

## IPR XXV

### Abstracts

**Averdung, Denise et al.**

#### **Rhine River Bank Deposits at Biebrich Castle – An Accumulation Site of Palaeontological and Archaeological Interest**

The Rhine river deposits in the region of the state capitals Wiesbaden and Mainz are widely known for numerous archaeological and paleontological river finds from different eras. Due to increasing seasonal low water levels of recent years, the Rhine gravel deposits in front of Biebrich Castle (Fig. 1) in Wiesbaden was well accessible; and is extremely rich in palaeontological and archaeological remains.

The stratigraphic range of finds extends from the fossil-rich Neogene Wiesbaden Formation (Miocene, about 21 million years BP) and mammal teeth from the Quaternary ice ages of up to settlement artifacts from the Roman to recent times (Fig. 2).

Dealing with multidisciplinary disciplines, our project is of regional scientific interest. Due to special hydrodynamic fluvial conditions and historical river interventions, new material accumulates steadily, which is examined and, if necessary, restored or prepared. On the basis of material distribution, river sediment investigations and regional flow analysis we would like to evaluate the origin of the finds and to determine the sedimentation conditions at the undercut slope of Wiesbaden-Biebrich.

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## **Bekić, Luka**

### **Research of a shipwreck on the Island of Velika Sestrica near Rovinj**

Back in 2013, we discovered a new position of a potential shipwreck near the islet of Velika Sestrica near Rovinj. The scattered finds lie close to a rocky island, in shallow water. The first exploration campaign was conducted in 2018 and at that time several large pits in rock bottom with findings were explored and the mapping and photogrammetric documentation of the site was started. Out of the 152 kilograms of documented archeological finds, 190 special finds were extracted. Obviously, it was a shipwreck with a load of amphorae of type Forlimpopoli and various glass and ceramics that were part of the ship's inventory. In addition, a number of regular stone blocks were suspected to be part of the cargo.

This year, the research continued and confirmed our current knowledge of the site and provided additional evidence of the existence of a shipwreck at this site, namely three metal nails. In addition to the already known Forlimpopoli type amphorae, few fragments of some other types of amphorae have been found, but overall, it is clear that the cargo consisted almost entirely of Forlimpopoli type amphorae, in various variants and dimensions. In addition, others finds were collected, like fragments of rough pots for cooking and storing food, jugs, bowls, bottles, oil lamps and other necessities for living at sea, probably owned by the crew. Stone blocks were also analyzed by petrographic analysis, which were considered to be a cargo of stone blocks as a semi-finished product. Shipwreck can preliminary be dated to the 2<sup>nd</sup> or 3<sup>rd</sup> century, but another field research campaign is still planned for 2020.

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**Bockius, Ronald**

**Spuren altmediterraner Schiffbaustandards in der eisenzeitlichen Binnenschifffahrt  
Nordeuropas und Südostasiens.**

**Traces of Mediterranean Shipbuilding Standards in N. European and SE Asian Iron  
Age Inland Navigation**

Edge-joined carvel planking, made by pegged mortise & tenon fasteners is meant for the most distinctive feature of ancient Mediterranean Shipbuilding. With its earliest evidences in Old and Middle Kingdom Egypt as well as in middle and late Bronze Age contexts from Levant, Syria and the Cilician coast the origin of this woodworking tradition might be the E Mediterranean. According a written source of the 2nd c. BC, mortise & tenon construction (coagmenta Punicana) was seen as a particular feature of Phoenician timber processing.

It was not before the 7th c BC on, that especially ships with edge-joined planking sunk equally in the central and W part of the Mediterranean. Among them a number of remains are found from the pre-Hellenistic periods showing combinations of mortise & tenon and stitched construction. Could such spatial dynamics be understood as a result of Greek and Phoinician colonization, evidence of mortise & tenon construction from early 1st c. Dutch and German places are clearly connected to the Roman army. Embedded in a barbarian archaeological environment this building tradition represents Mediterranean/Roman influence although not necessarily technological transfer, i.e. the ability of indigenous people to copy such a complex building method.

Since a couple of years only, unmistakable proof of mortise & tenon edge fastening is known surprisingly also from local Iron Age civilizations in N Vietnam and Irland where namely a small number of logboat finds imply the use of this technique. The present author discusses their cultural backgrounds and tries a historic interpretation.

