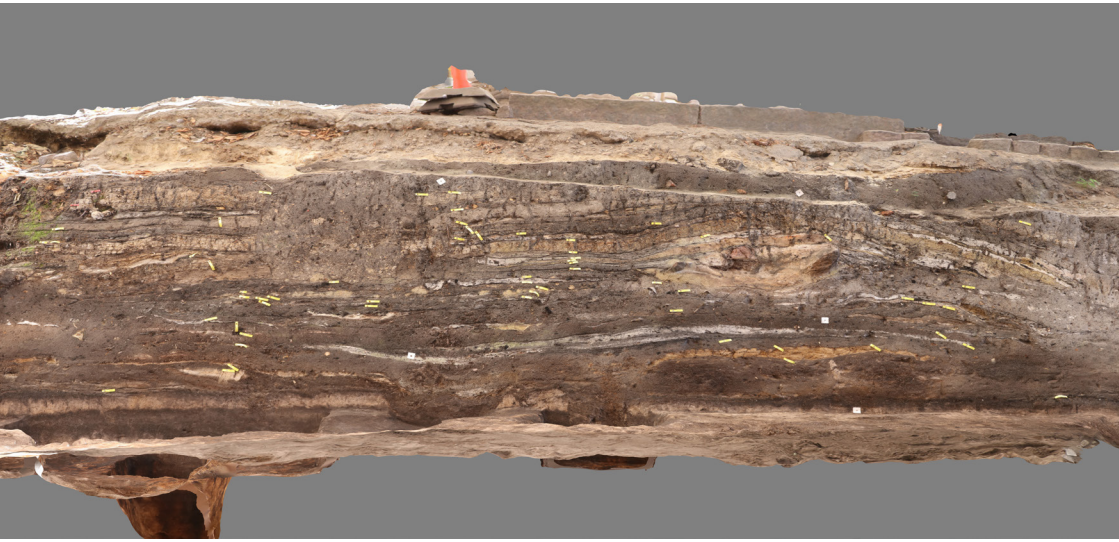
Complex Stratigraphies

8–9 May 2023

Organizers:
Søren M. Sindbæk, Rubina Raja, and Søren M. Kristiansen
Centre for Urban Network Evolutions (UrbNet), Aarhus University



UrbNet
CENTRE FOR URBAN NETWORK EVOLUTIONS
The Danish National Research Foundation

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Research Foundation

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Stratigraphy from Caesar's Forum, Rome, trench A, November 2021 (Photo: Søren M. Kristiansen).

Front cover
Stratigraphy from Ribe, Denmark (Photo: Søren M. Sindbæk).

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Stratigraphy from the Northern Emporium excavation in Ribe (Photo: Søren M. Sindbæk).

Outline

Since 2015 the Danish National Research Foundation's Centre for Urban Network Evolutions (UrbNet) has worked to develop high-definition approaches to excavations in complex anthropogenic deposits such as urban stratigraphies. This work has aimed to improve archaeology's methods for studying changes in human societies and their environment in relation to high-resolution chronologies. In the process, UrbNet projects have established refined integration of existing methods, and pointers to new emerging technologies. The aim of this conference is to discuss the state-of-the-art and prospects of this work with research partners and collaborators in the field.

