



On the Geometry of the Minoan Water Conduits

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Minoan grapes and/or olives crusher-press in ancient Vathipetro, Iraklion

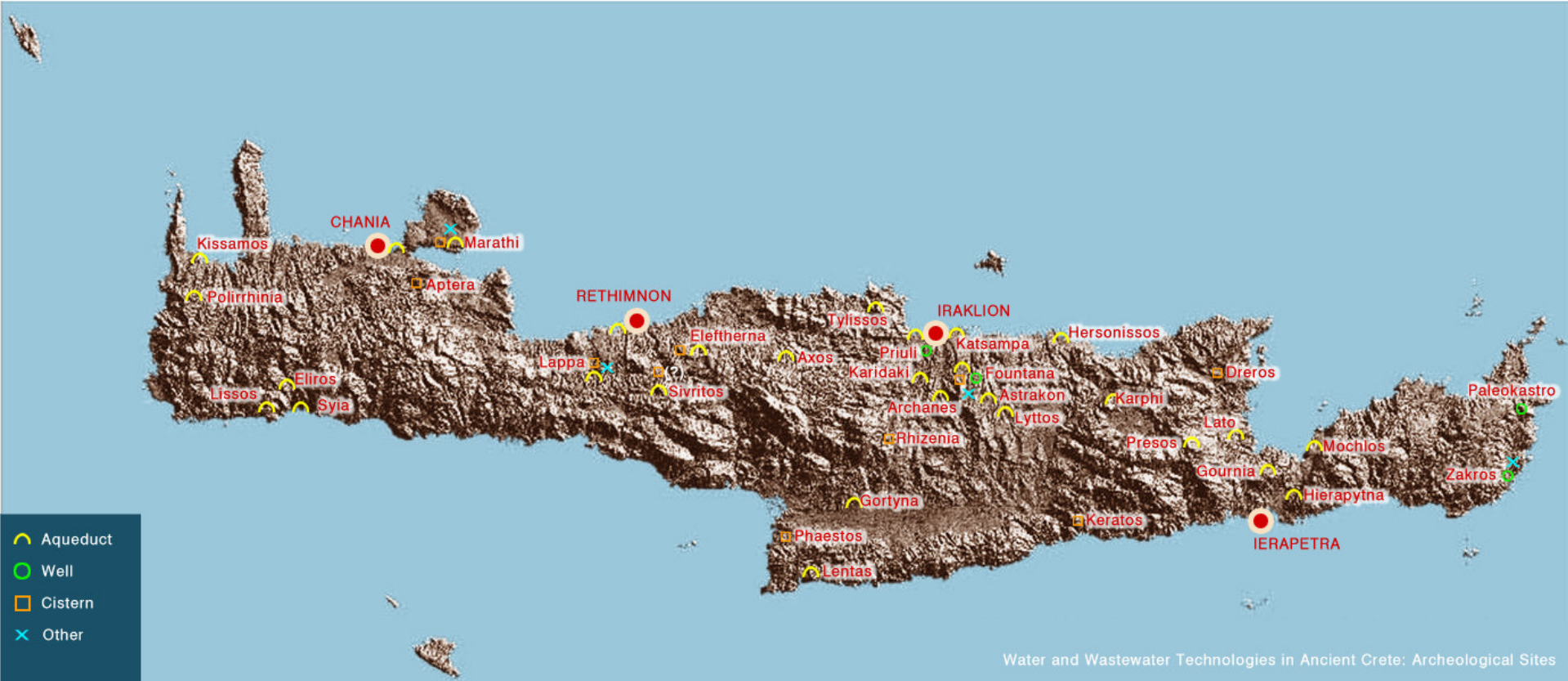
Presentation topics

- **Introduction: Historical background**
- **Conduits**
- **Stone Conduits**
- **Terracotta Conduits**
- ✓ **Opened**
- ✓ **Closed (pipes): (a) Rectangular and (b) of conical geometry**
- **First experimental results**
- **Closing thoughts**

Presentation topics

- **Introduction: Historical background**
- ✓ ***Προμηθεὺς δὲ ἐξ ὕδατος καὶ γῆς ἀνθρώπους πλάσας...***
(“Prometheus created the human gender from water and earth...”)
(Apollodorus, *Library*, The myth of Prometheus, 1,7,1)
- ✓ ***The past is the key to the future***

Map of Crete with major Minoan water supply sites





Typical view

Minoan Era (Bronze Age) ***ca. 3,300-1,100BC***

During that period of humankind nothing was more remarkable and elaborate than the water supply and sewerage systems. In each palace and other settlements those systems were well adapted to the environment, protected, constructed, and managed and were characterized by decentralized and water recycling and reuse principles.

