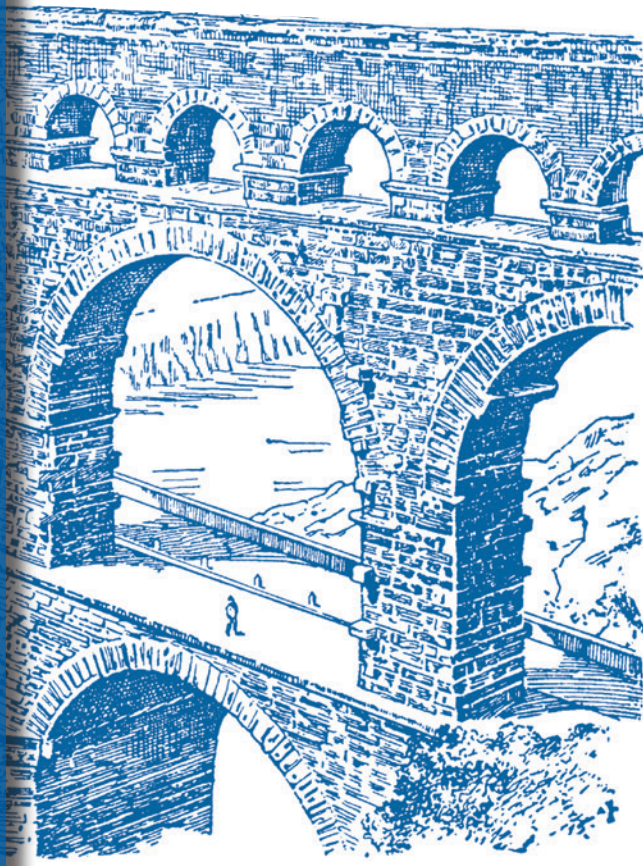
WORKSHOP WATER MANAGEMENT 13–14/02/2014



TOPOI BUILDING DAHLEM
CONFERENCE ROOM
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EXCELLENCE CLUSTER TOPOI
(A-3) WATER MANAGEMENT (KEY TOPIC)

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Dear participants of the water management workshop,

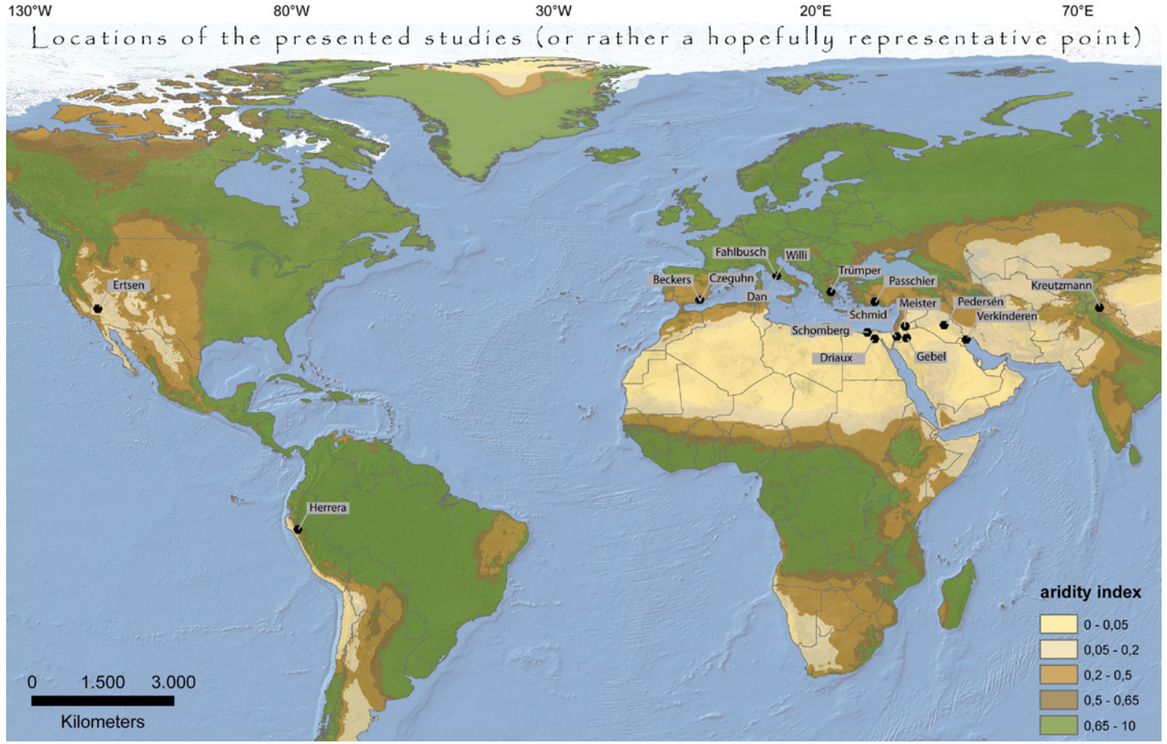
Water is a vital resource, which is neither homogenously available through time or space nor is it a simple matter of «having or not having it», hence the dependency of humans on water has let to most differentiated ways in managing it.

We welcome you for two days of interesting talks and discussions on the history of water management. The workshop is hosted by the Excellence Cluster Topoi – The Formation and Transformation of Space and Knowledge in Ancient Civilizations – and the keytopic «water management»

In the following you will find all information you need to know concerning: what, where and when...

Greetings, the organizers

Content



Introduction

Basic concept of the keytopic group water management

The group consist of researchers from different disciplines such as: Geography, the History of Science and Technology, Roman History of Law and Archaeology. One of the main topics is the history of water management with a focus on management strategies in semi-arid Spain, including the transition from Roman to Islamic and finally to modern management procedures. Another is the technical innovations that took place in the first Millennium BCE, mainly in Alexandria. One of the main tasks of the Keytopic group, is to analyse water management-systems, so that a comparison and evaluation over different scales, times and regions is possible. This is done either by case studies, mainly in the Mediterranean region, and by an intensive literature review and finally the merge in a database.

