

Social Metabolism and Historical Human–Environment Interaction: The Pergamon Micro–Region and Beyond

2nd Milestone Workshop
of the TransPergMicro project



10. – 11. January 2025 in Istanbul

AIMS AND DIRECTION

The 2nd milestone workshop of the interdisciplinary research project “The Transformation of the Pergamon Micro-Region between Hellenism and the Roman Imperial Period” (<https://www.dainst.blog/transpergmikro/>) will focus on the topic of social metabolism, i.e. the material and energy flows between natural space and society. Phenomena of social metabolism and its perception will be discussed for different areas such as nutrition, production, waste disposal, etc. The combination of speakers from the fields of archaeology, physical geography, building archaeology, classical philology, history, palaeoanthropology and social and economic geography is designed to ensure that the topic can be discussed on a broad theoretical and interdisciplinary basis. On the one hand, the results are to be incorporated into the further work of TransPergMicro in a formative way, on the other hand they are to initiate new collaborations and, above all, stimulate an even broader historical application of the concept of “social metabolism”. A roundtable discussion at the end provides the chance of a first critical reflection on the results of the workshop and on the second phase of TransPergMicro as presented in various papers, and will discuss some potential future directions.

It is intended to publish the results in the same format as the 1st TransPergMicro Milestone Workshop: <https://publications.dainst.org/books/dai/catalog/book/2106>

DATE

10.-11. January 2025

PLACE

Orient-Institut Istanbul
Galip Dede Cad. No. 65
Şahkulu Mah., Beyoğlu
34421 Istanbul

PROJECT



Transformation
of the
PERGAMON
Micro - Region

PARTICIPATION

If you would like to attend the event in person, please register in advance:

<https://terminplaner6.dfn.de/b/854e08b75e14549880eb649a74133df0-1008860>

The conference can be followed online. Please register in advance:

<https://dainst-org.zoom.us/meeting/register/tJEtdOuvqjMrE9IE4M9LyticlQTTCC6sykFJx>

After registering, you will receive a confirmation email with information on how to join the meeting.

INSTITUTIONS



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Friday, 10 January 2025

FELIX PIRSON – BRIGITTA SCHÜTT – THEKLA SCHULZ-BRIZE

9:15*
Welcome

FELIX PIRSON – FABIAN BECKER – URSULA QUATEMBER – BRIGITTA SCHÜTT

9:30
Social metabolism and historical human-environment interaction:
Introduction and application in the study of the Pergamon Micro-Region

1st Session “Social metabolism: Dimension and perspectives”

Chair: Brigitta Schütt

MANUEL GONZÁLEZ DE MOLINA

10:00
The dynamics of historical agroecosystems: The drivers of intensification
under organic metabolic regimes

COFFEE BREAK

10:30

EBERHARD ROTHFUß

11:00
Neither city nor countryside – The *rural-urban* interface as an ‘intrinsic
socio-spatial context’

IRIS NIEßEN – GERRIT JASPER SCHENK – RÜDIGER GLASER

11:30
‘Fluvio-social metabolism’ as a bridging concept of medium range. On the
interdisciplinary investigation of social relations to nature

DISCUSSION

12:00

LUNCH BREAK

12:30

2nd Session “Social metabolism in the ancient Mediterranean: Practice and perception”

Chair: Felix Pirson

PAUL PASIEKA

14:00
Roman agriculture in Italy: A socio-ecological perspective on micro-
regions, specialization, and integration

JEROEN POBLOME

14:30
Cities and socio-ecological systems in the Roman world

- DOMINIK MASCHKE**
15:00 The ecological footprint of Roman building projects: A valid indicator of social metabolism and human-environment interaction?
- COFFEE BREAK**
15:30
- CHIARA THUMIGER**
16:00 Change within the body, change within the world: Ecological conceptualisations of the body and its functions in Galen of Pergamon
- SABINA FIOŁNA**
16:30 Social network analysis of Roman provincial coinage – linking the micro-, and macro-perspectives on Anatolia
- DISCUSSION**
17:00
- CONFERENCE DINNER**
20:00

