Abstracts

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Presentations and Posters

Session: Past mitigation: Sucesses and failures

1) A future present: Wrap a wreck!

J.H.B. van Os, B. Speleers, L. Roorda, G. Schreurs and H. Huisman

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Many 16–18th century shipwrecks have been found after reclamation in parts of the former Zuyderzee, one of the busiest waterways in Dutch history. After the land fell dry, some shipwrecks were removed, reburied or covered with sand or clay. In the late 1970's a method was devised to mitigate degradation processes in some of the still remaining wrecks in good condition by wrapping them in plastic foil. First a small mound was constructed that was subsequently covered with plastic foil (0,5mm black PVC) but leaving an opening in the middle. The idea was that the plastic would prevent evaporation and lateral subsurface flow and that rainwater would be collected and transported towards the centre of mound, keeping the mound and wreck wet. Wet conditions would prevent the decomposing of wood by especially fungi as anaerobic conditions would quickly develop in the mound because of the limited water transport and the availability of organic matter.
Recent monitoring of wrapped shipwrecks has shown that this method of preventing rot worked exceptionally well. However, not all shipwrecks were wrapped in the 1970 and 1980's. As the method of wrapping was not applied for three decades, we adapted it using new technology nowadays applied for sealing tunnels and landfills. We will present the execution requirements, materials and the new adapted method for wrapping shipwrecks in reclaimed land.

Biography
Bertil van Os has a phD in marine geochemistry and a background in geochemical mapping and analytical methods. For 7 years now he has been working as Senior Scientist *in situ* conservation of archaeological sites at the cultural heritage agency, Netherlands. Special subjects: groundwater; soil; metal corrosion; mitigation measures; shipwrecks, archaeological information; combining public access and preservation.

Session: degradation processes …

2) Archaeological Artefacts, Strain Gauges and Servo-hydraulic Piston: Laboratory Research on the Effects of Heavy Equipment Compaction to the i*n situ* Preserved Archaeological Remains.

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Following the Malta-convention the preferable way for the physical protection of an archaeological site is its preservation *in situ*. When planning *in situ* preservation, besides other things, it is necessary to consider changes in physical environment and their impact on *in situ* preserved remains. This is especially important when human interaction takes place. Recently an increase of building on top of archaeological sites can be observed, so the effects of heavy equipment compaction needs to be studied in more detail.
This paper presents research on the effects of the use of heavy equipment (e. g. rammers and rollers) compaction on archaeological remains. For the purpose of our research, laboratory testing has been performed. In a custom made steel case artificial archaeological sites were created using layers of sandy silt and gravel. In such created environments a variety of archaeological and modern artefacts were placed. Some of them were equipped with strain gauges for deformation recording. Through a series of tests a servo-hydraulic piston was used, which simulated the loading of the artificial sites. Humidity and temperature were recorded before, during and after each test. Since layers and artefacts were three-dimensionally recorded before and after each test, compressions of layers and movements of artefacts could be studied. With strain gauges and visual inspection after each test deformations and thus damage to artefacts was recorded.
The goals of our laboratory tests were the development of a new methodological approach to study the effects of heavy equipment compaction to the archaeological sites, getting an insight into the problems of such tests and the estimation of the applicability of their results. With the presented results our research has been a step towards a better understanding of the effects of heavy equipment compaction to archaeological remains and thus to the preservation of archaeological sites *in situ*.

Biography

Tamara Leskovar has a university diploma in Archaeology at the University of Ljubljana, Faculty of Arts. From 2013 on she has been working as a young researcher at the private archaeological firm Arhej d.o.o. She is also a PhD student at the University of Ljubljana. Her PhD thesis is on the impact of physical environment to *in situ* preserved archaeological remains.

Vlatko Bosiljkov has a degree B.Sc. with a diploma at the University of Belgrade, Faculty for Civil engineering in Belgrade, since 1991, M.Sc. at the University of Ljubljana, Faculty of civil and geodetic engineering in Ljubljana since 1997 and Ph.D. at the same Faculty since 2000. He works as associate professor at the University of Ljubljana, Faculty of civil and geodetic engineering in Ljubljana.

3) The conservation and degradation of archaeological soil features in Flanders and Brussels: a state of the art

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Archaeological soil features can be defined as soil features and/or characteristics related to human activity. Examples are:

- negative features like ditches, pits and plough marks;
- positive features like barrows;
- living floors, trampling features, tillage layers;
- associated features like iron crusts and phosphorus concentrations.

In this contribution we will present an overview of our knowledge on the degradation processes affecting these archaeological soil features, illustrated with recent field data. This contribution presents an overview of the soil degradation processes detected during an interdisciplinary project between archaeologists and soil scientists launched in 2005 by the Belgian Flemish Community. This data base is further completed with recent field data. Main issues that will be dealt with include:

- the effect of the soil properties on their preservation;
- the impact of biological, physical and chemical processes;
- the impact of human activities (agriculture, forestry, building, …).

Based on this knowledge a series of good practices will be presented.

4) Oxygen dynamics and decay rates in unsaturated archaeological deposits

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Monitoring of the archaeological deposits at the World Heritage Site Bryggen in Bergen has been ongoing since 2001. The site and initial results have already been presented at PARIS3 in 2006 (focusing on hydrogeological modelling and mapping of areas with good/poor preservation conditions) and at PARIS4 in 2011 (focusing on modelling and visualization of decay, and standardization of monitoring methods). Since PARIS4 the work at Bryggen has moved into a new phase with a large-scale mitigation project aiming at raising groundwater-levels and increasing soil moisture content in areas that are characterized by poor preservation conditions. Monitoring is carried out both above and below the water-table, but this presentation focuses on the unsaturated deposits.
Oxygen is a key parameter in the degradation of archaeological material in the unsaturated zone, and the monitoring at Bryggen includes monitoring of oxygen concentration *in situ* in unsaturated deposits, including layers with varying porosities and grain size distributions. The data are compared to measurements of soil moisture content, temperature, groundwater level and precipitation, and this forms the basis for discussion of the oxygen dynamics in the deposits. Furthermore, the monitoring data are used to evaluate decay rates of organic material in the deposits, based on laboratory measurements of decay at various controlled temperatures and moisture contents. The data are used to evaluate the effects of soil moisture content on decay rates and to estimate "how wet is wet enough" in relation to reducing oxygen diffusion and rate of decay *in situ* to an acceptable level. The effects of drought, precipitation events, and the ongoing mitigation works at Bryggen are briefly discussed.

Biography

Henning Matthiesen is a senior researcher at the National Museum of Denmark, where he is working with the *in situ* preservation of archaeological remains. His research is focused on urban deposits, wetlands and frozen sites.

Jørgen Hollesen is a senior researcher at the National Museum of Denmark in the field of *in situ* resevation of archaeological remains. His work is focused on improving the understanding of the coupling between environmental conditions, soil processes and the decay of organic materials.

Rory Dunlop is an urban archaeologist working at NIKU's Bergen office, with more than 30 years' experience of all kinds of archaeological investigations. He has become increasingly specialized in aspects of archaeological monitoring since 2001, particularly in connection with the work at Bryggen.

5) Modelling environmental conditions and decomposition rates in organic cultural layers

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Methods to investigate and evaluate the sensitivity of the organic cultural layers to environmental changes are needed in order to cope with the increasing pressure from climate change and urban development. The use of computer models is becoming more common and almost a prerequisite for assessing the responses of the "natural" soils to changes in the complex and interacting climatic parameters. However, in relation to *in situ* preservation very few attempts have been made to model environmental conditions as well as decomposition. In this presentation we will present two different study sites where we have used computer models to perform a detailed investigation of the coupling between environmental conditions and decomposition. The first site is the archaeological deposit at the World Heritage Site Bryggen in Bergen representing an urban site that is highly influenced by drainage, reduced infiltration capacity as well by heat from buildings. The second case study is the Qajaa kitchen midden in Western Greenland representing an Arctic site which is threatened by increasing air temperatures, thawing permafrost as well as changes in the water balance. Our results emphasise the advantage of combining monitoring data with laboratory studies and the methods presented are applicable to practical mitigation work in order to document in more detail where and when degradation takes place, and thus also where and when mitigation should be carried out.

Biography

Jørgen Hollesen is working as a senior researcher in the field *in situ* preservation of archaeological remains. His work is focused on improving the understanding of the coupling between environmental conditions, soil processes and the decay of organic materials.

Henning Matthiesen has been working for 15 years as a senior researcher in the field of *in situ* preservation of archaeological remains, with special focus on organic materials and metals in wetlands, urban deposits and at frozen sites.

Bo Elberling is professor and head of Centre for Permafrost (CENPERM) at the University of Copenhagen. He is working with soil processes and release of greenhouse gases from natural soils especially in the Arctic and Antarctic area.

