

European Geosciences Union General Assembly 2008

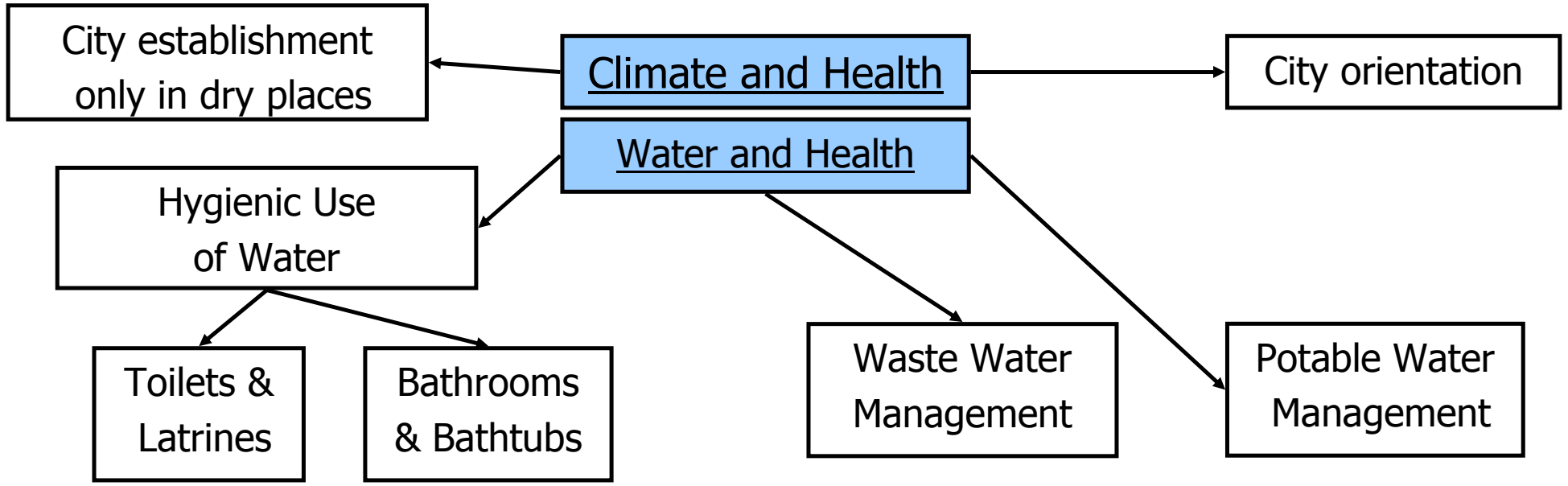
Vienna, Austria, 13-18 April 2008

Session IS22: Climate, Water and Health

Climate, Water and Health in Ancient Greece

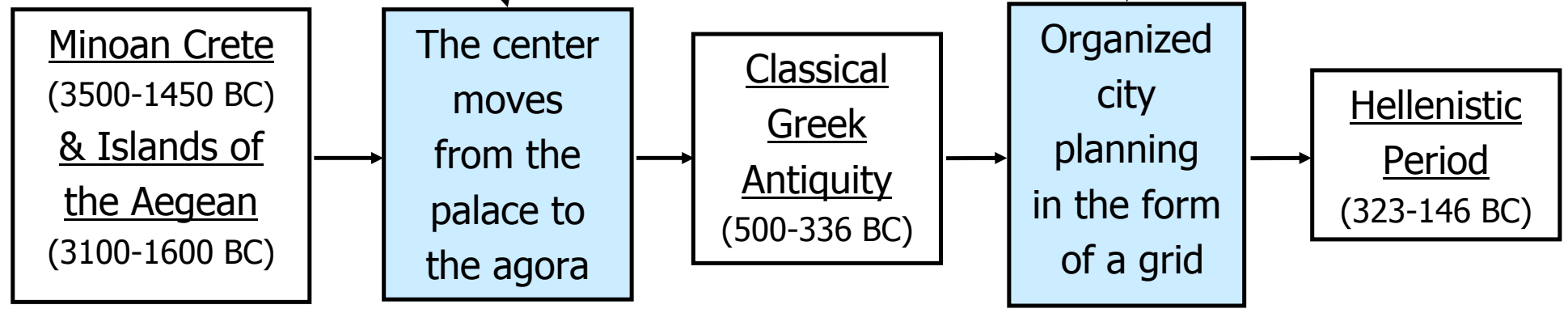
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1. Scope and Background Information



Social and Constitutional Progress:
(Greece moves from Monarchy to Democracy)

Progress of Urban Planning:
(cities gradually adopt Hippodameian system)



2. City Establishment

In contrast to earlier ancient civilizations (Egypt, Mesopotamia, Indus) that flourished in water-abundant environments (large river valleys), ancient Greeks preferred to establish their settlements in dry, water scarce sites.

It seems to be a paradox that all major Greek cities, during the several phases of the Greek civilization were established in those areas that had the minimal rainfall across the continental and insular Greece. Although some medium-scale rivers and lakes exist in Greece, there has been no major city close to them in Greek antiquity. However, the above criteria have not been applied for cultural centers (Delphi, Olympia or Dodoni), as their majority is situated in areas with adequate water resources.

Such a choice must have been driven primarily by the laws of the natural selection, with the populations established in dry climates having larger probabilities to survive, as they were protected from water-related diseases.

In the centuries that followed, Greeks, must have progressively assimilated the fact that dry climates are generally more convenient to live and healthier as they protect the population from water-related diseases.

