SKRIFTER UTGIVNA AV SVENSKA INSTITUTET I ATHEN, 8°, 23
ACTA INSTITUTI ATHENIENSIS REGNI SUECIAE, SERIES IN 8°, 23

# Going against the flow

## Wells, cisterns and water in ancient Greece

Edited by Patrik Klingborg

STOCKHOLM 2023

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Published with the aid of grants from Enboms donationsfond, Riksbankens jubileumsfond, Helge Ax:son Johnsons stiftelse and Gunvor och Josef Anérs stiftelse
The English text was revised by Rebecca Montague, Hindon, Salisbury, UK

ISSN 0081-9921
ISBN 978-91-7916-067-8

Printed by Taberg Media Group Stockholm, Sweden

## ABSTRACT

Despite the prevalent picture of the water supply in the ancient world as being dominated by fountains and aqueducts, the large number of excavated wells and cisterns show that these were the primary water sources for most individuals. Yet, little research has been done on their construction, function and use. This prompted the organization of the workshop *Going against the flow. Wells, cisterns and water in ancient Greece*, held at the Swedish Institute at Athens on 28–29 September 2017, and subsequent publication of the contributions in this volume. The ten papers presented here offer new evidence as well as a wide range of new perspectives on the use and function of wells and cisterns in ancient Greece. Considering the ubiquity of these installations in every type of setting during antiquity, from pan-Hellenic sanctuaries and civic centres to domestic workshops and remote farmhouses, it is hoped that the breadth of interest among the authors will allow other scholars to advance their own work further, illuminating new and exciting aspects of life in ancient Greece.

*Keywords:* wells, cisterns, water supply, ancient Greece, archaeology, climate, sanctuaries

https://doi.org/10.30549/actaath-8-23

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Cover illustration: section of typical ancient Greek cistern, by Patrik Klingborg
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JOHANNA FUCHS

# 7. The water supply of the Heraion of Samos

## Abstract

This paper presents the objectives, methods and some preliminary results of the ongoing interdisciplinary research project *Water and Cult in the Heraion of Samos* of the German Archaeological Institute at Athens and the Lübeck University of Applied Sciences, funded by the German Research Foundation. The focus of the text is a diachronic overview of wells and "cisterns" within the Samian Heraion. At the site 50 wells have been recorded so far. Three different types can be distinguished: shaft wells (including stair and so-called trial wells), groundwater flowing wells ("*Grundwasserlaufbrunnen*") and flowing wells ("*Laufbrunnen*"). Round shaft wells with masonry lining are the most common type. Groundwater flowing wells, with a spatially and chronologically limited distribution, are so far only known from the Heraion. Although up to now only two flowing wells are known, it has to be assumed that there were more, since at least from Hellenistic to Roman times the water supply of the Heraion depended largely on a terracotta pipe system bringing water from farther away to the sanctuary. A closer look at the structures so far often referred to as "cisterns" reveals that they are in fact collecting tanks of wine presses.*

https://doi.org/10.30549/actaath-8-23-07

## Introduction

The water supply of the extra-urban Sanctuary of Hera on the Greek island of Samos is currently studied within the framework of the interdisciplinary research project *Water and Cult in the Heraion of Samos* funded by the German Research Foundation. The aim of this paper is to present the objectives, methods and some preliminary results of the ongoing investigation. In its main part it presents for the first time an overview of wells and so-called cisterns within the sanctuary.

The Samian Heraion lies in the Kampos Choras plain in the south-east of the Greek island of Samos (see map in *Chapter 1*, *Fig. 3*). The coastal plain covering an area of about 19 km$^2$ is the largest of the island. It is bordered by the foothills of the Ampelos Mountains to the north-west and the Mytilinii Plateau to the

* My warm thanks to Patrik Klingborg for inviting me to contribute to this publication and his valuable comments on the first draft of this text. I was unfortunately not able to attend the workshop at the Swedish Institute at Athens, where the project was presented by its head at the German Archaeological Institute at Athens, Joachim Heiden. I would like to thank him as well as our team members at the Lübeck University of Applied Sciences, Anna Androvitsanea, Henning Fahlbusch, Modeus Fawzy Abdelnaby and Christoph Külls, for the successful co-operation and their help and support in finishing this text.

north-east. At the eastern end of the plain lies the ancient city of Samos, modern Pythagoreion, while close to its western border is situated the Heraion. From the 6th century BC onwards, the city and its extra-urban sanctuary were connected via the so-called sacred road.[1] About 600 m west of the Heraion, close to the modern village of Ireon, the Imbrasos River enters the sea. In terms of water discharge, the Imbrasos with a catchment area of about 36 km² forms the main watercourse within the plain. Over time, the river has changed its course and in the past its branches traversed the Heraion.

Due to its close proximity to the sea as well as to the nearby river, water has always played an important role in the history of the Heraion.[2] Today, it still continues to do so, as illustrated, for example, by the seasonal flooding of larger parts of the area and numerous complaints about unwanted water intrusions by excavators.[3] It has been assumed that the abundance of water available at the site, in combination with its consequently rich vegetation,[4] was responsible for the establishment of the sanctuary at this particular location.[5] A local legend, handed down by Pausanias and functioning as an etiological tale, localizes the birthplace of the goddess Hera under a tree by the side of the Imbrasos.[6]

Human occupation of the site began in the Late Chalcolithic period (*c*. 4500–3200 BC).[7] The settlement flourished in the Early and Middle Bronze Ages (*c*. 3200–1700 BC) and might have even continued through the early Late Bronze Age.[8] Cult activities in Minoan tradition began in the Late Bronze Age around 1400 BC.[9] The Hera sanctuary experienced its heyday during the Archaic period in the 7th and 6th century BC. During the Roman Imperial period a small settlement began to develop at the site that was succeeded by farmsteads and a basilica in Early Byzantine times.[10]

Excluding some small-scale investigations by earlier travellers and explorers, archaeological research at the Heraion began in the early 20th century AD with excavation work by the Archaeological Society of Athens in 1902/1903. From 1910 to 1914 the Royal Museums in Berlin conducted further excavations. From 1925 to the present, investigations have continued under the direction of the German Archaeological Institute at Athens.[11]

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[1] Remains of the approximately 6-km-long road have been uncovered within the sanctuary and at different spots within the plain (see Mohr 2013, 40–49; Herda 1995; Kyrieleis *et al*. 1985, 404–408; Kyrieleis 1981, 9).

[2] The excavation reports frequently mention e.g. silt layers that are attributed to flood events (cf. among others Walter 1957, 35–36, pls. 2–3). Furthermore, a great number of (drainage) channels have been found that have not yet been systematically recorded (cf. e.g. Reuther 1957, z. 3; Buschor 1930a, 52, 93–94, insert 13; Schede 1929, 8; Wiegand 1911, 11).

[3] Cf. e.g. Buschor 1959, 199–200 who vividly describes the problems caused by unwanted water intrusions: "*Hindernde und zerstörende Wassermassen gehen uns aus der Tiefe und aus den Überschwemmungen des nahen Flusses zu. Die Bekämpfung in den Grabungslöchern geschieht durch zeitraubendes Parzellieren, Schöpfen und Pumpen, Ableitungskanäle; schwieriger ist die Trockenlegung größerer Tümpel und Wasserflächen, die Beseitigung der Malariagefahr, die Reparatur größerer Hochwasserschäden.*"

[4] The impressive growth capacity of the vegetation at the site is often mentioned by researchers. Cf. e.g. Kyrieleis 1993, 126; Kienast 1982, 23; Buschor 1959, 199.

[5] Cf. e.g. Walter 1990, 17. The abundance of water is an essential characteristic of Greek cult places in general and especially sanctuaries of the goddess Hera. Cf. Dunant 2009, 294; O´Brien 1993, 59; Cole 1988, 163–164; Tomlinson 1988, 161–171. On the origin of not only the Heraion ἐν λίμναις ("in wetland") see also Kerschner 2015, 213.

[6] Paus. 7.4.4. Pausanias claims the famous "*vitex agnus castus*" tree was still standing in the 2nd century AD. For the discussion about the localization of said tree within the *temenos* see e.g. Kerschner 2015, 224–226.

[7] Kouka 2017, 167–168; 2015, 226.

[8] Kouka 2017; 2015, 226–230.

[9] Niemeier 2017, 197–199; Kouka 2015, 223, 230; Niemeier & Kouka 2010, 114; Niemeier & Maniatis 2010, 106–108.

[10] See e.g. Krösser 2006; Westphalen 1994; Sinn 1978.

