 180.000 (Sommerey 2008; Schneider et al. 2014). Based on the 'Mediterranean Triad' consisting of cereals, wine, and olive oil (e.g. White 1995; Wilkins and Hill 2006) it is assumed, that plants like wheat, barley and legumes as well as olives were cultivated in the Chora of Pergamon (Zimmermann 2011). Furthermore, the husbandry of small sheep and goat herds is documented (Sommerey 2008).

The simulated agropastoralist settlement is located at the transition between the Yuntdağ-mountains and the plain. It corresponds to the modern village Tekedere, whose environs are still intensively used for olive production. The study area is characterized by a temperate climate. Due to moist western winds, the winters are humid and temperate, whereas the summers, characterized by the Etesians, are hot and dry (Lionello et al. 2006).

Materials and Methods

Acquisition, Processing and Analysis of the Input Data

The ABM requires different input data sets:

– The yearly required amount of animals and olive trees to subside the pastoralist settlement is based on estimation using the R package LandUseQuantifieR (Knitter et al. 2019), based on Hughes et al. (2018).

– The assumed initial biomass was calculated based on the Normalized Difference Vegetation Index (NDVI). The NDVI was derived of Landsat 8 imagery. To transform the mean NDVI values into 'biomass for grazing', the concept of Livestock Units (*LU*) was used, which is a method of comparing the numbers and density of livestock grazing in agriculture (Chilonda and Otte 2006; Natural Resources Conservation Service (NRCS) 2009).

– The employed climate data were obtained from Fick and Hijmans (2017) at a spatial resolution of 30 *sec*. It is used to simulate the growth of biomass and olive trees. This simplification of applying modern data to an antique setting is appropriate since, according to Finné et al. (2011), the general climate characteristics of the area became similar to those of the present-day from 4000 BC.

– The assessment of environmental suitability for the simulated land use activities (grazing and olive plantation) is based on knowledge on land-use practices combined with empirical data on environmental characteristics. The analysis of the raster based fuzzy rule-based system was done by employing the R package FuzzyLandscapes (Hamer and Knitter 2018).

– In order to distribute grazing spots which can be visited by the agropastoralist herders, an inhomogeneous point pattern with intensities proportional to the suitability raster was used (based on rpoint function from the R package spatstat, see Baddeley, Rubak, and Turner 2016).

Model Purpose and Description

The ABM was developed using the custom domain-specific language (DSL) of the multi-agent framework MARS (Multi-Agent Research and Simulation; Weyl, Glake, and Clemen 2018). The purpose of the model is to examine land-use patterns and animal husbandry practices of the inhabitants of an ancient agropastoralist settlement during a decade between 2nd and the 3rd century AD, focussing on pastoralist herding practices as well as olive plantation. The model consists of 15 different agent types, representing elements of the agropastoral value chain like e.g. pastoralists, milkers and olive farmers as well as individual goats, sheep and olive trees. In this case, each agent represents one individual goat, sheep, olive tree etc. The simulation is running in ticks, a method which specifies the behaviour of an agent that can be performed in this time step. To

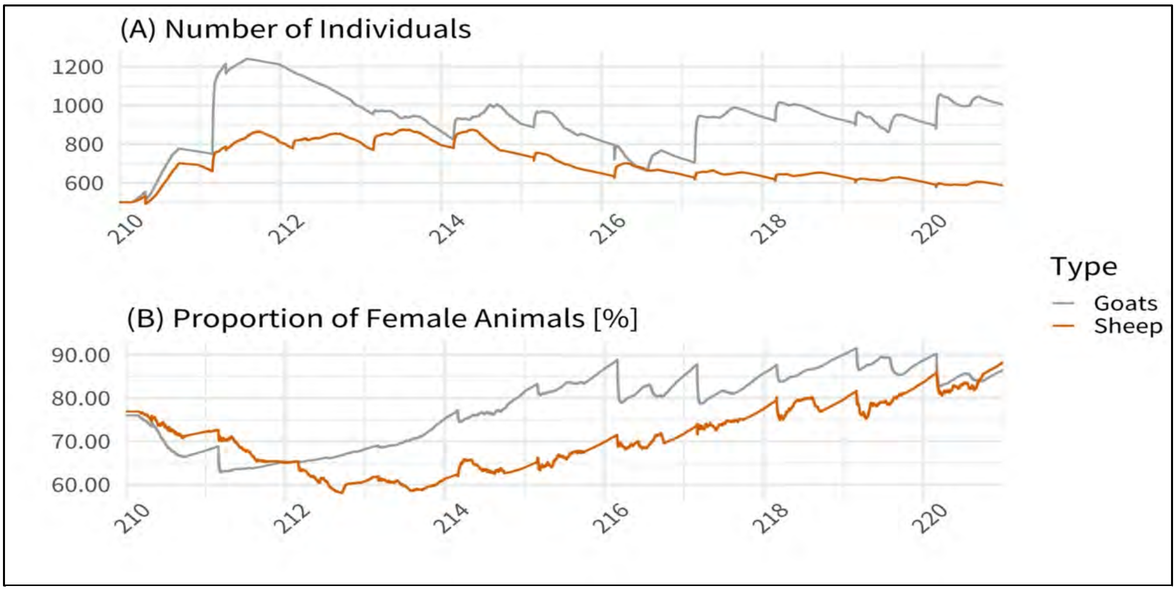

Figure 1. The total amount of individuals (A) as well as the proportion of female individuals (B) of the simulated herds. As seen in (A), there seems to be a trend of increasing herd sizes around the middle of the year. (B) shows a trend of decreasing proportions of female individuals during the first third of the simulated period of time, followed by increasing and towards the end possibly settling proportions of female individuals.

gain a general control of the agents' behaviour and to provide them with a 'daily routine', an hourly interval was chosen as a tick.

Results

In order to generate sample results and to show the capabilities of the simulation, 10 model runs were conducted and averaged (Figure 1 - 3). The results show that from the year 217 AD onwards, an equilibrium between the number of animals taken from the herds for human consumption and the animal's reproductive behaviour was/is established (Figure 1). A similar, but earlier occurring trend is visible for the amount of produced and stored goods (Fig. 3). Grazing spots were chosen south and west of the agent's home, where the conditions are defined to be appropriate (Figure 2)

Discussion

Effects of Agropastoralist Practices on Herd Dynamics

In contrast to other studies that modelled a linear increase in herd sizes (see e.g. Moritz et al. 2017), the results of this study (esp. Figure 1A) show a cyclical pattern of herd size. The implemented, according to e.g. Zeder and Hesse (2000) or Arbuckle and Atici (2013) common pastoralist practice of heavily culling male juvenile individuals leads to herds predominantly consisting of female individuals. This in turn ensures the popula

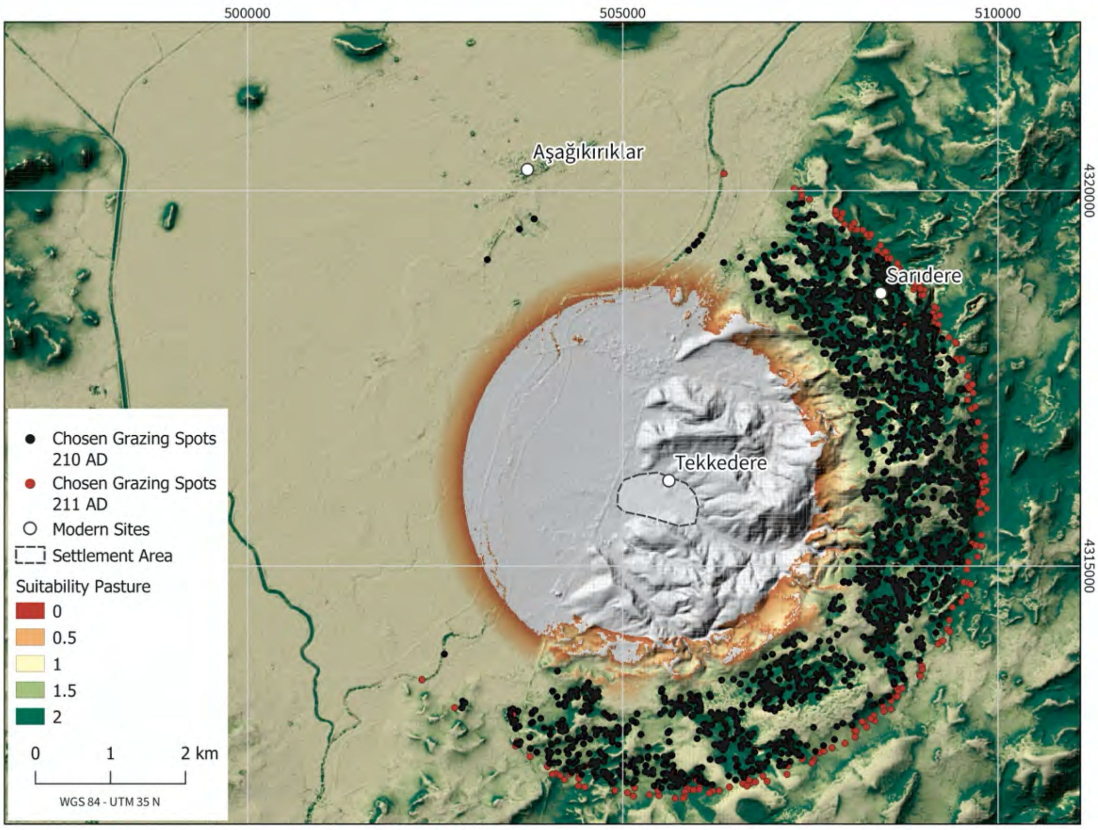

Figure 2. Grazing spots chosen by the pastoralist agents during the year 210 AD (black) and of the year 211 AD (red) of one simulation run. The pastoralist agents have mostly chosen the same grazing spots over the 2 a. The pastoralist herders moved within a radius of ca. 4.3 km around the settlement and choose grazing spots in the more elevated region of the study area, which are assumed to be highly suitable.