More specific problems are:

≈ What would be a clear definition of water management? You could state either that the management of water is simply the redirection and collection of water for human purposes or you could demand that (ii) water management are all regulating measures between natural water availability and societal water demands. The difference is that the first definition just includes the technological prescription, while the second states that for any technological measures societal processes are of equal or high importance.

≈ Derived from the first problem it is also not easy to say, when or where water management started, was it, (i) with the first installations of wells, (ii) the onset of irrigation measures or (iii) the first canals dams and reservoirs? However all of these approaches have most probably been in use long before the Bronze Ages, which also evokes the huge uncertainties for any direct and exact age determination.

≈ To which extend was (and is) the colonization of marginal areas possible due to water management strategies (and the intended practical knowledge)?

≈ Do comparable conditions (environments, climates) create comparable water management strategies (techniques)?

≈ How did water technologies and the practical knowledge of it spread through time and space – and is diffusion a valid approach?

Programme

Thursday 13/02/2014

9.30 Jonas Berking (Brigitta Schütt, Michael Meyer), Freie Universität Berlin
Introduction, Welcome

10.00 Maurits Ertsen, Delft University of Technology
A thousand miles in small steps. Human agency and water control in ancient societies

11.00–11.30 Coffee break

11.30 Stephan G. Schmid, Humboldt-Universität zu Berlin
Aspects of water management in Petra, Jordan

12.00 Julia Meister, Freie Universität Berlin, Deutsches Archäologisches Institut
Water management of Jawa, Jordan

12.30 Hans Georg K. Gebel, Freie Universität Berlin
Archaeohydrology. Research imperatives, theoretical frameworks, and transdisciplinary experiences

13.00–14.30 Lunch break

14.30 Ignacio Czeguhn and Quesada Morillas, Freie Universität Berlin
Al-Andalus: The muslim model »Water and rights to water«

15.00 Anna Willi, University of Zurich
Irrigation in Roman Hispania

15.30 Peter Verkinderen, Netherlands-Flemish Institute in Cairo
Early Islamic irrigation systems in Khuzestan, W Iran

16.00–16.30 Coffee break

16.30 Hermann Kreutzmann, Freie Universität Berlin
The system nobody knows – water management in Hunza (Keynote)

17.30 Alexander Herrera, Universidad de los Andes, Colombia
From hydromythology to archaeohydrology, and back: Water management in the precolonial Andes

Dinner – (Alter Krug Dahlem, around 19.30)

Friday 14/02/2014

9.00 Henning Fahlbusch, Fachhochschule Lübeck
Comparison between ancient Greek and Roman water supply systems (Keynote)

10.00 Anette Schomberg, Topoi
Sources reconsidered – new perspectives on innovation in Hellenistic water technology

10.30–11.00 Coffee break

11.00 Cees Passchier and Gül Sürmelihindi, Johannes Gutenberg Universität Mainz
Carbonate deposits in ancient aqueducts as a data source in archaeology, archaeoseismology and paleoclimate

11.30 Delphine Driaux, Université Paris-Sorbonne, France
The water supply in Ancient Egypt and the role of the state

12.00 Olof Pedersén, Department of Linguistics and Philology, Uppsala University, Sweden
Water at Babylon and the surroundings

12.30–14.00 Lunch

14.00 Anca Dan, Topoi
Ancient resistance to water management

14.30 Brian Beckers, Freie Universität Berlin
Strategies to cope with water scarcity – ancient to modern examples of water harvesting techniques

15.00–15.30 Coffee break

15.30 Monika Trümper, Institut für Klassische Archäologie, Freie Universität Berlin
Water management of Greek public baths

16.00 Final discussions

Abstracts

Maurits W. Ertsen, Water Resources Management, Delft University of Technology

A thousand miles in small steps. Human agency and water control in ancient societies

Irrigation systems are spatial assemblies of built elements supplying crops with water. System's operation is a mixture of physical distribution facilities that bring water to fields and crops, and socio-political coordination between the different actors that use the water flows. Irrigated agriculture is more than simply managing volumes each month or season; irrigation is indeed typically about manipulating flows of water in time periods as short as hours and days – not just acre-feet per year, but liters per second. Such short-term manipulations do result in water balances and volumes on larger temporal and spatial scales. Using those lumped volumes and balances cannot be used, however, to derive the many small-scale manipulations of water flows that built the lumped results: reading back the detail from the general is impossible. Irrigated landscapes are the result of many individual activities – on their own or within entities like households and social groups – within the physical boundaries (hydraulic and hydrological) of the irrigated areas. Agent-based modeling (ABM) is a promising way forward in analyzing ancient irrigation. When simulating social action in modeling efforts, an issue of obvious importance is how to ensure that social action by human agents is well-represented in the analysis and the model. Generally, human decision-making in ABM-environments is either modeled on a yearly basis or lumped together as collective social structures. Both responses are problematic, as human decision making is more complex and organizations are the result of human agency and cannot be used as explanatory forces. A way out of the dilemma how to include human agency is to go to the largest societal and environmental clustering possible: society itself and climate, with time steps of years or decades. In this paper, the other way out is developed: to face human agency squarely, and direct the modeling approach to the human agency of individuals and couple this with the lowest appropriate hydrological level and time step. This approach is supported theoretically by the work of Bruno Latour, the French sociologist/philosopher and illustrated with examples from the Hohokam civilization in the American South West (Arizona), along the Salt and Gila Rivers roughly between 500 and 1500. The issue is not just what scale to use: it is what scale matters. Understanding the arrangements that permitted the management of irrigation over centuries, requires modeling and understanding the small-scale, day-to-day operations and personal interactions upon which they were built. This effort, however, must be informed by the longer-term dynamics as these provide the context within which human agency is acted out.