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## **Bram, Moshe**

### **Preparing wooden planks for bending by heating over open fire: Preliminary results**

Techniques of bending wooden planks for ship building have been in use since the days of the Pharaohs, and are still practised. The bending of relatively thick planks required some preparation: one of the methods used being heating the planks over an open fire. The sole archaeological evidence for this is their charred surfaces. Examination of charred-bent planks showed that they were always charred on the concave side.

The components of wood – cellulose, hemicellulose and lignin – become pliable above their glass transition temperatures ( $T_g$ ), which are all slightly different, the  $T_g$  of a piece of timber is a combination. Heating green or water-soaked-seasoned wood to or above the  $T_g$  allows wood to be more easily bent. Experiments on heating 5-cm-thick seasoned pine planks showed that the temperature inside the plank reached  $100\pm 2^\circ\text{C}$ . A similar set of experiments on water-soaked-seasoned pine planks showed a lower temperature inside the plank:  $90\pm 2^\circ\text{C}$ . In both cases the planks were charred.

Based on these results, it seems likely that char-bending was done on green or water-soaked wood, and that the charring is done on the concave side of the plank for two reasons:

- Cracks in charred wood are stress concentration sites. This might lead to failure on the convex side, which is subjected to tensile stresses on bending.
- To reduce the water content in the concave face. This reduces the chance of compression failure during bending.

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**Capulli, Massimo**

**The Via Annia Shipwrecks**

**Traces of a navigation in a waterscape between rivers and lagoons**

The consular Roman road via Annia was constructed in the year 128 B.C. by Praetor Titus Annius Rufus it run along the Adriatic area, linking Atria (currently known as Adria) to Aquileia, passing through important centres such as Altinum (Altino), one of the greatest ports on the upper Adriatic Sea and Iulia Concordia (Concordia Saggitaria).

Moreover, thanks to several rivers and creeks, the via Annia was connected with an inside navigable route, that ran parallel to it through lagoons and channels, and so to the sea.

It is therefore not surprising that many remains of boats have been found along its route (image 1), almost all in wetland environment and of the “sewn” shipbuilding tradition.

The paper will present an overview of these shipwrecks in relationship with the via annia and their function in the roman network of the northern-east of Italy. The conference will be also the opportunity to present the 2019 excavation on the via Annia Bridge in Stella river (image 2).

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**Dunsch, Boris**

**Nautische Fachliteratur in der Antike.**

Lange Zeit galt es in der marinehistorischen wie auch altertumskundlichen Forschung als ausgemacht, dass die Kunst der Schiffsführung (κυβερνητική τέχνη/ars gubernatoria) in der griechisch-römischen Antike ausschließlich oral tradiert wurde. Neuere Forschungen zeigen, dass daneben auch mit einer schriftlichen Transmission des nautisch-navigatorischen Fachwissens zu rechnen ist.

Der Umfang und die konkrete Gestalt der in diesem Umfeld entstandenen Fachliteratur ist aufgrund der ungünstigen Quellenlage nur schwer konkret zu bestimmen. In diesem Beitrag soll versucht werden, die bisherigen Forschungen auf diesem Gebiet zusammenzufassen und Vorschläge zu machen, wie die fachliterarischen Werke im einzelnen ausgestaltet gewesen sein könnten.

## **Enzmann, Jonas**

### **Submerged Mesolithic: preliminary results of the excavations at an aceramic Ertebølle site at Strande LA 163 in the Kiel Bay, Schleswig-Holstein, Germany.**

Since 2011, the site Strande LA 163, in 6 m depth around 1 km in front of the modern coast, is known as one of the few aceramic Ertebølle sites in Northern Germany. A first excavation campaign in 2012 and a survey in 2014 had very promising results, which led to the current project. Under the title: „Subsistence strategies, settlement structure and communication during the terminal mesolithic exemplified by a submarine micro region in the Bay of Kiel” the German Research Foundation (DFG) granted a three years project to the Lower Saxony Institute for Historical Coastal Research (NIHK).