Presentation topics

- **Conduits**

Presentation topics

- **Stone Conduits**



Carved stone elements of collecting rainfall falling from roof in Knossos



Minoan stone conduit systems at Tylissos (part of distribution network)



***Part of restored Minoan
stairway with parabolic
runnels at the Knossos
«palace», Iraklion***



Minoan stone conduit systems at Tyliisos (part of distribution network) (left) and stone drain at Knossos palace (right)

Presentation topics

- **Terracotta Conduits**
- ✓ **Opened**
- ✓ **Closed (pipes): (a) Rectangular and (b) of conical geometry**

Presentation topics

- **Terracotta Conduits**
- ✓ **Opened**



Minoan terracotta sewer of semi- cylindrical shape at the «palace» of Phaestos, Iraklion



U-shaped terracotta drains at Knossos



Inverted U-shaped terracotta drains at Knossos

Presentation topics

- **Terracotta Conduits**
- ✓ **Closed (pipes):**
- ✓ **(a) Rectangular**



Minoan terracotta pipes used for collecting and storage of rainwater of rectangular shape from Myrtos- Pyrgos in the south-eastern Crete

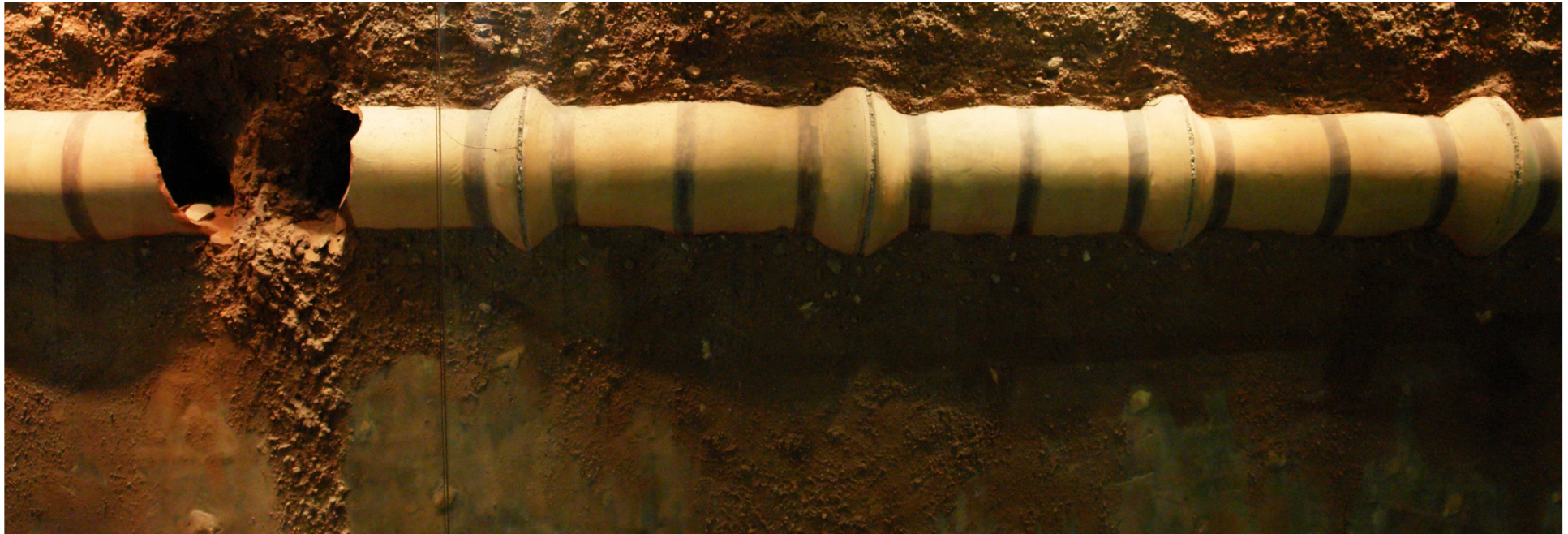
Presentation topics

- **Terracotta Conduits**
- ✓ **Closed (pipes):**
- ✓ **(b) Conical**

Conical terracotta pipes are entirely unique to Minoan Crete, which have been used predominantly in the context of water supply. There is some reason to expect that the Minoans had a good reason to support their conical geometry.