6) The deterioration of archaeological remains by shipworm

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Since *in situ* preservation of archaeological material has become more widespread (European Union, 1992) the need to stop an active attack of *Teredo navalis*, a wood-boring mollusc, on waterlogged archaeological wood has become more urgent. The aim of the current study is to examine the ability of two plastic materials (TERRAM4000 and a plastic membrane) to stop both initial attacks by *T. navalis* and their effects on wood with active woodborer degradation. The shipworm feeds on the sugar molecules in the wooden cell. In the degradation process of wood the cellulose is lost and thereby the shipworms means of nutrition. The aim of the study is also to examine the state of degradation of waterlogged archaeological wood in order to assess the possibility of a potential attack of *T. navalis*. Blocks of pinewood were submerged in the southern part of the Kattegat in Denmark, where shipworm is known to be prolific. After settling and an attack had been confirmed, the blocks were removed and wrapped in either TERRAM4000 (polypropylene and polyethylene) or a proprietary plastic membrane (polyethylene), normally used on fishing piles or piers, as a protection against shipworm in Denmark. An optical oxygen sensor was packed together with each block to measure the amount of available oxygen around the wood. After one week the oxygen level around the test blocks wrapped in the plastic membrane had dropped drastically and lead to the death of all shipworms within the test blocks after one-four weeks. Although no new shipworm attacked the wood wrapped in TERRAM4000, the geotextile did not impede the passage of oxygenated seawater, as living individuals were found in the blocks after 46 weeks of wrapping and submersion. Blocks of waterlogged archaeological wood in different states of preservation (detected by density and composition analyses) where also submerged and the attack rate was observed. After submersion the well-preserved heartwood of the wood was attacked where the less well-preserved sapwood was left intact.

Biography

Anne Marie Eriksen, MSc, has a degree in Conservation of Natural History. She has been working as a Research Assistant at the National Museum of Denmark since 2013 and has specialized in biological degradation of wooden objects in the marine environment. She is also a commercial diver.

David Gregory gained a BSc in archaeology at the University of Leicester, MPhil in maritime studies at St Andrews University and PhD in 1996 at the University of Leicester. He is currently employed as a research professor at the National Museum of Denmark investigating methods of *in situ* preservation of waterlogged and underwater environments.

7) *In situ* preservation of the Iron Age Warrior Bones of Alken Enge, Denmark. Preliminary Results

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The rich Iron Age human sacrificial material of a defeated army from the Danish bog, Alken Enge, is extraordinary not only from an archaeological perspective but also from a preservation point of view. By dividing the human tibia into three groups, different research possibilities are provided: 1) recently excavated, very well preserved, 2) recently excavated, very poorly preserved and 3) 50 years old excavated, very well preserved (same site). The focus of this project is to link the state of preservation and diagenetic changes of the material directly to the preservation conditions and threats *in situ.*
The human bones are examined using a broad combination of techniques ranging from High Resolution peripheral Quantitative Computed Tomography (HR-pQCT) scanning, histological examinations by transmitted light microscopy, Fourier Transform Infrared Attenuated Total Reflection spectroscopy (FTIRATR), thermogravimetric analysis and synchrotron FTIR spectromicroscopy. The environmental conditions *in situ* are monitored by automatic logging of water table, temperature and groundwater conductivity, measuring soil moisture in the unsaturated zone, assessing groundwater chemistry through traditional sampling and passive Sorbisense® units, and measuring *in situ* pH, oxygen and redox potential during several campaigns. The vegetation is mapped to identify and locate plant species with long roots that can have adverse effects on organic artefacts. To investigate ongoing decay (types and rates), femur bone samples from recent pig (*scrofa domesticus*) have been placed *in situ* and will be retrieved and examined after 1-2 years. To further examine the decay rate, respirometer measurements of archaeological human tibia are carried out, assuming the microbial decay of organic components takes place under oxygen consumption. Decay rates and processes are evaluated by combining the different measurements with geochemical modelling (PhreeqC). This study will produce qualitative and quantitative decay rates for archaeological human bone, enabling cost-effective future assessments of *in situ* preservation conditions in semi-wetlands.

Session: first things first

8) Dom Under, displaying *in situ* archaeological remains; Keeping it wet and dark

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Dom Under, a new underground visitor centre in Utrecht, the Netherlands, is displaying spectacular brickwork from Roman and Mediaeval times as well as clayey soil profiles encapsulating the story of the Roman occupation and the transition to early Mediaeval Christianity. As the groundwater level is close to the lowest point of the exhibition, the clayey profiles and the brickwork are still relatively moist. The exposure to open air will eventually dry out the soil profiles and the mortar of the brickwork. Therefore the challenge was to prevent this dehydration and to stabilize the brickwork while keeping the archaeological integrity of the site intact. The first idea was to impregnate all profiles and brickwork and seal the exhibition form the groundwater creating a museum environment. However, experiments to impregnate and to stabilize clay profiles failed. Using the experience of partners from the Portico[1] network and similar exhibitions in Cologne and Ljubljana, several micro climatic environments were created ensuring high humidity where needed, to secure the stability of the exhibition. In our presentation, all aspects of how to exhibit fragile archaeological remains *in situ*, from visitor management, monitoring and micro climatic control will be addressed.

[1] www.portico.nu

9) How to carefully construct a hospital over a Roman boat in central London

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This paper will examine the case of a Roman boat, buried beneath Guys Hospital in London, England. The boat was discovered in 1958, with a small part of one end uncovered. The land has been carefully left free of disturbance since that date, and the site was legally protected in the 1980's. In 2009, a proposal was put forward to construct a 14-storey Cancer Care building within Guys Hospital, on the site of the boat; clearly raising challenges for the preservation of the boat. However, planning law in England requires the significance of the heritage to be considered in line with the public benefits of the proposed scheme. In this case, with clear need for cancer treatment, it was important to consider whether the building could be constructed, whilst preserving the boat *in situ*.

Design parameters were explored, and it seemed feasible to proceed. A trial pit was opened to see if any remains of the boat survived. It was of course possible that the remains seen in 1958 were the entirety of the boat remains, or that any other remains might have deteriorated since then. However, well-preserved timber planks and nails were preserved 4.5m below ground level, and thought to represent the middle part of the boat. Archaeologists worked closely with the designers, but from the outset determined that more was needed than the usual scheme of preserving a site, monitoring it but having no solution if the monitoring data showed deterioration.

A monitoring scheme has been devised with trigger levels, and a timetable where if the data are ambivalent, the timetable will be extended. If additional trigger levels are met, then it will be concluded that the boat is in danger, and should be excavated. The structural engineers were instructed to design foundations that would permit excavation (via tunnelling) of the boat. This was all secured through a legal agreement, making this one of the few projects in the world to have a clearly structured and enforceable plan, should the monitoring of a site show demonstrable deterioration.

Session: changing climate …

10) Research and monitoring on conservation state and preservation conditions in unsaturated archaeological deposits of a medieval farm mound in Troms and a late Stone Age midden

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This paper presents the archaeological observations and archaeobotanical and geochemical samples analysed from investigations in 2013 of two rural sites with preserved archaeological deposits, which constitute the basic research material for evaluations of conservation state and preservation conditions. These are combined with climate data and the first year of continuously monitored soil temperature, moisture and redox potential in sections, using two different sets of equipment on both sites. The data has been collected in collaboration with the partners of the NCR funded research project, 'Archaeological Deposits in a Changing Climate. *In Situ* Preservation of Farm Mounds in Northern Norway'. It is the first Norwegian research project on preserved rural archaeological deposits and the results may have consequences for heritage management of a large number of sites from all periods
The sites differ considerably, both in time and contents. The Finnmark site had dry, porous deposits with a high content of marine remains, ensuring good preservation conditions for bone. The Troms site had a very high content of organic matter and water, showing high potential for preservation of organic materials and was dominated by terrestrial remains. Archaeological samples have been investigated for decay rate or decomposition. The preservation conditions measured and monitored show stable conditions in Troms and stabilizing at the Finnmark site. Can we discern any changes in preservation at the two sites? If so, are they caused by climate change, or do we merely see what happens in an extreme environment? How safely are these sites preserved *in situ* for the future?

11) Tools for predicting damage to archaeological sites caused by one-dimensional loading

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We present the tools that we are developing to predict damage to archaeological remains caused by the construction of line infrastructure, at scales ranging from the site scale to the millimeter scale. Our tools are based on numerical modelling and laboratory testing supported by X-ray micro-computed tomographic observations, as well as micro-morphological analysis of thin sections. They have been partially validated for one-dimensional (1D) loading at two Dutch test sites where soil has been placed on top of organic layers rich in ecofacts and overlaying Pleistocene sands.
We show that predicting numerically the deformation of soft layers underneath an embankment remains a challenge for geotechnical engineers. Despite a thorough site investigation, errors on surface settlement prediction reach +/- 10% of the measured total settlement. The complexity of soft organic soil behaviour is not captured in the models currently implemented in commercial software. Moreover, scale effects in fibrous peat and sample disturbance can affect soil test results and, therefore soil parameter determination.
From our laboratory simulations and observations we concluded the following:

- Vulnerable artefacts (crushable charred wood and cereal grains) can get crushed when packed loosely in pure assemblies under 1D loading equivalent to less than 5 m of sand. Fragmentation is assimilated in our study to loss of archaeological value as it compromises recovery during sieving.
- Embedment in a sandy or a very compressible organic matrix has a beneficial effect on the resistance of charred and non-charred ecofacts. Ecofacts can then support more than 12 m of sand.
- Flattening and re-orientation of soft plant remains occurs during 1D loading without microscopic damage of tissues.