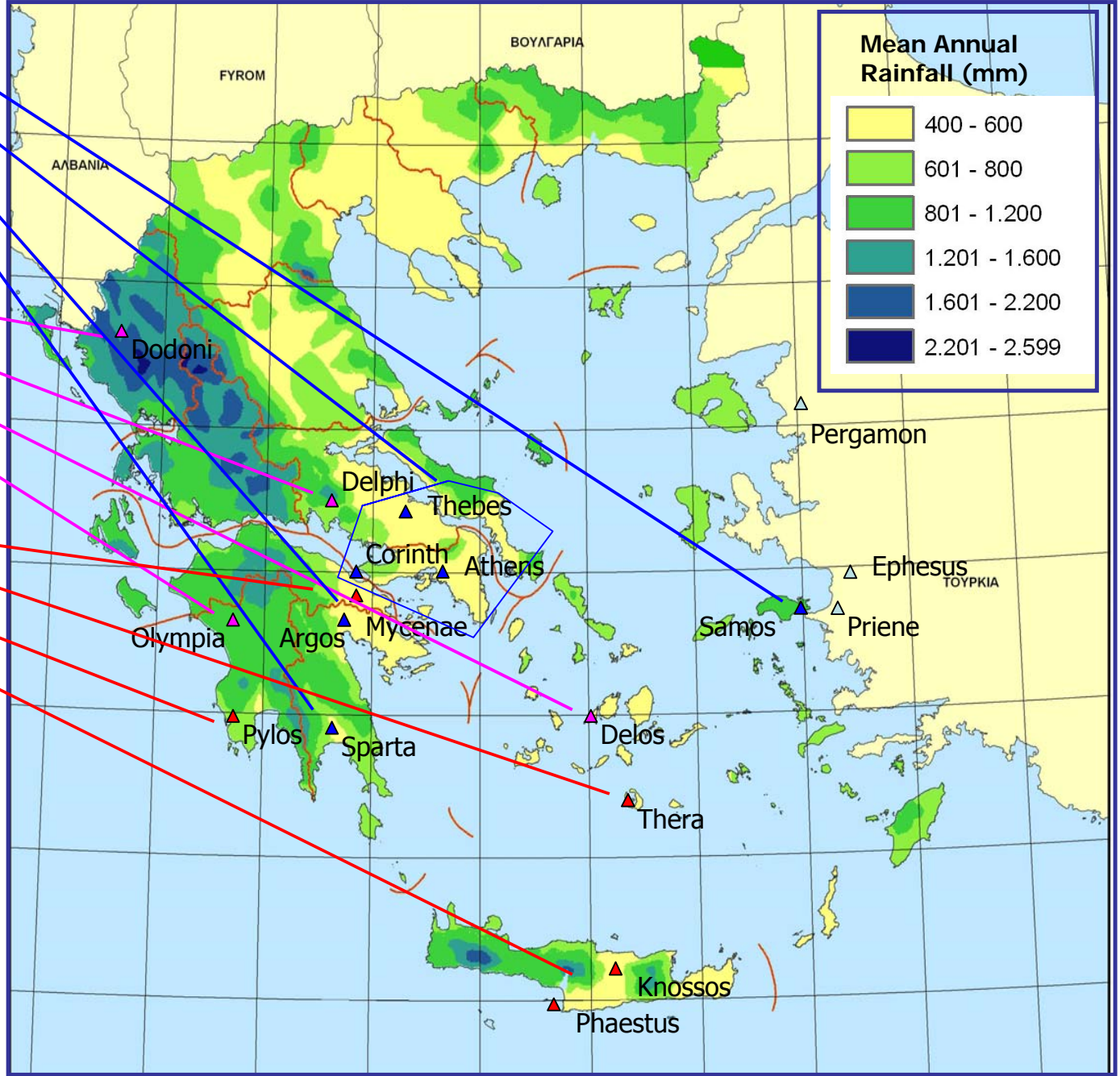
3. City Establishment II

Most cities in classical antiquity are situated in areas with shortage on water resources

Most major cultural centers are situated in areas with satisfactory rainfall

Major installations of prehistorical antiquity are located in areas with water scarcity

- ▲ Major prehistorical cities / installations
- ▲ Major cities classical antiquity
- ▲ Major cultural centers
- ▲ Major Hellenistic cities



4. Prehistorical Greek Antiquity

Minoan Crete (3500-1450 BC)

The centre of the life is the palace

Cycladic (3100-1600 BC)

Hydraulic infrastructures include:

- Systems for water transportation
- Wastewater and stormwater sewage systems
- Bathrooms with flushing toilets

Hydraulic infrastructures include:

- Sewage systems
- Bathrooms and bathtubs

We focus on Knossos Palace, although similar hydraulic technologies were practiced in other palaces as well (Phaistos, Mallia)

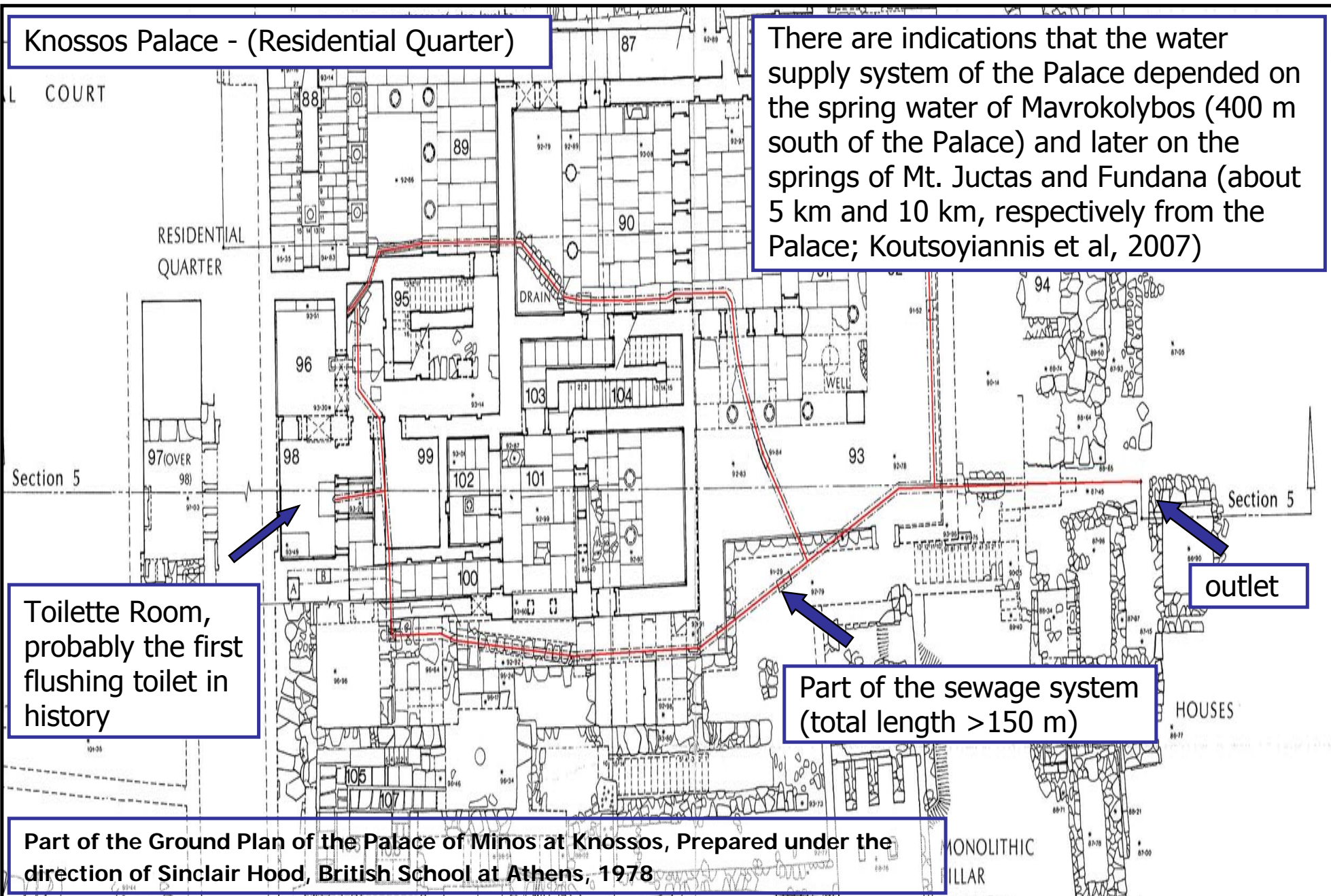
We focus on Acrotiri, which is regarded to be the main settlement of the island of Thera

According to "Volcanic Destruction" theory, the vast eruption of the Thera volcano destroyed both civilizations

The expatriates moved in mainland Greece and particularly in Western Peloponnese, transferring their culture, art and technology to Mycenaean Greece (1550-1150 BC)

5. Minoan Crete: Water Supply, Sewage and Flushing Toilet

Knossos Palace - (Residential Quarter)