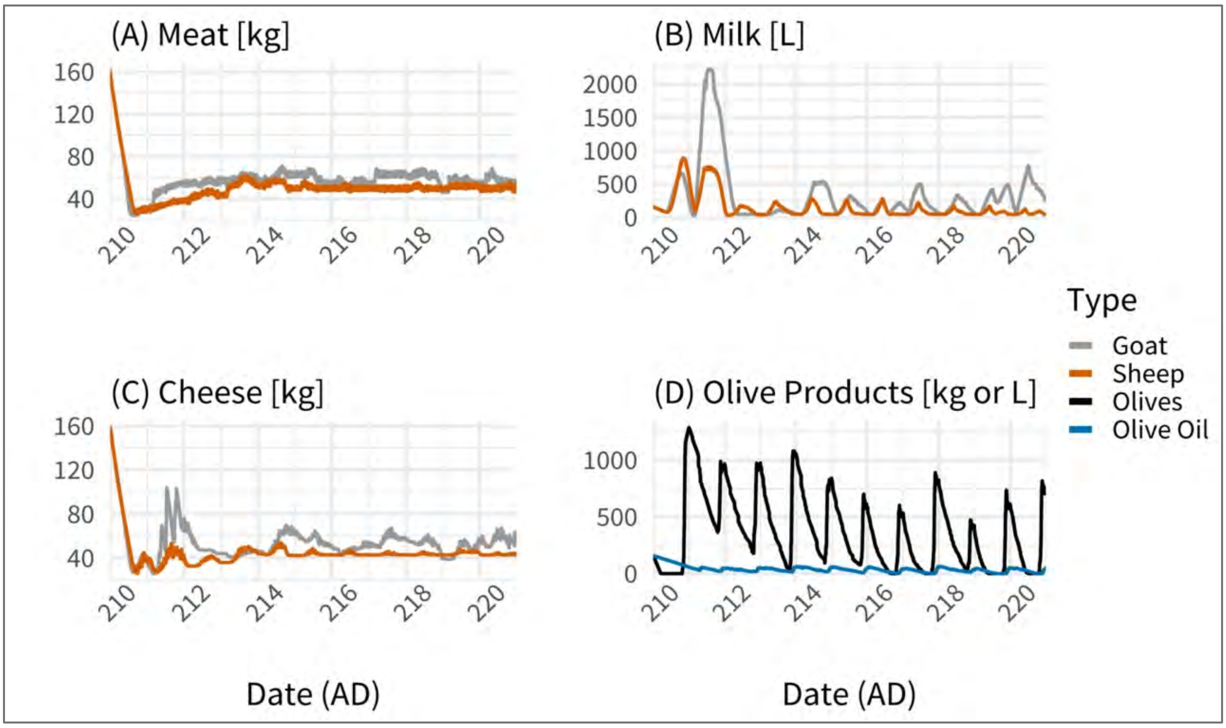

Figure 3. Amount of goods stored at the settlement over the course of the simulation, divided by type. (A) shows the amount of stored meat, which settles after the year 212 AD. (B) and (C) show the amount of stored milk and cheese, each settling after peaking in the year 211 AD. (D) shows the amount of stored olive products, increasing towards the end of each year. After a peak during the end of 210 AD, each year's maximum amount decreases and settles towards the end of the simulation.

tion's supply of milk and dairy products as well as the survival of the herds and the population itself (Figure 1B).

Grazing Patterns

The grazing patterns (Fig. 2) are comparable to those reported by e.g. Fryxell and Sinclair (1988); Thevenin (2011) and Makarewicz, Arbuckle, and Öztan (2017). According to these, lower forage productivity occurs in lowland areas, whereas during summer, pastoralists move to the highland areas, to benefit from high quality pastures. In general, the mountainous and more humid landscape of western Anatolia might have played a central role for pastoralist societies (Hammer and Arbuckle 2017).

Stored Goods

The dynamics of stored goods show that the simulated agropastoralist practices are sufficient to subside the limited population growth of the settlement. The fluctuations of the stored goods can be explained by the increasing and decreasing number of animals. The amount of the milk available for human consumption is directly linked to the number of birth giving and therefore lactating animals (Dahl and Hjort 1976). In addition, the quantity of stored cheese is connected to the amount of stored milk and the population's increasing demands, which is used as an indicator for cheese production. The fluctuating amount of olive products is linked to the climatic conditions (Frankel, Avitsur, and Ayalon 1994, 22) and the olive tree's vegetative cycle (Torres et al. 2017) as well as the population's increasing demand, which is used as an indicator for olive oil production.

Conclusions

The developed model is able to capture the basic dynamics and patterns of agropastoralist land-use practices and can be used to gain insights into the simulated parts of the agropastoralist value chain. At the current state, animal husbandry — including dairy and meat production — as well as olive plantation are implemented. The results show, that the environs of the simulated settlement are sufficient for agropastoralist herding practices, including reproductive behaviour, inducing herd growth and lactation. In addition, the goods produced in this way allow a limited growth of the simulated population.

In order to improve the validity of the simulation's results and to further increase the model's resilience and robustness, future modelling approaches should include the — at the current state assumed, but not actively simulated — parts of agricultural production as well as more detailed information about the study area's types of soil, the vegetation and its regrowth as well as the simulated animal's eating behaviour. Furthermore, the simulation's results could benefit from implementing learning algorithms which would enable to e.g. let the agents choose e.g. grazing spots based on previous experiences.

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SESSION 4

General Session and Poster Session

Urban Mining? - A New Look at Taphonomic Processes as Key to the Reconstruction of Waste and Resource Management in Later La Tène Society

David Brönnimann, Johannes Wimmer, Milena Müller-Kissing, Barbara Stopp, Hannele Rissanen and Norbert Spichtig

Keywords

Taphonomic Processes, Statistical Analysis, Recycling, Waste Disposal Practices, Material Stores, Settlement, Pit Fillings, Interdisciplinary Research

Introduction

Waste is without a doubt one of the most important sources of information for (prehistoric) societies and allows insights into crafts and subsistence as well as every day and ritual practices. While interpreting this source it is paramount to take into account that the valuation and treatment of waste is very much influenced by cultural imprint. Uselessness, dirtiness or even danger are attributes that modern western society associates with waste. Even though our attitude towards waste management and recycling has been challenged and changed in recent decades, a lot of what we perceive as trash is still considered taboo to reuse and will be disposed off permanently. This does not have to be true for pre-modern societies. Sommer (1991) instead suggests that waste in prehistoric settlements very probably remained accessible at least for a while (Brönnimann, et. al., 2020; Wimmer, et. al, in review). This indicates that materials that were no longer suitable to fulfil their primary functions nevertheless were not perceived as worthless but could be repurposed at any time and for a wide variety of uses. We consider "waste" therefore not as disposable trash or garbage but as a potential resource and therefore of value for prehistoric societies.

To take a closer look at how waste was treated in the Later La Tène period settlement at Basel-Gasfabrik, ceramic sherds, animal bones and archaeological sediments were examined as part of the interdisciplinary research project "Über den Grubenrand geschaut" (Thinking outside the Pits). They were assessed in respect of 21 taphonomic features (proxies) that could be attributed to various taphonomic processes.

This manifest themselves as changes on the artefact or sediment and allow us to draw conclusions concerning the way in which they were treated and what kinds of depositional, redepositional and postdepositional processes were involved (Brönnimann, et. al., 2020b).

The Site

The site of Basel-Gasfabrik was discovered in 1911 and is located 2 km north of today's

Basel city centre on the banks of the River Rhine (Figure 1). Stretching over c. 17 hectares, the unfortified settlement dated from the Later La Tène period (200/150 – 100/80 BC) (Hecht and Niederhäuser, 20 11). Countless coins and Mediterranean wine amphorae emphasised its importance within a long-distance trade network (Nick, 2015; Martin-Kilcher et al., 2013). Two associated cemeteries with more than 200 inhumations were situated north of the settlement (Rissanen, in prep.). Large parts of the settlement have been excavated, with the bulk of the work taking place between the 1980s and 2010s. It has produced an extraordinary wealth of data and provided extensive archaeological, biological and geo-archaeological insight (Schaer and Stopp,

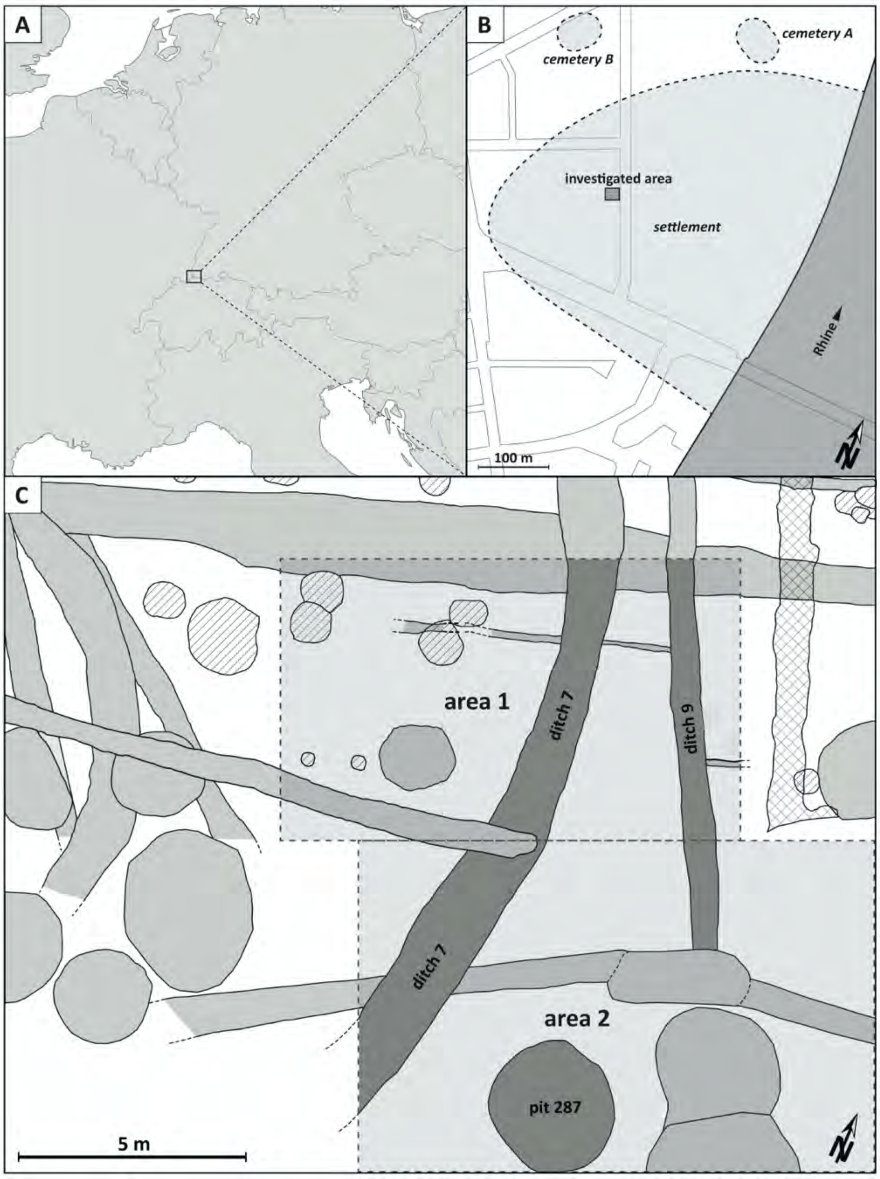

Figure 1. Location of the settlement of Basel-Gasfabrik in north-western Switzerland (A) on the left bank of the River Rhine in the city of Basel. The area examined (dark-grey zone) is situated in the western part of the settlement (B). Bottom (C): Plan of the examined areas and features. The ditch sections (ditch 7 and 9) and pit 287 are marked in dark-grey. The finds from the archaeological horizons aH1-aH4 were examined in area 1, while in area 2 only those from aH1 were analysed. Hatching and cross-hatching denotes later intrusions and disturbances (Brönnimann, et. al., 2020b).

2005; Jud, 2008; Pichler et al., 2015; Pichler et al., 2017; Brönnimann et al., 2020). The features recorded over the years comprised almost 600 large pits, which had probably served mainly as silos and cellars and yielded a substantial amount of finds; other features included a small number of wells and numerous sections of ditches and post pits. Remains of stratified archaeological layers only survived in natural depressions in the ground.

A well-preserved section in the western area of the settlement was selected for the purposes of this study (Figure 1). Located in an extended natural depression, it yielded a sequence of archaeological layers measuring a total of c. 50 cm in thickness (Rentzel, 1997; Brönnimann et al., 2020a). Four archaeological horizons (aH1-aH4) extending over the entire section were identified during the excavations. Ditches, pits and post pits were also recorded (Jud and Spichtig, 1995; Hecht et al., 2004).