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The author will present the first results of his PhD after four campaigns of coring and excavating the site in 2018 and 2019. Aim of the presentation is an overview of the work that is done so far and the applied methods as well as the general spectrum of artefacts. Due to the complexity of the site's formation there will be only a few remarks on that subject.



**Friedman, Zaraza**

**Mediterranean Sea:  
Continental Waters and the Economy Source of the Roman Empire**

The Mediterranean Sea is unique, not only geographically connecting three continents, namely Africa, Asia and Europe, but also because of its great importance since antiquity until nowadays, in the economy, cultural development and exchange of ideas.

The Romans called the Mediterranean Mare Internum (Internal Sea) or Mare Nostrum (Our Sea). Aelius Aristides, a Greek sophist and rethorian, when visiting Rome in 143/144 CE, expressed his vision on the role of the Roman Empire and the importance of the Mediterranean Sea in their economy:

The sea (Mediterranean) is like a belt that extends in the middle of the oikoumene (the inhabited world), as well as in the middle of your empire (Roman). Around this sea, the great continents extend far and wide, constantly augmenting your wealth with something of their own.

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The purpose of this paper is to shed light on different aspects of the maritime trade as the economy base of the Roman Empire, and what we can learn from historical, archaeological and iconographic sources throughout the centuries. Combined pictographic evidences from all arts, especially from mosaics and reliefs, and from archaeological remains of shipwrecks and their cargoes, all reflect the economy development and demands of the Roman Empire.

Ports and harbors are the actual evidence of the economy development and exchanges carried on the continental waters of the Mediterranean Sea.

## **Gerasimov, Vyacheslav**

### **Forschungen der internationalen Schwarzmeer-Unterwasserarchäologischen-Expedition im versunkenen Teil der antiken Stadt Olbia auf der Insel Beresan und am antiken Schiffswrack des 4 - 3 Jahrhunderts v. Chr. bei der Kinburn Nehrung im Jahre 2019.**

In der Feldsaison 2019 führte die Internationale Schwarzmeer-Unterwasserarchäologische Expedition Forschungen im Bereich des versunkenen Teils der Unterstadt von Olbia, im Gewässer der Insel Beresan und am antiken Schiffswrack aus dem späten 4. – 3. Jahrhunderts v. Chr., das in der vorangegangenen Saison in der Nähe der Kinburn Nehrung entdeckt worden war, durch.

Im versunkenen Teil von Olbia wurde ein 20 x 20 m großes Flussbodengelände visuell untersucht und ein detaillierter Wasserflächenplan erstellt. Im Laufe der Arbeit wurde eine Vielzahl von archäologischem Material entdeckt, darunter auch numismatisches, sowie drei antike Briefe auf Bleitafeln.

Im Gebiet der Insel Beresan konnte ein Ankerplatz mit zahlreichen Keramikmaterialien aus verschiedenen Epochen von der Antike bis zum frühen Mittelalter lokalisiert werden.

Auf dem im Laufe der Saisons 2018 bei der Kinburn Nehrung entdeckten antiken Schiffswrack aus dem späten 4. - frühen 3. Jahrhunderts v. Chr. wurden die Ausgrabungen fortgesetzt. Als Ergebnis wurde zahlreiches Keramik-Material entdeckt, einschließlich eines ganzen Lagenos, sowie Holz- und Metallteile des Schiffes.

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## Grossmann, Eva

### Tel Michal - Trade

The eastern Mediterranean coast being centrally placed between Africa, Asia and Europe has been of great importance to all the nations surrounding the sea throughout time, Cyprus serving as a hub.

Tel Michal, a settlement on the Israeli coast, some 10 km north of Tel Aviv, was occupied from the 17th to the 6th century BC. According to the artifacts discovered in land excavations, the town traded with neighboring towns and islands, mainly Cyprus. It seems that merchandize from the Aegean Sea, Athens, even from Crete travelled through Cyprus.

Its anchorage, as usual during this time, was situated in the estuary of wadi Gilot, which throughout the millennia did not significantly change its flow/ course.

The commercial relations with Egypt, not only during Tel Michal's occupation, are well documented. The story of Sinuhe (20th century BC), Thutmose III campaign (15th century BC), Wen-Amun's journey (11th century BC) to buy wood for the bark of Amen-Re, and many others, are all examples based on traded and sea transport.