There are indications that the water supply system of the Palace depended on the spring water of Mavrokolybos (400 m south of the Palace) and later on the springs of Mt. Juktas and Fundana (about 5 km and 10 km, respectively from the Palace; Koutsoyiannis et al, 2007)

Toilette Room, probably the first flushing toilet in history

Part of the sewage system (total length > 150 m)

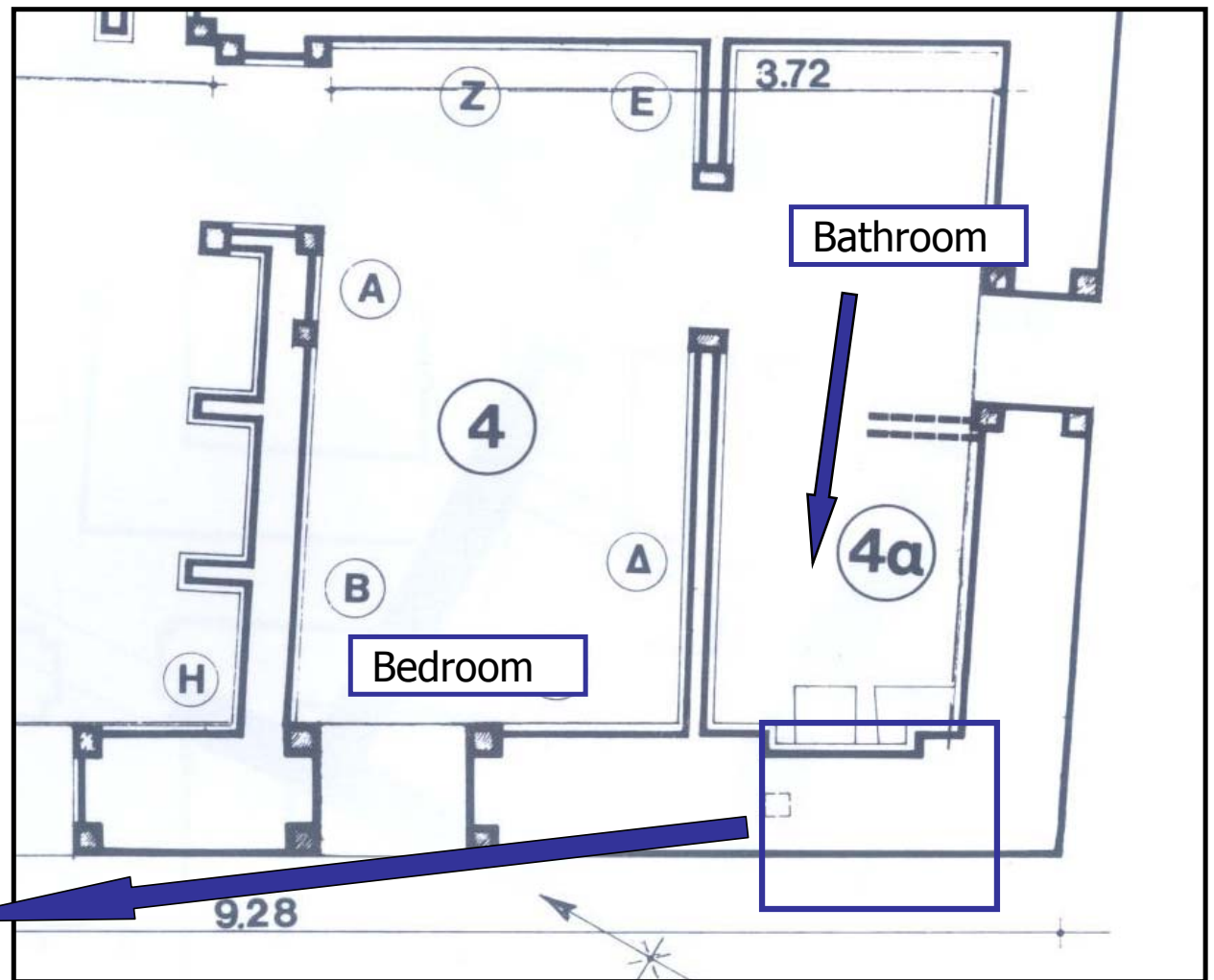
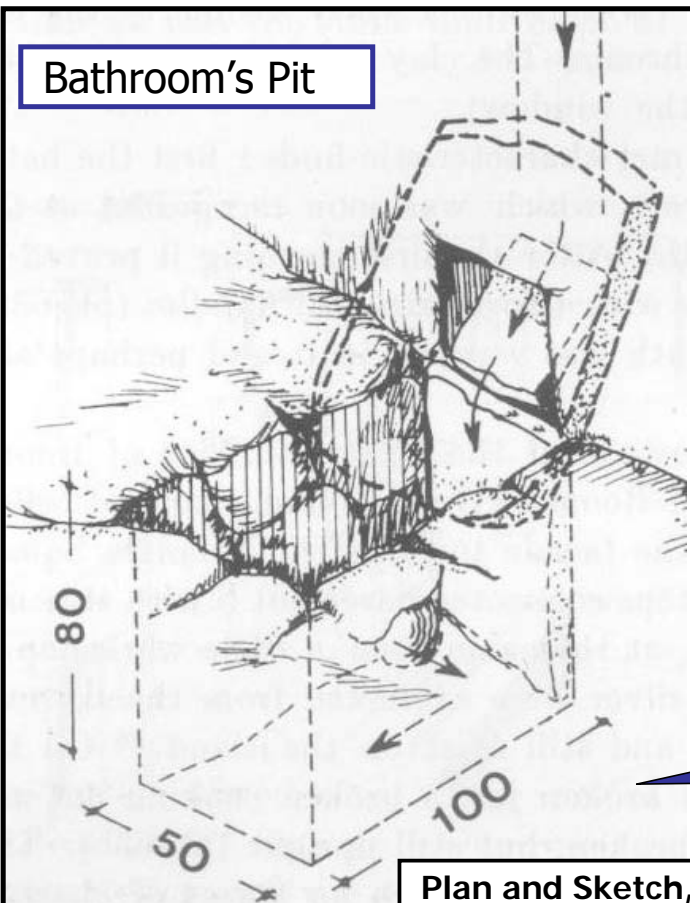
Part of the Ground Plan of the Palace of Minos at Knossos, Prepared under the direction of Sinclair Hood, British School at Athens, 1978

6. Island of Thera: West House, Bathroom with Sewage System (Room 4a)

From the west wall of the bathroom clay pipes about 20 cm in diameter descend unseen through the walls of the house down to the foundations, where a pit was built externally. Its function was to act as an outlet for water directly into the drain - pipe (Marinatos, 1972).

Fragments of a bathtub were found, as well as two slabs upon which it may have stood.