Method

As part of the interdisciplinary research project, ceramic sherds, animal bones and archaeological sediments were examined from one pit, sections of two ditches and the archaeological horizons of a selected area. The aim was to determine which taphonomic features can be identified and which processes they can be linked to (Brönnimann, et. al., 2020b). In order to be able to compare the formation of 21 of those taphonomic features, each proxy was linked to one or more pre-defined processes, which could have been involved in the formation of the proxy concerned. Only those processes that tend to leave visible traces on the objects were assessed, like mechanical stress, redeposition, exposure, covering and post-depositional processes. The focus in defining these processes was not on an object's primary use but on what occurred after it had ceased to be used and before it was deposited in the ground (Brönnimann, et. al. 2020b). The next step involved estimating how much or how often each proxy recorded was impacted by each process. Because of the lack of experimental data, the estimated weighting of the proxies was evaluated using statistical methods. (Brönnimann, et. al., 2020b).

Results

Comparing the proxies between the different feature types (pit, ditches and archaeological horizons) revealed significant differences in the taphonomic alteration of the animal bones, ceramic sherds and sediments. Although there were some discrepancies, the different material categories react similarly in most processes. However, the pottery and bone fragments behaved differently concerning their use and the influence of heat or fire. In case of pottery, various reuses in a craftworking or domestic context may be considered. Animal bones, on the other hand, may have been used as fuel. The alteration by fire therefore showed that ceramic sherds and animal bones were reused in different ways (Brönnimann, et. al., 2020b).

The artefacts and sediments in pits exhibited the least taphonomic alteration (= best state of preservation). The pottery and bone fragments and the sediments from archaeological horizons, on the other hand, provided the opposite picture, i.e. an intensive taphonomic alteration (= poor state of preservation), whilst the material from ditches bore average taphonomic alteration but showed significant differences between the ditches in regards to mechanical stress, exposure and heat impact. This clearly shows that ditches and ditch fillings are by no means homogenous features (Brönnimann, et. al., 2020b).

The strikingly good state of preservation observed in objects from the pit (Figure 2) was due to the fact that they were quickly deposited and covered and thus withdrawn from everyday use. Such intentional and

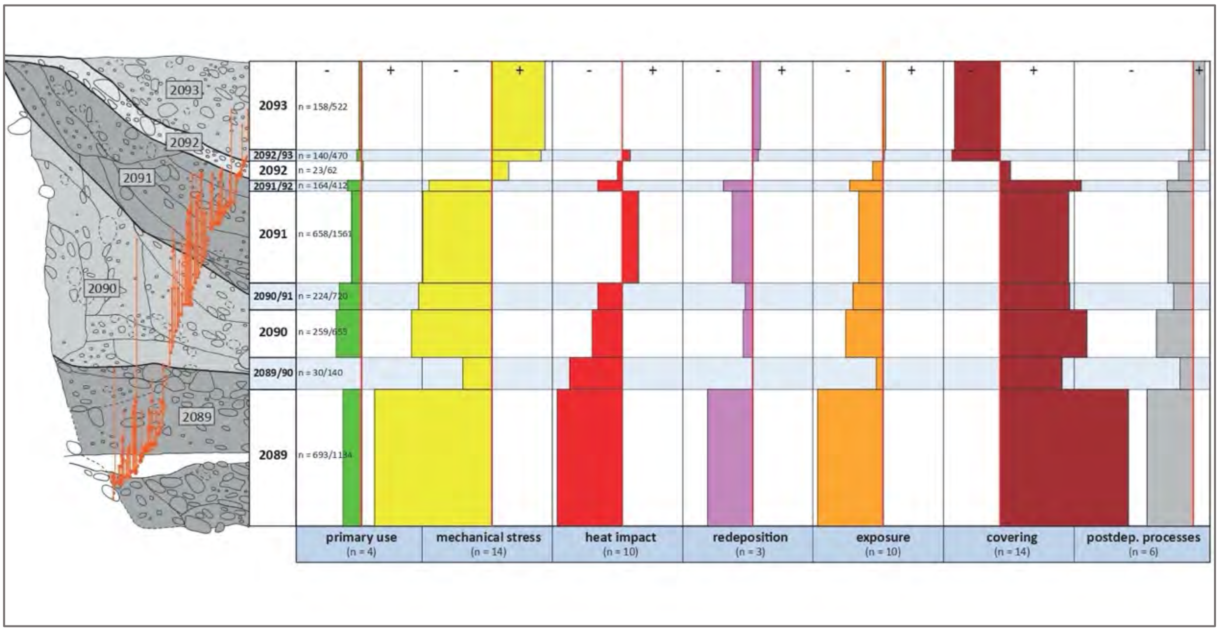

Fig. 2: The impact of the taphonomic processes on the different fills (stratigraphic units) of pit 287 (pottery and animal bones combined). Bars to the left show slight/rare manifestation, whilst bars to the right signify strong/frequent manifestation of the process. The orange dots and lines in the image on the left denote joins between ceramic fragments (Brönnimann, et. al., 2020b).

rapid pit fillings were recorded in several instances on the site (Rentzel, 1998; Brönnimann and Rissanen, 2017; Brönnimann et. al., 2020). They consisted of sediments, ceramic sherds, bone fragments and other materials (slag etc.) and required large amounts of material to be available at that time. We have therefore put forward the hypothesis that material deposits or middens existed where pottery sherds, animal bones and other materials like sediments were stored together in a location that was only rarely exposed to settlement activities. The almost complete lack of conjoining sherds and slight differences in the taphonomic alteration between different fills of certain pits indicate that at least two different "material stores" were used to rapidly fill them in (Brönnimann, et. al., 2020b).

Although most pits yielded several thousand ceramic fragments and many conjoining sherds were found within each pit, it was hardly ever possible to reconstruct whole vessels. The same can be said for the animal bones: whilst the archaeological analyses showed that many of the pits yielded large minimum numbers of cattle, pig and sheep/goat individuals, each pit generally contained no more than 10% of an entire skeleton. This means that only a remarkably small proportion of the original vessel or individual animal skeleton ended up in any one pit. This raises the question of what became of the remainder. In contrast to other organic material, neither the animal bones nor the pottery would have decayed completely (Brönnimann, et. al., 2020b).

In addition, the post-excavation work that has been carried out to date has rarely revealed conjoining sherds or animal bone fragments from different pits (Jud, 2008). Distribution between various pits cannot therefore have been the only reason for the absence of material. Another possibility is that parts of vessels or carcasses remained out in the open and were incorporated in the archaeological horizons, given that the latter also yielded large quantities of both pottery and animal bone fragments. However, this theory is difficult to substantiate archaeologically. Yet another possibility is that some of the ceramic sherds or animal bone fragments were reused as raw material and almost completely destroyed in the process. Ceramic fragments, for instance, were used as grog in local pottery production (Steiner, 2012), whilst bone was probably used as fuel. Ultimately, we cannot exclude the possibility that some of the pottery or animal bones were disposed of in a manner that cannot be detected by archaeological means, for instance by dumping them in the Rhine (Brönnimann, et. al., 2020b).

A specialised use was also observed in the naturally occurring overbank deposit loam and Rhine gravel (Brönnimann et al., 2020a), great amounts of which came to light anytime the ground was broken. The calcareous loam (C horizon overbank deposit) was used as daub, whilst the decalcified, clayey loam (Bt horizon overbank deposit) was utilised in the production of pottery or in the construction of ovens or hearths (Steiner, 2012). Rhine gravel, on the other hand, was severely underrepresented and rarely occurred in the archaeological layers. One exception to this rule was layer aH3, which consisted of similar-sized large pebbles from the Rhine. This suggests that the pebbles were preselected for their size and then stored for a time (Brönnimann, et. al., 2020b).

Conclusion

The differences in the taphonomic alteration of the finds from the pit and the archaeological layers show that objects of the same type may have taken different paths. In fact, there is a wide variety of ways how ceramic sherds, animal bones and sediments, as well as metal and glass objects were used and reused in the settlement and how they finally ended up in the ground or became undetectable. After they had outlived their primary use, some were kept in material stores or middens. Even though they contained a variety of different materials, these material stores can be compared to raw material deposits, only man-made instead of naturally occurring. They could then be "mined" for recyclable or reusable resources until they were disposed off permanently in one of the many pits in the settlement (secondary waste). Other objects were again integrated into everyday life and severely altered (object recycling),

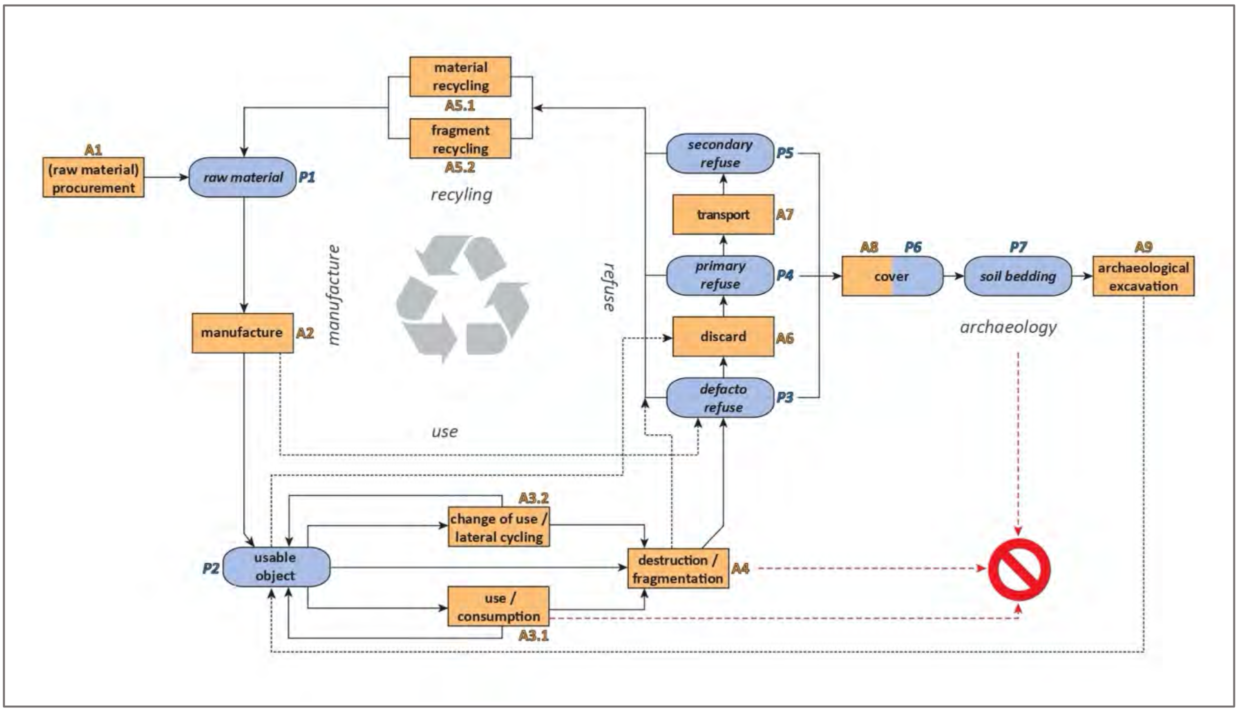

Figure 3. Flowchart based on Schiffer (1972) and extended to reflect in a somewhat simplified manner the genesis, use, re-use and recycling as well as the disposal, destruction and deposition of an object in the ground and to illustrate this as part of a partially closed cycle. "Passive phases" are marked in blue, the "activated phases" in orange. The red symbol signifies the destruction or dissolution of the object (Brönnimann, et. al., in review).

stored as raw material and reused (object or material recycling), or else completely transformed (grog) or destroyed (fuel or material recycling) (Figure 3) (Brönnimann, et. al., 2020b). This multi-branched path appears to have been a regular pattern and points to a clearly defined treatment of "waste" and resources on the one hand and a complex and intricate cultural biography of objects on the other. This leads us to the conclusion, that "waste" was not just meant to be discarded, but has regularly been used as a resource in Later La Tène society. Objects and materials were frequently and cyclically used, reused and recycled before they were disposed of, destroyed or deposited in the ground (Figure 3). Thus concepts of "waste" and "resource" can be entangled with each other and are determined by value concepts and social practices (Brönnimann, et. al., 2020b).