[11] For a more detailed history of the excavation see e.g. Miller 1999, 77–82; Kyrieleis 1981, 55–60. Excavation

## The project *Water and Cult in the Heraion of Samos*

In the course of the excavations a wide range of hydrotechnical elements has been exposed. Over the years numerous wells, basins, channels and pipelines have been brought to light. However, they have not previously been the focus of research. The joint interdisciplinary project *Water and Cult in the Heraion of Samos* aims to finally fulfil that desideratum.[12] This project brings together archaeologists from the German Archaeological Institute at Athens and hydrologists as well as hydraulic and environmental engineers from the Lübeck University of Applied Sciences (TH Lübeck) to study the references between water and cult in the Heraion. On the basis of an integrated view of the wide range of hydrotechnical elements discovered at the site and a systematic analysis of the hydrologic and hydrogeologic system within its catchment area, the role of the Imbrasos River and local groundwater conditions through time are to be investigated. Still to be undertaken is a diachronic treatment of the correlation between changing hydrological conditions and adaptive changes in hydrotechnical engineering. In addition to stationary features such as, for example, wells, movable finds such as stone basins etc. are also taken into account to determine the importance of water within the sanctuary.

## Methods

At first, the project team focused on collecting data, both in archives and on site. Publications about the Samian Heraion, as well as unpublished material such as diaries, plans, photographs, etc. were systematically scanned for information about all kinds of water installations within the sanctuary.[13] The data were collected and arranged within a geographic information system (GIS). To date, nearly 200 fountains, channels, pipelines and other hydrotechnical constructions have been mapped (*Fig. 1*). Unfortunately, the quantity and quality of the available data are very heterogeneous. Whereas some features have been recorded in great detail, others are mentioned only in passing. Considering that most of these structures after their first exposure have been destroyed, removed from their original position,[14] restored, recovered or are no longer accessible due to the lush vegetation, the many cases of insufficient docu-

reports have been successively published in the *Archäologischer Anzeiger* and the *Mitteilungen des Deutschen Archäologischen Instituts, Athenische Abteilung*. Further results are submitted within the *Samos* series by the German Archaeological Institute.

[12] The three-year project was launched in September 2016. It is funded by the German Research Foundation. Short reports about the project were published in Fuchs 2017a; 2017b. It was further presented at the workshop "Going against the flow. Wells, cisterns and water in ancient Greece" at the Swedish Institute in Athens in September 2017, at the international conferences "15 Years of Aigeiros" and "Neue Forschungen zu frühen griechischen Heiligtümern" at the German Archaeological Institute at Athens in December 2017 and April 2018 respectively, as well as at the international congress "Sanctuaries and Cults in the Aegean from Early Historic Times to Late Antiquity" on Lemnos in September 2019.

[13] My warm thanks to Martin Maischberger who granted access to the archive of the Berlin Antiquities Collection and the colleagues from the Samos Excavation (Angelika Clemente, Hermann Kienast, Helmut Kyrieleis), who made their records and unpublished manuscripts available.

[14] Clay pipes were a desired building material in modern times. Therefore, they were often removed from their original find-spots after exposure, as one can determine e.g. from an entry in the excavation diary dated to October 1910: "*Reste zweier später Tonrohrwasserleitungen ziehen sich von W nach O durch diesen Säulenumgang. Einige Arbeiter teilen mit, daß Sophulis* [in 1902/1903] *davon noch mehrere gefunden habe, die parallel gelaufen seien. Alle diese Stücke waren aber verschwunden, da die Bauern gerne solche Tonrohre als Schornsteine ihrer Hütten gebrauchen.*" (Samos excavation diary 1909–1911). Ancient pipes that have been reused as chimneys can still be seen at, for example, the excavation house at the Heraion.

mentation are especially problematic. Another reoccurring problem is the imprecise terminology used in many reports; e.g. Ernst Buschor refers to a structure in N 14 first as "*Brunnenschacht*" ("well shaft") and then as "*Zisterne*" ("cistern").[15]

In addition to the archival work mentioned, geological, hydrological and meteorological data for Samos were collected by the hydrology team of the TH Lübeck.[16] During a field trip in spring 2017, geology, soils, land use and springs within the catchment area of the Imbrasos were investigated. Furthermore, data loggers were installed in several accessible and aquiferous wells within and outside the Hera sanctuary as well as in the Imbrasos and its inflows. The sensors continuously log the water level.[17] In combination with precipitation data, they indicate the conditions that define the behaviour of the local aquifer. Within the wider catchment area, water temperature, conductivity, oxygen, carbon and pH level were also measured at various water sites (rivers, wells, drill-holes and springs) and 29 samples of ground and surface water were taken.[18] The analysis of their stable isotopes, hydrochemistry and important trace substances will in comparison help to determine the origin, quality and permanence of the water supply within the Heraion.

During a longer field campaign in summer 2017 the current surface topography of the archaeological site of Heraion was mapped with the use of a total station. On the basis of that data, a digital elevation model of the site was created. Furthermore, a series of five drill-hole sections was executed within the sanctuary. The objective of those was primarily to deduce the former course of the Imbrasos River. The drill-hole sections were therefore placed in such a way as to intersect the presumed courses of the until-now largely hypothesized river beds. With the help of a cobra drill hammer, metal sleeves with a diameter of 5 cm were driven down to a maximum depth of 5 m. The cores obtained were described, drawn and photographed. Initial inspection of the cores on site identified sand and gravel layers, as well as flood silt layers that mark the actual course of the river, and flood horizons. Selected samples were then brought to Lübeck to be further analysed in the Hydrologic Laboratory. Isotopic analysis was undertaken at the laboratory to determine the recharge rate at the site. The shift of seepage water could be established. This amount, combined with the simulated behaviour of the groundwater aquifer, leads to a preliminary calculation of the available groundwater at the site to the sustainable amount of about 100,000 $m^3$ per year.[19]

A reconstruction of the evolution and perhaps the age of the stratigraphic sections and thus also of the related environmental conditions in their chronological sequence (such as droughts, floods and possibly also tsunamis) will hopefully be possible through further analysis. A correlation of the findings from the recent drill cores with other geological and archaeological sections obtained earlier will also help to understand the geological and anthropological genesis of the site.[20]

15 Buschor 1930a, 34.

16 Our sincere thanks to the local residents and authorities who generously supported our work: Ioannis Aksiotis (owner of a private meteorological station at Pagondas), Odysseas Ferentinos (Department of Water in the North Aegean of the Decentralized Administration of the Aegean Sea), Michalis Michaliadis (Department of Agricultural and Veterinary Medicine of the Samos region).

17 The raw data is available for the public at http://openmeteo.org.

18 Sample collection was repeated in summer 2017, as well as in spring 2018 and 2019.

19 Abdelnaby Fawzy 2018b.

20 Among the archaeological sections, the ones published by Walter 1957, pls. 2–3 and Kyrieleis *et al.* 1985, figs. 44–46 are especially instructive. A series of six drill-holes with a maximum depth of 13.65 m was executed