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Stephan G. Schmid, Winckelmann-Institut, Humboldt-Universität zu Berlin

Aspects of water management in Petra, Jordan

The ancient Nabataean capital Petra in southern Jordan (30019'43,64 N / 35026'35,99 E) is situated in a semi-arid zone with an average yearly rainfall between 50 and 100 mm. Only a few kilometres away, the average rainfall rises to between 100 and 200 mm and a little bit further East in the Shara mountains reaches up to 300 mm p.a. This situation raises a series of questions, one of them being why the Nabataeans insisted on building their capital at this specific spot and occupy it with a dense settlement pattern at least from the late 2nd c. BCE to the early 2nd c. CE. The answer to this question probably has nothing to do with water management, but with socio-cultural aspects that shall not be dealt with in extenso in this paper.

In order to be able to dwell on a permanent base at Petra, the Nabataeans had to develop a highly sophisticated water management along two basic lines:

1. Bringing drinking water to the city
2. Protecting the city from flash floods

After a short overview of the overall functioning of these two systems, a few case studies will be presented illustrating the ingenuity of Nabataean engineers and builders in order to adapt well known technologies of water management to the specific – and manifold – local situations. These case studies were developed and continue to be studied during ongoing fieldwork in the region.

≈ The fist case is a local micro-study of such a twofold water management system, located within the Wadi Farasa East on the periphery of the city centre. Here, the main problem was to protect the built structures from the violent flash floods and to re-use the run off water for luxurious water display but also for drinking.

≈ In the second case water needs to be provided for a luxurious residence on the highest mountain of the area with a restricted access and a very limited capacity to collect run off water.

≈ The third case shows what Nabataean builders were able to do when it comes to provide water for the elite housings of their society, i.e. the royal residences.

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Water management of Jawa, Jordan

The ancient site of Jawa (32.335367 N / 37.003909 E) is a fortified settlement in the basalt steppe desert of Northeastern Jordan, excavated in the 1970s and 1980s by Svend Helms. The major occupation phase of Jawa dates into the Late Chalcolithic/Early Bronze Age period, so the end of the 4th millennium B.C.. This major occupation phase is assumed to have lasted for only a short period of time. Next to an impressive fortification wall, Jawa is especially known for its highly sophisticated water management systems, made of a series of large pools, dams and channels. Moreover, several large agriculturally used areas in the vicinity of Jawa were identified by recent archaeological and geographical investigations of the German Archaeological Institute and the Freie Universität Berlin.

These agricultural field systems can be differentiated into two major types: a) those located on wadi terraces in the Wadi Rajil, irrigated by floodwater harvesting, and b) those located on plateaus and small tributary valleys close to Jawa, irrigated by rainwater harvesting. The results of the archaeological survey suggest that at least the latter date to the major occupation phase of Jawa, providing the oldest evidence for terraced rainwater harvesting irrigation agriculture in Southwest-Asia. Due to the peripheral location of Jawa in a nowadays arid environment this is puzzling.

The ongoing geographical investigations focus therefore on the questions (i) how these field systems functioned technically, (ii) how much water was needed to supply these agricultural areas, and (iii) how many people could be supplied by the produced field crops. In order to answer these questions and to gain some information about paleoenvironmental conditions different methodological approaches, including geomorphological, sedimentological and hydrological investigations, as well as water budget models, will be applied. The talk gives an overview of the results achieved so far.

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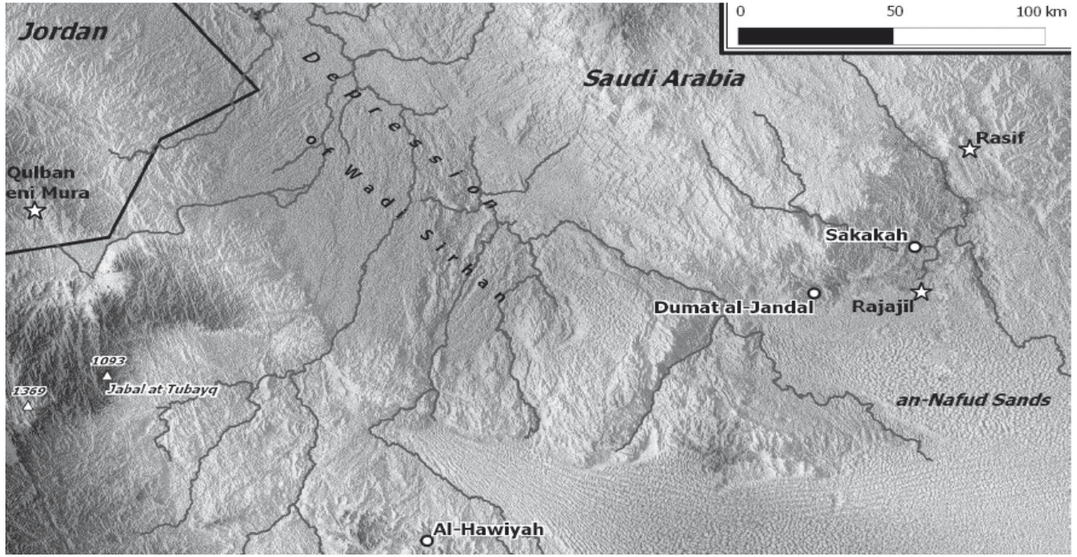
Archaeohydrology. Research imperatives, theoretical frameworks, and transdisciplinary experiences