To further investigate the effects of construction on archaeological sites, our work has to be extended to shear loading, known to be more destructive than 1D loading. Shear conditions prevail underneath the toe of an embankment or the tip of piles.

Biography

Dr Dominique Ngan-Tillard is an Engineering geologist at TUDelft, the Netherlands, expert in: soft soil site investigation and characterisation for geo-engineering applications, physical modelling of the impact of environmental changes on geomaterials including archeological materials, soil and rock testing supported by observations with the help of X-ray (micro-)CT scanning and ESEM.

Session: Lake Constance Area

12) Archaeology and *in situ* Preservation in Canton Thurgau

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The canton of Thurgau (approx. 1000 m^2) is situated in the north-east of Switzerland and stands out through its diverse landscape by Lake Constance, hill range and the Thurtal. The archaeology is overseen by the cantonal Department of Archaeology Thurgau. The archaeological map is very complete. Over 1000 sites exist beginning with the Paleolithic up until modern time. The main focus lies on the prehistoric lakeside dwellings (among them four UNESCO-World Heritage Sites) as well as roman sites with partly extraordinarily good conservation conditions. The *vicus Tasgetium* (Eschenz) has brought forward one of the internationally largest collections of roman wooden objects and wooden findings.
The Department of Archaeology Thurgau conducts field surveys, excavations and scientific research. The collections and archive are also of great importance. The main goal is to keep the numerous sites of the canton *in situ*. In sensitive shore areas, where erosion (pounding of the waves, shipping etc.) threatens the exposed prehistoric cultural layers of the pile dwellings, measures are taken to cover the areas and keep the destruction at bay. These interventions are accompanied by monitoring. But also numerous roman and medieval ruins are restored to the latest level of standard and therefore prevented from gradual destruction. Due to zone plans and a close working relationship with the local authorities timely intervention can take place when threatened.
The results of the archaeological research are conveyed to the public and professional circles in the Museum for Archaeology as well as in popular and subject-specific publications.

Biography

Hansjörg Brem is the head of the Archaeology Department of Canton Thurgau, he was chairman of the Swiss Archaeological Society 2006–2009. Before joining the management of the Department, he specialised in numismatics, roman and medieval archaeology in Switzerland, Italy and Germany. He is currently attending different international projects about preservation of archaeological remains in the region of Lake of Constance.

Urs Leuzinger is Deputy Canton Archaeologist and Conservator of the Museum at the Archaeology Department of Canton Thurgau. He is also associate lecturer at the Institute for Archaeology of Leopold-Franzens University Innsbruck, Austria. His field of research is the Neolithic lake-dwellings in the Circum-Alpine region, but recently, he has also been appointed as Project Manager of the interdisciplinary research project “Eschenz – the Roman vicus Tasgetium”.

13) Lake dwellings in Baden-Wuerttemberg, Projects of conservation *in situ* at the Lake of Constance and in the Lake Federsee moors

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The Baden-Wuerttemberg shoreline of Lake Constance and the lakes and moors of Upper Swabia contain more than 100 wetlandsites of the Neolithic (4200–2400 BC), Bronze Age (1900–850 BC) and Iron Age (700–600 BC), 15 of them are definitely listed within the UNESCO World Heritage "Pile Dwellings around the Alps" since 2011. The discovery of the lake dwelling settlements in the 19th century was met with fascination and sparked off the beginning of a multi-discipline research approach. During the 1920s, a broad program of research excavations was undertaken in the SW German wetlands, but aspects of cultural heritage preservation developped slowly. Since 1979 new research brought not only important finds to light, new chronologies and scientific results but also increasing information about bank erosion in the lakes and dessication in the moorlands. First attempts to prevent further erosion by geotextiles and a coverage of gravel started in 1986 in the bays of Wangen and Sipplingen on the northern shore of Lake Constance. With further preventive projects at Bodman, Nussdorf and Unteruhldingen the know-how improved, but crucial questions still remained: best practise?, ecologic compatibility?, other options? The international project "Erosion and Archaeological Heritage Protection in Lake Constance and Lake Zuerich" in the frame of INTERREG IV 2008–2011 brought deeper insights and opened the field for new experiments with preventive measures. In the Federsee moor, the archaeologically most important wetland in SW Germany, a long term project started in 1980 in close collaboration with nature conservancy and archaeological heritage management. With archaeological stock taking, the acquisition of land, the establishement of new nature-sanctuaries, the exchange of landholding and ventures of hydrographic egineering the project came to an end with the help of EU-funding by LIFE+ in 2013. The groundwater table in large parts of the moor could be enhanced by filling up 26km of drainage ditches and altering the level of the main watercourses. The State Office for the Protection of historical Monuments Baden-Wuerttemberg subsequently follows the measures at Lake Constance and in the Federsee moor by monitoring.

Biography

Helmut Schlichtherle is director of the section „Wetland Archaeology at Baden-Wuerttemberg Heritage“. As an archaeologist he has directed rescue and research excavations in the wetlands of Lake Constance and Upper Swabia for 40 years. He is involved in projects for the preservation of prehistoric lake dwellings *in situ*. Since 2011 he is a member of the International Coordination Group for the World Heritage Pile Dwellings around the Alps.

14) Erosion hazards to prehistoric cultural layers in the littoral of large pre-alpine lakes: a conceptual framework with examples from Lake Constance

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The destruction of underwater cultural remains is a widespread phenomenon in the littoral zone of large pre-alpine lakes, as it is the case in Lake Constance. This contribution opens a broader view of the erosion of sediments and similar processes on the littoral platform, covering aspects of (1) identification of erosion and related processes, (2) time scales, dating, and the importance of palaeolimnological archives, (3) measuring current erosion/accumulation rates and sediment budgets, (4) measuring and modelling the wave field, currents, shore exposure and sediment transport, (5) natural *vs*. anthropogenic factors, and (6) options for the preservation of threatened cultural remains.
Specifically, we focus on (i) the surface wave field at selected UNESCO World Heritage Sites of Lake Constance, (ii) the mobilisation of surface sediments (suspension and bed load transport), and (iii) the efficacy of archaeological preservation measures. Besides the occasionally occurring windstorm waves, ship-generated waves are locally also very important. During the summer months, the surface wave field in terms of wave energy fluxes to the shore can be dominated by ship waves. The suspended load typically contains particles with grain sizes up to 2 mm. In the sediment traps mainly coarse silts and fine sands (0.035 to 0.112 mm) accumulated during the study period of nine months. The bed load transport was investigated using newly developed particle tracers. Pebble tracers showed virtually no significant movement. Only the fine gravel and smaller grains (Ø <3.5 mm) were transported over greater distances. These results strongly indicate that the preservation measures, composed of gravels and pebbles, are hydrodynamically stable.
We conclude that surface waves, their interaction with seasonal water level fluctuations and the negative trend of water level in Lake Constance, are one of the main reasons for the progressive sediment erosion at the UNESCO World Heritage Sites investigated.

Biography
The authors are limnologists with a professional background in sedimentology (WO) and environmental physics (HH, FP) and an archaeologist with special expertise in wetland archaeology (HS).

Session: Monitoring + Mitigation

15) Monitoring and management options in urban waterlogged deposits

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Baseline survey in 2007 characterized the physical and chemical conditions for preservation within waterlogged remains at Nantwich. Installation of 17 dipwells has allowed a five year monitoring programme to be conducted, initiated in January 2011. Groundwater level and water quality parameters are recorded including dissolved oxygen, conductivity, pH, temperature and redox potential on a quarterly interval, whilst gas meter readings (H2S, methane, CO2, oxygen, CO) are also taken on this interval. Groundwater levels were taken using an audible dipmeter, whilst *in situ* water quality parameters were measured by inserting a digital YSI 556© water quality meter into the dipwell , In order to provide more frequent groundwater level measurements, six water level data loggers (Solinst© Levellogger pressure transducers) were installed into key locations, which recorded data on a daily basis. Groundwater samples have been taken annually using a peristaltic pump discharging through a flow cell connected to a water quality meter, to record pH, redox potential, conductivity, temperature and dissolved oxygen.
Initial results show two main zones of preservation, with reducing conditions adjacent to the river attributed to location of the deposits within the capillary zone, into which increased levels of oxidisation are introduced by rainfall, and a second zone uphill with more variable conditions for preservation. Waterlogging is closely related to underlying geology. Geochemical groundwater analysis shows sulphates within all samples but no sulphides, with dissolved methane in 10 samples. Ground gas monitoring indicates elevated concentrations of methane and carbon dioxide in areas adjacent to the river, which correspond with depleted oxygen levels. The investigations at Nantwich show that sediment coring programmes combined with dipwell installations can provide useful data to assess and monitor *in situ* preservation conditions, and can help in formulating management strategies for the conservation of waterlogged archaeological deposits.