Saturday, 11 January 2025

3rd Session “Social metabolism of the Pergamon Micro-Region”
Part 1

Chair: Thekla Schulz-Brize

- FABIAN BECKER – ROBERT BUSCH – BRIGITTA SCHÜTT – JORIS STARKE**
9:00 Roots to ruins: Environment perspectives on the social metabolism of the Pergamon Micro-Region
- WOLF-RÜDIGER TEEGEN**
9:30 Humans and animals as agents of social metabolism – Ancient Pergamon as an example
- BERNHARD LUDWIG – FELIX PIRSON – ANNEKE KEWELOH-KALETTA – ZEKI METE AKSAN – GÜLER ATEŞ – PHILIP BES – BERGLIND HATJE – BERSLAN KORKUT**
10:00 The rural landscape and its role in the social metabolism of the Pergamon Micro-Region: Challenges and perspectives of archaeological research
- COFFEE BREAK**
10:30

4th Session

“Social metabolism of the Pergamon Micro-Region” Part 2

Chair: Victor Walser

11:00

LÉA GEISLER – ULRICH MANIA – URSULA QUATEMBER – THEKLA SCHULZ-BRIZE

Lower Agora and East Baths in Pergamon. Construction under different social-metabolistic regimes

11:30

NICOLE NEUENFELD

Rubbish heaps of history – The significance of waste and waste disposal in the Pergamene urban organism

12:00

JULIAN LAABS – FABIAN BECKER – ROBERT BUSCH

Exosomatic and endosomatic flows: Modelling Pergamon’s social metabolism, review and prospects

12:30

DISCUSSION

13:00

LUNCH BREAK

Roundtable discussion

“Social metabolism as a bridge between ancient studies and contemporary challenges?”

Moderation: Marianne Braig

14:30

MANUEL GONZÁLEZ DE MOLINA – DOMINIK MASCHEK – JEROEN POBLOME – EBERHARD ROTHFUß – GERRIT JASPER SCHENK – CHIARA THUMIGER – VICTOR WALSER

to be followed by a plenary discussion

16:30

COFFEE BREAK

Special session “Archaeoseismology”

Chair: Ulrich Mania

ÖKMEN SÜMER

17:00

Archaeoseismology: A very important tool in active tectonic studies:
Examples from Western Anatolia

MAHMUT GÖKTUĞ DRAHOR

17:30

Active tectonics and seismicity in Western Anatolia. An example: on
earthquakes in and around Pergamon

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MANUEL GONZÁLEZ DE MOLINA

The dynamics of historical agroecosystems: The drivers of intensification under organic metabolic regimes

The most widely disseminated narrative regarding the evolution of societies prior to the Industrial Revolution directly relates the increased intensity of land use to population growth. The employment of more labor typically results in an increase in soil productivity while simultaneously leading to a decline in labor productivity, as demonstrated by E. Boserup. However, this linear causality does not account for the complexity of the processes of intensification, extensification, and even collapse that have occurred since the spread of agriculture. Indeed, the process of land-use intensification has not been linear, nor has there been a continuous linear growth in productivity; rather, it has been interspersed with phases of regression and crisis. In recent years, there have been consistent critiques of Boserup's theses and those of her followers. Ellis et al. propose understanding land-use intensification as the adaptive response of human populations not only to demographic pressures but also to social and economic pressures. Finally, some authors suggest that land changes at all spatial levels are influenced by flows of raw materials, energy, products, people, information, and capital, creating a need for novel theoretical and methodological approaches to the analysis of causal relations in land system dynamics. Thus, they advocate for considering land systems as coupled human-environment systems. In this sense, land use systems can be better understood and analyzed if viewed as a reflection of a specific metabolic arrangement.

This presentation aims to analyze the dynamics inherent to societies under organic metabolic regimes and to highlight the main drivers of productive intensification processes in agroecosystems. Given the complexity of such societies and the multiplicity of factors influencing land use decision-making, I propose to understand this process as the result of the trade-off that all societies establish between physical entropy and social entropy. This relationship is regulated by political institutions (community, state, etc.) that seek to find solutions to the mismatches arising between the population and natural resources. Such imbalances lead to the breaking of the steady state that the socio-ecological conditions of this type of metabolic regime have forced it to maintain. Finally, the most common responses are examined, including the possibility that they may fail, leading to metabolic collapses of greater or lesser magnitude.