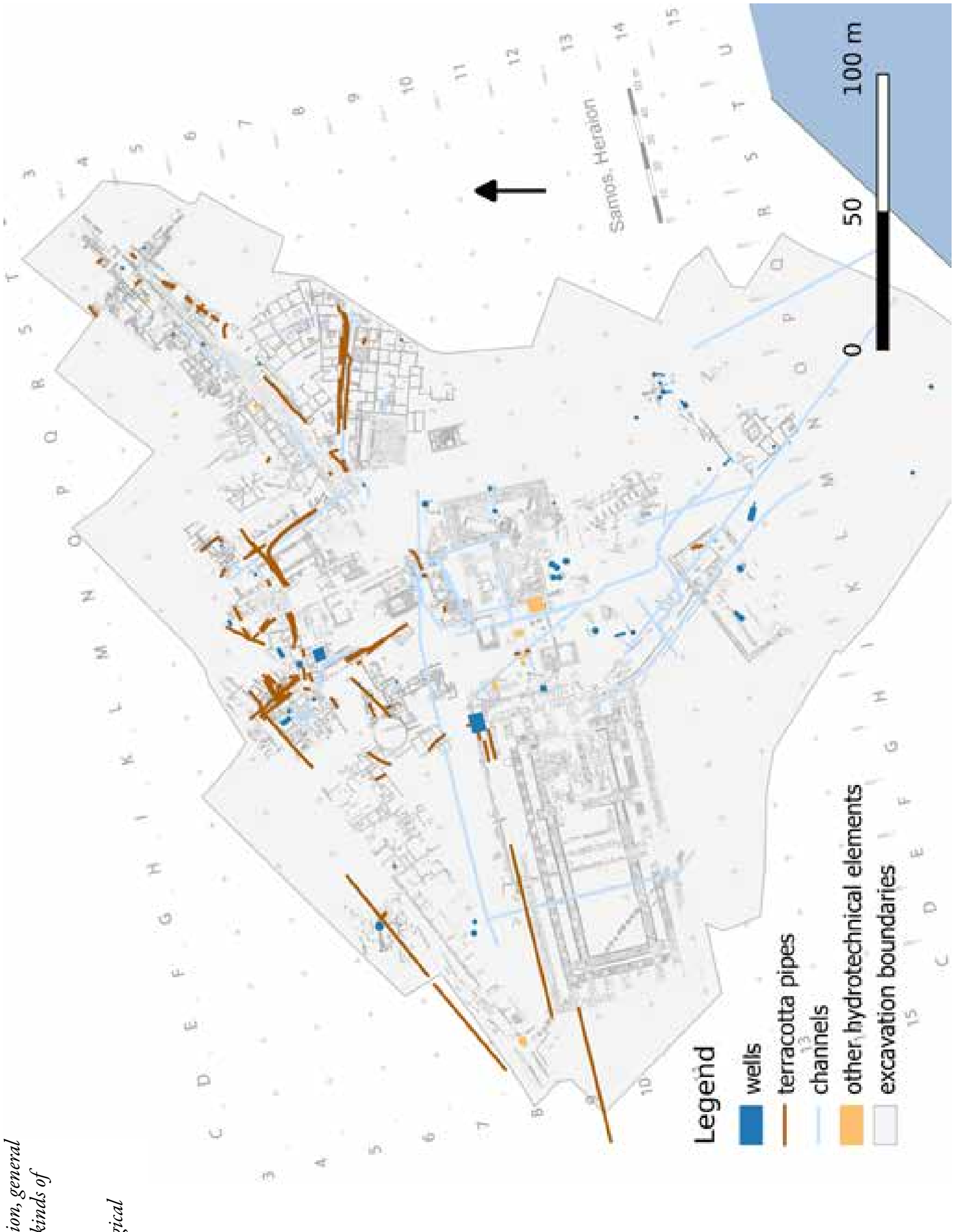


*Fig. 1. Samos, Heraion, general plan with different kinds of water installations. Johanna Fuchs, German Archaeological Institute at Athens.*

At various locations within the sanctuary, in particular within terracotta pipes, calcium carbonate deposits are preserved. Deposit samples were taken from some pipes that were still *in situ*. As the climate at Samos varies greatly according to the season, it is possible to deduce relative dates and utilization phases from the deposit sequence. The analysis of the residue may also provide information about the source of the water distributed here. To this end, the chemical and isotopic analyses of the samples will be compared with the isotopic analyses of the water samples mentioned above. Furthermore, thin sections are to be made which will allow the differentiation of mineral phases which can point to the temperature and salinity of the precipitation environment.[21]

Taking into account all the data collected on- and off-site, a groundwater model of the coastal aquifer at the Heraion was developed.[22] The modelled area of about 20 km$^2$ is naturally demarcated according to geological-topographical characteristics. The model, incorporating the groundwater recharge rate, boundary inflows and numerous other system-related parameters, underwent an extensive modelling calibration process. Accordingly, the results of the groundwater simulation deliver an elaborate understanding of the water flow system of the region. They provide a comprehensive analysis of the origins, mixing patterns and travel times of the groundwater flow paths feeding the Heraion site, and the interdependencies of these with adjacent water basins across different layers and aquifer geological formations. Furthermore the results offer an understanding of the system's response capabilities to heavy as well as well low rainfalls and its development in terms of recent and past environmental changes.[23]

Currently, Anna Androvitsanea is occupied with the development of a hydrological model of the catchment area. Interlinked with the groundwater model, it will enable us to model different scenarios based on, for instance, a change in precipitation, temperature, land use, sea water level, etc. The coupled model is also intended to be used in the process of developing and reviewing a flood protection plan for the Heraion.

## Wells and "cisterns" in the Heraion

The term "well" or "fountain" is subsequently used to address a man-made access to ground or spring water. According to the common usage of the term, it does not matter whether the water is tapped directly or if it is indirectly brought to the fountain by means of tunnels, pipes or similar structures.[24] A further distinction of different types of wells is possible on the basis of their manner of water supply and water withdrawal as well as their ground plan and elevation. In the Heraion we can generally differentiate between shaft wells ("*Schachtbrunnen*")[25], groundwater flowing wells ("*Grundwasserlaufbrunnen*") and flowing wells ("*Laufbrunnen*").

Shaft wells are dug into the ground until the local groundwater table is reached. Water enters the well via its permeable bottom and/or openings or joints in its walls. The water level within a shaft well levels itself according to the

in 1994 in the course of an earlier geological investigation of the Heraion site (see Mourtzas & Kolaitē 1994).

[21] The analysis of the calcium carbonate deposits will take place in co-operation with the Institute of Geosciences at the Johannes Gutenberg University Mainz (Cees Passchier, Gül Sürmelihindi).

[22] The creation of the model was part of the Master´s thesis of Modeus Abdelnaby Fawzy at the TH Lübeck (see Abdelnaby Fawzy 2018a).

[23] Abdelnaby Fawzy 2018a, 1–2.

[24] For the terms to describe water sources in antiquity cf. Tölle-Kastenbein 1985a; 1985b, 158; Glaser 1983, 5, 165.

[25] Other German terms to describe this type of well include "*Grundwasserbrunnen*" (cf. e.g. *Samos* 14, 109), "*Brunnenschacht*" (cf. e.g. Glaser 1983, 165) and "*Tiefbrunnen*" (cf. e.g. Brinker 1990, 3).

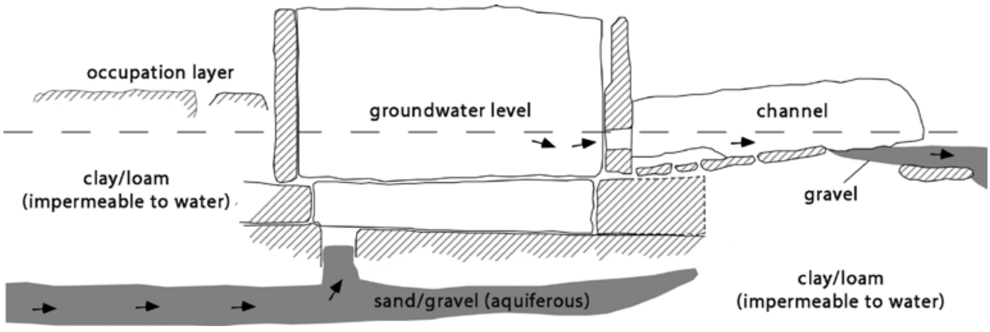


*Fig. 2. Sketch showing the function of a groundwater flowing well. After Furtwängler 1981, fig. 4 and Mehnert 2008, 206, fig. 4.*

respective pressure altitude of the aquifer.[26] If water is taken from such a well, the water table rises back to its former level. A subgroup of these shaft wells was equipped with a stairway allowing access to the water table.

The wells referred to as groundwater flowing wells are so far known exclusively from the Samian Heraion. Like shaft wells, they provide access to the local groundwater that enters the well through permeable openings in its base and/or walls. Unlike shaft wells, however, the water in the groundwater flowing wells is in a constant flow exiting the well via an outlet in its walls and a connected channel that lies beneath the local groundwater table (*Fig. 2*).[27]

A flowing well is constantly supplied with water through a pipe or similar means and has no connection to the local ground or layer water. In addition to a steady inflow it is furthermore provided with a continuous outflow.[28]

A cistern on the other hand is defined as a natural or artificially made stationary and waterproof container for collecting and storing water from an external source such as rainwater. Cisterns can be created above and below ground and they can be open or covered. Unlike reservoirs, that are a part of a water supply system, cisterns do not have a constant in- and outflow.[29]

[26] Cf. Brinker 1990, 3.