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Dynamic Resourcescapes. Bronze Age metal exploitation, production and distribution in the Central Alps

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Keywords
Settlement Metallurgy, Copper, Salez Type Axes, Grooved Hammerstones, Anvil Stones

Introduction

The fact that access to natural resources was subject to constant transformation depending on socioeconomic, technological and other factors is particularly obvious when we turn our attention to the Alpine region. The study area in this case stretches from the inner Alpine area of the Canton of Grisons (GR) and the St. Gallen (SG) and Liechtenstein (LI) Alpine Rhine and Seeztal Valleys northwards to Lakes Constance and Zurich in the foothills of the Alps.

The region is rich in archaeological heritage and was extensively studied over the course of the 20th century, particularly at settlement level (Burkart, 1946; Thomas, 1974; Conrad, 1981; Stauffer-Isenring, 1983; Rageth, 1986; Fetz, 1988; Steinhauser-Zimmermann, 1989; Neubauer, 1994; Maçzynska, 1999; Wyss, 2002; Primas, et al. 2004; Merz, 2007; Brunner, 2018). In recent times it has also been the subject of various diachronic and (supra)regional studies on a variety of aspects of settlement and economic archaeology and of sacred topography (Primas, Della Casa and Schmid-Sikimić, 1992; Heeb, 2012; Ballmer, 2015; Turck, Della Casa and Naef, 2014; Reitmaier, 2017; Brunner, (in prep.)). This comparatively reliable data set will be used here as a frame of reference for an attempt to conduct a comprehensive and interconnected examination of the exploitation of natural resources. The focus will be on developments in the production, processing and distribution of metal resources (copper) that took place over the course of the Bronze Age against the background of social, economic and environmental change.

According to the current state of research, changes in the patterns of access to the Alpine landscape as a living environment and resource base can be divided into three phases, which roughly correspond to the chronological divisions of the era and are briefly outlined here (for the development in the Eastern Alps see Tomedi and Töchterle, 2012; Stöllner 2015; Staudt and Tomedi, 2015).

The initial phase

Whilst permanent settlements already existed, mainly in the southern Alpine Rhine Valley (Sarganserland region, SG), during the initial phase (Early Bronze Age), the

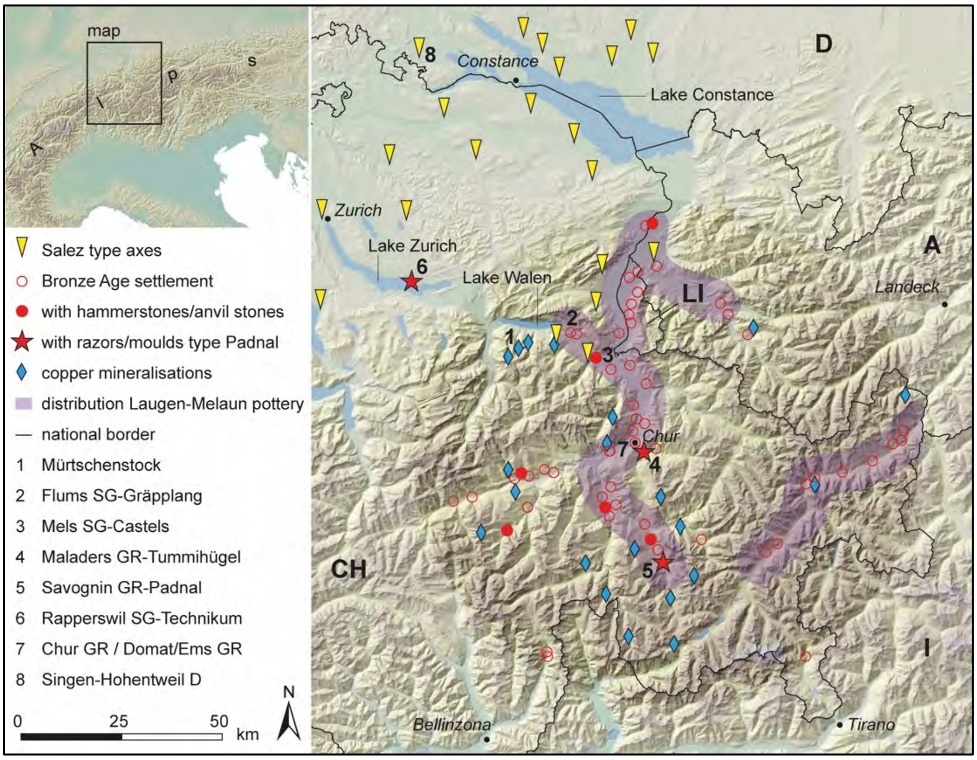

Figure 1. Map of the enlarged study area with distribution of Salez type axes, all mentioned Bronze Age Settlements, copper mineralisations and distribution of Laugen-Melaun pottery (within study area). Map: L. Reitmaier-Naef.

inner-Alpine area probably still boasted a seasonal, resource-oriented land use in the Final Neolithic tradition. It primarily relied on the Alpine pastures (small ruminants) and mineral/lithic resources available in certain areas (Della Casa 2000a, p.140-141; Della Casa 200b, 82-84; Kienlin and Stöllner, 2009; Reitmaier, (in press)).

This rather sporadic access pattern is also reflected in the ritual appropriation of the landscape borne out by various deposits of a highly individual, intermittent nature (high-altitude deposits, isolated deposits etc.) from the Early Bronze Age onwards (Ballmer, 2015; Ballmer, 2017, p.74-82).

This ritual practice is most clearly reflected in depositions of solitary or groups of Salez type axes in the Alpine Rhine Valley (see Bill, 1977; Bill, 1996; Kienlin, 2006) (Figure 1). The phenomenon did not spread to inner-Alpine areas and was therefore probably associated with an early and quite localised phase of copper mining. Kienlin and Stöllner (2009) published a detailed discussion on the theory that the extraction of raw materials is more likely to have been seasonal and extensive rather than targeted, intensive, economically motivated and controlled by pre-Alpine elites (Krause 2002). However, none of the searches for the mining area or areas associated with this specifically "Singen-type copper" – an Early Bronze Age fahlore copper signature with nickel named after the cemetery at Singen-Hohentweil (D) (Krause, 1988) – in the Montafon area of Austria have so far yielded any results (Krause, et al., 2012). Another potential raw material source besides the deposits in the western and eastern Alps is the immediate hinterland of the Sarganserland (SG) settlement area, in particular Mürtschenstock mountain (GL). (Figure 2) This mountain massif south of Lake Walen has rich deposits of bornite-covellite mineralisations, which were easy to process and continued to be extracted up until the 19th century (Bächtiger, 1963; v. Arx, 1992; Schindler, 1988). Against this background, further mineralogical and mining archaeological surveys in the area, a geochemical characterisation of the ores, a review of the rich analytical data available on Singen copper and a re-evaluation of the finds from nearby settlements such as Flums SG-Gräpplang and Mels SG-Castels (summarised in Heeb 2012, pp.340-343), some of which are still unpublished, could potentially yield invaluable insight.

The phase of consolidation

The beginning of the second phase can be identified at the transition between the Early and Middle Bronze Ages, when the presence of humans became increasingly consolidated in the central-Alpine region and a network of year-round settlements developed in most Alpine valleys. Rather small in size and often fortified, these were situated in specific topographical locations (morainic hills, promontories, brows of hills, rock crevices). The subsistence strategy, in all cases, seems to have been based on a combination of small-scale crop farming and extensive animal husbandry with a seasonal use of upland pastures (Della Casa 2000a, p.141-142; Della Casa 2000b, p.84; Reitmaier, (in press)). The almost constant and sometimes abundant presence of grooved hammerstones and other metallurgical stone tools (Figure 3) suggests that the economic strategy in some cases also included the extraction and processing of mineral raw materials.

Surface analyses (pXRF analyses and optical examinations) of these finds together with geochemical analyses of various metallurgical remains, which have previously not or not satisfactorily been characterised, will provide insight into the composition of the raw materials used. This will clarify, on the one hand, whether these are the remains of primary and/or secondary metallurgy, and on the other, which deposits can be identified as potential sources for the non-ferrous metals used.

Figure 3. Grooved Hammerstones from the Bronze Age (mining?) settlement Maladers GR-Tummihügel. Photo: L. Reitmaier-Naef.

The permanent settlement of the inner-Alpine region at that time ultimately also led to an increased consolidation of trans-Alpine trade networks with areas to the south and east, as attested to by non-local shapes and imported artefacts in the archaeological record (Primas, 1977; Rageth 1986, pp.88-89; Wyss 2002). At the same time, the inner-Alpine range of pottery styles showed clear links with the northern foothills of the Alps, where the primary wave of inner-Alpine settlement probably originated from (Jecker 2015). Finds from Savognin GR-Padnal, Maladers GR-Tummihügel and Rapperswil SG-Technikum are particularly good examples to show that the Alpine Rhine-Seez Valley (water) route acted as a communications axis from the early Middle Bronze Age at the latest, through which metallurgical technology (and perhaps raw materials?) from the central Alps spread as far as Lake Zurich (Figures 1 and 2). All three sites yielded the same type of Alpine razor (type Padnal) and associated casting mould made of Alpine steatite, supposed "cup-marked stones" (anvil stones) and grooved hammerstones or pestles (Gredig, 1979; Rageth, 1986; Schmidheiny, 2010).

The phase of intensification

The Late Bronze Age, finally, brought a phase of economic intensification reflected in individual specialised microregions. Targeted overproduction of locally available resources or produce such as salt, copper, meat and dairy, appears to have occurred from this period onwards (Primas, 2009;

Reitmaier and Kruse, 2019; Reitmaier, in press).

This diversification or progressive specialisation is also reflected in the spatial restructuring of the settlement landscape. Besides local settlement shifts, relatively large-scale settlements with an emphasis on craftworking began to grow up in areas like the Chur Alpine Rhine Valley (GR), e.g. Domat/Ems (GR) and Chur (GR) (Rageth, 1985; Rageth, 1993; Seifert, 2000). Various metallurgical remains and tools suggest that a specialised metal craft was established here, within easy reach of the transportation network. Preliminary metallurgical evaluations using pXRF analyses point to a considerable variability in the composition of the abundant metallurgical remains, which at the very least does not argue against the theory of a targeted, potentially supraregional processing and (re)-distribution of raw materials.

The fact that these economic developments were also linked with drastic social transformation, is illustrated by changes in the ritual practices. At that time, decentralised deposits were increasingly replaced by a collective ritual practice characterised by spatial continuity in the form of early proto-sanctuaries (*Brandopferplätze* / burnt offerings sites). This also appears to be an expression of a changed perception of territoriality and therefore points to a targeted (political?) effort to take control of social and economic resources (Ballmer, 2017; Reitmaier, in press).