EBERHARD ROTHFUß

Neither city nor countryside – The *rural-urban* interface as an ‘intrinsic socio-spatial context’

The rural-urban interface as an ‘intrinsic socio-spatial context’ suggests that *space* and *place* are not just a transitional zone between the urban and the rural, but are qualitatively constituted through a specific social and spatial sphere, which plays a significant role in shaping the ‘life-world’ and the social networks of “weak and strong ties” (Granovetter 1973) of the people living there and the way in which spaces and places are experienced and organized. From a trans-local perspective, the rural-urban interface is by no means bounded or static but has “capacity” for connecting with other rural and urban places at the regional, national and global scale (Chen, 2023).

This specific intrinsic socio-spatial context of the rural-urban interface (where mostly small and medium-sized towns occur) has consequences for its *social metabolism*. Social metabolism describes the complex process of exchange between

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nature and society, i.e. the energy and material flows related to the functions and reproduction of the structures of human societies (Şorman & Giampietro 2013). My conceptualization of a specific social metabolism at the rural-urban interface is further related to Philosophical Anthropology. Philosophical Anthropology provides a philosophical classification of the debate on the relationship between *man as a natural being and the nature of man*. In this context, Helmuth Plessner's approach is particularly informative, as it emphasizes man's corporeal existence and his "eccentric positionality" / integration into the *bios* – the natural conditions of life (Plessner 1982).

Chen, N. (2023): Geographical articulations of rurality at the rural-urban interface. In: Geography Compass 17, p. 1-14.

Granovetter, M. S. (1973): The Strength of Weak Ties. In American Journal of Sociology 78 (6), pp. 1360-1380.

Plessner, H. (1982): Mit anderen Augen. Aspekte einer philosophischen Anthropologie. Stuttgart.

Şorman, A. & Giampietro, M. (2013): The Energetic Metabolism of Societies and the Degrowth Paradigm. Analyzing Biophysical Constraints and Realities. In: Journal of Cleaner Production 38, 80-93.

IRIS NIEßEN – GERRIT JASPER SCHENK – RÜDIGER GLASER

'Fluvio-social metabolism' as a bridging concept of medium range. On the interdisciplinary investigation of social relations to nature

Societies organized their relationship with nature in different ways, but have always been dependent on a material exchange with it. This social metabolism connects society and nature. Because it entangles both socio-cultural and natural processes, several disciplines are required to analyze it. It is therefore appropriate to examine social relations to nature with the help of a bridging concept that allows access to the object of investigation by several disciplines.

In order to keep the number of parameters to be scrutinised manageable, it is also useful to focus. We have therefore chosen a specific socio-natural site, namely floodplains, which have exhibited a close interweaving of socio-cultural and natural factors from early on in human history. According to our premise, they show a specific socio-fluvial metabolism that significantly shaped the 'fluvial anthroposphere' and continues to have an effect today through path dependencies.

First, the lecture situates fluvio-social metabolism as a suitable bridging concept within the theories, models and concepts discussed in the environmental sciences for analysing systems from the world down to micro-regions. Second, we discuss the possibilities and limitations of analysing fluvio-social metabolism. For this purpose, specific resource complexes will be analysed. Using the specific example of medieval tanneries, we explain the application of the bridge concept from the intertwined perspective of several disciplines. Third, in this context we draw attention to the opportunities and problems of a partially quantifiable research model.

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PAUL PASIEKA

Roman agriculture in Italy: A socio-ecological perspective on micro-regions, specialization, and integration

Roman agriculture in Italy has been a dynamic and vibrant field of research in recent years. While archaeological research in the 1980s and to some extent in the 1990s was still very strongly oriented towards the texts of the agronomists Cato, Columella, Varro and Palladius, which were largely read as a guidebook for the interpretation of archaeological features and interpreted as a succession of ideal typical socioeconomic formations, numerous new archaeological sources have since been identified and genuinely archaeological questions developed. Four thematic fields should be emphasized in particular, which have seen a significant development both theoretically and methodologically:

- 1) Infrastructure: Various agricultural infrastructures have increasingly come into focus, which not only intervene massively in the natural environment and have a lasting impact, requiring enormous investments, but which are being understood as interdependent systems.
- 2) Diversity: The villa as place of agricultural production was long associated with the classic Mediterranean triad (olives, wine, wheat) or with fish farming, but it is now understood that it has been used for a wide variety of agricultural and productive activities.
- 3) Scale: New quantitative approaches and the combination and comparison of different landscape archaeological data sets make it possible to better estimate the scale and significance of different agricultural productions in individual regions.
- 4) Integration: While on the one hand, regional specialization in agricultural products is becoming increasingly apparent, on the other hand, it appears to be accompanied by ever closer supra-regional interdependencies.