[27] The first two of these wells (N 14 b and M 14) were discovered in the 1920s (Buschor 1930a, 11, 27–32, fig. 4, insert 1). They were referred to by Buschor as "*Wasserschacht*" ("water shaft" = well N 14 b) and "*Wasserbassin*" ("water basin" = well M 14), respectively. Buschor assumed that the "water shaft" must have been filled with water transported to it from elsewhere (Buschor 1930a, 11) and postulated an inflow for the so-called "water basin" (Buschor 1930a, 30–31). The function of the groundwater flowing wells was correctly described by Furtwängler 1981, 149–150 with fig. 4. For further discussion, see Mehnert 2009; 2008 (the wells are herein addressed as "groundwater basins" ["*Grundwasserbecken*"]) and *Samos* 21:1, 102–104. Furtwängler and Mehnert assumed that the infiltration within the groundwater flowing wells was dependent on the channel flow of the Imbrasos River. It has to be stressed, however, that the groundwater table within the Heraion and the water table of the Imbrasos are not interdependent. The groundwater table within the sanctuary, and therefore its wells, is rather conditional on the peripheral inflow, the ground permeability and the water table of the river.

[28] Cf. Wellbrock 2016, 117, 341, n. 1332.

[29] This definition is derived from Klingborg 2017, 4. For a discussion of the relevance, or rather irrelevance, of further subtypes see Klingborg 2017, 16–17 with nn. The definition given by Brinker 1990, 3 sees artificial supply of surface water, coverage and impermeability as distinguishing characteristics of cisterns in contrast to wells.

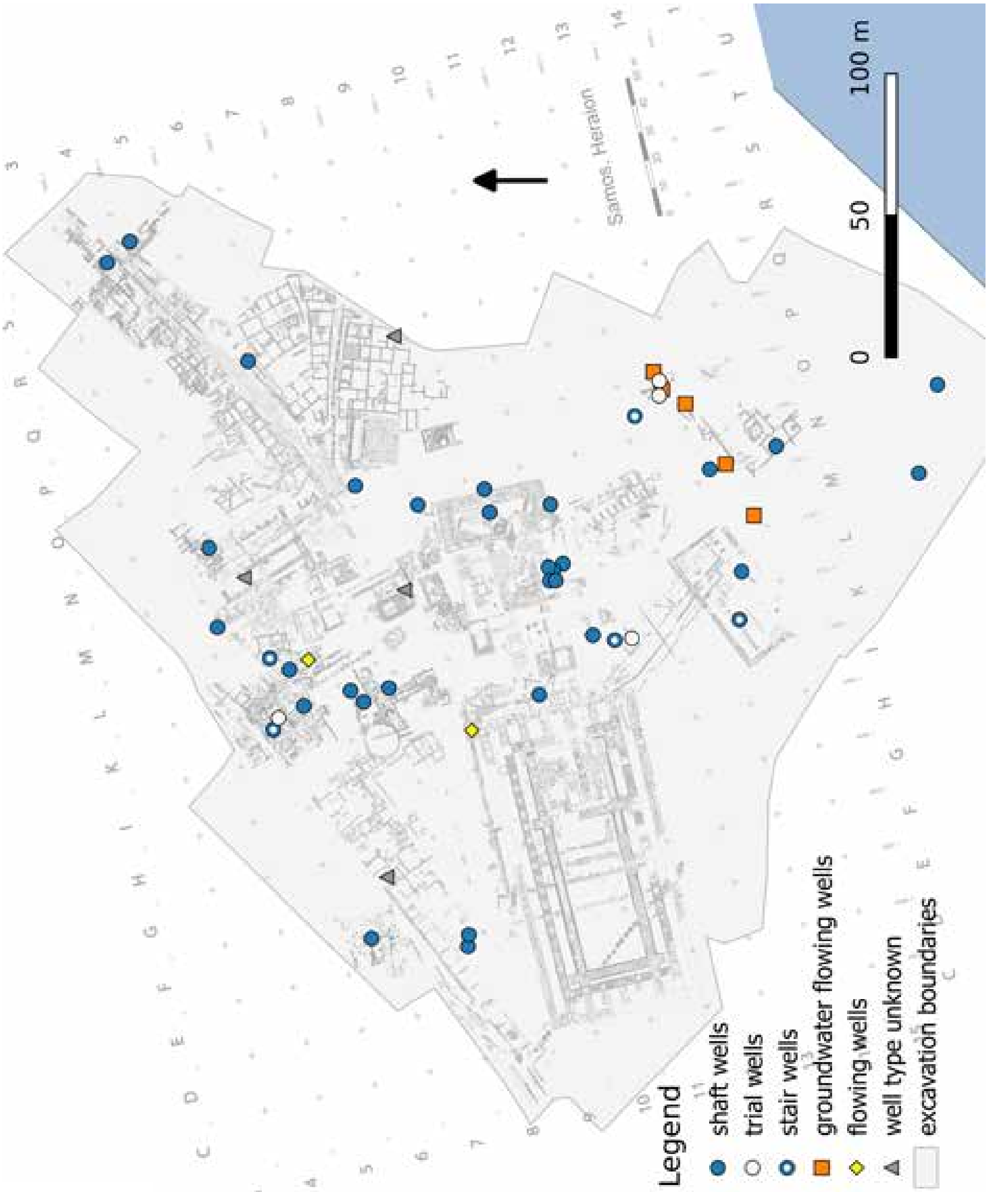


*Fig. 3. Samos, Heraion, general plan with wells. Johanna Fuchs, German Archaeological Institute at Athens.*

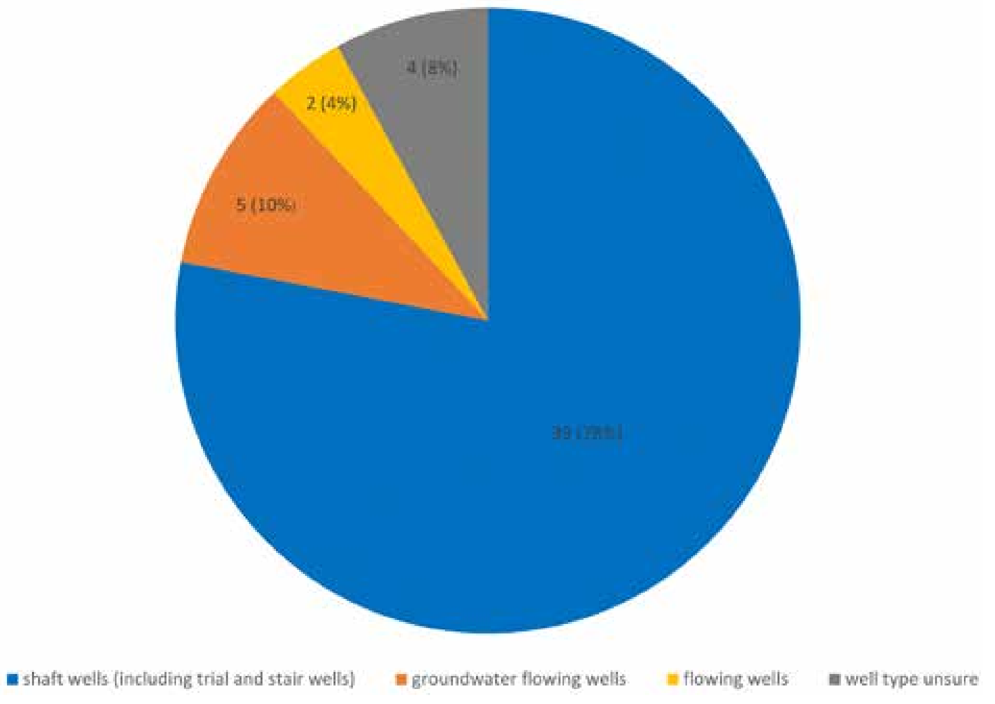


*Fig. 4. Samos, Heraion. Pie chart with well types. Johanna Fuchs, German Archaeological Institute at Athens.*

## Wells

At the archaeological site of the Heraion, 50 wells have been recorded so far (*Figs. 3–4*).[30] To be able to clearly address each of them, all wells were given an identification code in the course of the project.[31] Those IDs are composed of a letter and a number. They refer to the location of a certain well within the 20 × 20 m grid that was superimposed on the site by the excavators.[32] A well situated in grid square K 14 is subsequently called "well K 14". If there is more than one well situated within a quadrant, the identifier is extended by a lower-case letter.[33]

The existence of some of the wells within the sanctuary is only known through a mention in passing, a picture or a sketch. Even the surviving excavation diaries in many cases do not provide further details, since the excavators usually did not focus on the water installations. The available data therefore sometimes does not even provide the most fundamental infor-

[30] Three of these wells (K 7 a, M 17 and N 18) are not antique. For the sake of completeness, they have been incorporated in this compilation.