16) Re-evaluating the monitoring of the Shardlow log boat

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Following the discovery of a second Bronze Age log boat in Shardlow Quarry, Derbyshire in 2003, Hanson Aggregates devised a scheme to preserve this boat *in situ*. This scheme included a monitoring programme to ensure that the reducing conditions that had led to the boat's preservation were maintained. This solution was agreed to by the mineral planning authority Derbyshire County Council, with input and advice from English Heritage. Monitoring has now taken place for nearly ten years, during which time gravel deposits surrounding the boat have been extracted. The boat was protected from dewatering during this time by a clay bund, installed around the area containing the boat before extraction begun. After the mineral around the log boat was removed, the adjacent area was backfilled and restored with on-site soils. Mineral extraction then continued from the remainder of the quarry area which was subsequently lined with clay and is currently being backfilled with inert waste.

The initial agreement was that the monitoring would last for the duration of the quarrying, through the period of backfilling / restoration, and for a period afterwards when the site was returned to previous agricultural use. However, during review of the results, it was suggested that the boat had already undergone all of the water stresses it was likely to face and it was clear that the burial environment was suitable for long-term preservation. Following careful and considered discussion it was agreed that the monitoring programme would cease as there was no further need to continue with data collection.

The presentation will use this site as an example to highlight the benefits of involving hydrogeologists on preservation *in situ* schemes, something which is recommended in forthcoming guidance on Preservation in site, condition assessment and monitoring, which is currently out for consultation. To see the guidance and comment on it by the end of April, go to www.HistoricEngland/about/what-we-do/consultations/guidance-open-for-consultation/

Biography

Jim Williams is the Historic England Senior Science Advisor, responsible for providing science advice in the East Midlands, to Historic England and local authority colleagues, as well as to anyone else who asks! Although interested in all aspects of archaeological and heritage science, Jim's research over the past ten years has focused on *in situ* preservation and he is currently working on guidance on condition assessment and preservation *in situ*. Jim is also responsible for the line management of the other Historic England science advisors.

17) The lake village and the trackway – monitoring, mitigation and moving on

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Two of the most significant waterlogged sites in the UK are the Neolithic Sweet Track and the Iron Age Glastonbury Lake Village in Somerset. Both sites have been subject to extensive excavation but their ongoing survival is threatened by desiccation. This paper explores the continuing decision making process for the monuments in regard to condition assessment, monitoring and mitigation.

The Lake Village has benefited from intensive monitoring over a very short time scale but has suffered from the lack of baseline condition information and uncertainty over the depth of the undisturbed remains. In 2014 the monitoring has hugely reduced in both the number of locations and the parameters under consideration. Focus has shifted to gaining a more comprehensive assessment of survival and condition through small scale fieldwork. Simple mitigation measures will also create a more controlled water table in the surrounding ditches for the first time. The new data will then suggest priorities for further mitigation and monitoring.

The Sweet Track is a linear monument that has had a long history of monitoring and mitigation stretching back over thirty years. Over a significant part of its length, assessment and monitoring has provided enough information to know that the monument is relatively safe and the only visual checks on pumps, ditches and vegetation are required. In other fields further mitigation is required. In places this will be carried out in 2014 with further monitoring to assess the effectiveness of the scheme. Some parts of the monument in private ownership have never been monitored, have had little condition assessment and no mitigation.

The two case studies illustrate the complexities of the decision making process on condition assessment, monitoring and mitigation. These are not only driven by the science of preservation but also by land ownership, finance, physical infrastructure and archaeological research agendas.

18) Erosion and errors: Testing the use of repeated LIDAR analyses and erosion modelling for assessment and prediction of erosion of archaeological sites?

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Erosion damage to archaeological sites is difficult to assess. In the framework of a larger project on erosion damage, we tested whether existing and newly gathered elevation data in the Netherlands can be used to derive erosion rates. Moreover, we wanted to test whether the LAPSUS soil erosion model – developed at Wageningen University – could be used to predict future erosion and compare scenario's.

In the Netherlands, three elevation datasets are freely available now:

- A dataset of elevation data gathered for the national ordinance map in the 1950'ies and 1960'ies (TOP; 1 point/4 ha).
- Aerial LIDAR from 1998 (AHN1; 5 m resolution)
- Aerial LIDAR from 2012 (AHN2; 0,5 m resolution)

This data was supplemented with terrestrial LIDAR measurements in 2013.
Comparisons showed that the TOP dataset had too low resolution to be used in this research. The three LIDAR datasets were found to have 10–15 cm offsets. Correcting for that, difference maps were dominated by acquisition errors and noise.
The high resolution of the LIDAR was found to be problematic for the erosion modelling. Recalculating to a lower resolution was needed to allow modelling, and indication of the areas that were most vulnerable to erosion. More work is needed, however, before accurate modelling of erosion rates on timescales relevant for archaeological heritage management is possible.

Biography
Hans D.J. Huisman works as senior researcher in degradation and preservation of archaeological remains at the Cultural Heritage Agency of the Netherlands and as lecturer at Leiden University. His publications include the handbook "Degradation of Archaeological Remains" (2009). He is also associate editor of the Journal of Archaeological Science.

19) Implementation of sustainable urban drainage systems to preserve cultural heritage

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The landscape of many cities and the character of their shallow subsurface environments are defined by a legacy of interactions between anthropogenic and geological processes. The shallow subsurface in historic cities often contains extensive archaeological remains, also known as cultural deposits. Modern and historic buildings and monuments are resting on these cultural deposits. Preservation conditions for naturally degradable archaeological remains are strongly dependent on both water quality and the presence or absence of groundwater in particular. Deterioration of archaeological material and context often occurs as a consequence of lowering of the groundwater level. A main goal at such heritage sites is therefore to establish a stable hydrological environment, so the site will be safeguarded for posterity. Green infrastructural solutions such as Sustainable Urban D\rainage Systems (SUDS) facilitate restoration and upholding of the water balance, and thus support preservation of cultural deposits. Three Dutch cases are discussed that use the cheap infiltration solutions: Motte of Montferland, City mound of Vlaardingen, Weiwerd in Delfzijl and the Leidse Rijn area. In all cases SUDS as bioswales, IT drainage, permeable pavement and rainwatergardens are planned and constructed to preserve the water balance and thus the cultural heritage. The first monitoring results and evaluation of the processes give valuable lessons learned that are translated into guidelines for design, construction and maintenance. Transnational knowledge exchange is an important element to bring the experiences across boundaries. Visualisation of the performance and maintenance of SUDS by photos, videos, apps and serious gaming seemed very valuable in this process and will be part of this paper and presentation.

Biography

Floris Boogaard is professor of Spatial Transformations at the Centre of Applied Research and Innovation on Area Development at the Hanze University of Applied Sciences in Groningen. His research fields include stormwater drainage and infiltration, complex monitoring, design of drainage facilities and urban water management planning.

Michel Vorenhout is an affiliate researcher at the University of Amsterdam (UvA) and specialises on redox processes in soils. He is involved in various archaeological monitoring projects through his company MVH Consult.

Hans de Beer is a hydrogeologist and leader of the Groundwater and Urban Geology group at the Geological Survey of Norway. He has 20 years' of experience in groundwater research, particularly in urban areas. Research on groundwater and *in situ* preservation of cultural heritage is a primary focus area since 2005.

Ronald Wentink is a senior consultant who is specialized in design, construction and maintenance on sustainable urban drainage systems. His is involved in various projects as 'The Motte' where implementation of SUDS enables to preserve cultural heritage.

Marike Snoek works as consultant at Rijksdienst voor het Cultureel Erfgoed and is involved in the project "Weiwerd', which was a village in the Dutch province of Groningen that is now rebuilt. It is a part of the municipality of Delfzijl, and lies about 27 km east of Groningen and has a rich history. For this reason a 'no dig' policy is made and surface SUDS provide the new watermanagement system.