Socio-ecological or socio-metabolistic questions play a role in all of these areas, even if they are rarely addressed explicitly. In particular, the role of Rome was repeatedly discussed with regard to material flows, its impact on the environment and the resulting economic entanglements.

JEROEN POBLOME

Cities and socio-ecological systems in the Roman world

Ecology studies the distribution and abundance of organisms and the interactions that underly these. Since emerging, *Homo sapiens* has been an increasingly impactful player in the ecosystems that spring from these various interactions. As human societies can also be conceptualized as systems, consisting of multiple components and interactions at different spatio-temporal scales, they are often juxtaposed to ecosystems. Socioecological systems subsume both types of system, along with the various connections between the two. The long-term perspective and interdisciplinary arsenal of archaeology is ideally suited to study humanity's roles in these socioecological systems through time and space. This paper uses the Roman Imperial period (31 BCE - c. 300 CE) as a case study for understanding the environmental impact of urbanization in the Graeco-Roman world. Considerable socio-ecological shifts, an abundance of datasets from multiple disciplines, and the proliferation of cities across a vast and diverse area, make the Roman Empire a

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fruitful playground for historical ecology. This paper aims to present the basic principles of socioecological systems, before using a socio-metabolic framework to discuss a wide variety of archaeological and interdisciplinary studies which provide the necessary building blocks to examine the socioecological systems of Roman cities.

DOMINIK MASCHEK

The ecological footprint of Roman building projects: A valid indicator of social metabolism and human-environment interaction?

This paper proposes a new framework for understanding Roman construction, emphasizing its integration within a complex network of social, economic, and ecological factors that connected urban centers and their supply chains. This perspective challenges the traditional view of the Roman construction industry as a monolithic entity, revealing instead a diverse landscape shaped by local resources and specific environmental conditions. Roman construction was driven by continuous adaptation to available natural resources, influencing planning and building practices. This intricate relationship between ecological factors, such as climate and topography, and urban development is crucial for understanding the socio-ecological diversity of Roman architecture. The paper argues against reducing Roman architecture to mere typology, instead advocating for regional comparisons that illuminate the dynamics of monumental building activities across the empire.

To contextualize this proposition, the paper uses the ecological footprint concept as defined by the Global Footprint Network, which quantifies human demand on natural resources. However, given the lack of comparable data for the Roman period, particularly in terms of 'global hectares', the paper adopts a localized method centered around the town of Tusculum in late Republican central Italy. By utilizing the standardized measure of 'Late Republican Latin Hectare' (LRLH), the study assesses the ecological footprint of three distinct phases of a monumental sanctuary, evaluating whether their construction was sustainable within the local agricultural and resource management capacities. Future research directions proposed include deeper investigations into macro-scale environmental data, such as climate and agricultural productivity, to better understand workforce dynamics and logistics in Roman construction. Overall, the paper emphasizes the need to correlate construction materials and techniques with these ecological factors, ultimately allowing for a comprehensive understanding of the socio-ecological diversity that informed Roman architectural practices throughout the empire. By envisioning a potential 'Roman global hectare', the study aims to establish metrics that could facilitate broader comparisons of ecological impacts from Roman construction and other economic activities.

CHIARA THUMIGER

Change within the body, change within the world: Ecological conceptualisations of the body and its functions in Galen of Pergamon

Within Galen's immense output most specifically medical not only anatomy, individual pathologies and their localisations, bodily fluids and functions are scrutinised but also a strong interest in the human animal as a whole emerges: physiologically, as part of a system of sympathetic and (with our terminology) metabolic relations, ecologically, as influenced by the environment, and

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semiotically, as ensemble of signs to be observed, remembered, interpreted by the learned doctor.

On a number of occasions these clinical and physiological narratives resort to environmental images, in particular landscape, urbanistic, tending and gardening, and waters. These not only reflect a complex view of the body as community and interplay of forces and matters, but activate a particular depiction of the physician's role and activities as inserted within a larger context of operations.