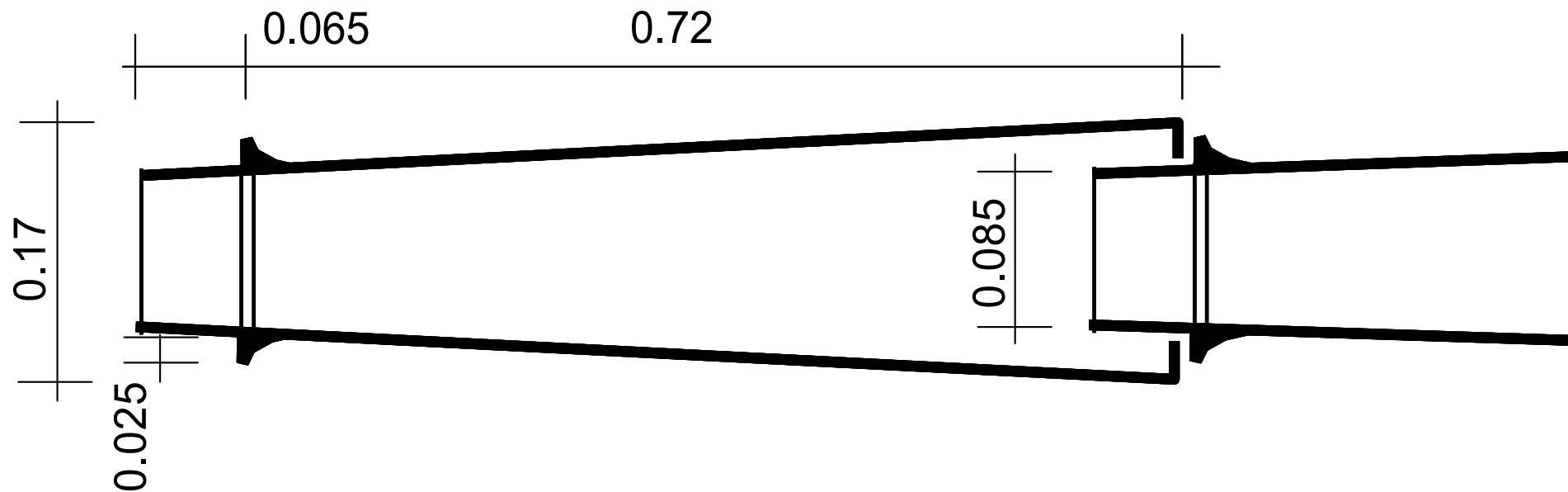
Remains of Minoan terracotta pipes part of water supply system at Knossos palace



Peisistratean aqueduct terracotta pipe segments in Athens, Greece that were laid in a channel of Classical period



***Venetian aqueduct terracotta pipe segments
at Kentri in the south-eastern Crete***



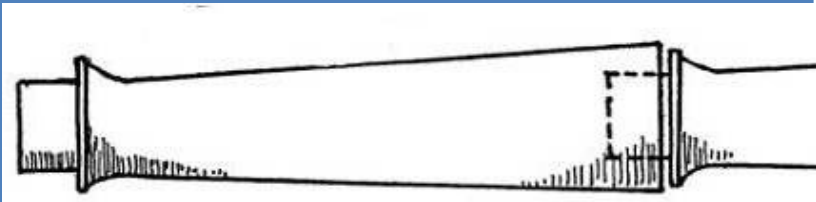
Knossos water supply pipes: Terracotta pipe dimensions



Terracotta pipes recently constructed of same material and geometry as those used at Knossos water supply system



Terracotta pipes recently constructed of same material and geometry as those used at Knossos water supply system



***Formation of sediments and salts deposits in pipes:
Schematic representation in Minoan pipes (left) and real
formation in today's' water pipes (right).***