The expansion of the Laugen-Melaun Group probably played a significant role in driving these socioeconomic changes in eastern and central-Alpine areas, though the exact details of this phenomenon and its economic and societal consequences still requires further, differentiated study. It will be important for the north-western periphery of the Laugen-Melaun sphere of influence, which is of particular interest here, to critically assess the suspicion voiced by various researchers that the group was also responsible for the trade in non-ferrous metals and the expansion of specialised mining and metallurgical know-how (Marzatico 2012; Bellintani, 2014; Stöllner 2016; Koch Waldner 2019).

Methods and outlook

In order to gather an as comprehensive data set as possible to find an overarching answer to these questions, the published archaeological information has been combined with various quite abundant assemblages from primary sources (archaeological finds, archival records). Particular emphasis has been placed on categories of finds that have previously not attracted much attention or have been completely overlooked, such as stone tools used in primary and/or secondary metallurgy and waste products from metallurgical processes (slag, casting waste) retrieved from settlement contexts. These and other finds have undergone an initial archaeological material study and an archaeometallurgical "survey" by means of pXRF analyses, on the one hand to directly associate "suspected" stone tools wherever possible with procedures of metallurgical processing, and on the other to correctly identify the composition of the waste products (copper or bronze?), which is difficult to achieve macroscopically.

The data set will been further extended by targeted sampling (through fieldwalking, examining mineralogical collections) of raw material deposits in the catchment areas of certain settlements, which have not yet been sufficiently characterised, so that previously unknown raw material signatures can also be taken into account.

On this basis, a series of samples have been selected for additional geochemical analyses (ICP-MS, LIA), which will hopefully also further clarify questions of provenance. The classification and examination of the archaeometallurgical analysis results will be based on a series of several hundred data sets obtained primarily from ores and finished objects and compiled from various sources throughout the extended study area. The results will be combined with a GIS-based site database in order to allow us to propose a spatial, and with a limited resolution even a spatio-temporal, interpretation of the data. Various possibilities of adding procedures to review the overall data set under network analytical aspects are currently being evaluated.

The primary goal will be to identify the role played by individual sites, groups of sites and landscapes within the chain of Bronze Age non-ferrous metal production as part of the pattern of extraction – processing – distribution – consumption.

Taking a landscape archaeological approach, the results will, finally, be incurporated into the overarching context, critically reflected and their social and environmental interrelations examined. In order to avoid taking a perspective of settlement, economic or environmental determinism, the study must be based on an holistic understanding of landscape. The description and reconstruction of the physical and cultural aspects of the landscape will therefore serve as a basis for a proposed interpretation of the underlying economic, cultural, social and religious or political structures, meanings, ideas and concepts (Doneus 2013, p.354). Particular emphasis will also be placed on the insight gained from ethnographic studies on the topics of craftworking-/craftspeople, specialisation and the structure of society (see e.g. Neipert, 2006; Kienlin and Stöllner 2009).

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Mining Religious Aspirations in Imperial Rome

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Keywords
Religious Placemaking, Aspirations, Transferred Religioscapes, Rome

Introduction

Religions and religious practices transform dynamically and are strongly influenced by local socio-cultural, political and historical life world conditions. Hence, religion is a cultural resource, which can be articulated and expressed not only by powerful and rich elites, who for instance were constructing temples, but also through individual agency (Fuchs and Rüpke, 2015), which in archaeology can be traced through contexts and assemblages such as dedications, votives, commemorations of the dead, etc. These are practices in which a system existing of symbols serves to navigate through, re-create and re-live a specific intended life world. In order to minimize a contingency of the semantics of the symbols, rituals assist in establishing an order that others than the performers can encode and understand. (Rappaport, 1999) Behind these rituals, and therefore behind these religions, lie specifically developed aspirations. In antiquity, aspirations apparently were stable elements, which due to their stability that provoked above all hope, can be considered as the reason for society´s or for the individuum´s resilience. (Elwert, 2015)

In my view, ritualistic behavior as well as aspirations, the hope for a positive outcome, both represent raw materials and in consequence make religion a cultural resource in comparisons to Bourdieu´s term of a "cultural capital" (Bourdieu, 1993), which people in antiquity used in order to maintain their lives and manage crises from a social macro- until micro-level, such as natural calamities or infant death. (Pirner, 2017)

Conceptualizing rituals and aspirations as raw material, one needs to stress that the procurement of these kind of raw material is culturally bound as the procurement of geological raw materials. (Stöllner and in collaboration with Gambasidze, 2017) During the mining they were further processed, subsequently transformed their shapes, even when the inherent material substance remained. Especially, when investigating transferred religious landscapes and their materialization, this fact becomes very obvious; in the case of cult transfers or distributions to different geographical regions, for instance the architecture of the sanctuaries or the appearance of the votive objects could differ tremendously.

Nonetheless, as I argue in this paper, aspirations remained the same. Only the form in which aspirations were materialized, be it an object or a practice, was appropriated according to the individual needs of the people inhabiting that region.

In order to elaborate on the argument, I will discuss a case study, which is the veneration of the goddess Mater Magna, a deity that - after the later literary sources - due to an oracle saying, which predicted Rome to be saved from Hannibal, was transferred from Asia Minor, where she was previously called Cybele, to Rome during the 3rd century BCE. Several places for the veneration of Mater Magna emerged in the city, which were strongly characterized by various aspirations and therefore involved different religious practices (see below).

The specific religious landscape, or one could say 'religioscape' (Hayden and Walker, 2013, O'Dowd and McKnight, 2016, Appadurai, 2005 (1996)), of the city of Rome was then transferred to the Roman provinces. Previous interpretations state that the veneration for Mater Magna was solely distributed by imperial and military networks to the provinces. However, after revising the epigraphic, archaeological and zooarchaeological findings in Mogontiacum (Mainz/Germany), I argue in contrast that the religious life world of the Vaticane sanctuary was promulgated with its aspiration for the adherent to find individual salvation, as also the finding of *tabellae defixionis* show, rather than the Palatine sanctuary which was driven by the political elite that advertised a communal aspiration of saving the whole empire through military success. In fact, refining precisely the provenance of aspirations provides a clearer understanding of individual life worlds in religioscapes.

Localising the mines in the urban religioscape

When conceptualizing religion as resource, the ancient city of Rome turns into a landscape for a myriad of various sources for raw materials. For this presentation I focus on the goddess Mater Magna. The earliest place for venerating her in urban Rome is archaeologically detected at the Palatine hill. The myths about the arrival of the goddess in Rome that were invented and narrated over the period of the Republic until the imperial era, culminated in the creation of the Palatine hill as place for 'urban nostalgia'. (Berneder, 2004, Coletti and Pensabene, 2017, Clewell, 2013) However, the specific nostalgia here refers to the military power of Rome as heroic republic and later empire. Therefore – and not surprisingly – the Mater Magna temple was placed directly next to the temple of the goddess Victoria (Fig. 1), though its orientation was aligned to the Circus Maximus in order to get a view on the annual chariot races and the various (triumphal) processions. (Beard, 2007) The spatial arrangement was supported by other eminent historical buildings designed as an open-air museum presenting the mythical core of the city and place of origin.[1]

In fact, the sanctuary complex for Mater Magna was planned to host masses and conduct practices there, which attracted big parts of the population. For instance, the monumental staircase in front of the hexastyle pseudoperipteros gave enough space to stage theatrical plays during the festival days from the 2nd century BCE until the at least the mid of the 4th century CE.[2] Practices, which involved individuals, such as the ritual washings, where held in basins that were firstly located in front and later shifted to the west side of the temple. Eventually, they were abandoned and covered in the Severan period, so that then no ritual washings could be performed. (Mattern, 2000) The representative and symbolic semantics of the deity as redeemer of Rome came to the fore. Visitors to the Mater Magna temple were aspired to power, strength and military success.

[1] For instance, the Lupercal (cave where the she-wolf nurtured the mythical twins Remus and Romulus), the Curia Saliorum, where the sacred *lituus* of Romulus was stored as Cicero reported, see Cic. de div. 1, 30. – 4. Or the hut of Romulus (*Casa Romuli*), which was an Iron Age building made of clay and straw that is still mentioned in the calendar of Filocalus from 354 CE and is located at the south-western side of the Palatine hill. The hut burned down at least twice during the period of the Roman Republic and again in the early Imperial period, but was repeatedly reconstructed in the older building technique, see Dionys. I.79; Plut. Rom. 20; Cass. Dio XLVIII. 43; Liv. 29.

[2] In the calendar of Filocalus/Chronograph of 354 it is stated that two festivals were held, one for Mater Magna called Megale(n)sia and one for her companion Attis, the so called Hilaria, see Alvar, J. 2008. *Romanising Oriental Gods. Myth, Salvation and Ethics in the Cults of Cybele, Isis and Mithras*, Leiden. 138; 282-292.

In contrast, the second sanctuary on the Vatican hill may not have had such an impressive location or appearance – it is never shown on coinage for instance – however, it was supra-regionally known for its specific services which implied religious practices for seeking one´s individual salvation, such as through the taurobolium.[3] The evaluation of 22 dedicatory altars that derive from the 3rd and 4th century CE and where found at the foot of the mons Vaticanus indicates firstly that the worship for the deity was a family business, and secondly that the peri-urban sanctuary was frequented by migrants from the East, or people who accumulated priestly offices, especially of mystery religions, such as the Eleusinian cult. Adherents were aspiring positive outcomes for their relatives or themselves from the deity.

Mining urban aspirations in the provinces

In the Northwest provinces several georeferences to the Vatican Sanctuary are handed down in Mogontiacum/Upper Germany. In the middle of the city upon a Hallstatt burial ground, which was apparently still visible as a burial mound in the cityscape in the 1st century AD, a sanctuary was erected in honor of two goddesses, Mater Magna and Isis. The extraordinary finds point to the special services that were offered by religious specialists in this sanctuary. Although the area was redesigned around 130 CE, some of the previous fireplaces for offerings installed in the first construction phase remained in exactly the same place. The bones of seven fireplaces were archaeozoologically examined. (Hochmuth, 2005) Most of the 30,756 bones belonged to adult cocks and various species of local and seasonally immigrated finches, but no bull or ram (for a tauro- or criobolium) was offered. However, in the northern area, where a concentration of cremation sites has been found, several stone hearths have been brought to light, which, in addition to the animal bones, also contained small finds such as the lead plates and a not inconsiderable number of oil lamps, some of which were placed upside down in the fire. The small curse tablets made of lead, which were partly wrapped around animal bones, and three magic dolls (voodoo dolls) were used to curse or enchant certain people. From the inscriptions, which are almost exclusively addressed to Mater Magna, it can be seen that the topics which appeared, were primarily those concerning love, jealousy, and financial damage. Visitors to the sanctuary were aspiring that the deity would avenge them in their very private and individual issue. No evidences of soldiers dedicating or offering votives in the temple in order to achieve military success are recorded. Therefore, it is not surprising that the inscription in Mainz refers to the Vaticane sanctuary in Rome, which seems to have been accessible for every social strata on a daily basis, rather than to the Palatine sanctuary, which served the political actors with a representative character.