Harbours and anchorages had to be very busy, if we consider the story of Wen-Amun, where the Prince of Byblos mentions 20 ships in his harbour and later 11 Tjeker ships pursuing Wan-Amun to Cyprus. Likewise, Sinuhe preferred the faster transport home - by ship.

The main merchandizes from the coast were timber (missing in Egypt), but also honey, raisin, oil and wine (rarer in Egypt) whereas Egypt exported corn. This trad continued to developed throughout the centuries. Bitumen was needed during the Hellenistic period and later for sealing amphorae. Not to mention that enslaved prisoners of war were transported through the Mediterranean Sea.

If we consider the perils of the sea, transport by ship was still preferred over trade/transport on land. The sailors were aware of the preferable month and even daytime for sailing, water currents and whirlpools, seasonal winds, all familiar today thanks to modern know how.

The knowledge obtained by sailing the replicas of Kirenia II and Ma'agan II through the Eastern Mediterranean Sea can give a partial picture of sailors' expertise in ancient times. Even these ships, reconstructions of ships built in the 6th century BC, approximately the time Tel Michal declined, can provide us a vivid image of the difficulties in navigating merchandize vessels with a square sail without oars in opened sea.

## **Hazenberg, Tom , Vorst, Yardeni and Koehler, Laura**

### **Operation Roman Ship of Zwammerdam (NL)**

#### **On preservation and restoration of a major inland maritime collection belonging to the future World Heritage Lower German Limes**

Since 2 years, a group of scientists and historical shipbuilders are working on the restoration of the State Maritime Collection of six Roman ships, discovered in the early 1970's in Zwammerdam (NL), a village with a Roman fort along the Lower German Limes. The main archaeologist is Dr. Maarten de Weerd, still associated to project Operation Roman Ships of Zwammerdam. The ships are the name-givers of the inland ship type "Zwammerdam", declared by Peter Marsden (GB) in 1972.

The first ship, carrier barge Zwammerdam 2, is nearly finished. Team Restoration is now preparing the Zwammerdam 6. The whole ship collection will be restored to serve as the core collection of the new to be built National Roman Maritime Museum, as an extension of Museumpark Archeon in Alphen aan den Rijn, just a few kilometers from the place of discovery.

The lecture will be held by: Tom Hazenberg, archaeologist, entrepreneur, guest researcher University Leiden

With contributions of Yardeni Vorst, archaeologist and Laura Koehler, archaeologist, curator

We propose to give a paper on this project by telling about the famous ships of Zwammerdam, their strategic, economic and cultural significance for the Roman army, the distribution of products as well as the significance for the future UNESCO World Heritage status of the Lower German Limes. In our paper we will explain the way of preservation and restoration, the choices we make in restoration and reconstruction.

The project is an cooperation of Museumpark Archeon, 1 Arch/Hazenberg Archeologie, Vorst Wood Research, Batavialand, supported by State Departments of Education, Sciencen & Culture, Province of Zuid Holland, municipality of Alphen aan den Rijn, Mondriaan Fonds, Leiden University and more.

## **Kaszab-Olschewski, Tünde**

### **Ein Flusshafen am Lech bei Augusta Vindelicum**

Im Zuge einer archäologischen Notbergung im Jahr 1994 in Augsburg (Augusta Vindelicum bzw. Aelia Augusta), ist ein größerer Holzbefund aus der römischen Epoche entdeckt worden. Die im bzw. am ehemaligen Lech-Flussbett, parallel mit diesem ausgerichteten Artefakte aus unterschiedlichen Holzarten dienten offenbar als Schiffanlegestelle. Diese stammt dendrochronologischen Analysen zu folge aus der zweiten Hälfte des 2. Jahrhundert n. Chr. Etwa in jener Zeit ist Augsburg als Statthaltersitz des neu entsandten Legaten ausgebaut, und die steinerne Stadtmauer vollendet worden. Anzunehmen ist, dass in der Hafenanlage die Lieferung von größeren Mengen an Baumaterialien an der Tagesordnung war. Es ist sogar wahrscheinlich, dass der Flusshafen zumindest an dieser Stelle primär für die Abwicklung dieses Transportes angelegt wurde. Aber auch die Heranschaffung von landwirtschaftlichen Produkten über den Lech mit Löschung der Wasserfahrzeuge an dieser Stelle ist anzunehmen.