In my paper I shall present some examples of these particular images of the body, and reflect on how they connect to the relationship with the patient Galen seems to describe, but also on the theoretical edifice they rely on. I will also offer some additional thought on Galen's biography (travels, sojourns, variations in professional setting) and how these might have influenced his work and choice of language.

SABINA FIOŁNA

Social network analysis of Roman provincial coinage – linking the micro-, and macro-perspectives on Anatolia

This presentation investigates the applications of Social Network Analysis (SNA) to Roman provincial coinage as a case study for linking micro- and macro perspectives. Despite its nascent application in numismatics and the challenges posed by the limited and fragmented nature of numismatic data, SNA holds promise for illuminating the interconnectedness of historical socio-ecosystems. By analyzing the structure of social networks of peer polities in Roman Anatolia, it reveals the underlying energy flows and interactions within past societies and bridges localized interactions with broader socio-economic dynamics across the Roman Empire. This perspective allows to move beyond linear, mono-causal explanations, embracing multi-causality, and interdisciplinarity. By mathematizing real-world phenomena, SNA connects humanities and sciences, providing a robust analytical tool to model socio-economic systems that can be used within the framework of social metabolism.

FABIAN BECKER – ROBERT BUSCH – BRIGITTA SCHÜTT – JORIS STARKE

Roots to ruins: Environment perspectives on the social metabolism of the Pergamon Micro-Region

Environmental dynamics impact the flow of materials and energy between nature and societies, i.e. the social metabolism. Social metabolism, in turn, affects flows of material and energy in the natural sphere of causation, which is traditionally analysed under the umbrella of *Landschaftshaushalt* (landscape balance). *Landschaftshaushalt* and social metabolism create a complex feedback loop between society and ecological dynamics.

In our talk, we review studies from the Pergamon micro-region to highlight the interplay between social metabolism and environmental change. We therefore integrate findings of landscape-geoarchaeological studies of alluvial sediment archives, erosion modelling, agroclimatic potential models for crop and olive cultivation, and a spatial analysis of the distribution of ceramic production sites.

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The relationship between social metabolism and environmental change in the micro-region depends on spatial scales. Land use for daily consumption in Pergamon might have focused on the direct environs of the city and small towns (Tobler-Thünen-law). The use of fuel for e.g. ceramic production is determined by the location of multiple resources including e.g. raw clay. Sediment analysis shows that besides an overall trend of increasing environmental dynamics during Roman times, (ex)urban areas are more clearly affected, while in remote areas, the effect is only vaguely visible. The crop-specific agroclimatic model shows that social metabolism of food production was in some areas of the micro-region heavily affected by (climatic) perturbations while other remained stable.

Overall, our approach highlights the importance of thinking social metabolism from different geographical perspectives. Social metabolism can be understood as a connecting link between archaeological and environmental data, but different spatial scales of analysis require further investigations to establish an unequivocal understanding of both. We advocate that environmental change in its temporal and spatial variability should be understood as an essential part of the social metabolism.

WOLF-RÜDIGER TEEGEN

Humans and animals as agents of social metabolism – Ancient Pergamon as an example

The following remarks are based on the model of social metabolism of the TransPergMicro project. Material and energy flows between the natural environment and society are examined. My contribution focuses on the role of humans and animals in this process. These interrelationships are explained using the example of ancient, especially Roman, Pergamon.

Paleopathological investigations contribute to a better understanding of the role of humans in the network of social metabolism. This is examined in more detail using the example of indoor and outdoor air pollution and the climatic conditions indoor and outdoor in the ancient city of Pergamon, based on diseases of the upper respiratory tract. It is noteworthy that in the Hellenistic period, people from the highest and lowest levels of society must have been similarly affected. Improved heating conditions (e.g. hypocausts) improved living conditions for the upper classes (at least for some?). This may also have reduced indoor air pollution. However, everyone was similarly affected by outdoor air pollution in the ancient city.