Programme

DAY 1: Monday 8 May	
8:30–9:00	**Coffee**
9:00–9:30	**Welcome to UrbNet and Introduction to the Workshop** Søren M. Sindbæk, Rubina Raja, and Søren M. Kristiansen
Session 1: UrbNet Project Experience **Chair**: Rubina Raja	
9:30–10:00	**Northern Emporium Excavations in Ribe** Sarah Croix (Aarhus University)
10:00–10:30	**Reading Complex Stratigraphies through Soil Physicochemical Parameters: Sediments, Soils, and Sequences from Eastern Africa and Denmark** Federica Sulas (University of Cambridge)
10:30–11:00	**Coffee Break**
11:00–11:30	**A Tale of Luck and Quality: On High-Resolution Chronologies in Roman Towns** Guido Furlan (Aarhus University)
11:30–12:00	**Radiocarbon Dating and Urban Stratigraphy** Jesper Olsen (Aarhus University)
12:00–12:30	**On the use of Portable OSL Readers to Interpret Complex Sediment Stratigraphies** Tim Kinnaird (University of St. Andrews)
12:30–12:40	**General Discussion**
12:40–13:30	**Lunch** UrbNet
Session 2: The Methodological Frontier: Micromorphology, Lipidomics, SedaDNA **Chair**: Søren M. Kristiansen	
13:30–14:00	**Lab Visit: Department of Conservation and Natural Science, Moesgaard Museum**
14:00–14:30	**Defining the Criteria for Success: Micromorphological Sediment Screening (MSS) as a Quick Tool for On-Site Prioritization** Anna K. E. Tjelldén (Moesgaard Museum)
14:30–15:00	**Integrating Soil Micromorphology within the Archaeological Excavation Workflow** Cristiano Nicosia (Università degli Studi di Padova)
15:00–15:10	**General Discussion**
15:10–15:30	**Coffee Break**
15:30–16:00	**Environmental Forensics to Discover Emerging Pollutants, Natural Products, and Metabolites** Martin Hansen (Aarhus University)
16:00–16:30	**Ancient DNA in Sediments from Archaeological Contexts: How Far Have We Come?** Mikkel Winther Pedersen (University of Copenhagen)
16:30–16:50	**General Discussion**
19:00–	**Speakers' Dinner** Restaurant Et (Mindegade 8, 8000 Aarhus C)

DAY 2: Tuesday 9 May	
8:30–9:00	**Coffee**
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Session 3: New Projects and Prospects **Chair:** Søren M. Sindbæk	
9:10–9:40	**Dig for Eboracum: The Roman Quarter in Rougier Street** David Jennings (York Archaeological Trust, UK)
9:40–10:10	**Unlocking the Archaeological Potential of the Strategic Masterplan for the Castle Street / Werburgh Street / Ship Street Area** Ruth Johnson (Dublin City Council)
10:10–10:30	**General Discussion**
10:30–11:00	**Coffee Break**
11:00–11:30	**Wolin: Legacy and New Plans** Wojciech Filipowiak (The Polish Academy of Sciences)
11:30–12:20	**The SANDUR Projects – the Faroe Islands: Archaeological Investigations to Date and Promising Potentials** Ann Sølvia Selmarsdóttir Purkhús and Helgi Michelsen (Tjóðsavnið, Færeyska þjóðminjasafnið)
12:20–13:00	**Concluding Discussion**

13:00–13:40	**Lunch** Moesgaard Museum
14:00–16:00	**Visit to Laboratory Facilities at Geoscience and Aarhus AMS Centre**

Stratigraphy from Caesar's Forum, Rome, trench A, November 2021 (Photo: Søren M. Kristiansen).

Abstracts

Stratigraphy from Zanzibar, 2016 (Photo: Søren M. Kristiansen).

Northern Emporium Excavations in Ribe

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Complex stratigraphies hold the key to understanding archaeological site formation, as highly intricate objects shaped by multiple timelines, from the day-to-day to century-long developments. To track this high degree of eventfulness requires, however, excavation and analytical procedures able to generate acknowledge and integrate multi-scalarity, from the fine-grained to the structural.

The Northern Emporium project sought to answer old questions and gain new insights into the emergence and fate of an original form of urbanism in Viking-age Scandinavia, the emporium of Ribe in south-west Jutland. Previous excavations at the site observed the complexity of the stratigraphy, combining dark earths and millimetre-thin deposits, and great differences of preservation across the site. This allowed defining an effective excavation and recording methodology which allied micro-approaches (micromorphology) and macro-approaches (stratigraphic surface recording via 3D laser scanning).

Our efforts at integrating these multiple scales, as well as the constraints and potentials inherent to these approaches, led to intense discussions on-site and in post-processing concerning the 'nature' of the archaeological context, stratigraphic integrity, and the visualization of stratigraphic data.