20) Preserving medieval farm mounds in a large stormwater retention area

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The Netherlands have denoted large areas as stormwater retention areas. These areas function as temporary storage locations for stormwater when rivers cannot cope with the amount of water. A large area, the Onlanden, 2500 hectares, was developed as such a storage area between 2008 and 2013. This peat area contains up to 300 medieval housing areas. These "peatmounds", named after the current visible small mounds, were explicitly mentioned as a preservation goal in the project. The preservation of the peatmounds during and after the project has been guaranteed by a combination of protective measures, research and monitoring actions.
At first a risk evaluation was performed, followed by a monitoring project focusing on the preservation of the organic part of the mounds. This evaluation showed that the rewetting of the mounds might improve the overall preservation. A total of 15 monitoring stations were selectively distributed over the total area, covering the four main types of land use. The measured parameters at these stations focus on the desiccation/rewetting effects. The second threat, as determined in the risk evaluation, is the growth of deep penetrating plants. These roots might disturb the archaeological profile. Preventive coverage with plastic and up to a meter of soil could prevent root growth into the archaeology. An experimental coverage showed the effectiveness of this technique, but also the risks. This presentation focuses on the lessons that can be learned from this six year project, the monitoring results and it clearly shows the benefits of a combined approach in large scale projects.

Biography
Michel Vorenhout is an affiliate researcher at the University of Amsterdam and specialises in redox processes in soils. He is involved in various archaeological monitoring projects through his company MVH Consult.

21) To have and to hold? Recent research on the state of preservation of the Roman fort Fectio (municipality of Bunnik, the Netherlands)

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In the Netherlands, the well preserved remains of Roman forts of the Lower German Limes can be found along the river Rhine. Fort Fectio, near Utrecht was one of the earliest and largest Roman forts and was situated on the south bank of and very close to the river Rhine. The site consists of many layers containing the several building stages of the fort. After its abandonment the whole site was possibly flooded and covered with clayey sediment, allowing for the preservation of organic archaeological remains as well as metals and structures.
The site was listed in 1967. However, legal protection does not guarantee long lasting preservation. As Roman sites are well known for their abundance of metal finds, Fectio has since the advancement of the metal detector been prone to illegal collecting of metals. In addition, as the land is still in agricultural use, archaeological material is being taken up in the plough layer and vulnerable for manure and changed burial conditions.
As the monument is now being transformed in to an archaeological park, we decided to investigate the effects of the past land use and illegal metal detection on the preservation of the archaeological remains. Three test trenches were dug and all finds (ceramics, building material, bone, metal, features, etc) were assessed on their (mostly qualitative) preservation status in relation to their position in the soil, burial conditions and archaeological context.
Our presentation will give the results of this research. We established that the current land use has almost no effect on the degradation of most find categories. However, the Roman metal assemblage in the plough layer/ tops soil is different compared to other context groups. This can most likely be attributed to metal detector activities.

22) Monitoring, Mitigation and Management: The Groundwater Project – Safeguarding the World Heritage Site of Bryggen in Bergen

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Bryggen in Bergen is the best-preserved monument to Hanseatic trading activities in the North Sea and Baltic regions. The ground below the historic buildings is made up of invaluable archaeological deposits - many of which contain a high proportion of organic material - reaching thicknesses in excess of 10 metres in places. This unparalleled combination of standing buildings and archaeological deposits constitutes the basis for Bryggen's status as a World Heritage Site.

By the end of the 20th century, it had become apparent that the buildings were suffering from severe subsidence, and surveying of fixed measurement points showed that the rate of subsidence in some parts of the site was alarming. It did not take long to identify a likely causal train: simply stated, loss of groundwater, leading to accelerated decay of organic matter in the archaeological deposits, resulting in potentially catastrophic subsidence.

On initiative from Riksantikvaren (the Directorate for Cultural Heritage) a monitoring programme was established to map, analyse and interpret the site's subsurface situation: the state of preservation of the archaeological deposits, the preservation conditions in the deposits, and the complex hydrogeological system. The programme soon established a firm link between the loss of groundwater and the documented damages to the buildings and deposits, and identified drainage of groundwater into the neighbouring hotel site as the principal cause of the problem. As a result of the monitoring programme, the Norwegian National Standard NS 9451:2009 'Requirements for environmental monitoring and investigation of cultural deposits was developed. In the Groundwater Project all the documentation of state of preservation and preservation conditions has been carried out in accordance with this standard.

In the spring of 2011 Norway's Parliament approved an extraordinary allocation of NOK 45 million to combat the problem. Riksantikvaren was assigned overall responsibility for the task of raising groundwater levels and reducing rates of organic decomposition and, ultimately, subsidence, but with the proviso that the work should entail negligible removal of intact archaeological deposits. Riksantikvaren recruited a variety of specialists to form an advisory team, and engaged Statsbygg (the Directorate of Public Construction and Property) to direct and coordinate the work.

After four years of mitigation work, we can now conclude that most of the goals have been reached. Groundwater loss has been greatly reduced and groundwater levels have been raised considerably in sizeable portions of the most badly affected area. Subsidence of the buildings and ground has been reduced to a virtually natural rate. However, no matter what we do, the damage sustained by the archaeological deposits since the building of the hotel cannot be reversed, nor can we ever re-establish the original hydrogeological conditions. Infiltration will continue to be necessary for the foreseeable future in order to maintain the area's water balance, and we have opted for infiltration solutions that will ensure the most sustainable water supply, and will be resilient in the face of climate change. Continued monitoring will

enable us to keep a close eye on trends and changes. Riksantikvaren hopes that the results from this work will contribute to the conservation of other heritage sites.

Biography

Iver Schonhowd, senior adviser at Riksantikvaren, Directorate for Cultural Heritage in Norway. Educated as a conservator on archaeological objects and has been working in the Viking ship museum in Oslo for 17 years. Now working as a special Adviser, dedicated as a coordinator for the activities of Riksantikvaren at the World Heritage Site, Bryggen in Bergen.

Jens Rytter is educated as an archaeologist and working as senior advisor at the Directorate for Cultural Heritage. Since the late 1980´s he's been working with excavations and management of medieval Towns in Norway. Interpreting the state of preservation and preservation conditions for the cultural deposits is an important part of this work.

Ann Christensson was a senior advisor at the Directorate of Cultural Heritage. Since 2001 she has been in charge of the monitoring project concerning the archaeological deposits at World Heritage Site Bryggen in Bergen. Since 2011 she worked to establish the groundwater situation to improve conditions for *in situ* preservation.

23) *In situ* protection and management of the protected site of Medieval Trondheim

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Medieval Trondheim was located on the eastern part of Nidarneset, a small peninsula on the river plain at the mouth of the river Nid on the southern shore of Trondheimsfjord. The topographic conditions of medieval Trondheim differ from those of the other Norwegian medieval towns (notably Bergen, Oslo and Tønsberg), and the protected, historic part of Trondheim is unique in containing anthropogenic sediments which lie entirely in an unsaturated environment. A large proportion of these sediments contain wood and other types of organic material. The thickness of the anthropogenic sediments varies greatly from more than 4 m to less than 0.5 m and they overlie well-drained alluvial sands and gravels. The Directorate for Cultural Heritage (Riksantikvaren) and the Norwegian Institute for Cultural Heritage Research (NIKU) have different roles in the administration of cultural heritage sites. However, they cooperate in developing a sustainable management and a scientific approach to research, as well as finding practical solutions aimed at securing stable preservation conditions for anthropogenic sediments that are vulnerable and sensitive to environmental changes, both chemical and mechanical.
In this paper we present the results from recent interdisciplinary work on a number of archaeological investigations where analysis and monitoring of chemical parameters has been undertaken. We present basic parameters such as temperature, moister and redoxpotential in anthropogenic sediments from different parts of the medieval town, and discuss them in relation to the cultural-historical background as well as the challenges involved in meeting the demands of growth and exploitation in urban development.

Biography

Anna Petersén is a researcher and senior archaeologist working for the Norwegian institute of Cultural Heritage Research (NIKU). She specialises in archaeological projects where *in situ* preservation and monitoring is required.

Ove Bergersen finished a Ph D -(Dr. Scient), "Molecular Genetics" in the Departments of Biochemistry and Animal genetics, Norwegian College of Veterinary Medicine 1990. Main work as scientist at SINTEF "Environmental microbiology" (e.g. degradation of oil, creosote, PCB, phthalates) to 2001 and "Environmental microbiology and soil chemistry" the last 10 years as a senior scientist at the Norwegian Institute for Agricultural and Environmental Research.

24) The Australian Historic Shipwreck Preservation Project – *in situ* preservation and long-term monitoring of the *Clarence* (1850) and *James Matthews* (1841) shipwreck sites

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Increasingly archaeologists are opting for on-site examination, reinterment and *in situ* preservation of underwater cultural heritage sites as the first option in the management of sites at risk as opposed to the more traditional excavation, recovery, conservation and display/storage methods. This decision will inevitably be based on significance assessment, degree of perceived risk and resourcing issues. However, long-term monitoring must become an integral part of these management programmes in order to quantitatively evaluate the effectiveness of the *in situ* preservation techniques employed.
In 2012 the Australian Historic Shipwreck Preservation Project (AHSPP) was awarded a large Australian Research Council (ARC) Linkage Grant, enabling ten Partner Organisations and three Australian Universities to collaborate in one of the largest multi-organisational maritime archaeology projects to be undertaken in Australia to date. One of the major aims of the project is to develop a protocol for the excavation, detailed recording and reburial of significant shipwrecks under threat, fostering a strategic national approach for the management of underwater cultural heritage sites at risk. Two historically significant shipwreck sites that are considered under threat were chosen for this longitudinal comparative study – the *Clarence* (1850) located in Port Phillip Bay, Victoria and the *James Matthews* (1841) which lies in Cockburn Sound, Western Australia. Both sites have been preserved *in situ* using two very different but innovative remediation strategies. More importantly, long-term monitoring programmes have been implemented on both sites, which will characterise changes in the reburial environment and the effect on the reinterred materials. In this way, the efficacy of both *in situ* preservation techniques will be systematically tested, providing a comparative analysis of practical protocols for the long-term protection and management of underwater cultural heritage.