The importance of (domestic) animals is often forgotten, with the focus being on humans as the acting and determining subject. They are exposed to environmental pollution in the same way as humans. Domestic animals are not only a source of food and raw materials for humans, but also connect urban and rural areas through their labor. By transporting a wide variety of materials, they contribute significantly to a connection between the different areas of social metabolism. In addition, they play an important role in everyday religious practice as sacrificial animals in the communication between humans and deities. The dog has a special function in the cult of the dead, not only accompanying and protecting humans on their journey to the afterlife. In the form of miniature dogs, they also embody a special emotional element. Separate graves for dogs can also be interpreted as an expression of dog personalities. This gives them their own agency.

Humans can infect their animals with zoonotic diseases, but the same applies the other way around. The ancient city offered a wide range of opportunities for infection. However, these are only partially known and still require extensive research.

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BERNHARD LUDWIG – FELIX PIRSON – ANNEKE KEWELOH-KALETТА – ZEKI METE AKSAN – GÜLER ATEŞ – PHILIP BES – BERGLIND HATJE – BERSLAN KORKUT

The rural landscape and its role in the social metabolism of the Pergamon Micro-Region: Challenges and perspectives of archaeological research

The Pergamon micro-region, with its diverse landscapes of fertile plains, rugged hills, and natural resources, provides a promising setting for the study of ancient rural life in a diachronic perspective. Analyzing these rural landscapes allows us to understand the roles played by rural areas in sustaining both local communities and urban centers like Pergamon. This approach is framed within the concept of “social metabolism”—a term that refers to the interaction between human activity and natural resources. By examining how people extracted, processed, and consumed resources, we can better understand how ancient societies managed and transformed their environment.

This research is part of the interdisciplinary TransPergMicro project, which aims to investigate how urban transformation in Pergamon during the Hellenistic and Roman Imperial periods affected the settlement, resource use, and social-ecological dynamics of the surrounding micro-region, and vice versa. In this presentation, we want to illustrate key aspects of the rural landscape by focusing on five examples: clay mining, pottery production and consumption, agro-pastoralism, settlement patterns, and water engineering. Each of these represents a specific component within the project’s socio-ecological model: mining, crafts, agro-pastoralism, settlement, and infrastructure. These landscape components are coupled with the ecological sphere through the process of metabolism.

Our presentation aims to provide insight into these mutual relations, while also addressing the challenges we face as archaeologists in reconstructing complex metabolic processes.

LÉA GEISLER – ULRICH MANIA – URSULA QUATEMBER – THEKLA SCHULZ-BRIZE

Lower Agora and East Baths in Pergamon. Construction under different social-metabolistic regimes

The concept of urban metabolism has been a topic of discussion for decades, particularly in the context of modern cities. It focuses on the relationship between the consumption of materials and energy and the waste generated by human activities in urban spaces. This area of research is especially pertinent when addressing the need to make cities more sustainable. Keywords like “circular cities” highlight the emphasis on reducing waste, carbon dioxide emissions, and pollution while implementing material recycling and circular systems.

In contrast, within the framework of the TransPergMicro project, our focus shifts towards understanding the relationship between input and the outcomes of productive processes and their environmental impact. Accordingly, this paper aims to explore urban metabolism in ancient Pergamon, specifically in the context of construction and building practices.

To achieve meaningful and comparable insights, we analyze two distinct socio-metabolic regimes. These regimes correspond to typical patterns of material and energy flows during construction in two historical periods: the late Hellenistic era and the early Roman Imperial period. Our study centers on comparing the *chaîne opératoire* from the construction of the Lower Agora in the 1st century BCE and of the

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East Baths in the Gymnasium in the late 1st century CE.

This comparison enables us to estimate the relative energy and material demands required for the construction of these buildings. More broadly, it allows us to draw conclusions about the impact of construction on socio-metabolism during these two historical periods.

NICOLE NEUENFELD

Rubbish heaps of history – The significance of waste and waste disposal in the Pergamene urban organism

Within dense structures of human coexistence, waste represents a substantial category of material evidence that provides insights into various dimensions of ancient life. Drawing on Fischer-Kowalski's concept of social metabolism, waste and emissions are considered key outcomes of human activity. While this framework primarily addresses industrial societies, its principles can also be applied to Hellenistic and Roman contexts, though on a different scale. Waste provides diachronic insights into human activities and their spatial distribution within the urban fabric and surrounding micro-region. Beyond that, it also points to multi-scalar flows of material resources in a complex network, for example regarding interdependencies of economic activities.