While hydraulic structures and water management are substantial subjects and topics of many archaeological research projects, only a limited number of projects employ hydrologists or engage in building interdisciplinary frameworks for the study of their hydraulic and hydrological findings. Many archaeologists feel able to cover archaeohydrological research by the means of their discipline, and the landscape, ethological, social, economic, and ideological meaning of water in an ancient society is understood as just one of the many ressource aspects an occupation may have. Different from archaeozoology, archaeobotany/ palaeoethnobotany, geoarchaeology, palaeoclimatology, and other disciplines helping to create corporate research milieus, archaeohydrology does not exist as a discipline with a debated definition and a foundation in research theory. Confusion even exists over the difference between palaeohydrology and archaeohydrology. The web almost does not know the term, and academia.edu names two (!) colleagues engaged in archaeohydrology, against more than 300.000 archaeologists and anthropologists. However, several projects recently focus on archaeohydrological subjects with the explicit or implicit aim to lay the foundations of an archaeohydrological discipline, often starting from other approaches (e.g. the landscape archaeological approach of the CBRL Wadi Feinan Project), or projects in China and South America. On the other hand, empirically based archaeohydrological projects successfully work in especially the classical periods without a disciplinary claim. This contribution aims to discuss, from a prehistoric perspective,

1. the need to promote and formally establish archaeohydrology as a discipline
2. to define its various sectors and links to other disciplines
3. to circumscribe its potential frameworks in research theory while linking it to systemic approaches, and
4. to argue for a transdisciplinary – rather than an interdisciplinary – embedding of archaeohydrology in research frameworks.

The latter is exemplified by most recent Chalcolithic research in arid Northwestern Arabia. Certain ill-considered or new aspects of prehistoric archaeohydrological research will be stressed: hydroethology/ human water territoriality, the difference between «foraged» and «productive» water/ water as an agent of vulnerability, water management as hydrosocial management, archaeohydrology in systemic/ holistic transdisziplinary models.



The location of Qulbān Banī Murra, Rajājil and Rasif in south-east Jordan/north-west Arabia

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Ignacio Czeguhn and Quesada Morillas, Lehrstuhl für Bürgerliches Recht, Deutsche und Europäische sowie vergleichende Rechtsgeschichte, Freie Universität Berlin

Al-Andalus: The muslim model »Water and rights to water«

1. The management and usage as well as preservation of water in the state of Al-Andalus (711-ca. 950) is analysed. Which means of infrastructure did the Arabs employ to use water in the agricultural industry and everday life?

2. The legal sources:

≈ Quran and Sunnah
Already the religious scriptures include regulations concerning the water that can be regarded as legal sources.

≈ The science of fiqh (doctrine and interpretation of Quran)
Matters of interpretation are essential to legal sciences, viz. how is a legal norm with an undefined legal term interpreted? How is the code filled with meaning?

≈ Legislation and regulation of the «comunidades de regantes» («water communities»)
In the independent caliphates we come across so called «water communities». Are they of Arab origin, or are there precedents in Roman law or in the Germanic-influenced law of the Visigoths?

≈ The jurisprudence in Al-Andalus
How does the Arabic-influenced jurisprudence in Al-Andalus influence the pre-existing water legislation? Is it modified or assimilated, or completely repealed?

≈ The arbitral courts in water disputes (still standing today)
In practice, arbitral courts in water disputes were established from the beginning. Why exactly this form of judiciary, that is still standing today?

These are the questions that the project of the lecturer and the scholarship holder Ms. Quesada Morillas has focused on since February 2013. First careful results will be presented to you during the speech.

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Anna Willi, Historisches Seminar der Universität Zürich, Fachbereich Alte Geschichte

Irrigation in Roman Hispania

The study of agricultural irrigation in the west of the Roman empire has long been neglected by historians. This neglect is particularly striking for the Iberian Peninsula, where the climate is far from favourable and irrigation is vital for agricultural production and profit also today. Moreover, a great number of remains of ancient rural hydraulic infrastructure such as dams, aqueducts and cisterns are known from this region and have been documented and described. Yet, a synthesis and comprehensive interpretation of these remains in the context of Roman settlement and economy is still lacking.

The projected presentation is based on an overview of Roman irrigation infrastructures in the Hispanic provinces and their geographical and hydrological situation. It aims at providing a broader economic context for the interpretation of this infrastructure: To what extent can the infrastructure, and thus irrigation as a means of agricultural production, be put in relation to markets and trade? Who initiated or enabled irrigation in the Hispanic provinces, and who profited from it? The answers to such questions can be expected to provide an insight also into further implications for the administration of water use in the rural environment and for agricultural production in the Hispanic provinces.

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Early Islamic irrigation systems in Khuzestan, W Iran

Khuzestan, which is the western extension of the Mesopotamian plain, was one of the main centers of agricultural produce in the Early Islamic Empire. During most of the year, the climate is very hot and dry, so rain-based agriculture is impossible, and crops have to be watered by canals derived from the main rivers in the area: the Karkhe, Dez, Karun, and Jarrahi.

This paper is concerned with the irrigation systems that were in use in Khuzestan in the Early Islamic period. Very little research has been done on this topic. The main sources of information are medieval (mostly Arabic) texts, landscape descriptions by later (mostly Western) travelers, archaeological surveys and descriptions of dams, satellite images and aerial photographs.

This paper will present the results of a Belgian interdisciplinary research project that aimed to reconstruct the evolution of the Lower Khuzestan plain, and focus on the massive irrigation systems that were detected in the area.

This research project was carried out by researchers from Ghent University and the Geological Survey of Belgium. Using a combination of geological corings, an archaeological survey, analysis of remote sensing material (CORONA, LANDSAT, SRTM, SPOT, aerial photographs) and texts. A new model for the evolution of the plain was proposed. The team found numerous traces of very large irrigation systems in the plain, which water a far greater area than is under cultivation today. This paper will present the main features of these irrigation systems, and some of the questions they raise about the way water was managed in the area.

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The system nobody knows – water management in Hunza

Argument: The paper investigates possible ways to analyse and interpret irrigation systems and water management in the Hunza community which has no written language - Burushaski - and no written records regarding water rights, division of duties and entitlements. Oral traditions and local histories describing the deeds and hydraulic accomplishments of former rulers *(mir)* and their ministers *(wazir)* contain several hints for the attribution of time frames to individual irrigation canals. Their combination with the agro-ecological setting, distributive systems, allocation rights and linkages to hydro-glacial sources of irrigation water allows a reconstruction of the settlement development and agricultural value creation in a compact oasis setting.