Der Lech-Hafen befand sich in einiger Entfernung außerhalb der Stadtmauer, offenbar in der Nähe einer vicusartigen Ansiedlung, die sich entlang des Flussufers erstreckte.

Neben der Vorstellung des Befundes, erfolgt auch die typologische und funktionale Einordnung sowie die Verortung der Kaianlage im Weichbild der Siedlung.

## **Özdaş, Harun – Winfried Held – Nilhan Kızıldağ**

### **A Newly-Detected Potential Submerged Minoan Settlement in the Karian Chersonesos**

“The Coasts of the Karian Chersonesos” is the title of a new project in cooperation of Dokuz Eylül University Izmir and Marburg University, which aims at the investigation of coastal structures at the transition of land and water. During the 2019 season, a Minoan settlement has been detected with a rich variety of Middle Minoan II-III pottery. As a preliminary result, it seems to be a Minoan “colony” for the trade with Anatolia comparable to Iasos and Miletos. The settlement has been situated at the shoreline, and through sea level change is now mainly submerged.

**Oliveri, Francesca \*; Lo Porto, Antonina \*\***

**Presented by Detlef Peukert**

**Comunication and economic network by water: Phoenician - punic port systems in Western Sicily**

It is fair to say that the Phoenicians dominated Mediterranean sea travel, trade and commerce for over two thousand years. Yet, for most of their glorious history they were not a maritime military power, but more a business empire and a multicultural melting pot, usually maintaining good relations with all neighbors.

Western Sicily preserves many traces and remains of underwater structures that testify the evolution of harbors in the ancient Mediterranean, related to Phoenician – punic settlements, that this work aims to analyze.

Starting with the Phoenician colony of Motya, island situated at the western farthest end of Sicily, on a stretch of sea known as the Stagnone Lagoon, whose shallow waters gave a safe harbor for ships, in the best Phoenician tradition, with that unique dock system that is represented by the so-called “submerged causeway”, to the continuity represented by Lilybeum-Marsala, whose harbor system extension has yet to be determined, but the location of the three ports is known through many evidences and ancient sources. Not too distant, the city of Selinus, had to process such a mass of maritime traffic that two ports were needed: one to the East and the other to the West of the acropolis. The remains of these ports found so far are some architectural structures along the beach.

The site where the city of Mazara del Vallo lies, was probably the seat of an ancient emporium of Phoenician origin, given its fairly important position on the coast, at the mouth of the Mazara river, on the border of the territory of Selinunte.

At last, Eraclea Minoa was founded in the late 5<sup>th</sup> century BC by colonists from Selinunte. It was built on the left bank of the river Halycos near Capo Bianco, in the area where it flows into the sea. The strategic importance of Eraclea Minoa’s harbor is made clear from the sources and it must have had both military and commercial features.

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## **Pešić, Mladen**

### **Remains of ancient shipwreck near Cape Zanavin on Rivanj Island, Croatia**

A number of underwater sites were discovered during the conducting of archaeological surveys of the underwater area in the Zadar County that were done by the International Center for Underwater Archeology in Zadar. One of them witnesses about remains of the shipwreck from Roman era. On a slope from 4 to 10 meters deep, fragments of amphorae were observed. They were situated on the sandy bottom mostly covered by dense posidonia. Certain amount of characteristic parts like bottoms, rims and handles helped us to establish the origin of the cargo. Among them, most of the finds could be attributed to Keay 25 type African amphorae and ceramic vessels of the same origin. Several fragments belong to the fine African sigillata and several fragments of coarse vessels belong to Pantelleria ware. What makes this cargo even more interesting are finds of several conglomerates made up of amphora fragments. Scattered fragments of the pottery cover the area that is 20 by 30 meters.

By manual removal of sediment on one part of the site, it was found that the sand was covering a thicker cultural layer of amphora fragments. Surface documentation of the site was performed during 2018, and thirty findings that can be typologically defined were collected. Traditional 2D documentation method and modern 3D modeling technology were used during the study to compare the results obtained. This lecture will present the results of preliminary research and define this shipwreck within the wider picture of Adriatic shipwrecks with the cargo of North African findings.