Biography
Vicki Richards has been a Conservation Scientist in the Materials Conservation Department of the Western Australian Museum for the past 28 years. One of her primary research areas is devising and implementing appropriate on-site management plans for the long-term *in situ* preservation of shipwreck sites.

Ian MacLeod has extensive experience in the analysis and interpretation of corrosion products and *in situ* corrosion measurements on historic shipwrecks and archaeological sites. His current role is Executive Director of the Fremantle Museums and Collections.

Peter Veth has directed numerous archaeological projects on the evolution of maritime societies in Australia, Maluku and East Timor. He has published widely on site formation models and heritage conservation strategies. He is Winthrop Professor of Archaeology at the University of Western Australia.

25) Relax, don't do it: a future for archaeological monitoring?

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Preservation *in situ* and monitoring of archaeological sites have become important themes after the acceptance and implementation of the Valletta treaty. In the last few decades, knowledge on degradation process has increased manifold, and a range of techniques have been tested and applied for use in assessment and monitoring. We are now at a stage where we can look back to evaluate the results of these efforts.
Despite successes, not all is well. Firstly, we have little notion of the speed of decay processes. This makes it difficult to distinguish between acute degradation - destroying archaeological remains within a generation - and slow that should be regarded as part of the normal (taphonomical) development of an archaeological site. Apart from that, many assessments and monitoring projects rely (too?) heavily on complex and costly specialist technology, contributing to the problem that monitoring of archaeological sites is difficult to finance. Moreover, a strong focus on knowledge and technology in practice seems to obscure the actual goal of many such projects.
For the future of *in situ* preservation of archaeological sites, refocussing is essential: Low-tech observations and best estimates of decay rates and archaeological site information should be combined to make a good and efficient prediction of the effects of decay on the archaeological record. This prediction forms the basis for decisions on protection and mitigation strategies. Monitoring of preservation purposes is only appropriate if (1) decay processes occur on a relevant and measurable time scale and (2) if mitigating measures can be taken or a preservation *ex situ* can be performed (i.e. a rescue excavation) if the monitoring results show significant degradation on relevant time scales.

Biography
Hans D.J. Huisman works as senior researcher in degradation and preservation of archaeological remains at the Cultural Heritage Agency of the Netherlands and as lecturer at Leiden University. His publications include the handbook "Degradation of Archaeological Remains" (2009). He is also associate editor of the Journal of Archaeological Science.

Session: Posters

Development of Tools and Techniques to Survey, Assess, Stabilise, Monitor and Preserve Underwater Archaeological Sites: SASMAP

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Development of Tools and Techniques to Survey, Assess, Stabilise, Monitor and Preserve Underwater Archaeological Sites (SASMAP) is an EC funded project, with the purpose of developing new technologies and best practices in order to locate, assess and manage Europe's underwater cultural heritage. SASMAP takes a holistic- and process- based approach to investigate underwater environments and archaeological sites. The project involves developing and utilising tools and technologies to facilitate this. The starting point is "down-scaling" from the large scale regional level, moving on to the local site level and includes the development and use of various remote sensing techniques (satellite imagery and underwater geophysics). Results obtained from the down-scaling approach show the effectiveness of such an approach for locating and detailed mapping of archaeological sites and their preservation potential. Moving on from the regional and site level, the individual components of a site and archaeological materials are examined in order to assess the state of preservation of wooden material, the effects of the environment on deterioration, and methods to excavate or conversely preserve a site *in situ*. The end results of the project will be used to develop a plan for assessing archaeological sites in European waters. The results of SASMAP will benefit the management of underwater cultural heritage in Europe and in the rest of the world by providing valuable tools to plan the preservation of offshore archaeological sites and their contents in accordance with both the Treaty of Valletta (1992) and UNESCO 2001 convention for the protection of underwater cultural heritage. The project started in September 2012 and finishes in the autumn of 2014, the aim of the paper is to give a brief overview of the project to date. More information is available on the project home page www.sasmap.eu

Biography
David Gregory gained a BSc in archaeology at the University of Leicester, MPhil in maritime studies at St Andrews University and PhD in 1996 at the University of Leicester. He is currently research professor at the National Museum of Denmark investigating deterioration and of *in situ* preservation of archaeological materials in waterlogged and underwater environments.

Assessing archaeological material sensitivity for reburial system design

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Reburial systems are designed to protect the buried archaeological material while allowing for continued use of the land. The system is meant to provide a burial environment conducive to the preservation of archaeological material by slowing down the degradation processes. As there is no quantitative method to assess archaeological material conditions, the goals for the burial environment are often ill defined, and lack clear design goals to achieve. Oftentimes reburial systems focus on mimicking the conditions present at the site prior to the site's discovery, without consideration for other burial environments which may be better suited for the conservation of archaeological material.
The author developed a "Site Sensitivity Equation" to assess and prioritize the condition and preservation needs of an archaeological assemblage. This equation can also be modified to prioritize the conservation of a particular material type in an archaeological assemblage. The equation evaluates the type, condition, and quantity of archaeological material in a given assemblage, and provides an objective quantification of the sensitivity of the archaeological assemblage to various damage sources. As archaeological materials in an assemblage are affected by environmental conditions in different ways, a reburial environment can delay the degradation of one type of material, while accelerating the decay of another. The site sensitivity equation identifies the most important environmental factors in the conservation of an archaeological assemblage and provides a numerical assessment of the conservation necessities of the archaeological material. This information can be used to design a reburial system that provides the optimum environment for conservation.

Biography
Ari Perez-Mejia is an assistant professor in the engineering department at Quinnipiac University. While working on his doctorate in geotechnical engineering, he became interested in the engineering design and performance of archaeological reburial systems. Currently, he is developing a design method for reburial systems.

Between the Piles. A new approach to establishing the amount of damage caused by piling

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This paper describes a study of the damage to archaeological sites caused by piling, focusing specifically on the extent of the area of damage around the pile. The plan is to use an as yet unused source of information: photographs from archaeological excavations at redevelopment sites. A study in the Dutch city of Gouda has shown that these photos often include piles, and in many cases the size of the visible disturbance around these piles can be recorded from the picture (Groenendijk 2009). Expanding that study to all the cities in the Netherlands will result in enough photos with piling effects on them to provide a huge set of data on the area of disturbance around these piles.
The research will focus primarily on macroscopically visible effects of pilling. A distinction will be made between different types of piles, between different types of soil and between different archeological periods and complex types. When enough data are collected, a conclusion can be drawn on the physical and visible effects of different techniques of piling on the archaeological remains in different burial environments. This information will then be used in the second phase of the research to determine what archaeological information is still available between the piles and how much is actually lost.
The paper will describe the preliminary results of the photo study, and will give a preview of the second phase of the research.

Biography
M. J. Groenendijk is municipal archaeologist of Gouda, the Netherlands, and is currently working on a PhD-research on the effects of piling.

Dom Under; the best of two worlds. How to combine participation and awareness with *in situ* preservation of an underground archaeological monument

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4 LBP|Sight engineers
5 Dom Under public initiative

Almost all archaeological remains in the Netherlands are below the subsurface and not visible except for (building) mounds, tumuli and dolmen. From the perspective of preservation *in situ* this is a favourable situation, but for creating awareness and support for archaeology, which is also one of Valetta Agreement objectives, it is not always the best option.
In Utrecht, the fourth city of the Netherlands and founded on a Roman North Rhenish fortress along the Limes, a private initiative, has asked permission to develop an underground archaeological museum. It is planned, and built in the heart of the City Centre, the Domplein, exposing remnant of the Roman fortress and roads, remnant of one of oldest early Romanesque Medieval Churches founded by the English missionary Willibrord, the Medieval Gothic DOM Church that collapsed in the 18th century and one of Castles of Holy Roman Emperor Henry III.
The permission to build the centre was given on the condition that the archaeological remains and context remained intact during the build and use of the new museum. If the site was undisturbed this would not be possible, but luckily, one of the first Dutch archaeologists prof. A.E. van Giffen had already excavated parts of the Domplein in the 1940's. The museum is built within the two old excavation pits, which are separated from the undisturbed part by large 10 meter deep Corten steel sheet pilings.
In our contribution we will address the tension that exists between preservation *in situ* and the construction and maintenance of a public accessible archaeological site. What choices were made for consolidation of soil profiles and brickwork, construction of technical installations and the actual re-excavation of the site. How will the site be maintained, and which measures are taken to prevent biological growth, salt efflorescence, flooding, or damage by visitors? Who will take responsibility in case of bankruptcy or decommissioning of the museum, and will the site be restored to its original form? Some solutions for these challenges will be given in our presentation.