Bathroom's Pit



Plan and Sketch, of Koumadoudes from: Marinatos, M. "Excavations at Thera VI-VII, 1972-73 Seasons", The Archaeological Society at Athens Library No. 180, 2nd edition, Athens, 1999

7. Island of Thera: Terracotta Bathtubs

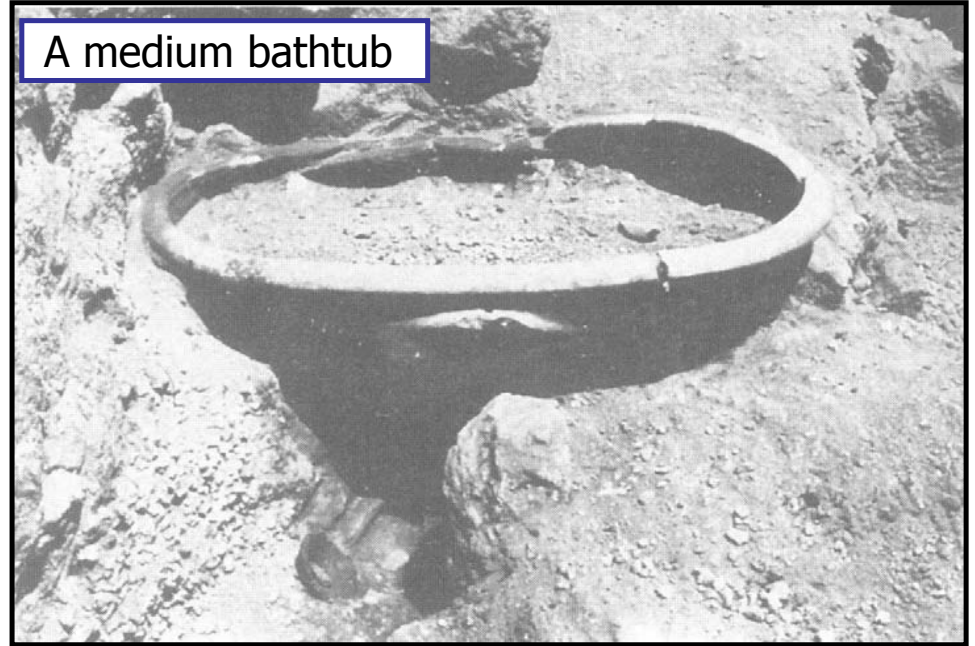
At least four terracotta bathtubs have been found during the excavations at Thera. There is a great variety among them in size and shape. One of them is possibly a baby's cradle.

A great bathtub

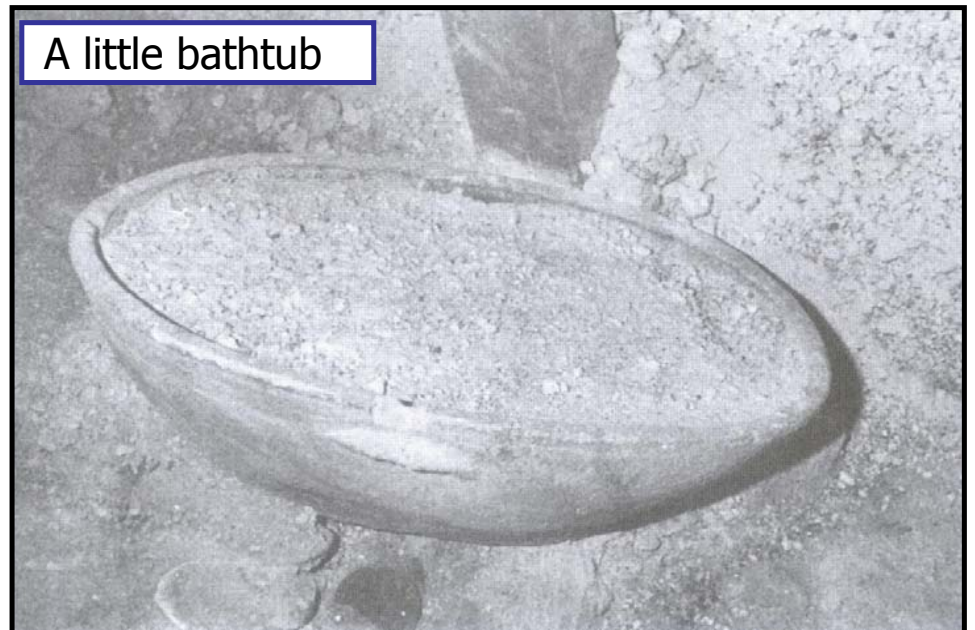


Photos from: Marinatos, M. "Excavations at Thera I-III, 1967-69 Seasons", The Archaeological Society at Athens Library No. 178, 2nd edition, Athens, 1999)

A medium bathtub



A little bathtub



8. Classical Greek Antiquity – The Case of Athens

IN THAT PERIOD, HYGIENIC TECHNOLOGIES ARE DRIVEN BY SOCIAL AND CONSTITUTIONAL PROGRESS, AS POLITICAL POWER GRADUALLY MOVES FROM PRIESTS AND MONARCHY TO ARISTOCRACY AND DEMOCRACY

The core of the city moves from the palace or the Acropolis to the Agora. As Agora gradually becomes the center of political, social and commercial activity, hygienic technologies are gradually implemented in a larger scale, the scale of the Agora.

Infrastructures that ensure potable water quality as well as sewage systems are constructed.

Special attention is given for the life and the living standards of all the citizens of the city.

Public baths and latrines are built.

We focus on Athens. The centre of classical world and a unique example of the progress of hygienic technologies on that period.

We examine: (i) Peisistratean aqueduct, (ii) Athenian Agora "Great Drain", (iii) public baths and (iv) public latrines (case of Gymnasium of Amorgos).

9. City of Athens: Potable Water Quality

Peisistratean Aqueduct of Athens

- transferred water from the foothills of Hymettos Mountain to the city center (near the Acropolis)
- built under the tyranny of Peisistratos



Its longest part was carved as a tunnel at a depth reaching 14 m. In other parts it was constructed as a channel.

- In the bottom of the tunnel or channel, a pipe made of ceramic sections was placed.
- The pipe sections had elliptic openings in their upper part, covered by ceramic covers, for cleaning and maintenance.
- The ends of the sections were appropriately shaped, so that each could be tightly fitted into the next. Joints were filled with lead.

10. City of Athens: Sewage System

Athenian Agora "Great Drain"

A system of large stone channels of the early 5th century BC carried off wastewater from the buildings of the Agora and storm water from the entire area of the agora and the surrounding hills.