The analysis and interpretation of the irrigation system provides valuable hints and indicators for community structures regarding kinship and authority. The complexity of rules and regulations is a reflection of the paradox situation of water scarcity within glacial opulence. The arid setting of the Hunza oasis amidst the most extensive glaciated area outside the Polar Regions in the Karakoram Mountains provides a fine example of peculiar rules that apply to locality and not to regions. The Central Hunza oasis will be discussed as a case in point where the precipitation gradient reaches from desert to glacial zone and where the Burusho people have managed to bring the necessary hydraulic resources to a suitable location. The process of utilising the given environment and the subsequent settlement expansion will be discussed in light of the available sources. The 'system nobody knows' is a metaphor borrowed from Robert Netting (1974) and his alpine investigations. The Hunza is known to the living adopters and especially to the office bearers who organise the proper distribution and legal conformity. Until today the properties of the system have never been written down locally and are a living memory regularly to be renegotiated and sometimes contested. The system proves to be a rather flexible approach to available resources that bears a legacy and is prone to modification when system properties change. The paper aims at providing a historical development of the irrigation system in Central Hunza and some reflections on its management.

Database: The research is based on extensive fieldwork in the Hunza Karakoram, Northern Pakistan. Oral traditions, colonial records, own interviews and field surveys

are taken for reconstructing the water management system in the Central Hunza oasis.

Coordinates of Hunza: 36° 19' N, 74° 39' E

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Alexander Herrera W., Marie Curie Fellow at KAAK (DAI) by Gerda Henkel Foundation

From hydromythology to archaeohydrology, and back: Water management in the precolonial Andes

Relations of kinship between people and places in the pre-colonial Andes typically include those between farmers and the mountains and lakes from whence they received water for irrigation. Collective claims over sources of water were expressed thorough mortuary architecture, with availability assessment and allocation structured through mortuary practice. Drawing from indigenous mythology, this paper discusses selected field survey data from the desert valley of Nepeña and the Cordillera Negra and Blanca of Peru (9° lat. S), to show how the history of water relations is variably inscribed in the landscape.

Springs and areas of high ground water table are suggested to have been harvested early (c. 3.000 B.C.) with transport canals – and the labour tax extraction and bureaucracy concomitant to large-scale construction projects – emerging and consolidating in bursts that may mirror successes (and failures) in responding to water availability shifts. Allocation of water by turns appears as the norm throughout the sequence, monumental Inca flow dividers suggesting imperial prerogative claims may have emerged as late as c. A.D. 1.500.

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Prof. Dr.-Ing. Henning Fahlbusch, Fachhochschule Lübeck / Deutsche Wasserhistorische Gesellschaft e.V.

Comparison between Greek and Roman water supply systems

The aim of water management was and is to cover the water demand of a society from local water resources. When these are insufficient temporal and/or local transfers are applied, i.e. storage of water in times of a surplus to use it in times of shortage and/or transfer of water from a distant resource by aqueducts to the point of demand. The aim and method of these transfers didn't change from the first applications in Europe during the Bronze Age until today. However the necessary structures for them were chosen in dependency of the local conditions and these changed in the course of history.

Evans excavated in Knossos wells and springhouses for the use of local groundwater. Angelakis et al. report about cisterns from Minoan times. Again Evans detected an aqueduct for the palace at Knossos consisting of conical pipes.

The Mycenaean settlements like Tiryns, Athens, Korinthos, or Mycenae were founded on top of a hill resp. mountain due to military aspects. Springs at the site (Athens, Korinthos) or in its vicinity (Tiryns, Mycenae) were important for the supply of water. In the last cases it was necessary to have a safe access to the water by tunnels.

Little is known about the technological development in Greece during the dark ages from the end of the Bronze Age until archaic times. This changed in archaic times when Athens rose to a dominant political power in Greece. It was Peisistratus who ordered the construction of a long distance aqueduct for Athens which supplied the fountain houses, which are to be seen at paintings. A nearly 8 km long tunnel was excavated from the east and a pipeline installed in it. The aqueduct supplied the famous fountain houses like Enneakrounos or Kallirrhoe which are mentioned from various authors. The construction of a tunnel was obviously chosen because of safety reasons, to protect the aqueduct. This method was also applied later on at Samos where the famous tunnel of Eupalinos, which had been constructed from both ends, was obviously the peak of tunnel construction for many centuries.

The pipes of the archaic aqueducts were very carefully conically shaped especially with collars at the joints. When looking at Hellenistic pipes, for instance in Pergamum, it is obvious that there the single cylindrical elements were produced in an industrialised way, in order to save money. The importance of costs for the construction of an aqueduct results also in the installation of the pipelines in the soil.

Depressions were crossed by means of pressure pipelines. The one in Pergamum supplying the acropolis had to bear a pressure of about 190 m water column. And naturally the temporal transfer was applied. The storage basin in Megara is an excellent example. It got its water from an aqueduct.

The 1st aqueduct in Rome, i.e. the *Aqua Appia*, was already constructed during the 3rd century BC as a canal in which the water flowed probably cecause of the limited cross-section of the latter which also limited the discharge. In the course of Rome's 3rd aqueduct, i.e. the *Aqua Marcia*, a long bridge south of Rome was constructed bearing the *specus*. Thus the aqueduct was not hidden any longer. These bridges then became the synonym for Roman aqueducts.

Many cities grew during the *pax Romana*, got a big population and thus also a big water demand. More or less all cities got aqueducts for their water supply system which cost a lot. Thus new technologies were developed like the *opus caementitium* and the *opus signinum*. Lead-pipes were standardized and pressure pipe-lines often constructed of stone-pipes.