[31] For references to earlier names (cf. e.g. Walter & Vierneisel 1959; *Samos* 21:1) a concordance has been created.

[32] A plan of the sanctuary with this grid was first published by Buschor 1928, 53.

[33] The sequence of those letters complies with the location of a well within the grid square. The letter "a" marks the well in the upper left corner of a quadrant (e.g. "well M 11 a"). Further wells within the same grid square are identified with subsequent letters in alphabetical order following reading direction from top left to on the bottom right (e.g. "well M 11 b" etc.).

*Fig. 5. Samos, Heraion, shaft well K 10 (1958). Photograph: D-DAI-ATH-Samos-4080B, E.-M. Czakó.*

mation, such as exact location, construction type, diameter, depth, and date.[34]

The majority of wells (at least 39 out of 50)[35] are shaft wells (*Figs. 3–4*). Those simple constructions usually have a masonry lining consisting of boulders and limestone slabs (*Fig. 5*). The inner diameter of the generally round shafts is usually 0.50–1.00 m.[36] The depth ranges between about 0.60 m and 3.00 m. The walls of well L 14, which taper from 1.85 m at the top to approximately 0.82 m towards the bottom, are created from small pebble and rubble stones and have stabilizing interlayers of stone slabs and reused ashlars at a spacing of about 0.50 m.[37] Two other wells stand out due to their more elaborate building material and technique. Well K 11 had "very carefully" constructed walls formed with limestone ashlars with the undermost layer being supported by a wooden plank,[38] and well N 14 walling "beautifully built" out of concave ashlars.[39] Well N 15 is in equal parts constructed from limestone slabs and tile fragments.[40] Further striking examples are well M 5 at the north-west corner of the so-called north building, with a narrow rectangular ground plan,[41] and well N 10 b (formerly known as "W 2"), which has an oval shaft constructed from ashlars and stone slabs, but a rectangular superstructure above ground.[42] In this latter well, four vertical stone slabs with a height of about 0.60 m form a perimeter of about 0.90 × 1.10 m around the well shaft (*Fig. 6*), and the structure was enclosed by a paving of large stone slabs, originally covering an area of about 3 × 3 m. With this surround-

[34] Additional archaeological excavations in the future could help to fill some of the gaps. However due to restraints in resources and time they were not included in the project schedule. During summer 2017 only some restricted cleaning work of some of the hydraulic installations on the site was executed.

[35] The limited available information on four wells does not allow for a definitive assignment to a well type. However it is most likely that those are also shaft wells.

[36] See e.g. well L 11 a (Walter & Vierneisel 1959, 10–12, 34, fig. 1, insert 13; Walter 1990, 63, fig. 59; *Samos* 21:1, 100, z. 2–4, insert 2), well L 11 b (Walter & Vierneisel 1959, 10–12, 34, fig. 1, insert 13; *Samos* 5, 86, pls. 11, 14–15, 17; *Samos* 21:1, 100, z. 2–4, insert 2) and well M 11 a (Walter & Vierneisel 1959, 10–12, 34, fig. 1, inserts 12–13; Walter 1990, 73, fig. 76; *Samos* 21:1, 100, z. 4–6, insert 2).

[37] Ziegenaus 1957, 74, insert 94.3, pls. 4, 8; Walter 1957, 37, 51, fig. 1; Gruben 1957, pl. 4; Walter 1963, 292; Kopcke 1968, 311 with n. 5; *Samos* 3, 73, 145 with n. 487; Walter 1990, fig. 139; Mehnert 2009, 384; *Samos* 21:1, 101–102, z. 9, insert 5.

[38] The excavators labelled the well "F". See Walter & Vierneisel 1959, 10–18, 34, fig. 1, inserts 14–25, 27.1, 29–30; Vierneisel 1961, 25; *Samos* 5, 86; Furtwängler 1980, 162; *Samos* 21:1, 100, z. 4–6, insert 5.

[39] Buschor 1930a, 34, 59, insert 1; *Samos* 21:1, 101, z. 8–9, insert 5.

[40] Homann-Wedeking 1964a, figs. 1, 3; Kopcke 1968, 311–314, insert 8, pl. 89.3; *Samos* 21:1, 102, insert 5.

[41] Kyrieleis 1980a, 337 fig. 1; *Samos* 3, 9–10, 12, 69–70, 140, pls. 14.1–2, 17.6, insert 1; Ohnesorg 2009, 86, n. 210.

[42] Buschor 1930a, 42; Buschor & Schleif 1933, 168–169, inserts 45, 47.1, 53.5; Homann-Wedeking 1964b, 225; 1964c, 402, pl. 467; *Samos* 6:1, 96; Kyrieleis 1978b, 394, n. 15; Furtwängler 1980, 159–160 with n. 30, 183; Kyrieleis *et al.* 1985, 378, n. 29; *Samos* 3, 73–75, 145–152; Kienast 1992, fig. 8; Ohnesorg 2009, 64, n. 130; *Samos* 21:1, 101, z. 8–9, 25, insert 1, 5, pl. 27.2.

*Fig. 6. Samos, Heraion, shaft well N 10 b (1933). Photograph: D-DAI-ATH-Samos-1923, H. Wagner.*

ing, well N 10 b is also one of the few wells in the Heraion with a preserved upper finish.

Four "trial wells" ("*Versuchsbrunnen*") have also been recorded at the site (*Fig. 3*).[43] These are simple shaft well pits that are not lined with masonry etc. According to the excavators these wells were abandoned before being brought into use. However, it also seems possible that they were only temporarily used and therefore not further developed.

Apart from those more or less plain shaft well constructions, there are also five stair wells ("*Stufenbrunnen*") at the site (*Figs. 3–4*).[44] Characteristic for this subgroup of shaft wells is the existence of a series of steps leading down from the surface to the water table.[45] Most of these wells have a rectangular masonry well shaft with a stairway with lateral walling at one narrow end. The width of the stairways varies between approximately 0.60 m and 1.00 m; the number of steps between four and nine. The stair wells frequently incorporate reused building material.[46] On the basis of the thickness of the enclosing walls which incorporated *spoliae* that might have served as support bases, Karl Krösser suspects that well K 5 a could have originally had a shed roof.[47] The same might be true for well L 5 with pillar-type attachments between stairway and well basin[48] and well O 13 which also shows traces of roofing. Stair well K 11–12 (*Fig. 7*) shows a slightly different ground plan. Seven steps out of reused building material lead down to an oval well shaft lined with limestone slabs and surrounded by a pebble pavement.

[43] For the one in grid square K 5 cf. *Samos* 4, 6, 57, 73, pl. 20.2, plan 2; for the one in K 12 cf. Walter 1957, pl. 2; 1958, 73. The other two "trial wells" are situated in O 13. They were excavated by Helmut Kyrieleis and are not yet published.

[44] Well K 5 a (Homann-Wedeking 1965a, 500 (?); *Samos* 4, pl. 2; Krösser 2006, 316–317, 323, figs. 1–2, pls. 43.1–2, 44.3), Well K 11–12 (Gruben 1957, pl. 5; Walter 1957, pl. 2; 1958, 73–83, figs. 1–14), well K 14 (Ziegenaus 1957, 75–76, pl. 8, suppl. 94.1–2; Walter 1958, 84), well L 5 (according to Hermann Kienast most probably excavated in the course of the investigation of the so-called North Gate and not yet published) and well O 13 a (excavated by Helmut Kyrieleis in 1984, not yet published).

[45] Cf. Glaser (New Pauly, s.v. well) who calls this type "step wells".

[46] For example, the steps of well K 11–12 (Gruben 1957, pl. 5; Walter 1957, pl. 2; 1958, 73–83, figs. 1–14) and well K 14 (Ziegenaus 1957, 75–76, pl. 8, suppl. 94.1–2; Walter 1958, 84) consist in part of split tambours.

[47] Krösser 2006, 316.

[48] Personal observation in August 2018.