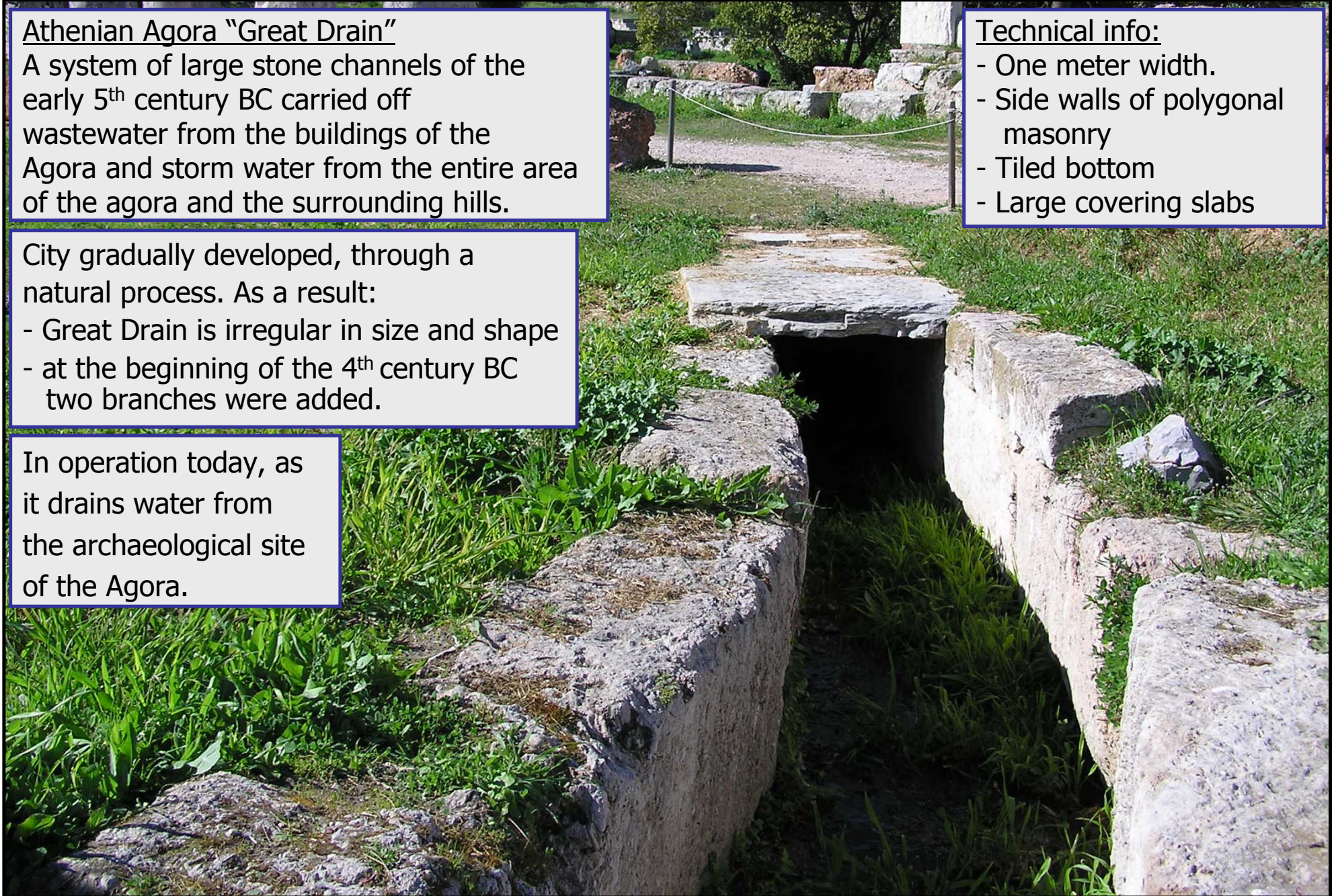
City gradually developed, through a natural process. As a result:

- Great Drain is irregular in size and shape
- at the beginning of the 4th century BC two branches were added.

In operation today, as it drains water from the archaeological site of the Agora.

Technical info:

- One meter width.
- Side walls of polygonal masonry
- Tiled bottom
- Large covering slabs



11. Classical Period: Public Baths

Until 6th century BC, Greeks used to bath in natural springs or fountains.

Classical Years:

Public Baths become common. Basic plan: a large circular room around the perimeter of which tubs were radially arranged with the heads to the outside and feet toward the inside.

Great variety among the tubs:

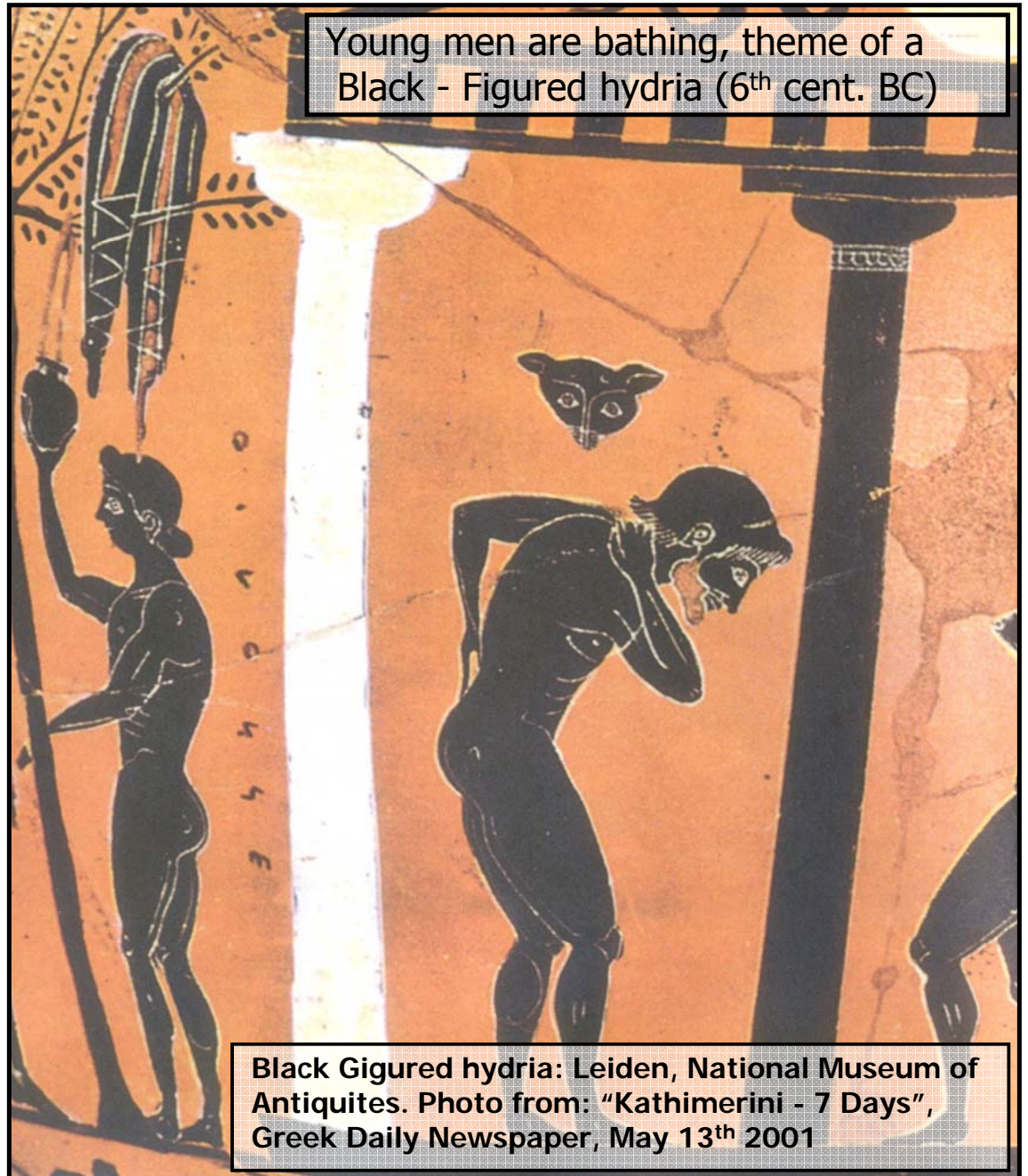
(i) hollowed out of the rock (ii) made of terracotta (iii) built of small stones or bricks with hydraulic cement coating.