At the end of an aqueduct the water was either directly distributed to the various consumers in the city like for instance in Rome or Pompeii or it was stored in big cisterns, like at the end of the Serino-aqueduct in the so called *piscine mirabilis*.

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Anette Schomberg, Excellence Cluster Topoi

Sources reconsidered – new perspectives on innovation in Hellenistic water technology

At least since Örjan Wikander's substantial contribution to invention and distribution of the water mill[1], there can be no doubt about the significant role water technology played in Antiquitiy and plays still as an indicator towards an estimation of technology in Antiquity in general. Especially the appreciation of range, intensity, diversity, and complexity of applied water technology has recently changed the long prevailing dismissive opinion about ancient technology as initiated for example by the historian Moses I. Finley.[2]

Finley argued that there haven't been technological innovations worth mentioning in Antiquity. In contrast, especially the Hellenistic time is nowadays regarded as a »period of promise« (Ö. Wikander) marked by technological innovation. Therefore, this contribution aims to discuss, by using the example of water-lifting devices (i.e. water-wheels, Archimedean screw, bucket chain and force-pump), if something like an »innovation push« can be traced in Hellenistic time. At first it is necessary to explore the level of water-lifting technology in pre-Hellenistic time and to contrast them with the devices invented subsequently. Useful for this purpose are for example the installations in the baths of Pompeji and in the fountain house of Cosa or the recently discovered bucket-chains from early Imperial time in London[3] which could be compared with descriptions by Vitruvius. At last, the information gained by a thorough re-examination of highly controversial sources like Philo of Byzantium's treatise about pneumatic and hydraulic devices from early Hellenistic times are indispensable.

By using well-known and recently discovered archeological sources as well as written records (while keeping the afore-mentioned discussion about technology in Antiquity explicitly in mind) this case study aims to present a revised perspective on ancient water-lifting devices and the Hellenistic contribution to technological development.

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3 Ian Blair, Robert Spain, Dan Swift, Tony Taylor and Damian Goodburn, Wells and Bucket-Chains: Unforeseen Elements of Water Supply in Early Roman London, Britannia 37, 2006, 1-52.

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Carbonate deposits in ancient aqueducts as a data source in archaeology, archaeoseismology and palaeoclimate

Carbonate deposits are common in many ancient aqueducts and are a new potential high-resolution data source for archaeology, archaeoseismology and palaeoclimate (Fig. 1). The arrangement of internal layering, microstructure and chemical composition of these deposits depends on a range of environmental and anthropogenic factors which can be unravelled using integrated field and laboratory research.

For the present study, a database of over 1500 Greek and Roman aqueducts (www.romaq.org) has been set up. Carbonate deposits were studied in Roman aqueducts in Turkey, Greece, France, Italy and Spain. It was shown that the type of deposit strongly depends on the water composition of the source, the shape and steepness of the channel, and local climate. Channels with slow flowing, nutrient rich water tend to have abundant development of biofilms and porous, poorly laminated deposits. Aqueducts with fast flowing water from karst sources generally have little biological activity and dense, solid deposits. Deposits can also change along an aqueduct channel if the slope or channel type changes, e.g. from closed pipes to an open channel. Samples from two Roman aqueducts in Turkey, Aspendos (36.93935°N, 31.16929°E) and Patara (36.26242°N, 29.31851°E) were studied in detail using optical microscopy, stable isotope and trace element analysis. The samples show a layering of alternating dense, coarse-crystalline and porous, microcrystalline calcite, which corresponds to a cyclical variation in oxygen and carbon isotope composition. Using the microstructure and stable isotope results of a range of samples from the Patara and Aspendos aqueducts, a method was developed to recognise a seasonal signal in the observed layering. This method can now be generally applied to calculate the time of operation of different segments in aqueduct systems and the temperature and quality of the water reaching ancient cities. Using the new method, the following results were obtained. In Patara, inauguration of the aqueduct could be dated to 51 CE based on carbonate deposits in a pipe segment that was destroyed by an earthquake in 68 CE. In Ephesos (37.94107°N, 27.34237°E), a fault was discovered that cut the 43 km long southern Değirmendere aqueduct during an earthquake in ca. 178 CE. Subsequently, a new channel was built aside the old one downstream from the fault. Carbonate deposits in both channels were used to show that the aqueduct was Hadrianic in setup, and was finally destroyed in one of the large earthquakes at the end of the 4th century. In

10 cm thick carbonate deposits from the Roman aqueduct of Cologne, Germany, representing 180 years of deposits.

Carbonate deposits in the aqueduct channel of the Fréjus Roman aqueduct, France

Cahors (44.44401°N, 1.43969°E) an analysis of deposits has shown that the Roman aqueduct was periodically cleaned of carbonate deposits. In Béziers (43.34425°N, 3.21485°E), deposits from a Roman aqueduct could be dated for the first time to an early Imperial age using U/Th dating. In all aqueducts, oxygen isotope analysis of carbonate deposits can in principle be used to determine local temperature fluctuation in Roman time.

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Water Supply in Ancient Egypt: the Role of the State

From an historical point of view, the control of water, and in particular the control of the flood, has played an important part in the development of the «hydraulic civilisations» to which Egypt belongs[1]. Since the creation of the Pharaonic state around 3100 B.C., irrigation and the distribution of water have been shown to be pivotal forces in achieving social and political cohesion. For example, on the mace-head of King Scorpion[2] we can see the King holding a hoe, digging a canal system. If the power of the King comes from his warlike and huntress qualities[3] the control of water through the flood, nevertheless played an important part in the cultural and political unification of the country[4]. Indeed, claiming to be the guarantor of a regular and fertile flood, and annihilating its destructive effect, the King appropriates for himself the sacred character of the Nile and, at the same time, the one of the water[5].