In this presentation, I will review the methodological framework of the Northern Emporium, as well as the team's experiences and reflections about complex stratigraphies.

Reading Complex Stratigraphies through Soil Physicochemical Parameters: Sediments, Soils, and Sequences from Eastern Africa and Denmark

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Coastal and tropical environments challenge mainstream archaeological methods, often developed in and for inland and temperate regions. In these environments, centuries of even intensive settlement often result in compressed, shallow, and loose stratigraphies where contexts and strata are hard to define, record, and sample. At the other end of the spectrum, tropical climates and intense occupation can speed up site formation and post-depositional processes, producing thick deposits made over a very short time. Analysis and dating of stratigraphies are complicated further where the combined influence of terrestrial and marine processes determines differential deposition and preservation of materials (organic, biogenic, inorganic) used for AMS and OSL dating. Confronted with these challenges, UrbNet-funded work has focused on examining soil physicochemical parameters to determine site formation and post-depositional processes, guiding sampling for dating and building of contextual chronologies. Drawing from research at medieval settlements in Africa (Unguja Ukwu, and Great Zimbabwe) and a Viking-age grave in Denmark (Fregerslev), I will discuss how physicochemical parameters resolved seemingly 'unclear' stratigraphies. Reviewing the scale and nature of sampling and analytical strategies developed, I argue that establishing baselines of local environmental conditions and contexts across multiple spatiotemporal scales is paramount to tackle stratigraphies. Whilst we wrestle with the urban past of tropical and coastal environments, finding refuge in 'unclear' stratigraphies hinders the recovery, documentation, and preservation of the archaeological record. Unclear stratigraphies? 'The fact is that the observer had simply failed to observe' (Wheeler M. 1954, Archaeology from the Earth, p. 60).

A Tale of Luck and Quality: On High-Resolution Chronologies in Roman Towns

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Building high-definition chronologies is often related to the collection and processing of large quantities of data. But what about their quality?

Settlement continuity is a characteristic of several Roman towns, and Roman architecture was also particularly 'aggressive', commonly requiring massive operations and the movement of substantial volumes of sediments and building materials. This attitude did not involve only public buildings and infrastructures, but also private dwellings, meaning that the whole urban environment was frequently re-shaped, even deeply transformed. The movement of large amounts of sediments for building purposes implies a major displacement of sherds, making residuality a big issue. In other terms, secondary deposits are the rule, not yet the exception, in many urban archaeological sequences of Roman age.

Additionally, the output of everyday systemic activities (refuse), was generally routinely collected and disposed beyond the urban boundaries.

The combination of these two factors makes primary contexts extremely rare in a typical Roman urban sequence, therefore making it difficult to build sound and accurate chronologies.

Through the examination of three case studies from the Latin colony of Aquileia, the presentation aims to discuss the role played by the quality of urban deposits in achieving HD chronologies, as well as the role played by a factor rarely tackled by archaeological thinking: luck.

Radiocarbon Dating and Urban Stratigraphy

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Modern urban areas are places characterized by high-intensity activities of various kinds, not unlike what we know about prehistoric urban areas. Consequently urban chronologies are particularly challenging because the intensity of activities often blurs the stratigraphy needed for constructing accurate chronologies. Prehistoric urban stratigraphies therefore often show a lack of datable of material, a reuse of materials, or a mixed context of materials of different chronological origin.

Here a review of mostly UrbNet-related projects will be provided with the purpose of extracting guidelines for future work. Further, the excavation of Caesar's Forum will be used as an example of complex urban stratigraphy and how new methods may help to surmount some of the problems involved in constructing accurate chronologies for prehistoric urban places.