Water provided by: reservoirs, fountain spouts or even wells.

Hot baths available, as Hermippos remarks :

"No, by Zeus, nor is it right for the true man to get drunk or take hot baths the way you do"

(Lang, M., 1968. "Waterworks in the Athenian Agora" *Excavations of the Athenian Agora*, Picture Book No. 11, ASCSA)



Young men are bathing, theme of a Black - Figured hydria (6th cent. BC)

Black Gighed hydria: Leiden, National Museum of Antiquites. Photo from: "Kathimerini - 7 Days", Greek Daily Newspaper, May 13th 2001

12. Classical Period: Lavatory at Amorgos island

Among the earliest well shaped lavatories is the small one in the Gymnasium of Minoa on Amorgos. It was built contemporarily with the Gymnasium at its south-western corner during the mid 4th century BC (Antoniou, 2007).

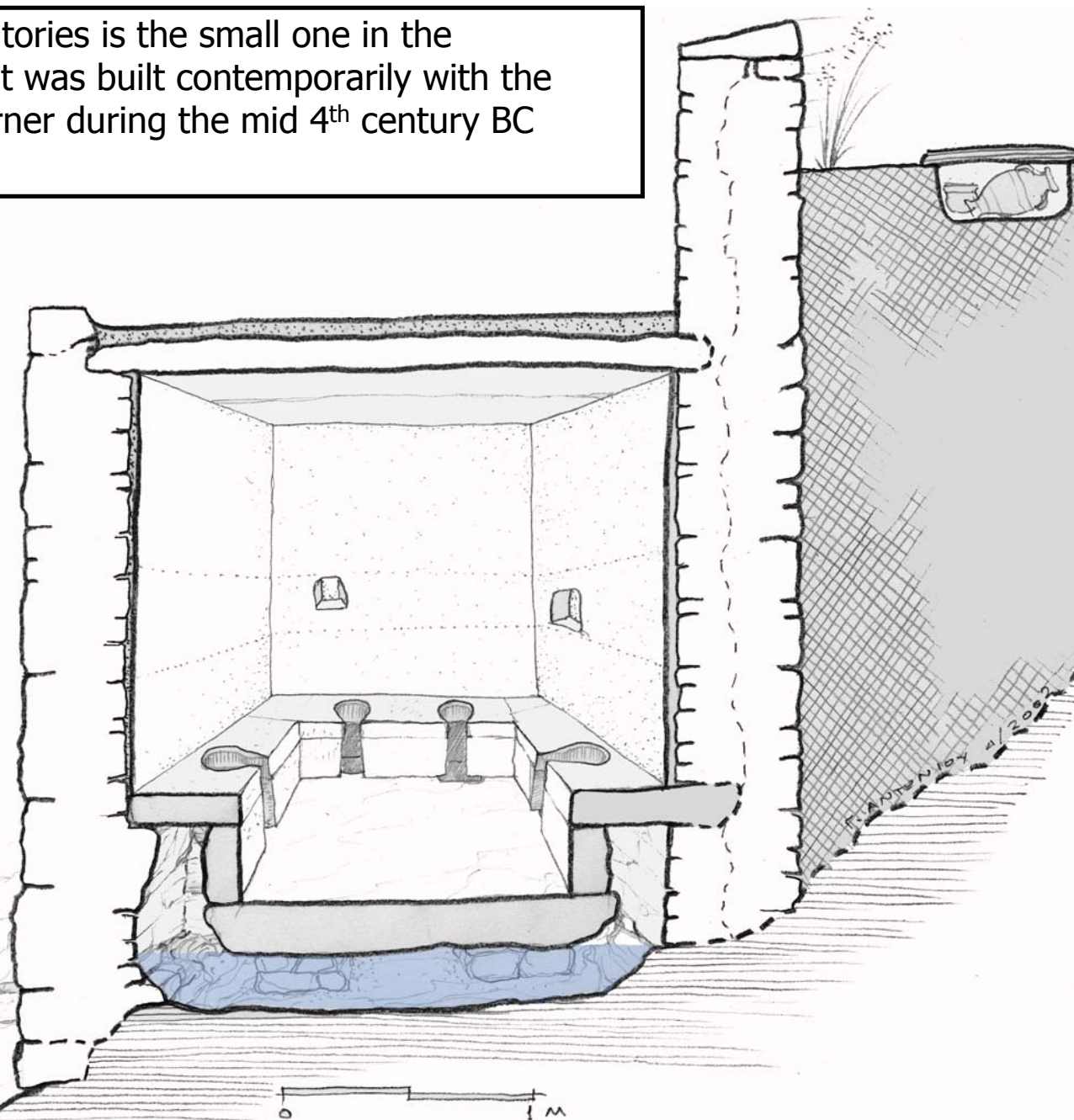
No privacy, as Antiphanes suggests that:

"whoever thinks he's more than human, going to the public latrine, will see himself just like everyone else"

Apart from its surviving roof and the benches on three sides, is also preserved the large conduit, supplied with natural flow water. A well shaped sewer was used along the south wall of the Gymnasium

The bench shaped seat is made of stone slabs, 10-20 cm thick.

Sketch from: Antoniou G.P., 2007. "Lavatories in Ancient Greece", *Water Science and Technology: Water Supply*, edit. A. Angelakis, D. Koutsoyiannis, IWA, London, p. 160



13. Hellenistic Period

IN THAT PERIOD, MOST CITIES (COLONIES, CITIES RECONSTRUCTED AFTER THE PERSIAN INVASIONS AND CITIES THAT MOVED IN NEW SITES IN ORDER TO STRENGTHEN THEIR LABOUR) ADOPT THE HIPPODAMEIAN SYSTEM

Hippodameian cities are characterized by parallel streets and the use of a grid in planning. The rectangular grid was dictated by purely functional reasons. Hippodamus the Milesian was the first to apply this system (Doxiadis, 1964)

As Hippodameian system gradually replaces the natural growth of the city beneath the Acropolis:

- (a) the scale of the city changes, requiring bigger infrastructures
- (b) organized city-planning and the regularity of the grid allows engineers to design and construct hydraulic infrastructures similar to modern ones
- (c) special attention is given in the orientation of the city

We focus on:

- Priene, possibly the best example of Hippodameian city planning and
- Pergamon, where, for the first time in history, pressure flow was applied on a large technological scale for water conveyance.