*Fig. 7. Samos, Heraion, stair well K 11–12 (1957). Photograph: D-DAI-ATH-Samos-3276, E.-M. Czakó.*

At the Heraion five groundwater flowing wells are known (*Figs. 3–4*). They are all situated within the southern part of the sanctuary and line up along an imaginary south-west–north-east line with a length of about 60 m. Well M 14 is located at the south-western end of said line.[49] It is a rectangular basin of 4.30 × 1.62 m with a depth of about 1.00 m. Its floor is paved with large stone slabs, and its walling consists of limestone masonry and orthostates. The lowest layers of the north-west and south-west walls are pierced by two and eight openings, respectively. Through those holes, groundwater from the local aquifer could enter the basin. The inflowing water rose up to groundwater level and then exited the basin through an opening of 0.11 × 0.065 m at its narrow south-eastern end where it was drained via an approximately 2.50-m-long channel. Therefore, the water within the well basin was in a constant flow. Further to the north-east, the two smaller wells N 14 b[50] (*Fig. 8*) and O 14[51] functioned according to the same principle.[52] Both are rectangular basins, measuring 0.56–0.60 × 0.98 × 0.85 m and 1.15 × 1.29 × 0.90 m, respectively. They are constructed out of vertical limestone slabs and connected with plate channels of about 2.00 m and 1.20 m in length. While the floor of well N 14 b was not paved

[49] Cf. Buschor 1930a, 11, 27–32, 57–59, figs. 10–12; 1930b, 147; Buschor & Schleif 1933, 164–165, 171; Dunkley 1935–1936, 151–152, 189; Buschor 1937, 204; 1953, 2, 8–9; Ohly 1953, 120; Walter 1957, 48–49, 51; Buschor 1959, 214, 216; Buschor & Ziegenaus 1959, 2; Walter 1963, 286–287, 292; Kopcke 1968, 310; Furtwängler 1980, 158, n. 20; Kyrieleis 1981, 43, 90–91, fig. 66; Glaser 1983, 189; *Samos* 3, 70, n. 257a; Walter 1990, figs. 15, 92, 139; Dorl-Klingenschmid 2001, 89; Mehnert 2008, 221; 2009; Avramidou 2016, 53; *Samos* 21:1, 103–104, z. 7–9, pls. 27.4–5.

[50] Buschor 1930a, 11, 18, 32, fig. 4, insert 1; Buschor & Schleif 1933, 165, 172; Buschor 1937, 204, 212–221; 1953, 9; Ohly 1953, 120; Buschor 1959, 209; Homann-Wedeking 1964a, fig. 1; Kopcke 1968, 307, 309–311, 313, insert 8; Kyrieleis 1978b, 394; Walter 1990, 32, 34, 83, figs. 15, 18, 92; Mehnert 2008, 221–222, figs. 1, 5, pls. 20.12, 21.1; 2009, 384, 390, pl. 2; Ohnesorg 2009, 64, n. 130; *Samos* 21:1, 102, z. 7, insert 5, pl. 27.3.

[51] Kyrieleis 1978b, 393–395, figs. 11–12; 1980b, 87–88; Furtwängler 1978, 113; 1980, 156–158, 160, pls. 41–43, inserts 2, 6; 1981, 149–157, figs. 3–5; Kyrieleis 1984, 295; Walter 1990, fig. 15; Kyrieleis 1993, 135–137, fig. 7.6; Mehnert 2008, 221, fig. 5; 2009, 384, pl. 2; Ohnesorg 2009, 64, n. 130; *Samos* 21:1, 102–103, z. 7, insert 5.

[52] Mehnert 2008, 201–205, fig. 3 (cf. Mehnert 2009, pl. 2) also discusses another installation in grid square M 7 which he assumes might have been a groundwater flowing well. Considering its location and the limited available information, this interpretation is questionable.

*Fig. 8. Samos, Heraion, groundwater flowing well N 14 b (1936). Photograph: D-DAI-ATH-Samos-2216, H. Wagner.*

at all,[53] the floor pavement of well O 14 left openings to the aquiferous layers and therefore ensured the infiltration of water into the well. Further north-east are the two wells O 13 c and P 13. Since both of those cylindrical well shafts are connected with a drain channel, it can be assumed that the water here was also in a constant flow.[54]

Only two flowing wells are to be found in the Heraion (*Figs. 3–4*). Both are supplied with water through clay pipes. Well I 9[55] at the north-eastern edge of Dipteros II was modified from an earlier base, the original purpose of which is not yet determined.[56] Apart from its substructure, the building consists of white marble. Two steps lead up to a rectangular basin of about 2.50 × 1.40 m with a reconstructed height of at least 1 m. A clay pipe with a diameter of 0.26 m enters the well through a hole in its western euthynteria and leaves it again at its northern side. Inside the structure, two stone bends redirect the pipeline vertically to serve as inflow and outflow.[57] The second flowing well L 6 b[58] (*Fig. 9*) is situated east of the so-called north–south street leading from the northern entrance to the centre of sanctuary.[59] Its rectangular limestone structure with an area of about 3.20 × 3.80 m indicates at least two building phases. At its four sides, bases and pillar drums attest a former roofing of the well. In the centre of its basin, water was conducted upwards through a lead pipe that was attached to a stone pillar.

Also, due to their often poor preservation status, we do not know much about wellheads

53 Mehnert´s presumption that water entered well N 14 b via its floor (Mehnert 2008, 222) is confirmed by a sectional drawing of the structure that is kept in the archive of the Berlin Antiquities Collection (inventory no. S 157) which shows no floor pavement at all.

54 Both wells are not yet published but briefly mentioned in Kyrieleis 1993, 135–137; 2019, 42–43. My thanks to the excavator Helmut Kyrieleis for granting insight into his manuscript which is in print preparation at the moment.

55 Samos excavation diary 1909–1911, 35–36, 40; Samos excavation diary 1911–1912, 14; Schede 1929, 10–12, 35–36, 41, pl. 4; Buschor 1930a, 97; Reuther 1957, 17, 65–68, fig. 8, z. 15, 17–18; Kyrieleis 1981, 102–103.

56 Cf. Schede 1929, 11; Reuther 1957, 68.

57 Fahlbusch presumes that the water was fed into an elevated tank installed above the well.

58 Buschor 1937, 218–221, figs. 10–12; *Samos* 4, 52 with n. 54; Sinn 1978, fig. 2; Samos excavation diary 1976–1980, 304, 314; Kyrieleis 1978b, 385, 391; 1980a, fig. 13; 1981, 50, fig. 80; Glaser 1983, 115, 178, figs. 213–214; Krösser 2006, 315, n. 17, figs. 9a–b; Ohnesorg 2009, 127, n. 363.

59 On the street system in the Heraion see Kienast 2007.


*Fig. 9. Samos, Heraion, flowing well L 6 b (1936). Photograph: D-DAI-ATH-Samos-2171, H. Wagner.*

and water lifting or drawing devices in the Heraion. The two Archaic wells O 13 c and P 13 in the southern *temenos* had thick-walled terracotta heads; possibly reused pithoi.[60] The upper part of such a storage vessel also formed the head of the Roman well K 6.[61] We can only assume that other (shaft) wells in the Heraion had similar terracotta heads. Kerbstones made of stone slabs or stone blocks are also possible.[62]

Looking at the chronological and spatial distribution of the Heraion wells, simple shaft wells were in use from the establishment of the sanctuary onwards.[63] From the 10th–7th centuries BC they were concentrated in the centre of the site between the altar and the later Dipteros II (cf. *Fig. 3*).[64] Only in the 6th century BC were a couple of new wells dug in the surroundings of the altar and in the southern part of the *temenos*. Also in Archaic times, shaft wells M 5,[65] at the corner of the so-called north building, and T 4 and T 5,[66] at the eastern entrance of the sanctuary, were built.[67] Furthermore, around the middle of the 7th century BC a new well type, the groundwater flowing well, emerged.[68] Apparently this type of well was in use for only a limited time span.[69] Apart from the flowing well L 6 b, the construction of which possibly dates back

[60] Well O 13 c and well P 13 (briefly mentioned in Kyrieleis 1993, 135–137; 2019, 42–43).

[61] Homann-Wedeking 1965a, 500; Krösser 2006, 311, 316–317, 320, 323, figs. 1–3, 6, pls. 42.2, 43.1, 44.3; Ohnesorg 2009, 148, n. 429.

[62] On wellheads and lifting devices especially in the Kerameikos in Athens see Stroszeck 2017, 52–59.

[63] There are no wells attested from the prehistoric layers.

[64] According to the excavators these wells partly replaced each other and were in use for up to a century (cf. Walter & Vierneisel 1959, 12; *Samos* 5, 85–86; *Samos* 21:1, 99–105).

[65] Kyrieleis 1980a, 337 fig. 1; *Samos* 3, 9–10, 12, 69–70, 140, pls. 14.1–2, 17.6, insert 1; Ohnesorg 2009, 86, n. 210.

[66] Cf. Kienast 2007, 206–207, fig. 3; Kienast *et al.* 2017, 136–137, figs. 1, 4–6, 14–15.