On the use of Portable OSL Readers to Interpret Complex Sediment Stratigraphies

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The development of portable OSL equipment has allowed relative luminescence stratigraphies to be generated in near real time in the field. Proxy information, in the form of IRSL and OSL signal intensities and depletion indices, can provide insights on the depositional histories in urban sediment stratigraphies. If conducted during excavation, the spatio-temporal trends observed in this proxy data, inform on sample selection such that dating priorities are matched to archaeological objectives. In post-excavation, evaluation(s) of geochronological data are frequently limited by uncertainties related to the inherent complex spatial and temporal variations in depositional mechanism(s) of anthropogenic deposits. Re-appraisal of the luminescence profiles generated in the field can provide insight on this, and create greater confidence in the chronological model(s).

To illustrate this, three case studies are presented (each at a different spatio-temporal scale): The first summarizes the OSL investigations at the Danish-Italian excavations at Caeser's Forum, Rome. Here, the > 4m of stratigraphy in area C of the forum was sampled at a high-resolution for OSL profiling, providing insight on the horizons/contexts that were likely re-deposited. This aided in the construction of the Bayesian model of the radiocarbon and OSL dates, and the establishment of a high-definition chronostratigraphy spanning from the Bronze Age to twentieth century. The second concerns the construction of cultivation terraces on Arthur's Seat, Edinburgh – an intra-urban rural setting. Here, by sampling across the entirety of the excavated feature, interpolated OSL intensity (-age) maps were generated, showing the gradual accumulation of soils on the cultivation slope, and enabling the terraces to be put into a relative chronological sequence across the slope. The third concerns soil erosion and degradation caused by historic landscape change in the municipality of Vetto d'Enza in the northern Appenines. Here, the relative luminescence stratigraphies were incorporated into soil dynamic models, and used to show how pre-industrial archaeological features can mitigate soil erosion in response to variable environmental conditions.

Defining the Criteria for Success: Micromorphological Sediment Screening (MSS) as a Quick Tool for On-Site Prioritization

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This project aims to develop a new tool for prioritizing effort and other decision making during excavation of complex anthropogenic deposits. Micromorphology is a well-known method to determine high-resolution chronologies, but a drawback is the long processing time that prevents it from feeding on-going excavations with crucial information. As part of the TITAN project at the Department of Geoscience, Aarhus University, alternative sediment fixation means are currently being examined in order to speed up the process. Low viscosity applications such as epoxy, acrylic, and Tetraethyl Orthosilicate are tested on soil samples with and without vacuum chamber impregnation. The aim is to fix and evaluate a sample within c. 3–4 days, giving the possibility to assist archaeologists with knowledge of complex stratigraphies still under excavation.

However, the question is how to define the criteria for success. Micromorphological sediment screening (MSS) does not equal a classical micromorphological analysis and may therefore not be considered as an alternative to such. Also, the type of information provided by MSS must be of actual use in the ongoing excavation. Therefore, three markers are used to determine whether the method is successful:

1) Discerning micro layers in dark, seemingly homogenous, depositions
2) Comparing and possibly differentiating depositions
3) Separating accumulated material in floors, ditches etc.

Finally, the screening method gives information where and what to sample for further analysis. MSS can thereby be used to guide strategy when excavating complex stratigraphies to ensure the fundamental research questions are addressed.

Integrating Soil Micromorphology within the Archaeological Excavation Workflow

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During open-air archaeological excavations undisturbed blocks are carved off the stratigraphic sequences of the site and brought to a lab where they are transformed into thin sections. Once these are available, the analysis of the site's stratigraphy can continue after excavations finish and, especially, at a resolution that could not be achieved by naked eye. Yet thin sections are very small 'windows' through which we observe stratigraphic units that can be laterally very wide and affected by marked lateral variability. This has an impact on the ability of soil micromorphology to reach its aim which, at the most basic level, is to establish what cultural activities or natural processes are responsible for the formation of a given stratigraphic unit. In the opposite scenario, stratigraphic units can be so finely stratified or even laminated that they cannot be resolved and properly excavated one by one in the field. In such a scenario, soil micromorphology is very useful to disentangle these superimposed repetitions of cultural activities and natural processes.

This presentation aims to present a selection of case studies pertaining to both scenarios outlined above, from both rescue and research archaeology projects. The idea is to try to highlight the limitations and the possibilities of soil micromorphology in archaeology, stimulating a discussion on how to better integrate the microscopic scale and the field scale.