14. Priene: Hippodameian City Planning

Hellenistic city of Priene

Population: 4 000

Area: 41.4 hectares

(Doxiades, 1964)

Moved to its present location from an earlier site in the mid-4th century BC

A perfect example of Hippodameian city

Agora

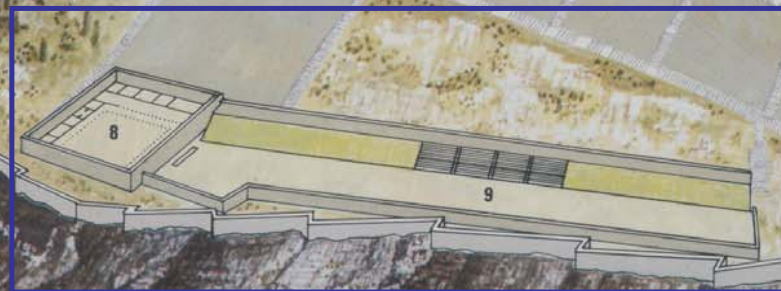
Aqueduct

Cistern

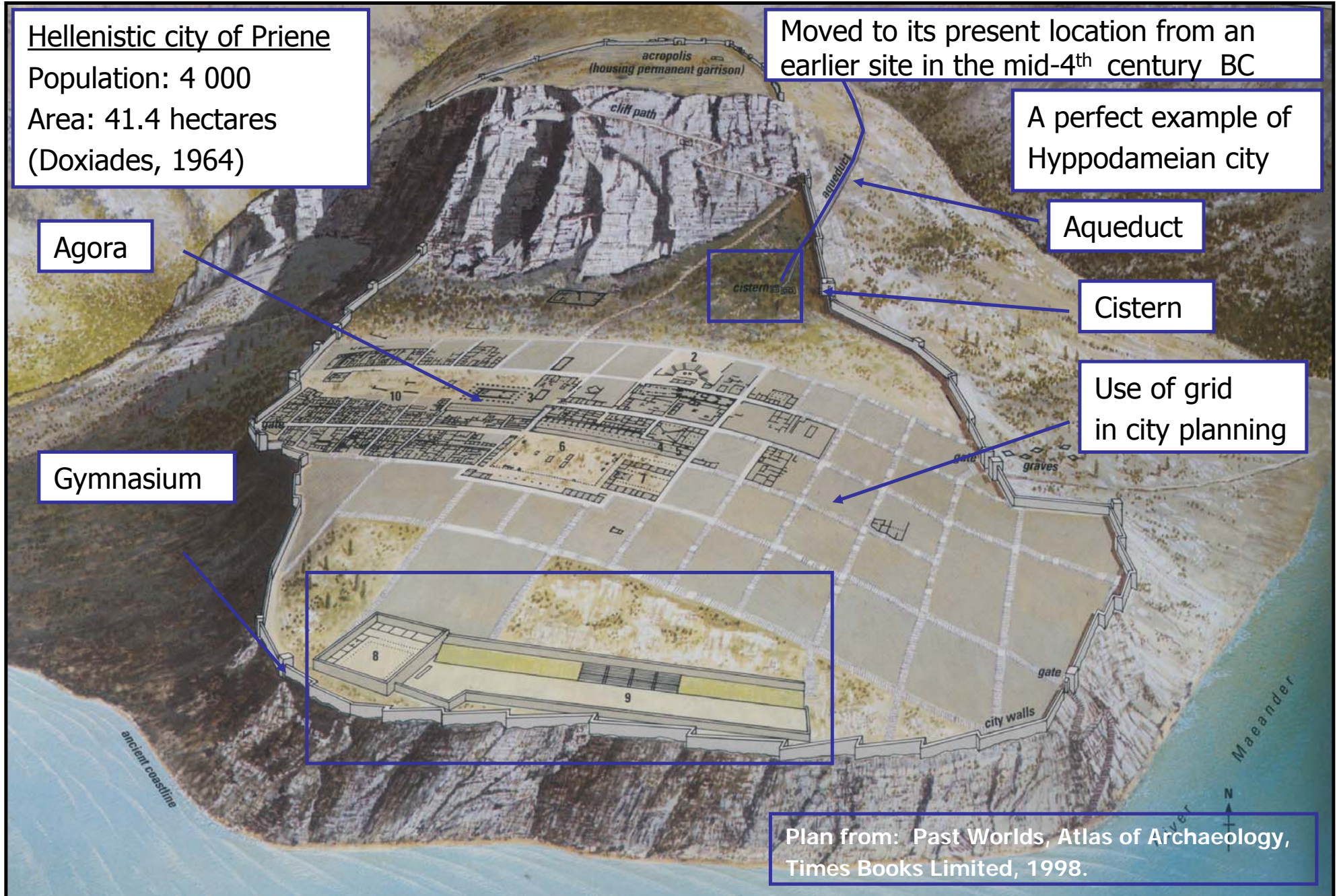
Gymnasium

Use of grid in city planning

ancient coastline



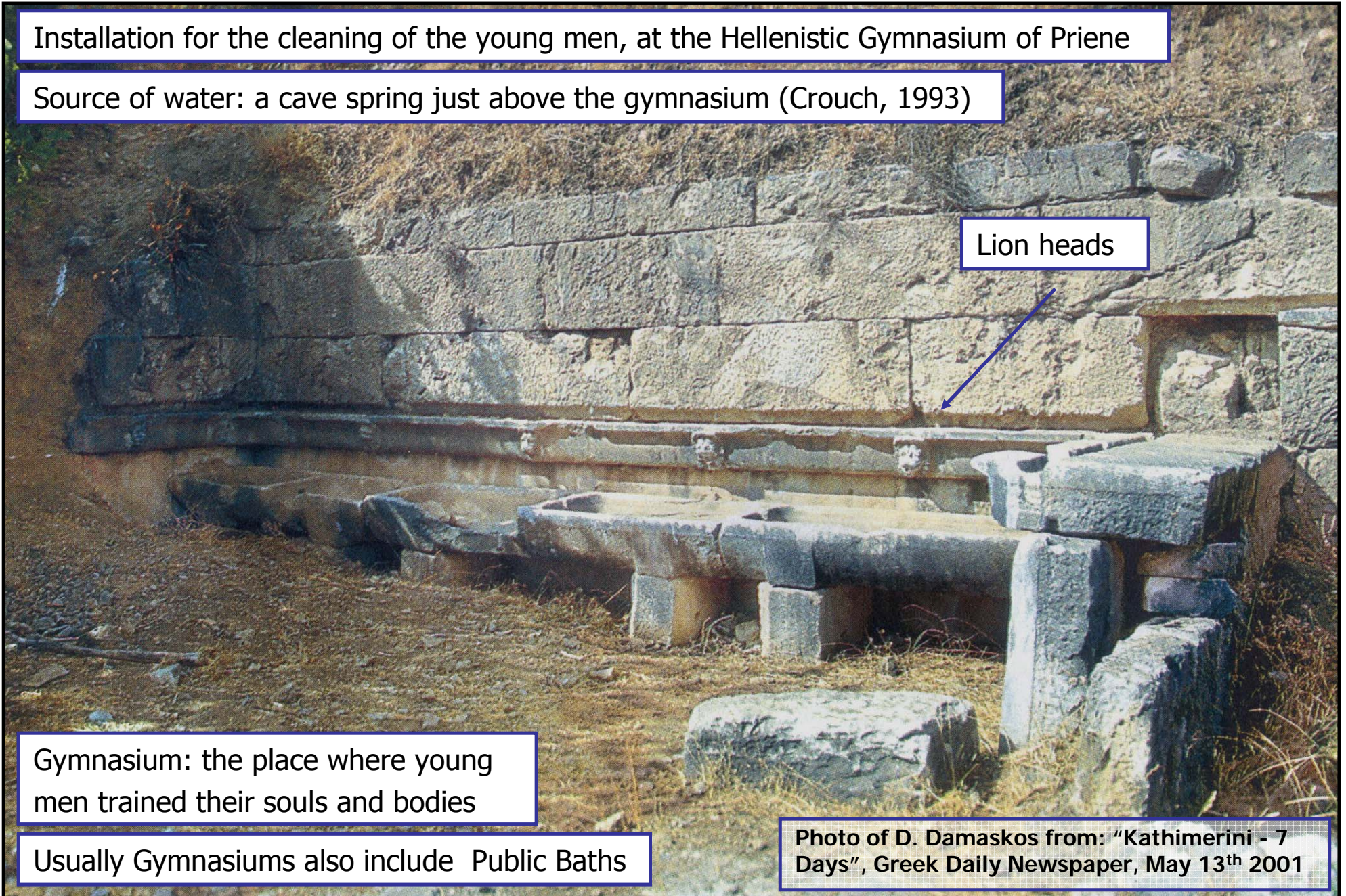
Plan from: Past Worlds, Atlas of Archaeology, Times Books Limited, 1998.