Conclusions

Aspirations are a basic feature of religion as well as of urbanity. They are the motor for action and for the materialization of life worlds, be it real ones, or imagined ones that should have been full of prosperity, security and quality of life, which was offered by the city they lived in. Aspirations supplied hope and motivation, either religious promises of salvation or in the case of urbanity a high

[3] The taurobolium was a special type of bull sacrifice, which probably originated in the urban context of Rome, and - at least by its name - had not been known in Greece and Asia Minor. In the history of research this special practice has been debated for a long time. Driven by the late antique, Christian polemics of Prudentius, the assumption was long held that it was a baptism with a shower of blood. Recent research has distanced itself from this. Alvar draws a comparison between the Vatican temple and the sanctuary complex in Ostia, where the findings show that the animal was sacrificed and parts of it were burned on an altar. A special treatment was also given to the testicles in Ostia, presumably as substitute for the self-castration of Attis. Ibid.

quality of life, all realized through the codes, norms and behavior of the ancient actors. (Goh and van der Veer, 2016) Hence, aspirations and rituals, which are religious practices that took form and were repeated, were used like geological raw materials; they were mined at a specific place, appropriated by shaping them according to one´s own preferences, then passed on, and finally distributed.

The case of Mater Magna evidently shows that aspirations, depending on the place where they were mined, evolved with different qualities and semantics that lied behind them, therefore they afforded different religious practices. Aspirations, even when distributed, could have the same meaning, but a different implementation and shape. Apparently, the comparison between the Palatine sanctuary, the Vaticane sanctuary and the Mater-Magna-and-Isis-temple in Mogontiacum show that these raw materials – aspirations and rituals – were shaped and transformed by specific local life worlds. However, the place of origin of the raw materials were not ignored, but a concrete georeference was given in the inscriptions (Spickermann, 2016).

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Black Resin in Funerary Equipment in New Kingdom and Deterioration Phenomena

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Keywords
Black Resin, Funerary Furniture, Wooden Objects, Deterioration, Human Damage

Wooden objects covered with a layer of black resin represent a unique collection of wooden objects that are part of funerary furniture because of the religious connotations of the other world, especially in the royal objects as Tutankhamun, Yuya and Tuya, and other kings of the New kingdom state and other eras.

Black resin was a resinous material, which was used to cover the funerary wooden artifacts in the New Kingdom. It was used to cover funerary furniture like coffins, shabti statues and boxes, stelae, canopic chests, human and animal statues, and statue bases (Nicholson and Shaw, 2000, p.459), and it was most likely It used for religious purposes.

Unfortunately, there several wooden artifacts covered with a layer of black resin in a deplorable condition due to the deterioration of its condition and complex structure, which consists of more than a layer and the result of the existence of these wooden artifacts in different environmental conditions, temperature changes, humidity and air pollution.

Common deterioration phenomena of black resin applied to funerary furniture:

Damage during application

– There is pitting on the surface of the black resin as a result of the continuous stirring of the black resin on the fire during its application. This pitting is an air bubble.

– Bristles were left from the brush used during the application of the ancient Egyptian black resin to the wooden monuments.

Damage during display and storage

They are subjected to many different deterioration factors, whether physical or chemical, leading to the emergence of many different manifestations of damage such as cracks and the separation and fall of layers of black resin and other aspects that sometimes reach the distortion of the shape of the artifacts.

– Cracks and detachment are the most common deterioration phenomena to the black resin.

– Fine cracks in the black resin layer may be caused by the difference of the expansion and shrinkage coefficients between the black resin layer and the wooden support.

– The difference in the expansion and shrinkage coefficients between the black resin and the wooden support leads to the deterioration of the gilding paper on the top of the black resin layer.

– The separation and fall of the black resin layer result from the difference of expansion and contraction between the black resin layer and the wooden support, as well as poor storage (Abdelmoniem, 2019).

Human damage (past and present)

– Deterioration in the past resulted from deliberate human damage to the destruction of facial features for religious purposes. Currently, it is caused by the use of wrong restoration materials that dissolving and deteriorating the black resin. It is called the wrong restoration.

Therefore, there was an urgent need to study this type of wooden artifacts covered with the layer of black resin where the wooden artifacts covered with a layer of black resin have not been studied yet (Abdelmoniem, et al., 2020).

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Thinking Transhumance and Agriculture in Irpinia as Dynamic Networks of Resources (5th Century BCE–1st Century CE)

Raffaella Da Vela

Keywords
Mobile Pastoralism, Pre-Roman Italy, Roman Colonization, Resource Complexes, Apennine

Transhumance is defined as the seasonal movement of herds from lowland to highland pastures (Cardete, 2019). The term includes different dimensional scales, ranging from the local to the superregional. Social actors of transhumance are the shepherds and their families. This form of mobility activates both material and immaterial resources. Material resources includes livestock and its products, infrastructure such as routes, water reserves, and pastures. Immaterial resources include the skills required to take care of the livestock and to transform animal products into different commodities, as well as knowledge of geography and the climate (Montanari and Stagno, 2015; Oteros-Rozas, et al., 2019). Thus, in the definition of the SFB 1070 ResourceCultures, transhumance is a resource complex, a "combination of things and representations, individuals or social groups, knowledge and practices" (Hardenberg, Bartelheim and Staecker, 2017, p.15). It cannot be studied, therefore, without taking a further resource complex into consideration: agriculture, with which transhumance shares spaces, landscapes, and resources. In Roman literary and epigraphic sources there is a narrative of a permanent interaction between these two resource complexes, both of which had to be ruled by central as well as by local political powers and institutions (Marcone, 2016; Pasquinucci, 2016). This interaction, which is also well known in ethno-anthropological studies, is due to the overlapping of the activated resources, something that frequently evolves into direct conflicts of interest. For example, livestock needs pastures in the fertile plains, which, however, are also the preferred site for the cultivation of cereals. Of course, conflict is not the only mode of interaction: mutual exchange and negotiation are also possible, because agriculture benefits from a byproduct of transhumance, manure, and more generally because pastoral societies are not self-sufficient (Gonin, et al., 2019). These two resource complexes were thus complementary networks of entangled material and immaterial resources rather than oppositional blocks.

Irpinia from the classical period to the Augustan era

Thinking about transhumance and agriculture as dynamic networks is a hermeneutic tool for understanding changes in the management of resources and in their sociocultural value. This perspective has been adopted to study the impact of the foundation of Roman settlements in Irpinia (within the Research Project B04 of the SFB 1070 ResourceCultures: Postdocs Christiane Nowak-Lipps and Raffaella Da Vela, Principal Investigator Richard Posamentir). A brief exposé of the adopted methodology and of the preliminary results (5th century BCE – 1st century CE) will be presented in what follows.

Irpinia is a geographic and cultural region of about 3.600 km2 in inland Campania, in southern Italy, at a crossroads between the Tyrrhenian and the Adriatic coasts (Fig. 1). The region consists of a plurality of resource landscapes, from the fertile plains of the rivers Ofanto and Calore to the impervious Apennine regions. Many studies deal with transhumance as well as agriculture in Italy from the late Republican to the Late Antique period (Corbier, 2016; Pasquinucci, 2016), but earlier periods are more difficult to analyze. A particular challenge is finding archaeological indicators of transhumance and agriculture in Pre-Roman times, a period for which scarce literary and epigraphic sources exist (Migliavacca, et al., 2015).

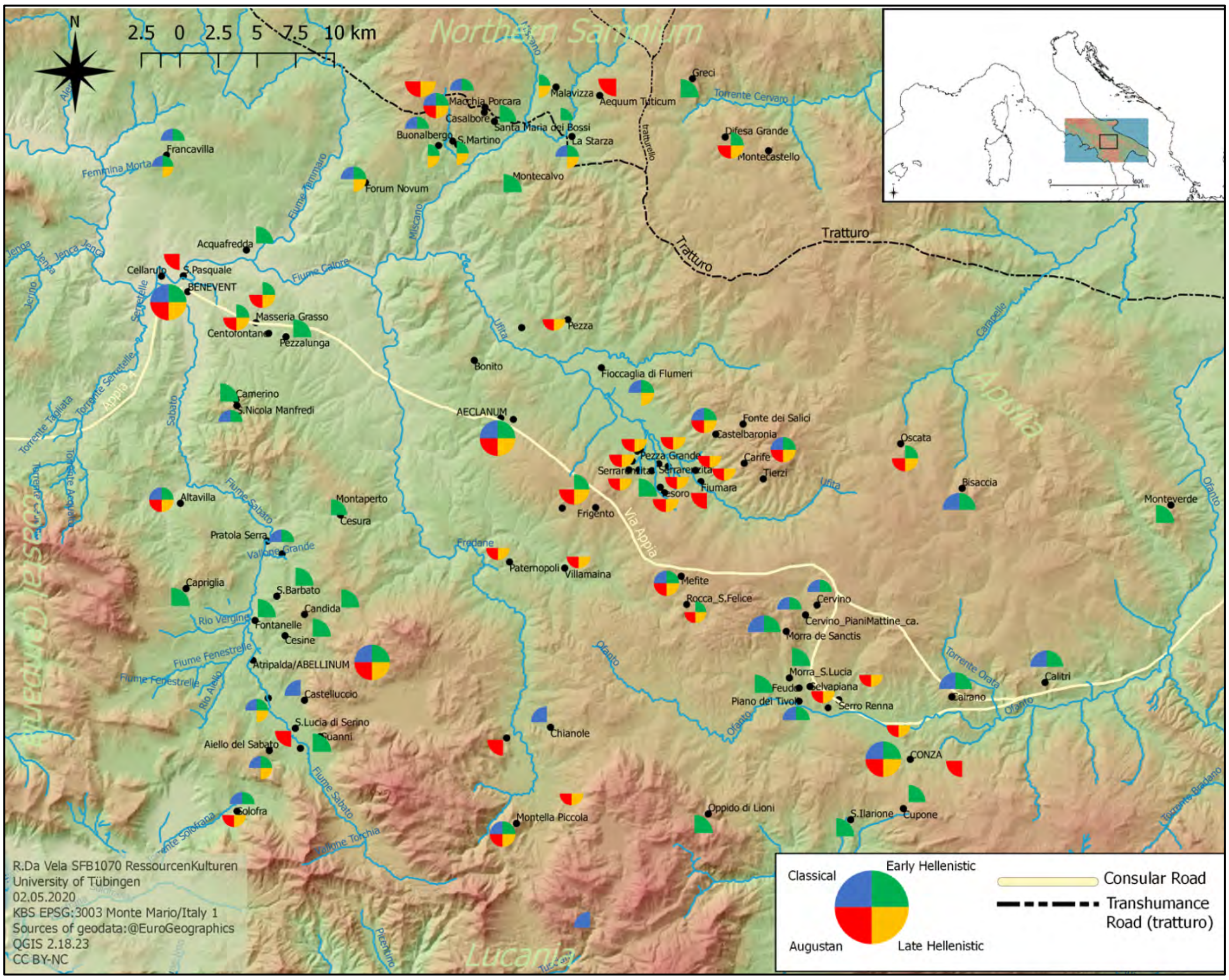

Figure 1. Settlement dynamics and drovers' roads in Irpinia.

Methodology

Landscape and spatial analysis, along with the archaeological record, allow us to approach this topic even in the absence of zoological, pedological and palynological data (Mientjes, 2012; Roubis, et al., 2015). The spatial distribution of settlements, farms and small manufacturing sites, can be related to the geographic preconditions (springs, pastures) and to the routes of historical transhumance. Not just the position in the route network, but also the viewshed is taken into account on the base of a Digital Elevation Model. The spatial organization of the small farms and of sub-urban and rural production sites is analyzed in order to detect production activities. Finally, the material record related to animal husbandry and textile and agricultural production is considered from the point of view of the daily dimension of these activities (households) as well as their symbolic values (cult places and necropoleis).