Environmental Forensics to Discover Emerging Pollutants, Natural Products, and Metabolites

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Environmental Forensics is a newly established field of research to study environmental pollution, uncover pollutants, and identify potential sources. Non-target analysis using a variety of high-resolution mass spectrometry (HRMS) platforms are typically applied, and in synergy with data processing and analysis pipelines thousands of chemicals and endogenous metabolites are frequently uncovered from environmental samples.

Strengths and weaknesses for several HRMS techniques hyphenated with gas, liquid, and ion exchange chromatography (GC, LC, and IC, respectively) will be discussed in the context of untargeted metabolomics, lipidomics, and environmental pollutants, followed by a series of environmental study cases using non-target analysis.

We present a field study from an agricultural soil divided into sub-plots, and each plot treated with various types of fertilizers (e.g inorganic, human urine, sludge, and animal manure) according to good agricultural practices for 14 years prior to analysis. After exhaustive extraction, purification, and analysis using nanoLC-Orbitrap HRMS/MS, multivariate statistics could separate the soil treatment groups' pollution profiles and highlight important molecular features. Animal manure revealed natural compounds such as bile acids and steroids, while human urine led to pollution with common medicines.

In a subsequent study, sludges used as agricultural fertilizers from five Danish wastewater facilities were investigated using LC and GC-Orbitrap HRMS platforms, and ICP-MS. After extensive sample preparation and data acquisition, the sludge analysis revealed site specific molecular fingerprints, more than 21,000 substances and 57 different inorganic elements. Pharmaceuticals contributed the largest identified share of molecules followed by pesticides and natural products.
Recently we collected river and surface waters across Denmark and analysed using IC and LC-Orbitrap HRMS systems. Collectively, we discovered thousands of molecular features and structures were confirmed for 83 xenobiotics or degradation products from a variety of sources in the aquatic environment.

Two other studies focusing on groundwater and drinking systems were initiated. Groundwaters are vulnerable to pollution from sources such as agriculture and urban areas. Drinking water quality is an ever-increasing public interest.

Ancient DNA in Sediments from Archaeological Contexts: How Far Have We Come?

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The use of ancient DNA (aDNA) in sediments has emerged as a powerful tool to reconstruct past ecosystems and understand human-environment interactions. It is no longer confined to inferring about the presence-absence of organisms but also their genomic relatedness and change over time. However, this technique also possesses several challenges that must be carefully addressed to fully exploit its potential. Some of these challenges are stratigraphic integrity, degradation of DNA over time, lack of comparative reference genomes and time/cost efficiency.

Despite these challenges, the possibilities of using ancient environmental DNA are numerous. For instance, it can provide valuable insights into past biodiversity and help identify rare species that have left few physical remains. It can also reveal past environmental changes in urban settings and ecosystems, such as climate change or human activities on landscapes. Moreover, it can potentially provide a deeper understanding of the relationship between humans and their environment, including how past societies adapted to environmental changes and utilized resources.

In this talk, I will discuss possibilities and constraints when working with aDNA in sediments, and present perspectives for applying this method in high-resolution on complex stratigraphy from urban environments.

Dig for Eboracum: The Roman Quarter in Rougier Street

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While York is renowned as a Viking City, its Roman foundations have received less attention, and it is more than 30 years since the deep-waterlogged Roman deposits in the ancient city centre were seen on any large scale. Over the last four years York Archaeological Trust has been developing a project proposal to undertake a once-in-a-generation exploration of the Roman city of Eboracum. Building on our experience of running visitor attractions and engaging with the public through multiple channels, we have now received planning permission to undertake a large-scale excavation, with a complimentary public engagement programme, that will lead to the development of a new, iconic attraction, exploring the archaeology of Roman York.