High resolution bathymetry – new challenges for the conservation of archeological heritage

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The combination of Multi-Beam-Echosounder and Airborne LIDAR-Bathymetry offers fascinating new possibilities for the mapping and visualization of the lake floor and the shallow water zone. This leads, however, to new challenges for the management of the cultural heritage, as the datasets can be analyzed by regular computer hardware of private persons. This potentially leads to threats for protected sites like prehistoric pile dwellings or historical shipwrecks.
We present first results of the project "Tiefenschärfe" ("depth of focus") which mapped the bottom of Lake Constance with very high resolution. Examples of relevant objects and their dimensions detected by modern instruments are shown, and how these objects are removed from the resulting data sets.

Biography
The authors have their professional background in limnogeology (MW), archeology (MM) and seafloor imaging (JG, PW). They are working together in the detection of wrecks and artificial remnants using hydro-acoustic methods.

Cover it! The next level in the escalating battle between treasure hunters and archaeologists

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Robbery and theft of valuable archaeological remains is from all ages. Especially burial gifts are popular, as they are often found concentrated in known areas. Since the development of the metal detector, the amount of metal objects being taken from known archaeological sites, despite legislation, has grown enormously. Although the cooperation between metal detector hobbyists and archaeologists generally is very friendly, some tend to have a more pirate-like approach. In Borgharen, municipality of Maastricht, the Netherlands, an early Medieval burial site has been partly excavated over the last decades. During one of those excavations robbers stole just discovered objects from several graves, despite a metal detection prohibition, a metal fence around the excavation and daily covering of the graves that were being excavated. As the rest of the site is being preserved *in situ*, the State Service for the Cultural Heritage of the Netherlands decided to take measures to prevent further looting of the site.
In this paper we describe the requirements, methods and materials that were used to prevent future robbery. A change in land use, from agriculture towards a nature reserve gave us the opportunity to protect the site by firstly applying a layer of root canvas, followed by galvanised harmonica wire. Finally a layer of 50 cm tamped loamy gravel was applied. It is expected that although this is a known "rich" site, our measures will be adequate to protect it from future theft and loss of archaeological information.

Biography
Bertil van Os has a phD in marine geochemistry and a background in geochemical mapping and analytical methods. For 7 years now he has been working as Senior Scientist *in situ* conservation of archaeological sites at the cultural heritage agency, Netherlands. Special subjects: groundwater; soil; metal corrosion; mitigation measures; shipwrecks, archaeological information; combining public access and preservation.

Going downhill; Measuring erosion rates at archaeological sites

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Archaeological sites with surface topography or on slopes can be susceptible to water erosion, resulting in progressing damage to the site. This is promoted by tillage. Not only because of the stronger susceptibility of barren, loose topsoil after ploughing but also due to direct soil displacement by the agricultural implements. Although there is ample visible evidence that this type of damage has occurred on multiple sites, there is little or no data to assess rates of erosion (e.g. in cm/yr). This makes it hard to determine scale and urgency of this threat.
A choice of techniques is available to measure erosion rates, each with its own pros and cons. Few of them, however have been tested or used on the short timescales (years or decades) needed to assess erosion rates on archaeological sites.
In a project to assess erosion rates, a series of techniques is combined on three archaeological sites (a Neolithic slope site in loess, a man-made mound in marine coastal deposits and a Roman villa site on a loess slope):

- Coring campaigns mapped out the thickness of the plough layer and colluvium
- Analysis of existing and newly collected elevation measurements was made to test whether measurable differences had occurred
- Assessment of the relative age of topsoil and colluvium layers using lead contents (pollution since c. 1950) and ^{137}Cs (1960's and 1984 nuclear input).
- Colluvium dating using OSL
- Assessment of recent plough damage to the archaeological deposits by gathering archaeological material (ceramics) form the surface and by plotting the distribution of the material, its size and the occurrence of fresh damage on the site map.

Biography
Hans D.J. Huisman works as senior researcher in degradation and preservation of archaeological remains at the Cultural Heritage Agency of the Netherlands and as lecturer at Leiden University. His publications include the handbook "Degradation of Archaeological Remains" (2009). He is also associate editor of the Journal of Archaeological Science.

In situ Preservation of marine archaelogical remains based on geodynamic conditions in the waters

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Marine archaeological remains in the Waters of Raja Ampat have an important role in the development of maritime history and culture in Indonesia. The World War II aircraft wreck sites are some of the marine archaeological remains found in the Waters of Raja Ampat. These sites prove that the Raja Ampat region was a strategic area during World War II. With their historic value and marine biophysical conditions, these wreck sites can be used as a marine tourism attraction and underwater archaeology laboratory. In other words, the aircraft wreck sites can be managed by using an *in situ* preservation model which has the purpose of protecting and at the same time utilizing the sites for the development of marine tourism in Raja Ampat. However, the result of the research of the wreck sites position on the seabed and marine geomorphological charateristics of the wreck sites environment, indicate the presence of active marine geodynamic processes. Marine geodynamic conditions of Raja Ampat traversed by the *Strike-Slip-fault* of Sorong can lead to an earthquake with the level of damage in the range of V - VI MMI (*Modified Mercally Intensity*). It will give a high degradation impact to the World War II aircraft wreck sites. Marine geodynamic conditions have become the most important aspect of *in situ* preservation management models in Raja Ampat Papua, Indonesia. Through this paper, a strategic model for *in situ* preservation based on marine geodynamics of Raja Ampat will be discussed by using the Archaeological Oceanography Method and Marine Geological Approach.

Non-invasive prospection and mapping in wetland archaeological contexts using Ground-Penetrating Radar (GPR)

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In the shallow lake margins and in peat bogs of the North-Western pre-Alpine forelands, the remains of Neolithic and Bronze age settlements have been found. While the first settlements were discovered by chance as early as the 1850ies, prospection programmes in the past 40 years were intensified. Agricultural drainage ditches were searched, coring programmes and diving prospections were conducted. However, the currently used methods are either slow, expensive, and/or rely to a large proportion on chance and fortune. Out of this reason, new methods are currently being tested on their applicability for wetland settlement prospection in the framework of a dissertation thesis. In 2013, a projected using GPR was set up to accompany rescue excavations and prospections conducted in the peat bogs north of Lake Feder in Oberschwaben, South-West Germany. Three questions were followed: I) Do the archaeological remains of wetland settlements produce anomalies in the radargrammes due to their difference from the surrounding peat bog? II) Can different materials such as wood or clay be distiguished in the radargramme? III) Is the method suitable for the archaeological prospection, or even for the mapping of structures? The results of the project will be presented and discussed here.

Two further projects were set up to test the applicability of GPR in shallow lakes. During a cold spell in February 2014, Lake Deger, a small lake near Friedrichshafen in South-West Germany, was thickly covered with ice. This opportunity was used to prospect a settlement that was partly excavated in 2007-2010 by the Landesamt für Denkmalpflege Baden-Württemberg. In autumn 2013, a programme was launched by the Amt für Städtebau Zürich to test the applicability of Georadar and Sonar for conservatory issues. Test case was a shoal 500 meters off the shore of Lake Zürich near the town of Rapperswil (CH). The location is characterized by a stony ridge of as yet unknown origin situated near a “shelf”-like situation, where shallow lake areas of 2-4 meters depth fall steeply downwards. Augering yielded evidence of anthropogenic layers, so the spot was chosen for a test of the applicability of GPR for conservatory measures.

Either as a preparatory measure for excavations to enhance knowledge of the stratigraphy, or alongside other methods in a prospection campaign, it can be demonstrated how GPR is a valuable tool for the non-invasive prospection of settlement remains. It can be used for mapping and prospection of terrestrial structures as well as for submerged sites in shallow lake areas.

Studying the cannons of *Punta de Santa Anna, Blanes,* Spain: *in situ* preservation, promoting public access, and monitoring iron corrosion.

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The 2001 UNESCO convention for the Protection of Underwater Cultural Heritage (UCH) encourages and supports projects that would make underwater cultural sites (rule 7) accessible to the general public. Since 2010 the Catalonian Federation of CMAS (FECDAS/CMAS) in collaboration with the Catalonian Centre of Underwater Archaeology (CASC), have been developing outreach activities with the objective of promoting the protection of the UCH among recreational scuba divers. The purpose of this paper is to introduce such a project, the *Punta de Santa Anna* in *Blanes*, Spain. This project has three objectives: the *in situ* protection of this underwater archaeological site; the promotion of UCH to the general public; and a case study on iron corrosion processes.