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## Schäfer, Christoph

### Propulsion and Performance of Roman River Barges

Nicht die schlanken, mit Ruderreihen versehenen Militärschiffe, die eher einfach gebauten und weit weniger ansehnlichen Plattbodenschiffe mit rampenartigem Bug und Heck bildeten das Rückgrat der römischen Präsenz am Rhein und seinen Nebenflüssen. Ohne sie hätten die gewaltigen Mengen an Baumaterial, die allein schon für den Ausbau des römischen Köln benötigt wurden, niemals die Metropole am Rhein erreicht. Hundertausende von Tonnen mussten aus den Steinbrüchen in Norroy-les-Pont-à Mousson, Trier, Rheinbrohl etc. herangeschafft werden. All dies konnte nicht über Straßen geschehen, da ein Karren nur etwa eine Tonne an Ladung befördern konnte und ein Landtransport weder zu leisten noch zu bezahlen war.

Nach Auswertung der Schriftquellen zum Warentransport gelangte R. Duncan-Jones für die römische Kaiserzeit zu folgender Kostenrelation von See-, Fluss- und Landtransport: 1 : 4,9 : 28-56. Der Transport auf den See- und Binnenwasserstraßen war also auch schon damals um ein Vielfaches günstiger. Das tatsächliche Verhältnis des Aufwands für den Transport auf Flüssen sowie die verschiedenen Arten des Antriebs der Flussschiffe (Prahme) zu untersuchen ist Gegenstand eines Projekts von Althistorikern der Universität Trier, Maschinenbauern der Hochschule Trier und Physikern der TU Hamburg-Harburg sowie des MIT in Massachusetts. An einem konkreten Beispiel soll das Vorgehen zur Ermittlung der Leistungsfähigkeit römischer Prahme vorgestellt werden.

It was not the slender oared military ships, the rather simple and far less attractive flat-bottomed ships with ramp-like bow and stern that formed the backbone of the Roman presence on the Rhine and its tributaries. Without them, the enormous quantities of building material needed e.g. for the expansion of Roman Cologne alone would never have reached the metropolis on the Rhine. Hundreds of thousands of tons had to be transported from the quarries in Norroy-les-Pont-à Mousson, Trier, Rheinbrohl, etc. All this could not be done by road, since a cart could only carry about one ton of cargo and land transport was neither to be afforded nor paid for.

After evaluating the written sources on the transport of goods, R. Duncan-Jones arrived at the following cost ratio of sea, river and land transport for the Roman Empire: 1 : 4.9 : 28-56. Transport on the sea and inland waterways was therefore already many times cheaper at that time.

It is the subject of a common project of ancient historians of the University of Trier, of mechanical engineers of the Technical University of Trier and of physicists of the TU Hamburg-Harburg as well as of the MIT in Massachusetts to examine the actual ratio of the expenditure for the transport on rivers as well as the different kinds of the drive of the river barges. A concrete example will be used to present the procedure for determining the performance of Roman barges.

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## **Wacker , Daniel**

### **Zwischen Aare, Rhein und Bodensee: Die Barcarii und das spätantike Confluentibus**

Durch die Notitia Dignitatum, ein spätantikes Staatshandbuch, sind für die Gebiete des Alpenvorlandes zwei Flotteneinheiten nachgewiesen, welche im Zusammenhang mit dem Hoahrheinabschnitt des Donau-Ille-rhein-Limes stehen. Die vermutlich größere der beiden, die classis barcariorum, Ebruduni Sapaudiae, kann mit ziemlicher Sicherheit im heutigen Yverdon-les-Bains (CH) verortet werden. Im Falle der anderen, an zwei Standorten stationierten numeri barcariorum, Confluentibus sive Brecentia ist die Sachlage wesentlich unklarer. Die Identifizierung von Bregenz (AT) als Brecentia lässt sich zwar schlüssig belegen, die Lage von Confluentibus ist aber bis heute Spekulation. Erst die Entdeckung eines spätrömischen Kastells im Zentrum von Konstanz (D) bestärkte die in der Forschung schon seit längerem gehegte Vermutung, dass der Standort Confluentibus tatsächlich an dieser Stelle zu verorten wäre.