Unlocking the Archaeological Potential of the Strategic Masterplan for the Castle Street / Werburgh Street / Ship Street Area

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Dublin City Council (DCC), in collaboration with the Office of Public Works (OPW), is undertaking a masterplanning and site feasibility exercise for the Castle Street/ Werburgh Street/ Ship Street area. Within this area are four key sites of archaeological significance.

The plan will provide preliminary design proposals for 3 sites and bring a new public realm plaza at the Castle gate to planning stage. It will carry out structural analysis and conservation appraisal of the City Wall a National Monument.

The area is one of key archaeological importance. The cluster of monuments represented includes urban defences, habitation, places of worship, burial, municipal functions, and industry. The archaeology is rich consisting 3–4m of waterlogged deposits. The earliest levels contain evidence of the ninth century dún, and the tenth to twelfth century town, with its earthen and stone defences, structures, and habitation-material.

The plan will develop methodologies for pre-development excavation using the latest research, cutting-edge methods, and techniques. Excavation will be balanced with a long-term preservation strategy. The publication of a 'high-definition' excavation would enable Dublin to take its place in scholarship besides other great Viking towns of the world such as York, Birka, Hedeby, Kaupang, Aarhus, Ribe, Staraya Ladoga, Novogrod, and Kyiv. The masterplan offers the opportunity to develop a long term cultural use incorporating interpretation of the archaeological results.

Wolin: Legacy and New Plans

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Wolin is one of the largest and most important archaeological sites from the early medieval period on the Baltic coast. Thanks to the favourable natural conditions in the marshy peat, the remains of a trading emporium, a proto-city functioning under changing socio-political-religious conditions from the eighth to the end of the twelfth century have been preserved. Numerous Latin, Old Icelandic, and Arabic written sources are also associated with Wolin. It is in them that legends connected with the city have been preserved – the legend of the sunken city of Wineta and the legend of the Viking fortress Jómsborg. The latter have been the cause of historians' interest in the city since the sixteenth century, while in the early nineteenth century archaeological research began in the city, which intermittently continues to this day. The largest dataset, on which most of today's interpretations are based, was acquired between 1952 and 2003.

In the paper, the author will briefly present the history of Wolin's research and critically discuss the theoretical and methodological approaches used to date. This will be followed by a presentation of recent discoveries and a summary of the hypothesis regarding the location of the legendary Jómsborg. Finally, the planned future wide-ranging research will be discussed, which is intended to be a grand archaeological and anthropological experiment, linked to public diplomacy. This research is being prepared jointly with the Danish side.

The SANDUR Projects – the Faroe Islands: Archaeological Investigations to Date and Promising Potentials

Ann Sølvia Selmarsdóttir Purkhús and Helgi Michelsen
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The archaeological investigations led by Tjóðsavnið in the village of Sandur has provided widespread and extensive knowledge about the archaeological remains, situated along the eroding coastline on both side of the bay.

Archaeological research has verified extensive settlements and early church phases. The settlements were abandoned ca 1200 AD due to environmental changes. Hereafter, 1–2 m deep and protective aeolian sand deposits sealed the remains of the settlement.

While working on the extension of the churchyard, investigations revealed remains deriving from earlier settlement and industrial activities as well as Viking burials. A recent PhD project reassess the Viking-age burials and adds new perspectives and understandings about the Viking burials and the surrounding landscape.

Tjóðsavnið has collaborated with international universities and institutes within the project the *Heart of the Atlantic*, which provided new insight in the exploitation of natural resources, covering three major occupation phases from around 800 to 1200 AD. New archaeological prospection has revealed widespread archaeological structures beneath the deep sandy soil layers.

The archaeological experience has shown that the eroding coastline, the aeolian deposits and the stratigraphy of the archaeological remains are highly complex to excavate. Large-scale future excavations therefore necessitate thorough planning.

The current plan is to continue to map and visualize the archaeological structures hidden under the sand, implementing existing and new state-of-the-art archaeological prospection methods.

Venues

Scan the QR code for a link to Google Maps

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Back cover: Exposed stratigraphy in Trajan's Forum adjacent to Caesar's Forum in Rome (Photo: Rubina Raja).