It is well-established, through the cosmogonies, that the Pharaoh, as the god's son, is the guarantor of the flood and he has, by its function, all powers over water. This is the King who lays down rules about the irrigation and, all in all, about water. The water management and the works related to the irrigation are entrusted to the Vizier, thus resulting not only in the emergence of a ruling class, but also a bureaucracy, since the Vizier delegated his authority to the local administrators. While many studies have been carried out on the water management of the irrigation and its administration, the part played by the Pharaonic institutions for daily water issues is not very well-known yet. Despite this, the system set up is the same.

Therefore, this talk will show how the State, through the local administration, acted in concrete terms on the water supply of its inhabitants. The study of the textual and archaeological evidence will show that the water supply of the cities seems to have worked on a simple and a relatively equitable schema. The water supply of the inhabitants was, indeed, completely managed by the local administration which was charged to bring the water (in general from a rural area) into the town and to redistribute it to the inhabitants. This mere functioning is perfectly illustrated by the case of the «water carriers» of the village of Deir el-Medina. I will demonstrate that, even when the city was far from a water source, the State did not set up complex installations such as pipe networks or wells to bring water, and preferred a more simple system using the manpower available.

References

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2 Ashmolean Museum d'Oxford, E 3632. Discovered by J.E. Quibell, *Hierakonpolis* I, BSAE 4, Londres, 1900, p. 9,pl. XXVIc. For a recent study, see P. Gautier and B. Midant-Reynes, «La tête de massue du roi Scorpion», *Archéo- Nil* 5, 1995, p. 87-127.

3 M.-A. Bonhême et A. Forgeau, *Pharaon. Les secrets du pouvoir*, Paris, 1988, p. 163.

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5 N. Grimal, «Le sage, l'eau et le roi», in B. Menu (ed.), *Les problèmes institutionnels de l'eau en Égypte ancienne et dans l'Antiquité méditerranéenne*, BdE 110, Cairo, 1994, p. 195.

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Olof Pedersén, Professor of Assyriology, Department of Linguistics and Philology, Uppsala University, Sweden

Water at Babylon and the surroundings

1. Survey of the basics of water conditions on the Mesopotamian floodplain will be presented dealing with precipitation, rivers, and ground water in the landscape including consideration of the recently published material of the Iraqi research. Differences between modern and ancient water systems will be shortly discussed.

2. Problems and possibilities with precipitation, rivers and canals, ground water in the area around Babylon seen in a historical perspective.

3. Details of the water situation in the city of Babylon (centre about 32.54N 44.42E) at the end of the reign of Nebuchadnezzar II (604-562 BC) when it was possibly the largest city in the world within town walls. Preliminary results from excavations and ancient texts compared with the modern landscape. Expected results from new research will be shortly outlined.

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Anca Dan, Excellence Cluster Topoi

Ancient resistance to water management

In ancient like in modern democratic cultures, measures meant for taming superhuman forces of nature in general and water, as the essential element for life, in particular, generated public debate. The aim of this paper is to explain the cases for which we have information, from Greek and Latin texts, preserved to our days, about actions which could have an impact on public access to drinking water. Our approach is historical and anthropological: in a comparative perspective, which takes into account different Mediterranean civilizations, from Iran to Greece, Rome and Gaul, we discuss the evidence concerning the decision of modifying nature, the support and the opposition voiced among the *elites* and the people, and the result of the measures finally undertaken.

Ancient people could impact on surface water resources in two ways: by modifying the rivers and their flood plains and by throwing objects into rivers and lakes. In the first part of this contribution, I will discuss the debates in the 1st century AD Rome about the changes proposed in the Senate for the modification of some tributaries of the Tiber. In the second part, I shall deal with cases of foreign objects put in public waters – forbidden by Greek and Roman legislation, sometimes favored by mystic traditions. In the end, I will analyze the case of the modification of the course of the Gyndes (modern Diyala), tributary of the Tigris, about 539 BC, as an interesting case of debate and interpretation, in different cultural contexts, of the gestures of Cyrus, the Great King. Iranian religion prohibited any form of pollution of water resources, domain of Anahita; the Greeks misunderstood the facts, by the prism of their own religious taboos. For both ancient cultures, the respect for divine forces mediated the human impact of nature. Not without considerable consequences, modern civilizations replaced religion by science.

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Strategies to cope with water scarcity – ancient to modern examples of water harvesting techniques

Water-harvesting methods play and played a vital part in coping with water scarcity mainly in drylands. Archaeological remains of these techniques are abundant in the drylands of the Mediterranean region and West-Asia. At least since the Bronze Age various water harvesting techniques evolved which in some places are applied even today. Many of those show evidence of more or less elaborated water supply structures that allowed the existence of (semi-) permanent settlements at locations of which nowadays many are abandoned.

Based on a literature review we give a brief overview of these water-harvesting methods and present the basic concepts behind these techniques together with references to archaeological case studies. An overview of the presented examples is given in the figure 1 (overleaf).

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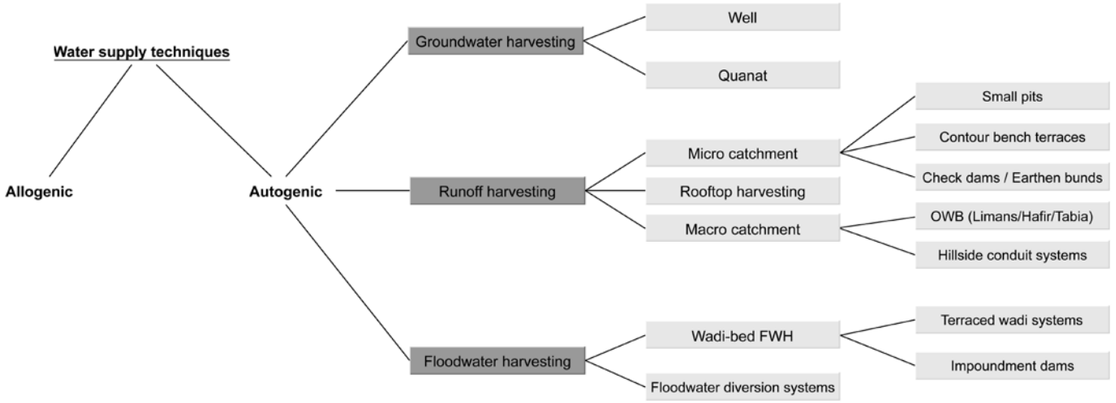