Data collection and analysis

Around 120 settlements, sanctuaries, and production sites were collected from the literature (51 were in use in the Classical and early Hellenistic period; 52 in the late Hellenistic period; 40 in the Augustan era). In the so-called Samnitic period (5th to 3rd c. BCE), the system of settlements was characterized by sparse occupation (vicatim), with small rural hubs along the transhumance routes. Urban centers (such as Atripalda and Maleventum) were rare. However, some small hilltop settlements (such as Cairano and Ariano Irpino) were located on the sites of previous protohistoric villages, which enabled visual control over the river valleys.. The new foundation of a few roman fora in the 3rd century BCE, (such as Fioccaglia di Flumeri) have been linked to an agricultural re-organization of the lowlands, which is evidenced by a number of boundary stones, limites gracchani (Colucci Pescatori, 2017; Gallo, 2015; in regard to the use for public pastures: Laffi, 1998). The abandonment of some of the hilltop settlements following the construction of the Via Appia seems to be linked to economic reasons rather than to political violence. Some colonies and municipia were founded in pre-existing Samnitic towns (beginning with Beneventum in 268 BCE). After their institution, three already existing trends intensified: conurbation, the concentration of manufacturing in the suburban areas, and the creation of a network of small farms in the form of a city belt.

Preliminary results and discussion

The traditional approach has considered the adoption of a Roman administrative system and the inclusion of Irpinia in the II Augustan Region as triggers for transhumance and extensive agriculture (Marcone, 2016).
The data collection shows that a number of aspects has been overestimated: the fragmented articulation of the pre-existing transhumance system does not necessarily imply that it was smaller in scale, because open access to pastures and agreements about their use are a possible alternative to a centralized power structure (Gonin, Filoche and Delville, 2019); the Via Appia was an improvement of already existing roads (Gangemi, 1987); finally, the supposed colonial implementation of extensive agriculture in the region seems to be very limited.
The proposed approach of linking different resource complexes in a single dynamic network opens up new perspectives. The traditional organization of transhumance required a growth of flocks due to changes in the macro-regional dimension, such as the introduction of a villa rustica production system in the neighboring regions (Johannowsky, 1981; Attema, et al., 2010). Consequently, the reorganization and unification of the administrative and fiscal system activated social and political resources to manage conflicts between different resource complexes.
A network approach enables us to reconsider the analysis of resource complexes and to reframe the impact of the foundation of Roman settlements in Irpinia. Moreover, this perspective invites us to consider the

global implications of the economic and political reorganization to which the Roman presence in the region gave rise, as well as the local responses to this presence, linking the economic use of resources to their cultural and social values.

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Copper Technology from the East? Knowledge Transfer to the Central Alps (Grisons, Switzerland)

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Keywords
Oberhalbstein/Grisons, Copper Technology, Tuyères, Archaeometrical Analysis

In the Oberhalbstein valley (Grisons CH) primary copper production can be evidenced for the Late Bronze Age and especially for the Early Iron Age. The chaîne opératoire for copper mining and smelting is described in recent studies (Reitmaier-Naef 2019; Turck 2019).

For the reconstruction of knowledge transfer, metallurgical analyses are often used. In this paper we introduce an additional method using tuyères (Nüssli 2019). Compared to Bronze Age tuyères from Austrian smelting districts, technological differences can be assumed for the Oberhalbstein. Archeometric analysis of tuyères and local domestic pottery show promising data of local and non-local clay and tempering. These results suggest technological knowledge transfer, "mobile knowledge", and local miners and smelters in the Oberhalbstein Valley.

Skill, Embodiment and the Growth of Knowledge

Introduction

Resources impact society beyond their function as raw materials. Not only the treatment of raw materials, but also their procurement requires a lot of skill and knowledge. A very good example for this is prehistoric copper smelting. It needs complex processes in several steps in order to smelt copper out of sulfidic ores (Reitmaier-Naef 2018). Archaeologists managed to understand the process on a chemical base, but they cannot reproduce this process experimentally so far (Anfinset 2011). Social anthropological studies on the so-called "Nepal Process" show a sequence of actions in which the copper smelter uses special knowledge.

An overview of the Alpine region shows that copper production indicates an evolution over time and space. By and by, new mining districts emerge while others lose their importance (Stöllner 2019). This brings up the question on how the knowledge of this technology moved around. One thesis would be migration (Reitmaier-Naef 2015, 118). Another option, at least for the Bronze Age, is that the process was controlled by an Elite located in lowland areas near the Alpes (Krause 2011). Eventually, there is the possibility that only the technology, but not the people moved. Various models for the Iron Age copper production are discussed (Turck/Della Casa in press.)

Up until now, quite a lot of research on the spread of copper artefacts with help of trace element and lead isotope analysis has been done, but there has not been much research on the topic of technological spread. In this paper, we want to show that the archaeometrical analysis of technical ceramics can be helpful in researching this question (Nüssli 2019).

Situation

Research on the copper production in the Oberhalbstein Valley is quite new in contrast to adjacent areas such as Tyrol or the Mitterberg district where there is a long tradition. However, in the last few years of intense activity quite a few results could be achieved. Two smelting places were excavated extensively (Turck 2019), several furnaces were discovered, and many fragments of tuyères were found. Moreover, the two smelting places as well as other findspots in the valley could be dated by dendrochronology (Oberhänsli et al. 2019). Copper was smelted in the Late Bronze Age and in particular in the Early Iron Age. This shows that the mining district emerges at the end of a long development, and it is quite reasonable to assume that the technology was adopted from neighbouring regions such as the Trentino, Vinschgau or Tyrol. All these mining districts can be accessed over Alpine passes. However, the technology could also have come from the north through the Alpine Rhine valley.

The high number of fragments of technical ceramics comes as a remarkable difference compared to other districts. The findings also offer new opportunities for a systematic archaeometric research into copper smelting. First results of a typological analysis show that two groups of tuyères can be distinguished (Nüssli 2019): The first group consists of hard, stable red ceramic, and was found in the smelting places Gruba I and Val Faller, Plaz. This group was defined as “Type A”. The second group is quite fragile, has a beige to orange colour, and was only found in Val Faller, Plaz. This group was defined as “Type B” and forms a "lesser class" of tuyères.

Archaeometrical analysis of the technical ceramics

In a MA thesis, tuyères fragments were probed with thin sections and pXRF. The central questions focused on provenance and local production, as well as on clay tempering with slag. The question of slag tempering is quite important, as it appears quite often in thin sections of tuyères fragments from the Inn valley (Töchterle et al. 2013, 9–10). Therefore, 62 fragments from the excavated smelting places Gruba I and Val Faller, Plaz were chosen for analysis. The aim was to take samples that represent the whole situation. Both the different parts of the the tuyère as well as the different types should be represented in the sample. All fragments were analysed with pXRF, and 11 fragments from Val Faller and 10 from Gruba I were analysed optically with thin sections. One vessel pottery fragment from each findspot was chosen as a comparison sample. The small number of pottery samples from the smelting places is explained by the overall small number of pottery finds (Turck 2019). The sample was enlarged with fragments from another smelting place as well as from a local settlement. The other smelting place is Riom (Rageth 1979), where all 20 fragments are of Type A. As a settlement, the recently revaluated Motta Vallac hilltop was chosen (Roffler 2018). Sample selection from Motta Vallac was quite difficult as the settlement existed over a long period of time. In the end, 19 samples could be selected that were most probably produced locally, and roughly represent the timeframe of the smelting activities in the valley (Late Bronze and Early Iron Age). All these fragments were tested with pXRF, and 10 from Motta Vallac and 9 from Riom were selected for thin section preparation. In addition, clay from a few local sites was tested with pXRF (Nüssli/Stockmaier 2019). The analysis of trace elements was done with Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). The temper was analysed in the thin section by optical microscopy.

Results

The trace element analysis yielded the following results (Nüssli 2019): PCA shows a big difference between the Types A and B – they were therefore not manufactured from the same clay. All fragments of Type A were part of the same cluster, but LDA differentiates the fragments according to the find sites. The vessel pottery from the smelting sites as well as from the settlement shows a different composition and does not form a cluster on its own. The same applies for the clay samples.

The analysis of the temper (Nüssli 2019) shows differences between the two tuyères types: Type A has quite a high amount of paragneiss and orthogneiss, but no serpentinite as temper. Type B shows a lot of serpentinite but no gneiss. Slag tempering cannot be proven at all, and chamotte was only found in one fragment. The visual observation of more temper in Type A than in type B can be confirmed. The pottery from Motta Vallac shows many fragments with serpentinite temper. The two pottery fragments from the smelting sites were tempered with mica schist (Glimmerschiefer).

Interpretation

The lack of chamotte or slag temper in the Oberhalbstein evidences a different crafting tradition than the copper production sites in Tyrol. It seems quite unlikely that copper smelters from Tyrol had a leading role in the Oberhalbstein's production, since chamotte and slag were not used in the valley, but both were available. Shennan (1992) sees slag tempering as a kind of identity symbol for the mining community of the Inn valley. The serpentinite temper in tuyères of Type B could connect to a local tradition of the Oberhalbstein as serpentine is quite common in the valley (Nievergelt 2001). Gneiss as well as mica schist are more special as they are only found in a few spots. The tempering components could also have been chosen according to availability, practical use and heat resistance. Tuyères have to withstand a lot of stress because of the enormous heating and cooling-off processes. One important indicator could be the use of mica schist in the pottery of the smelting sites. Comparison with the studies of Magetti (1983 & 1984) on the Laugen-Melaun pottery shows that serpentinite temper was used there as well. North of the Oberhalbstein valley up to the Rhine most of the pottery is equally tempered with serpentinite. In the Rhine valley serpentinite is not often available. Gneiss and mica schist tempering is found west of the Rhine. The Engadine valley south of the Oberhalbstein has a tempering tradition with volcanic elements such as porphyry and similar minerals (Marro 1979). This tradition derives from the Trentino.

A possible conclusion is that the mining community of the Oberhalbstein was at least in part non-local. It is quite possible that the miners came from the northern foothills of the Swiss Alps. This is also the region where the typical pottery seen in the smelting sites originated (Turck 2019, "Taminser Keramik"). From where the smelting technology came in, is still debatable but a direct spread from the Inntal or the Trentino seems rather improbable. Further studies are needed for a more precise capture of the technological transfer.

Perspectives

The analysis of temper in tuyères and pottery brought most promising results. It is, however, essential to continue these tests with a larger sample in order to verify the results. The geographical area for pottery testing should be enlarged as well. The effects of the different temper components with regard to heat resistance is an important study area. Last but not least, more information on the geology and mineralogy of the Oberhalbstein valley needs to be included with regard to clay sources. The combination of archaeological, archaeometrical and archaeometallurgical data has a great potential for questions on the spread of metallurgy in the Alpine regions.

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Spondylus Ornaments from Prehistoric Settlement Mound near Drama Village, Bulgaria

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Spondylus, Ornaments, Chalcolithic, Bulgaria

In prehistoric times people wore different ornaments made from stones, bones or shells to appear more impressive. Other than their aesthetic beauty, these decorations were also symbolling social differentiation and represented the position of their owner in the community.