This paper will provide an overview of common types of waste documented in Pergamon, focusing on the reconstruction of production, reuse, and disposal processes through material culture. By Cross-referencing the archaeological contexts with written sources, the administrative regulation of waste management and the utilisation of waste in legally regulated circumstances will be addressed. The study focuses on rubbish heaps located on the northern east slope of the city hill, exploring their role within the dynamic urban borderscape. These peripheral areas, rich in ancient waste and therefore archaeological evidence, offer key insights into interactions between the urban core and its surrounding micro-region. Based on a mapping of selected types of economic waste, it will be discussed whether and to what extent supply routes and economic networks can be reconstructed, shedding light on the interplay between the city, its borderscapes, and the micro-region. This approach underscores the critical role of waste management in understanding social metabolism.

JULIAN LAABS – FABIAN BECKER – ROBERT BUSCH

Exosomatic and endosomatic flows: Modelling Pergamon's social metabolism, review and prospects

The study of material and energy flows is essential for understanding ancient socio-ecological systems and exemplifies transdisciplinary entanglement. This paper reviews already developed numerical models of the social metabolism of the Pergamon micro-region. These models include estimates of the wood requirements for the production of building material (lime mortar, technical ceramics, bricks) that is used for the construction monumental buildings and the water supply system. They are complemented by agroclimatic models that address agricultural potentials, particularly crop and olive cultivation, in the Pergamon micro-region. Further, a template approach for modelling the material flows between economic sectors has been introduced.

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In a next step, we propose an approach that combines current models and incorporate additional details of material and energy flows such as a detailed chronology, labour, and dwellings. We distinguish between the endosomatic and the exosomatic metabolism of a society. The endosomatic metabolism includes the perennial energy and material flows required for the biological functions of the human body, e.g., heating, cooking, and bathing, as well as the periodic requirements for the production of the tools and products used to satisfy basic needs. Thus, it is a function of the size and demography of the population living in the Pergamon micro-region. The exosomatic metabolism covers the episodic, but often high requirements for building activities (viz. domestic and monumental buildings, supply infrastructure) and periodic requirements for the maintenance of infrastructure and buildings.

We highlight the complexity of modelling the social metabolism of the Pergamon micro-region, while proposing a rigorous yet implementable model to conceptualise and simulate it. Monte Carlo simulations help us to capture the inherent uncertainty of the model input parameters. A multi-scenario approach allows for testing various historical and archaeological hypotheses of the socio-ecological system of the Pergamon micro-region.

With our paper, we want to discuss the current main challenges of uncertainty connected to the modelling of past socio-metabolic flows such as an (absolute) chronological framework of activities and the system boundaries of the Pergamon micro-region, where most flows are located.

As part of the presentation, a poster is displayed to encourage attendees to further discuss the general structure and details of the models and to share their own thoughts.

ÖKMEN SÜMER

Archaeoseismology: A very important tool in active tectonic studies: Examples from Western Anatolia

Archaeoseismology is a field of science that investigates the remains of human structures of destructive earthquakes that occurred in their ancient history. In terms of etymological origin, 'Archaeoseismology' is opened in the form of 'scientific studies on ancient earthquakes' as the integrity of meaning with the combination of the ancient Greek words ἀρχαῖος (arkhaiōs) 'old/ancient', σεισμός (seismós), but in the sense used today, "Archaeoseismology" is an interdisciplinary branch of science that investigates the traces that occur as a result of destructive earthquakes in human structures and residential areas and that help define the characteristics of earthquakes. Although many authors wrote the effects of ancient earthquakes in various periods, the first modern archaeoseismology studies in the world gain momentum starting from the end of the 19th century at the same time with Türkiye, especially Western Anatolia. The formation of new data sets with the acceleration of systematic archaeological research after the 1950s contributed to the growth and development of archaeoseismology in Türkiye. Following the developments in the world in the mid-1990s, Türkiye's archaeoseismology also becomes a leap point for. Since the late 2000s, studies in different archaeological cities have gained momentum especially with in the Western Anatolian Extensional Province (WAEP). There are two main reasons for this; (1) Today, as in the past, human beings establish their settlements in areas made more suitable for life by courtesy of faults. In this direction, just like today, ancient settlements were also affected by the past earthquakes. (2) the WAEP, one of the most seismically active and rapidly