Fig. 1: Overview of water-harvesting methods

Prof. Dr. Monika Trümper, Institut für Klassische Archäologie, Freie Universität Berlin

Water management in Greek public baths

Water is crucial to the functioning and operation of baths. The water management of Greek bathing facilities has only been studied by Hubertus Manderscheid in an excellent handbook article from 2000 that could only draw upon very limited evidence for the most important category, however, namely that of public baths[1]. A recently published book on Greek baths and bathing culture includes a catalog of all currently known Greek public baths (70), which are distributed in the entire Mediterranean and date from the 5th century BC to the 2nd century AD[2]. These baths are identified as independent (independently accessible) buildings that offer bathing facilities for a larger number of people and include (among others) 7–50 hip-bathtubs for simple individual shower baths.

While several features of these 70 baths have been discussed in synthetic approaches[3], their water management has not yet been reassessed comprehensively. This paper provides a first attempt to fill this gap, addressing the following questions.

1. Which kind of water supply was available (well, reservoir/cistern, water pipe system)?
2. How was water used in these baths and how did it circulate (e.g. from water source to furnace, from furnace to bathing form)?
3. Can capacities of water supply be calculated, also in relation to bathing forms provided in the baths that required significantly differing amounts of water (basins for ablutions of body parts, hip-bathtubs, individual immersion bathtubs, collective immersion pools)?
4. How was waste water drained: from which bathing forms, rooms and facilities, and where to?
5. Which other sources (images, texts) give insight into the water management of these baths?

Analysis will be both qualitative (focusing in a close reading on significant, particularly conclusive case-studies) and quantitative (assessing the – often fragmentary – evidence from all of the 70 baths). Ultimately, this paper has two overarching aims: first, to assess the technological standard and sophistication as well as the realistic operation of Greek public baths (e.g., year round; hours per day or week; number of bathers); and second, to identify crucial lacunas in research on this topic and provide

directions and perspectives for future research, particularly with an interdisciplinary approach and framework in mind.

References

1 H. Manderscheid, The Water Management of Greek and Roman Baths, in: Ö. Wikander (ed.), *Handbook of Ancient Water Technology*. Leiden (2000) 467-484, focuses on two completely excavated examples.

2 T. Fournet - S. Lucore – B. Redon – M. Trümper, Catalog of Greek Public Baths, in: S. Lucore – M. Trümper (eds.), *Greek Baths and Bathing Culture: New Discoveries and Approaches.* BABESCH Suppl. 23. Leuven (2013) 265-333.

3 See various papers in S. Lucore – M. Trümper (eds.), *Greek Baths and Bathing Culture: New Discoveries and Approaches.* BABESCH Suppl. 23. Leuven (2013).

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Notes

Notes

Directions and Venue

1. Workshop
   Topoi Building Dahlem
   Hittorfstr. 18
   14195 Berlin

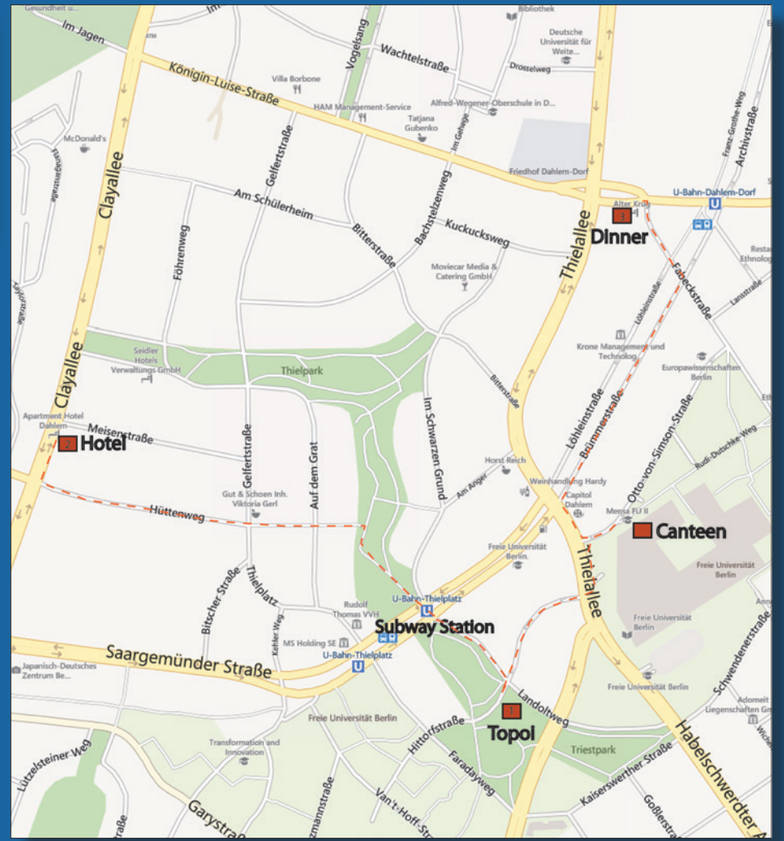
2. Apartment Hotel Dahlem
   Clayallee 150–152
   14195 Berlin

3. Dinner »Alter Krug«
   Königin-Luise-Str. 52
   14195 Berlin

Subway Station
Thielplatz, U3

Recommended walking routes

250 m



EXCELLENCE CLUSTER TOPOI

The workshop will cover different topics concerning the history of water management and aims to discuss aspects of the archaeological, cultural, social, legal, hydrological, climatic, technical and hydraulic dimensions of water management.

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