[67] Well L 6 a was also possibly established in that period (Buschor 1937, 215–217, fig. 11; Buschor & Ziegenaus 1959, 3; Samos excavation diary 1976–1980, 314; Kyrieleis 1978b, 385, 391–392; 1981, 106; Walter 1990, figs. 139, 169).

[68] Cf. Kyrieleis 1993, 137; *Samos* 21:1, 102–103.

[69] Cf. Kyrieleis 1993, 137; *Samos* 21:1, 102–104. Further investigation has to answer the question whether the abandonment of these wells possibly had something to do with a lowering of the local groundwater table in the 6th century BC.

to the Classical period,[70] there are no newly planned wells known at the Heraion until the Roman Imperial period. Of course, some of the older wells might have still been operating,[71] but it seems that at least from the Hellenistic period the water supply of the Heraion did not so much depend on the local groundwater, but rather on spring water brought to the site via terracotta pipes. The building of the pipeline system might have been a reaction to drought and a subsequent water shortage within the Heraion.[72] A focal point of the water supply system at least from Hellenistic times was the area of the so-called northern gate.[73] Following Henning Fahlbusch it might be reasonably assumed that elevated tanks were installed here and water coming from the north of the sanctuary was fed into them and then distributed further on by diverse terracotta pipelines (*Fig. 1*).[74] Remains of a number of these pipes leading to the eastern and southern parts of the site are preserved. Although a number of installations for water distribution are to be expected there, unfortunately we do not have any information other than the two flowing wells mentioned above. The pipe system was in use until Late Antiquity as can be observed, e.g. by the water supply of the small thermal bath that supposedly was erected in the 3rd century AD.[75] The Roman Imperial period saw the erection of new wells; simple shaft wells were incorporated in the yards of the dwellings of the then emerging settlement.[76] In Late Antiquity and Byzantine times stair wells become the prevalent well type at the site.

## "Cisterns"

In the research literature some "cisterns" are mentioned in the Heraion.[77] As for many of the wells, most of these features are mentioned only in passing and not described in further detail. Therefore, without further field investigation, it is hardly possible to give a sound analysis. However, the outcome of a closer look at the so-called cisterns is that many, if not all of them, were not used for water storage at all.

The most prominent example of such a misinterpretation is the "Early Byzantine cistern" published by Hans Peter Isler.[78] In the final addendum of his article, Isler himself notes, in reference to the statement of an elderly local, who in his youth had still seen such installations in use, that the "cistern" most probably was part of a wine press and served for the storage of grape

[70] Buschor 1937, 218–221, figs. 10–12; *Samos* 4, 52 with n. 54; Sinn 1978, fig. 2; Samos excavation diary 1976–1980, 304, 314; Kyrieleis 1978b, 385, 391; 1980a, fig. 13; 1981, 50, fig. 80; Glaser 1983, 115, 178, figs. 213–214; Krösser 2006, 315, n. 17, figs. 9a–b; Ohnesorg 2009, 127, n. 363.

[71] E.g. Wells T 4 and T 5 (Kienast 2007, 206–207, fig. 3; Kienast *et al.* 2017, 136–137, figs. 1, 4–6, 14–15) and possibly well L 6 b (Buschor 1937, 218–221, figs. 10–12; *Samos* 4, 52 with n. 54; Sinn 1978, fig. 2; Samos excavation diary 1976–1980, 304, 314; Kyrieleis 1978b, 385, 391; 1980a, fig. 13; 1981, 50, fig. 80; Glaser 1983, 115, 178, figs. 213–214; Krösser 2006, 315, n. 17, figs. 9a–b; Ohnesorg 2009, 127, n. 363).

[72] Cf. Camp 1982 on a proposed drought in Attica at the end of the 4th century BC that possibly also affected the wider Eastern Mediterranean region.

[73] Cf. *Samos* 4, 49–53 for the pipelines entering the sanctuary from the north.

[74] To differentiate the chronology of the pipelines, limited cleaning work was carried out in the area in summer 2017 and a catalogue of different types was created. This catalogue follows the categories given by Wellbrock 2016, 43, table 5-1.

[75] Cf. Schleif 1933, 242–243; Reuther 1957, 39; Kyrieleis 1981, 98–99.

[76] Well K 6 (Homann-Wedeking 1965a, 500; Krösser 2006, 311, 316–317, 320, 323, figs. 1–3, 6, pls. 42.2, 43.1, 44.3; Ohnesorg 2009, 148, n. 429), well K 7 b (Kyrieleis 1978b, fig. 1; Kienast 1985, fig. 7) and well N 5 a (Kyrieleis 1978a, figs. 4–5; Samos excavation diary 1976–1980, 43–44, 47–48, 76, 79; Kyrieleis 1980a, fig. 2; *Samos* 3, pls. 9.1, 15).

[77] Cf. e.g. Buschor 1937, fig. 12; Homann-Wedeking 1964b, figs. 9, 11; *Samos* 4, plan 2; Walter 1990, figs. 4–5.

[78] Isler 1969. The "cistern" is to be found in grid square K 5 (cf. *Samos* 4, pl. 2 "*byzantinische Zisterne*").

juice.[79] Indeed other "cisterns" and "basins"[80] in the Heraion also correspond to the very same building type.

At present at least nine of those collecting basins can be identified at the site (*Fig. 10*).[81] These are masonry constructions above ground. They are rectangular in shape with a base area of about 2 to 8 m² and a preserved maximum height of 1.60 m. Inside, the basins are lined.[82] Remains of an inflow channel with a round cross section at the upper end of the enclosing wall have been preserved at the larger basin in K 5.[83] The basins' floors are paved with large stone or terracotta slabs. Embedded within the floors are depressions of rectangular or round shape.[84] Within the smaller installation in K 5, a carefully carved marble tub with an outflow has been preserved inside such a depression. Unfortunately it is not clear whether or not the outflow had a connection to a drain or if the tub was in secondary use.[85] But since the smaller basin in K 5 was also equipped with an inserted tub with an outflow at the narrow end,[86] and there are hints of a similar tub within the basin in K 9,[87] we can assume that those tubs belonged to the standard equipment of the basins and that at least in some cases they were indeed connected to a drainage system.[88] In the walls of the basin in grid square Q/R 5, the underarm of the so-called great kouros,[89] longitudinally split into two pieces, was incorporated. Protruding to the inside, the fragments served as stepping stones for entering the basin.[90] Stepping stones are also attested for the two basins in grid square K 5.[91] Nearly all of these features seem to have been originally incorporated into a building and connected with other installa-

[79] Isler 1969, 230.

[80] Cf. Samos excavation diary 1912–1914, 13 ("*Wasserbehälter*" in K 9); Homann-Wedeking 1965b, 445, fig. 14 ("*Wasserbehälter*" in K 5); *Samos* 4, plan 2 ("*byzantinische Zisterne*" in L 4); Kyrieleis *et al.* 1985, 403, fig. 11 ("*Becken*" in Q/R 5); *Samos* 10, 1, pl. 3.1 (the feature in Q/R 5 is here referred to as "cistern").

[81] Two are to be found in grid square K 5 (for the first see Homann-Wedeking 1965a, 500–501; 1965b, 445, fig. 14; Isler 1969, 202–203, 226; *Samos* 17, 145 with n. 422; Carington Smith 1994, 371; Krösser 2006, 309, figs. 1, 3, 6–7; for the second see Homann-Wedeking 1965a, 500–501; 1965b, 445; Isler 1969, 202–230, figs. 1–3, pl. 82; Jantzen & Megow 1977, 175, n. 5; *Samos* 4, plan 2; *Samos* 17, 145; Carington Smith 1994, 372; Krösser 2006, 309). One in K 9 (see Samos excavation diary 1912–1914, 13; Reuther 1957, z. 3) was removed in 1912 and thus no longer exists, one in L 4 (*Samos* 4, plan 2), one in N 15 (see Homann-Wedeking 1964a, 83, fig. 1), one in O 8 (pers. comm. by Jan-Marc Henke in July 2018), at least one in Q 5 (not yet published; see Samos excavation diary 1981–2005, 71–72 and e.g. photographs Samos 1442-07 and Samos 1442-10), one in Q/R 5 (Kyrieleis *et al.* 1985, 375, 403, figs. 2, 11; Kyrieleis 1993, 149; *Samos* 10, 1. pl. 3.1) and one in R 8 (see photograph D-DAI-ATH-Samos-3145). Maybe also the three "cisterns" in L/M 6/7 mentioned by Buschor 1937, 221, fig. 12 are in fact parts of wine presses (cf. Isler 1969, 202–203, n. 4; *Samos* 17, 145 with n. 422). The same is possibly true for the two neighbouring "cistern-like rooms" in K/L 7 (Kyrieleis 1978b, figs. 1, 5–6; 1980a, fig. 8), another "cistern" north of the so-called sacred road (mentioned by Schneider 1929, 126–127) and two rectangular structures in R 7.