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expanding regions in the world, formed an approximately N–S-trending continental extension. Moreover, active tectonic studies conducted over the last twenty years within the WAEP reveal that the region is divided under the two main domains based on tectonic deformation. These are (1) Western Anatolian Grabens (WAG) which are characterized by approximately E–W-trending structures such as Gediz-Alaşehir, Küçük Menderes, and Büyük Menderes grabens, and (2) NE–SW-trending zone of weakness, named İzmir–Balıkesir Transfer Zone (İBTZ) which is characterized by active strike-slip faults. Both main tectonic domains are controlled by faults formed the basin structures, which are creates productive areas suitable for human life. Especially when we combined with these active fault structures and archeological sites on the same map within the WAEP, it is seen that almost every ancient settlement was built on the active fault. This situation is actually the most important indicator of how much the perspective of archaeoseismological data is needed to better understand the behavior and seismicity of faults for active tectonic studies.

In this presentation, first the inventory of archaeoseismological observations and studies prepared specifically for Western Anatolia, going back approximately 125 years, will be discussed in chronological order in the light of the Anatolian Archaeoseismology Catalog (ANARCA), which compiles all the archaeoseismological studies conducted in Anatolia to date with the tectonic position-time relationship, will be introduced. After, the contributions and importance of archaeoseismological data on the present-day Western Anatolian earthquake pattern and characteristics will be emphasized and discussed.

MAHMUT GÖKTUĞ DRAHOR

Active tectonics and seismicity in Western Anatolia. An example: on earthquakes in and around Pergamon

Earthquakes on the Anatolian plate, which is tectonically located between the Arabian, African and Eurasian plates, have caused significant changes and even interruptions in many Anatolian civilisations throughout history. The northward movement of the Arabian plate causes a continental collision with the Anatolian plate, while the northward movement of the African plate causes the development of subduction tectonics in the Hellenic arc. As a result of the southwestward movement of the Anatolian plate, extensional tectonics develops in western Anatolia. Depending on the tectonic evolution, the region generally develops N-S oriented and associated these orientations strike-slip faults and E-W oriented normal faults during the neotectonic process. Western Anatolia is one of the most seismically active continental regions in the world and much of it has been subject to NS-directed extensional deformation since the Early Miocene. The complex faulting mechanisms in the region give rise to large earthquakes. As a result of this phenomenon, the ancient cities of the region have suffered great destruction throughout history. The hypocentral distribution of earthquakes in the region indicates that the highest seismicity for the region occurs at depths of up to 10 km. Therefore, the region has high seismicity and generally shallow earthquakes with devastating consequences. While in the north of the region there are strike-slip faults associated with the North Anatolian Fault System, the central and southern parts of the region are predominantly normal faults and, in some parts strike-slip faults are observed in N-S and related directions. In particular, areas with sudden topographic changes due to the effects of normal faulting on the surface morphology of the region were chosen as settlement areas in historical periods, and the resulting major earthquakes caused great tragedies in these settlements. As a result, historical settlements within the influence of many active faults in western Anatolia were significantly destroyed, resulting in significant temporal breaks and

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sudden endings of historical periods in the civilisations of the region. As a result, in many settlements such as Sardis, Ephesus, Smyrna, Priene, Tralles, Hieropolis, Laodikia, which are located directly on fault zones, although the cities were completely destroyed as a result of major earthquakes in different periods, life in the cities, despite some interruptions, caused a continuity of settlement due to the richness brought by the tectonic features. The city of Pergamon, like other ancient settlements in the region, was built on a hill to the south of a Quaternary plain, controlled by active faults and affected by earthquakes that occurred at various times. In particular, the great earthquake that struck western Anatolia in 262 AD caused major damage to cities such as Ephesus, as well as serious damage to Pergamon and the collapse of some buildings. Probably due to the earthquake, Pergamon went into economic decline after this date and had to deal with various problems. At the end of this period the city was sacked by the Galatians. In conclusion, given the long period of high seismicity in the region, the documentation of the effects of earthquakes in the city of Pergamon and its surrounding historic cities and/or towns in geoarchaeological and archaeoseismological studies may help to shed light on some events in the history of the region.