FECDAS/CMAS will create, in 2015, an underwater archaeological park where recreational scuba divers will be able to visit some purposely-selected cannons. To expose UCH to the general public will potentially affect the integrity of these artefacts. This risks potential damage and so with the objective of minimizing potential threats, a series of protective measures and a systematic monitoring program have been planned.

The programme is designed to study the relationship established between the underwater environment and the artefacts. The aim is to acquire a better understanding of the corrosion processes of iron objects present in marine underwater sites. This will be accomplished by: documenting the underwater environment by systematically recording physical-chemical parameters, such as water temperature, salinity, oxygen levels, etc., to understand the environmental dynamics of the site; and secondly, it will record the degradation processes of the iron cannons by measuring the corrosion potential, pH levels of the metal surface, and the thickness of the corrosion layers.

The results of the *Punta de Santa Anna* project could be used to inform future conservationist strategies for the protection of the UCH.

Biography

Carles Aguillar Gil: MA in Mediterranean Nautical/Underwater Archaeology (University of Barcelona). Head of the department of Underwater Archaeology at FECDAS/CMAS. I have organized activities to disseminate and raise awareness on PCS among scuba divers. I have worked as a field archaeologist for different institutions and I have been working for CASC-MAC as a technician in underwater archaeology.

Carlos Cabrera Tejedor: DPhil Student in Archaeology at University of Oxford. MA degree from the Nautical Archaeology Program at Texas A&M University, BA Degrees in Archaeological Conservation and BA in Fine Arts Restoration. I have served as Project Director and Research Associate of the Institute of Nautical Archaeology. I have been working in different conservation and archaeological international projects.

Carla Riera Andreu: MA Student in Conservation and Restoration of Cultural Heritage (University of Valencia). I also attended an international advanced course on Underwater Metal Restoration at ICUA, Zadar. My main interest and expertise is the preservation of waterlogged archaeological artifacts and underwater environments. My final MA dissertation deals with the study, conservation and *in situ* musealization of metal artifacts found in underwater environments.

Monitoring mitigation measures and their effects on *in situ* preservation conditions

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During the last decade, unique multidisciplinary investigations have been carried out to understand and document the environmental conditions that have led to the observed worsening state of the preservation of archaeological deposits at Bryggen in Bergen. Current results of these investigations have already been presented and published at Paris3 and Paris4 conferences in 2006 and 2011. In 2011, a large-scale mitigation project was started. This presentation focuses on the monitoring of the long-term performance and effectiveness of different mitigation measures that have been implemented at Bryggen, with particular regard to determining if an improvement in environmental conditions for the *in situ* preservation of archaeological deposits can be observed.
Since September 2011, numerous mitigation measures have been implemented to improve conditions for the preservation of organic cultural deposits at Bryggen in Bergen. The main mitigation target is to create a hydrological divide between the area where urban development has disturbed the local water balance and the affected areas at Bryggen that are characterized by poor preservation conditions. The mitigation measures were selected to comply as far as possible with sustainable water-management principles, and are focused on increasing and stabilizing groundwater-levels and soil moisture content in affected areas. The use of sustainable water-management solutions specifically targeted on improving *in situ* archaeological preservation conditions is an innovative approach with multiple benefits. A long-term environmental monitoring programme will document the solutions' performance and effects. The monitoring plan, target parameters and preliminary results are briefly discussed, including a quick future outlook on the use of interferometric synthetic aperture radar (InSAR) as a non-destructive monitoring method.

Riksantikvaren is a directorate under the Ministry of Climate and Environment. Sustainability principles therefore form a fundamental part of the management of *in situ* preservation of the World Heritage Site Bryggen in Bergen. For the last 13 years we have been working with innovative methods aimed at developing monitoring programs in order to find out how to get the groundwater system back in balance. The project has increased our understanding of

processes in the ground, and has shown that the presence of water is the key factor in promoting the survival of organic archaeological materials.
Parts of Bryggen have been affected by serious dewatering for more than 30 years now, mainly due to the leaky sheet-piling wall encircling a neighbouring building complex. The extensive monitoring programme initiated in 2001 and expanded yearly since then has been key in our efforts to map the threats below ground, and many different parameters have been analyzed to understand the entire situation and find the optimal solutions to the problems. Since 2011 the Directorate has been in charge of mitigation works in order to raise/restore groundwater-levels in the dewatered areas. The main goal has been to replenish the area's groundwater using local water resources of equivalent quality – from roofs, open spaces, and even from the other side of the sheet piling – and using various infiltration-retention methods to try to ensure that some water is available during prolonged dry periods. The water-management system has been designed to be cost effective and to require a low level of maintenance. The work at Bryggen has been multidisciplinary, involving many specialists from numerous North European countries, and a complete publication of the groundwater project is planned for April 2015.

Biography

Hans de Beer is a hydrogeologist and leader of the Groundwater and Urban Geology group at the Geological Survey of Norway. He has 20 years' of experience in groundwater research, particularly in urban areas. Research on groundwater and *in situ* preservation of cultural heritage is a primary focus area since 2005.

Jens Rytter is educated as an archaeologist and working as senior advisor at the Directorate for Cultural Heritage. Since the late 1980´s he's been working with excavations and management of medieval Towns in Norway. Interpreting the state of preservation and preservation conditions for the cultural deposits is an important part of this work.

Iver Schonhowd, senior adviser at Riksantikvaren, Directorate for Cultural Heritage in Norway. Educated as a conservator on archaeological objects and has been working in the Viking ship museum in Oslo for 17 years. Now working as a special Adviser, dedicated as a coordinator for the activities of Riksantikvaren at the World Heritage Site, Bryggen in Bergen.

Henning Matthiesen is a senior researcher at the National Museum of Denmark, where he is working with the *in situ* preservation of archaeological remains. His research is focused on urban deposits, wetlands and frozen sites.

Floris Boogaard is professor of Spatial Transformations at the Centre of Applied Research and Innovation on Area Development at the Hanze University of Applied Sciences in Groningen. His research fields include stormwater drainage and infiltration, complex monitoring, design of drainage facilities and urban water management planning.

Jann Atle Jensen is a geotechnical engineer and senior consultant at Multiconsult AS. He has 16 years' experience on geotechnical engineering in soil and rock. He is responsible for planning, implementation and analysis of subsidence monitoring at Bryggen since 2000 and coordinates the technical planning and construction of groundwater mitigation measures.

Rory Dunlop is an urban archaeologist working at NIKU's Bergen office, with more than 30 years' experience of all kinds of archaeological investigations. He has become increasingly specialized in aspects of archaeological monitoring since 2001, particularly in connection with the work at Bryggen.

Michel Vorenhout is an affiliate researcher at the University of Amsterdam (UvA) and specialises in redox processes in soils. He is involved in various archaeological monitoring projects through his company MVH Consult.

Ann Christensson was a senior advisor at the Directorate of Cultural Heritage. Since 2001 she has been in charge of the monitoring project concerning the archaeological deposits at World Heritage Site Bryggen in Bergen. Since 2011 we have been working to establish the groundwater situation to improve conditions for *in situ* preservation.

Heritage Under Cover: A Case Study Of Two Protective Shelter Constructions At Neolithic Çatalhöyük

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This paper presents the casework of two protective shelters which were constructed for the long-term display and preservation of two excavation areas of the Neolithic site of Çatalhöyük, a renowned world heritage site in central Anatolia, Turkey. Famous for its size, well-preserved mudbrick architecture, elaborate wall paintings and relief sculptures, the aim has been to present the Neolithic buildings to visitors within their neighbourhood setting as well as within their temporal sequence. It has also been important to provide the Turkish Ministry of Culture and Tourism with a well-planned heritage site through a programme of presentation and public engagement as well as local community projects to enhance local awareness of the site.

Teams have been involved with the conservation and restoration of the excavated buildings, which have been covered with custom-built shelters over very different topography and to location specific specifications. These shelters aim to protect the very delicate mudbrick and clay plaster remains from the effects of the changing climate and the environmental conditions on an annual basis, and the archaeological remains would no longer require backfilling at the end of each season, a laborious but necessary task that leads to its own set of problems with the constant change of environmental conditions.

The success of the shelters has been acknowledged, however their long term impact and limitations are still being monitored. These constructions require regular condition monitoring, proactive and reactive solutions to a constantly dynamic environment including accommodating the summer excavation requirements, all within a very limited budget. For the long-term, such shelter construction projects need to include wear and tear costs as well as addressing the ultimate lifespan of the shelters with clear plans and resources for eventual dismantlement.

Biography

Duygu Çamurcuoğlu (Archaeological Conservator), Shahina Farid (Archaeologist, Field Director) and Sinan Omacan (Architect) are highly experienced practitioners in their fields and have been closely involved in the planning and execution of two protective and display shelters at the world famous site of Neolithic Çatalhöyük, a World Heritage site in Turkey.