Im Rahmen dieses Referats wird diese These anhand neuer archäologischer Forschungsergebnisse diskutiert und besonders im Zusammenhang mit den naturräumlichen und historischen Gegebenheiten betrachtet. Denn die zentrale Lage des Bodensees ist nicht nur für den Hoahrheinlimes von Bedeutung, sondern auch für die Logistik auf dem Alpenrhein sowie den damit zusammenhängenden Siedlungen und Befestigungsanlagen. Zudem legt die Erwähnung einer zweiten Einheit in Yverdon-les-Bains (CH) auch einen Zusammenhang mit dem Schiffsverkehr auf der Aare nahe.

Könnte diese Flotteneinheit also tatsächlich für Konstanz nachgewiesen werden, würden sich somit neue Erkenntnisse und interessante Fragestellungen für die Erforschung der römischen Logistik im Bereich des Hoahrheinlimes generieren lassen.

## **Wagener, Sieghard**

### **Investigation of an ancient sea battle by engineering methods**

More than a dozen rams have been lifted from the seabed around Egadi Islands. They are among other items the remains of the battle between the Punic and Roman fleet at 241 BC. Most of them have got minor damages only probably due to corrosion. Others show severe damages at different locations. Parts of the structure were torn off. The cause of these failures can be found out by using physical methods such as the shock theory and the law of conservation of energy. Stress calculations and fractional mechanics help to explain what kind of destruction happened at the ship's hull after a hit with a ram.

The data base for the evaluation is derived from the geometry of the cavity of the ram which provides the dimensions of the keel, the wales and the stem. Other ships data are taken from the replica of the Athenian Trireme "Olympias" build in 1985 and tested in 1987. Initially two scenarios are studied: A frontal and a sideward crash. The influence of motions in water is considered together with the shock theory.

The results of the calculations give a hint what happened during the crash phase and the order of loads and accelerations to which the ship and its crew are exposed. Even the kind of maneuver could be proved.

An interesting fact is that even a partly damaged ram was still good enough to perform a ramming again.

A comparison with scale 1:1 crash tests in water with modern ships (20000 to tankers) shows that the method described above gives good results.

For further investigations it would be favorable to carry out NDT test on each ram such as X-ray, CT and crack detection (Dye penetration) tests. This gives information of the quality of the cast and its strength. Some rams have wooden remains inside and outside the ram's housing. The classification of the type of wood and it's direction of grain would help here.

With a bigger data base, i.e. more rams from the same spot, it might be possible to tell something more about the tactic of a sea battle in the middle of the 3rd century BC.

**Watson, Philip L.**

**Informal Economies and Navicularii in the Balkans, 4th-7th c. CE**

The assumed authoritarian nature of the Late Roman state limits our perspective on supply, tempting us to ascribe everything to the needs of the state, claiming that depositional patterns reflect state desires as carried out by merchants and shippers. However, this is an overly simplistic view, as Banaji (2016) has demonstrated in relation to monetary history.

Furthermore, anthropological research has shown that we cannot ignore the existence of profit motives and self-interested economic activity prior to capitalism. To address this gap in scholarship, I propose an analysis of archaeological evidence for supply and trade informed by recent studies of informal or “grey” economies. This concept of economic activity outside the bounds of official authority can be usefully applied to the Eastern Roman Empire along the Danube, the Black Sea, and the eastern Mediterranean from the 4<sup>th</sup> to 7<sup>th</sup> century CE. By looking at the possibility of informal economic activity in the archaeological record, we may circumvent any simplistic view of shippers and shipping networks within an empire as vast as the Late Roman state.

As an initial step, I revisit amphora evidence for supply in the Late Roman Balkans. In conjunction with shipwreck evidence, and with an eye toward possible informal economic activity, this evidence provides possible avenues into analyzing the activities of navicularii. Through this, it may be possible to discern profit motives independent of the state. Ultimately, this will allow for a more nuanced approach to archaeological evidence for supply to the Late Roman provinces, and the ways in which such evidence may not refer to state-directed provisioning at all.

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