15. Priene: Gymnasium, bathing room

Installation for the cleaning of the young men, at the Hellenistic Gymnasium of Priene

Source of water: a cave spring just above the gymnasium (Crouch, 1993)



Lion heads

Gymnasium: the place where young men trained their souls and bodies

Usually Gymnasiums also include Public Baths

Photo of D. Damaskos from: "Kathimerini - 7 Days", Greek Daily Newspaper, May 13th 2001

16. Pergamon Aqueducts

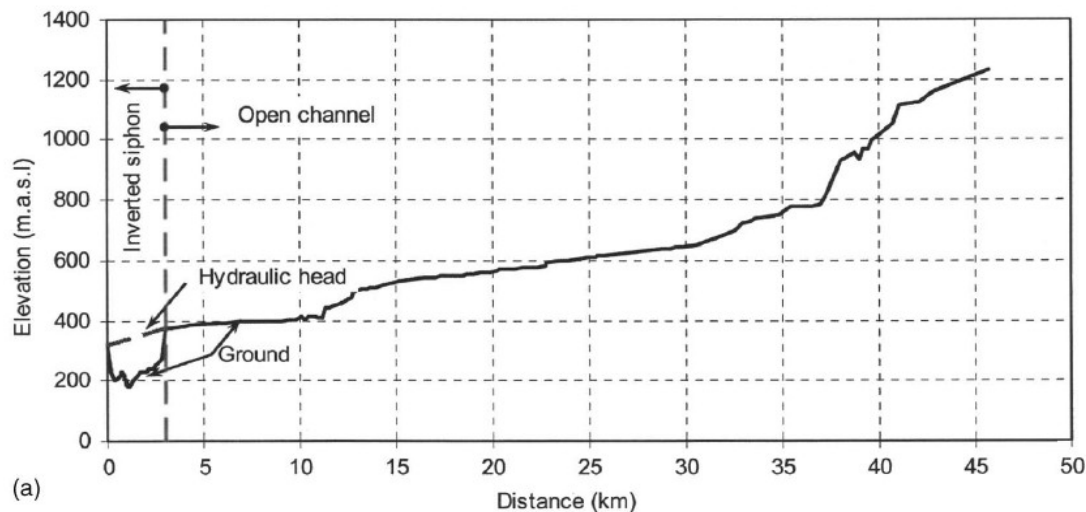
City of Pergamon: located 30 km inland from the Aegean Sea, in Western Anatolia (Turkey), on top of a hill

Pressure flow applied on a large scale for water conveyance, for the first time in history



Photo from www.flickr.com

Madradag Aqueduct, Longitudinal section indicating the 3 km long inverted siphon, Koutsoyiannis et al., 2007



Around 200 BC demand exceeded locally available supply. Three aqueducts were constructed in order to transfer water from the mountains. One of them, transferring water from the Madradag Mountain, crossed the depression north of City Hill as an inverted siphon of length exceeding 3 km with a maximum pressure head of about 180 m. The inverted siphon was made of metal lead and anchored with big stone constructions (Garbrecht et al. 2001)

17. City Orientation

From Aristotle's Politics (VII, X, 4), about the importance of the orientation of the city, we learn:

"The site of the city itself we must pray that fortune itself may place on sloping ground, having regard to four considerations: first, as a thing essential, the consideration of health (for cities whose sites slopes east or towards the breezes that blow from the sunrise are more healthy, and in the second degree those that face away from the north wind, for these are milder in winter); and among the remaining considerations, a sloping site is favourable both for political and for military purposes"

(translation from Doxiadis, C., "The Ancient Greek City and the City of the Present", Ekistics, v.18, no.108, November 1964, p. 346 - 364).

18. Conclusions

In Crete and the islands of the Aegean, during the Minoan period, and later in mainland Greece, during the Mycenaean period, all major hygienic technologies have been implemented.

The first big step forward occurs as Greece gradually moves from monarchy and oligarchy to democracy. Then: (i) The core of the city moves from the palace and Acropolis to the Agora. As Agora gradually becomes the center of political, social and commercial activity, hygienic technologies and practices start being implemented on a greater scale, the scale of the Agora. (ii) Special attention is given, for the first time in history, for the living standards of all citizens of the city-state.

The second (and last) big step happens when the Hippodameian system gradually replaces the natural growth of the city beneath the Acropolis. Then: (i) The scale of the city changes, requiring bigger infrastructures and (ii) Organized city-planning in the form of a grid allows engineers to design and construct infrastructures similar to modern ones.

The technological frame of the Hellenistic antiquity can only be compared to modern hygienic water systems reestablished in Europe and North America from the 2nd half of the 19th century A.D. until the present day.

19. Definitions and Useful Archaeological Information

I. Main periods of Greek antiquity

Minoan: Island of Crete, from 3500 BC to 1450 BC.

Cycladic: Islands of the Aegean, from 3100 BC to 1600 BC.

Mycenaean: Mainland Greece, from 1550 BC to 1150 BC.

Classical: Mainland Greece, Aegean, Asia Minor, Southern Italy, from 500 BC to 336 BC.

Hellenistic: The centre moves from mainland Greece to the eastern Aegean, from 323 BC to 146 BC.

II. Places and Cities mentioned

Knossos: The centre of Minoan Crete, 5 km South-East of Herakleion city. The present palace dates from 1700 BC when it was rebuilt after an earthquake that destroyed the original palace of 2000 BC.

Athens: The centre of the Classical Greek world, the largest and wealthiest city-state and a leading military and maritime power.

Athenian Agora: The area over the North-West slopes of the hill of Acropolis. The heart of ancient Athens, with trading, religious and political activities.

Pergamon: In western Anatolia (today Turkey), 30 km inland from the Aegean Sea. Little is known of the city's history before the Hellenistic period. The dynasty of the kingdom of Pergamon began with General Philetairos (283-263 BC) and ended in 133 BC with its surrender to the Romans (Ministry of the Aegean, 2006).

Priene: Hellenistic city in western Asia Minor, perfect example of an Hippodameian city.

Thera, Amorgos: Islands of the Aegean Sea.

III. Historical figures mentioned

Peisistratos: Tyrant of Athens, seized power in 546 BC and ruled until his death in 527 BC.

Antiphanes: Comic poet of the 4th century BC.

Hermippos: Comic poet of the 5th century BC.

Aristotle: 384 BC - 322 BC Philosopher, student of Plato. Greatly influenced philosophy up to modern times.

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