In Prehistory, the development towards social complexity led to separation of different groups and appearance of the first leaders – chiefs, priests, warriors. In this period, personal skills were important and supported accumulation of authority and 'prestige'. During the Neolithic and Chalcolithic periods 'prestige' was marked also by purchase and use of 'exotic' objects (like *Spondylus* ornaments). 'Exotic' objects had the following characteristics: - they were made of rare, nonlocal or valued raw material; - they had had faraway origin; - they were acquired by trade or expedition in distant, foreign lands; - they were accurately made; and – have unique form. Accumulation of 'exotic' objects displayed wealth, success and power in prehistoric society (Trubitt, 2003, p.244, pp.247-249, p.263; Gaydarska, et al., 2004, p.11, p.24; Николов, 2005, pp. 7-8; Николов, 2006, pp.77-78; Dimitrijević and Tripković, 2006, p. 248; Гайдарска, 2008, p. 271; Séfériadès, 2010, p.186; Chapman, et al. 2011, pp.139-140, p.142, pp.154-155; Ifantidis, 2011, p.131; Baysal and Erdoğu, 2014, p.366; Chapman and Gaydarska, 2015, pp.647-648; Bajčev and Stojanović, 2016, p.103; Vitezović, 2016, p.238, p. 246; Komšo, 2017, p.15; Lazăr, Mărgărit and Radu, 2018, p.18).

'Exotic' objects mark 'social connections', as well. They are evidences for construction of economic, cultural and political relationships with closer or more distance communities. 'Exotic' objects can be acquired in different ways: trough pure gift; exchange of gifts with economic equivalent; exchange of gifts without economic equivalent (generosity); payment for favor; exchange of material goods against immaterial goods (bribe); commercial trade. The last one can be done by direct contact between two sides or with the assistance of middlemen when the object travels 'from hand to hand' through the years. Except by peaceful way 'exotic' objects can be achieved also by force – as result of expedition in enemy territory. In this case they can be seen as trophies – symbols of military power (Trubitt, 2003, pp.243-244, pp.246-247, p.259; Gaydarska, et al. 2004, p. 11, p. 30; Гайдарска, 2008, pp. 263-264, p. 271; Séfériadès, 2010, pp.185-186; Chapman, et al., 2011, p.140; Windler, 2013, pp.95-96; Chapman and Gaydarska, 2015, pp.640-641, p.647; Bajčev and Stojanović, 2016, p.103;

Vitezović, 2016, pp.238-239, p.246). Archaeological excavations of different prehistoric sites like settlements, necropolises or ritual structures allows to examine social differentiation in this time.

The prehistoric settlement mound Merdzhumekya was situated near Drama village, Yambol district, South-east Bulgaria. It was fully excavated during the Bulgarian-German project running from 1983 to 2011. The joint project was undertaken by Sofia University "Sv. Kliment Ohridski" from Bulgaria and Saarland University from Germany.

The archaeological site was situated on 1 km north-east from the Drama village. Its measures were 6.00 m height and 160.00 x 120.00 m diameter at its base. The settlement mound was inhabited during the Late Neolithic – Karanovo IV culture (5200 – 4900 BC), Early Chalcolithic – Karanovo V culture (4900 – 4500 BC) and Late Chalcolithic – Kodžadermen-Gumelnița-Karanovo VI culture (4500 – 4300 BC). It was also partly inhabited during the Early Bronze Age. During the Middle Bronze Age (2200 – 1500 BC) a ritual ditch was added around the mound (Lichardus, et al., 2000).

During the archaeological excavations 9 pieces from bracelets, one plate with two holes and one pendant from *Spondylus* shells were found (Figure 1). Three pieces of shell ornaments were found in Obj. 371 – a stone structure with irregular form and connected with religion practices. It's dated in Late Chalcolithic period (Lichardus, et al., 2000, pp.50-51). Three other *Spondylus* decorations (2 pieces from bracelets and the plate) were found in Obj. 244 – two-story house. This was the most representative building from the Late Chalcolithic period. During the excavations more than 200 whole preserved ceramic vessels, different tools and cult objects were found (Lichardus, et al., 2000, p.55, p.57). One bracelet fragment was found in Late Chalcolithic houses Obj. 435 and Obj. 510. A pendant, made from broken bracelet, was recovered in Early Chalcolithic house Obj. 698. Finally, one piece of a bracelet was found during excavation at sq. P 12. Ornaments which were made from *Spondylus* shell are one of the most common symbols of 'prestige' in prehistoric time.

Spondylus gaederopus lives in the warm Aegean and Adriatic Seas. It lives in coastal areas at depth from 2.00 to 30.00 m. About its shape *Spondylus* shell is known as 'Thorny oyster'. The bigger lower valve has conical shape and is cemented to the rock base. The upper valve has irregular form with spikes. It can achieve a length of 15 cm (Tsuneki, 1989, pp.10-12; Dimitrijević and Tripković, 2006, p.241; Гайдарска, 2008, p.266; Иванов, 2010, p.56; Sefériadès, 2010, p.180; Chapman, et al., 2011, p.141;

Figure 1. Objects made of Spondylus shells from Drama. Author T. Valchev.

Chapman and Gaydarska, 2015, p.641, p.647; Bajčev and Stojanović, 2016, p.114; Komšo, 2017, p.7; Lazăr, Mărgărit and Radu, 2018, p.8, p.12).

Production of ornaments from *Spondylus* shells went through few phases. First, spikes were removed and surface polished until white surface of the shells appeared. It can have different colour like red or purple lines. After that, the shells were cut and drill. Side edges and bulges were smoothed. During treatment of shells different instruments were used like flint drillers, stone smoothers and mallets. Shells' surface was polished with the help of sand. During treatment of thincore shells and strings were used. The latter permitted easier cut of shells (Tsuneki, 1989, p.10; Dimitrijević and Tripković, 2006, pp.241-242; Trubitt, 2003, pp.252-253; Иванов, 2010, p.61; Séfériadès, 2010, p.180; Chapman, et al., 2011, p.141; Ifantidis, 2011, p.131; Chapman and Gaydarska, 2015, pp.641-643; Bajčev and Stojanović, 2016, p. 116; Vitezović, 2016, p.237, p.245; Baysal, 2017, p.7; Lazăr, Mărgărit and Radu, 2018, pp.8-13).

Esthetic qualities of decorations from *Spondylus* shells were highly valued by prehistoric people. Four main periods can be singled out in their popularity. During the first half of 6th Millennium BC decorations from Mediterranean shells were common for Southeast Europe and North Italy. During the second half of 6th Millennium BC they were distributed over most of the European lands, reach to Central Europe and the Valley of Seine River. During the 5th Millennium *Spondylus* decoration were more common for the North Greece and the Valleys of Danube and Tisza Rivers. During the 4th Millennium BC these decorations were only common in the settlements at the Mediterranean shore.

Spondylus decorations 'overcome' culture borders and reach to distant from the sea territories. They are indicators for economical, political, social, cultural and religion relationships between prehistoric communities (Trubitt, 2003, p.262; Gaydarska, et al., 2004, p.24; Dimitrijević and Tripković, 2006, pp. 246-248; Séfériadès, 2010, p. 179, pp. 181-183; Chapman, et al. 2011, p. 140; Windler, 2013, pp.98-103; Baysal and Erdoğu, 2014, p.366; Chapman and Gaydarska, 2015, pp.639-640, pp.643-646; Bajčev and Stojanović, 2016, p.119; Vitezović, 2016, pp. 238-239, p.246; Komšo, 2017, p.5; Lazăr, Mărgărit and Radu, 2018, pp.5-6).

Decorations made from *Spondylus* shells, which were discovered around Europe, are uniform in shape and manufacture technique. This show that they were produced on few places on the coast and the ready production were exported in Europe (Séfériadès, 2010, p. 184; Chapman, et al., 2011, p.144; Baysal and Erdoğu, 2014, p.373; Bajčev and Stojanović, 2016, p.118; Vitezović, 2016, p.245; Komšo, 2017, p.15; Lazăr, Mărgărit and Radu, 2018, p. 15)

Spondylus decorations were worn on the most visible area of human body. They were symbols of social position of their owners and represented their status in prehistoric society. They were marks of wealth and success (Trubitt, 2003, p.247; Ifantidis, 2011, p.131; Chapman and Gaydarska, 2015, p.646; Baysal, 2017, p.1-2; Lazăr, Mărgărit and Radu, 2018, p.5).

In case of breaking *Spondylus* decorations were repaired or reworked to prolong their use as 'exotic' objects and symbols of 'prestige'. From broken bracelets prehistoric people made pendants or beads. Also they were drilled at the edges to can be worn as bracelets connected with string or to be sewed to the clothes (Николов, 2005, p.11; Николов, 2006, p. 80; Dimitrijević and Tripković, 2006, p.245, p.249; Гайдарска, 2008, p.269; Chapman, et al., 2011, p.141, p.152; Ifantidis, 2011, p.128, p.131; Baysal and Erdoğu, 2014, pp.371-372; Chapman and Gaydarska, 2015, p.641; Bajčev and Stojanović, 2016, p.118; Vitezović, 2016, p.246; Baysal, 2017, pp.13-14; Lazăr, Mărgărit and Radu, 2018, pp.12-13).

Most of the *Spondylus* bracelets found in present Bulgaria are thin and with small diameter (up to 7 cm). According to V. Nikolov during Neolithic bracelets have been worn by children or young women. In this way they would have showed the prestige of the whole family not only the head (Николов, 2005, pp.10-11; Николов, 2006, p.80).

J. Chapman and B. Gaydarska made archaeometric anylyses on fragments from *Spondylus* bracelets recovered in the Omurtag hoard (Bulgaria). They showed that the bracelets with inner diameter less than 4 cm can be fit on wrist by children younger than 5-yr-old. Adult woman can wear bracelets with inner diameter more than 6 cm, and adult male – more than 8 cm. It was possible that bracelets were worn permanently from childhood until dead or until break (Gaydarska, et al., 2004, p.24; Dimitrijević and Tripković, 2006, p.245; Ifantidis, 2011, p.128; Baysal and Erdoğu, 2014, p.367; Chapman and Gaydarska, 2015, p.646; Bajčev and Stojanović, 2016, p.115; Vitezović, 2016, p.240).

As private property *Spondylus* decorations were usually placed in the graves. F. Ifantidis notes that we always have on mind that ornaments found on the mortuary domain, may not necessarily reflect the 'world of living' (Ifantidis, 2011, p.124).

Prehistoric settlement mound Merdzhumekya is situated on the left bank of the Kalnitsa River – right tributary of Tundzha River. Tundzha River is left tributary of the Maritza River which flows into Aegean Sea. During the prehistory period main trading roads passed along the valleys of large rivers and their tributaries. During this time, Tundzha River's valley represented a peculiar passage which connects the North Aegean coast with the inner lands of the Balkan Peninsula. It was a natural passage for cultural influences and import of 'exotic' adornments from the East Mediterranean Sea.

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Cover Image

The "Deer Stone" monument in central Mongolia. By around 1200 BC, this type of carved standing stone became a ubiquitous feature of burial ritual in the Late Bronze Age of northwest Mongolia. It depicts a belted warrior equipped with a typical assemblage of steppe artefacts (dagger, knife, mirror and bow) and stylised flying deer on his torso. This, together with horse remains found in the burial monument, signifies the rise of a highly mobile pastoral culture in eastern Eurasia. Photo: Y.K. Hsu.

metallum, i, n:
Mine (often pl.)
Metal, also stone, mineral

μεταλλον, το:
Mine, shaft, gallery;
esp. a) Mine (usually pl.)
b) Quarry

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