[82] Isler could distinguish at least three layers of plaster at the bigger basin in K 5 that attest several renovation phases (Isler 1969, 202).

[83] Isler 1969, 202, figs. 2–3.

[84] Their size varies between approximately 0.40 × 0.40 m and 1.00 × 0.80 m and a diameter of about 0.50 m, respectively. Their depth is about 0.40 m.

[85] Homann-Wedeking 1965b, 445, fig. 14. Cf. *Samos* 17, 145.

[86] Krösser 2006, pl. 44.4.

[87] Reuther 1957, z. 3.

[88] Cf. *Samos* 17, 145 on a wine press within the monastery property in Samos. Here too the assumption is that originally a tub was inserted in the depression found there.

[89] See *Samos* 10.

[90] *Samos* 10, 1, pl. 3.1. *Samos* 17, 32, 145 interprets protruding stones inside a basin within the monastery property in Samos as supports for a strainer. Unlike the two examples from the Heraion, however, the stones in Samos are fixed at the same height and therefore could not have served as steps.

[91] See Isler 1969, 202 and Krösser 2006, pl. 44.4, respectively.


*Fig. 10. Samos, Heraion, general plan with collecting bases of wine presses. Johanna Fuchs, German Archaeological Institute at Athens.*

tions such as smaller basins, paved floors, etc.[92] Although the building type itself seems not to be limited to a specific period,[93] the basins in the Heraion seem to be rather late chronologically. Proposed dates range from possibly Roman Imperial to Byzantine times.[94]

As can be observed from better-preserved wine presses and ethnographic research, those installations would have originally been connected to paved treading floors where freshly picked grapes were crushed.[95] From the treading floor, the juice flowed into the collecting basin from where it would have then been decanted into other vessels for maturing. The tubs embedded in the basins floor served as collecting tanks for emptying and cleaning purposes. To ensure the flow in the desired direction, the treading surface could be inclined towards the collecting basin and there were channels and/or inflows connecting both the floor and basin. Barriers between treading floor and the collecting basin, and strainers within the connecting devices prevented unwanted solids, such as grape skins, from entering the tank.[96]

The wine collecting basins found in the Heraion attest to the cultivation and processing of grapes within the area.[97] Given the high number of presses, wine production took place at a large scale.[98] The farmyards belonged to the small settlement that flourished at the site from Roman Imperial to Early Byzantine times.[99]

Excluding the basins that have been identified as (possible) collecting tanks for wine presses, there are only two so-called cisterns left.[100] These rectangular masonry basins are coated with waterproof plaster and have a base area of about 2.20 m$^2$ and 3.30 m$^2$, respective-

[92] See e.g. the smaller basin in K 5 situated within a building complex that served residential as well as economic purposes (Krösser 2006, 319, 323, figs. 3, 6–8) and the basin in K 9 with a smaller, bordering basin to the east and possibly connected remains of a paved floor to the north-east and south-east (Reuther 1957, z. 3).

[93] There are examples from Classical to modern times. See e.g. Carington Smith 1994, 371–372.

[94] Two coins found within the filling of the bigger basin in K 5 supply the date AD 538 as a *terminus post quem* for the destruction and backfilling of that installation (Isler 1969, 229–230). The proposed dates for the other basins are not that well founded. The peristyle building in the southern part of the Heraion, incorporating the basin in N 15, was, according to Homann-Wedeking 1964a, 82–83, established in the 3rd century AD. The smaller basin in K 5 was, according to Krösser, probably already established within a building of Roman Imperial times. Due to massive structural interventions in Early Byzantine times that obscure the findings, Krösser also considers a construction only possible in Byzantine times (Krösser 2006, 319). The basin in K 9 (Reuther 1957, Z. 3), as well as the basin in Q/R 5, is referred to as “Late Antique” (*Samos* 10, 1), while the basin in L 4 is indicated as “Byzantine” (*Samos* 4, plan 29).

[95] The paved areas that have been found in the surrounding area of the basins in grid square K 9 and R 8 are perhaps remains of such treading floors.

[96] For an obvious comparison of a wine press within the economy wing of the Early Byzantine monastery property in Samos see *Samos* 17, 32–34, 144–147, figs. 16, 41, pls. 18.2–3, 19.2. For further comparisons and a discussion of the differences between wine and oil presses see e.g. Teichner & Peña Cervantes 2010–2011; Carington Smith 1994; Pazaras & Tsanana 1991; Bruneau & Fraisse 1984; 1981.

[97] Bürchner 1896, 36 assumed that viticulture on Samos was practised only in hillside locations. However, the climatic conditions in the Mediterranean region also allow for wine cultivation on plains (cf. Schuler 1998, 110–111). Indeed, vineyards are attested in the surroundings of the Heraion in historical as well as in modern times (cf. Kučan 1995, 11–13; Ross 1843, 141). For a collection of literary sources for viticulture on Samos see Meyer 2012, 359–364.

[98] One also has to bear in mind that a wine press could be used by more than one party. This is testified by an inscription from the city of Hypaipa in Lydia dated to AD 301 (Schuler 1998, 93 with n. 93 and further references). The sharing practice was still occurring until very recently in Knossos on Crete, as reported by Carington Smith 1994, 370.

[99] For the settlement and its establishment possibly in connection with people seeking asylum at the sanctuary cf. Sinn 1978.

[100] A prehistoric feature in grid square F 7/8 (cf. Buschor 1959, 206, fig. 4; *Samos* 1, 16–17, pl. 7.1; Walter 1965, fig. 4; 1976, 13–14, fig. 3; 1990, figs. 4–5), that has also been referred to as “cistern” or “cistern-like basin”, is not fit for water storage since it neither has a solid floor nor any kind of waterproofing inside its walls.

ly.[101] The basins are ascribed to "Roman" and "Imperial" times.[102] Due to the limited information available, it cannot be ascertained whether they are actual cisterns that were used for water storage or if these features served other purposes, possibly in connection with agricultural or economic activities.[103] To summarize, there are no unequivocally established cisterns within the Heraion.

## Concluding remarks and future prospects

In conclusion, the water supply of the Heraion could be guaranteed continuously through groundwater tapping wells and, at least from Hellenistic to Roman times, also through a more elaborate pipe system that brought water from a more distant source to the sanctuary. Since no unambiguous cisterns have been found at the site, the collection and storage of rainwater seems to have not been a necessity throughout the history of the Heraion.

Whether the abandonment of the groundwater flowing wells in the 6th century BC, as well as the noticeable lack of newly dug wells from Classical to Roman Imperial times and the establishment of the water pipe system, were motivated by a water shortage within the Heraion itself has yet to be investigated.

Part of the ongoing research will also be a further analysis of the above-mentioned wells, their location, functionality, capacity, water quality and reactions to flood and drought events. Using the hydrological model currently in development at the TH Lübeck, it will be possible to calculate different scenarios and investigate the response capabilities of single wells and the whole system. The construction features of Heraion's wells (minimum and maximum possible water level) provide palaeo proxy data that will be used for the calibration of said model.

With the help of the previously mentioned water and calcium carbonate deposit analyses it will shortly be possible to identify the water sources tapped and led to the Heraion via terracotta pipes. An estimation of the quantity and quality of water brought into the sanctuary can be offered and compared to the amount of water available at the site.

Apart from wells and pipes, other features such as channels, bathing installations and water displays will also be explored further and add to the overall picture of hydrotechnical installations within the sanctuary. Similarly, the evaluation of the drill cores and other stratigraphic information is important in order to shed light on the geological and anthropological genesis of the site, as well as on the former courses of the Imbrasos River.

Last but not least, the project aims to understand possible ritual functions of water within the Heraion. After all, the liquid element seems to have played a significant role throughout the history of the sanctuary.

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[101] Since for the installation in H 6 there is no eastern limit preserved, the given number is only an estimation.
[102] The "Roman" feature is to be found in H 6 (Homann-Wedeking 1964b, figs. 9, 11; 1964c, 403, pl. 470c), the "Imperial" one in K 5 (*Samos* 4, plan 2).
[103] There are no suggestions of inflows or coverings that could point to an actual use as cisterns.

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