Presentation topics

- **First experimental results**

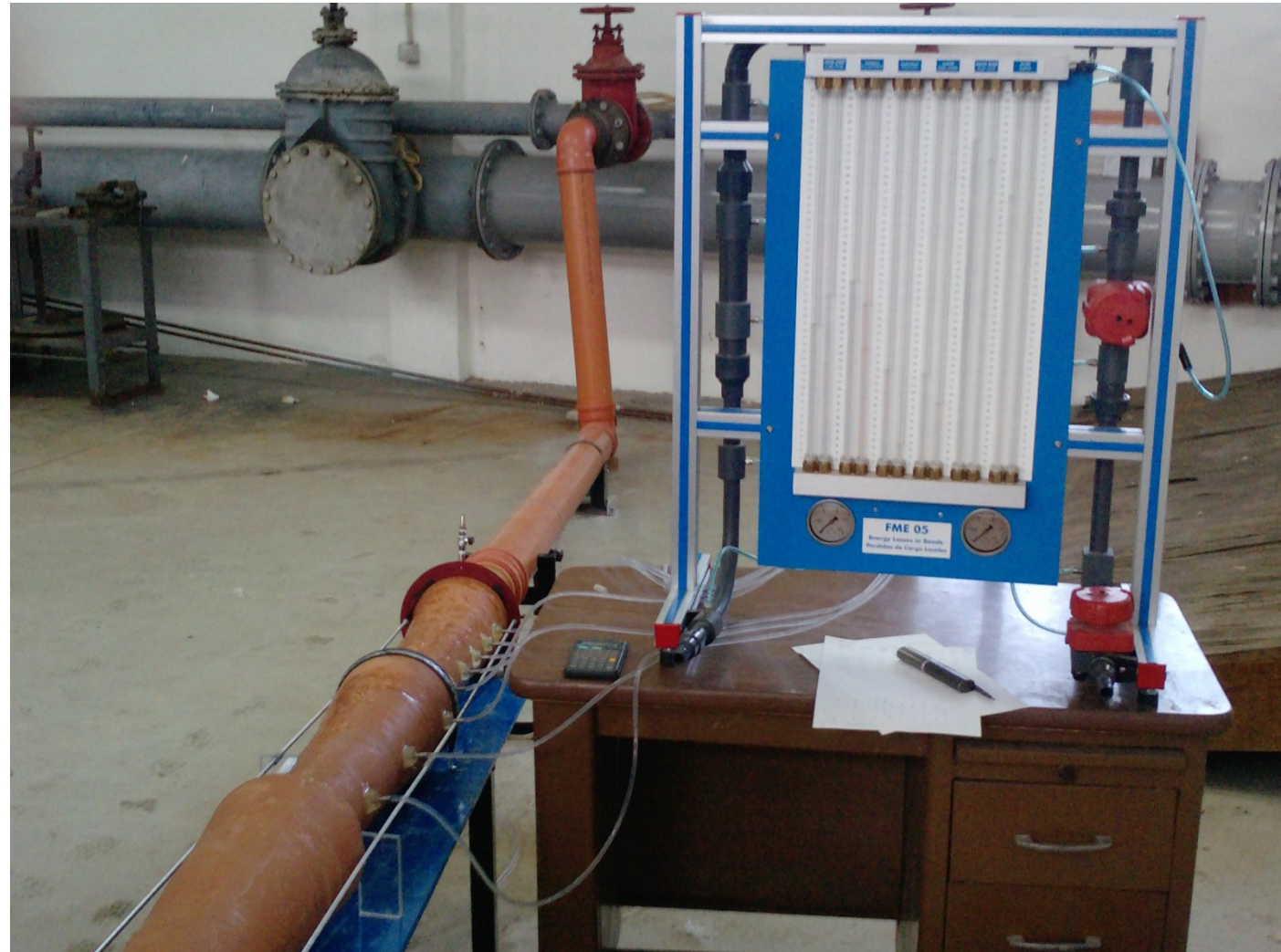
Modern hydraulic research for the Minoan conically-shaped pipes

An ongoing experiment in the Applied Hydraulics Laboratory (NTUA) to investigate the hydraulic behavior of the ceramic Minoan pipes

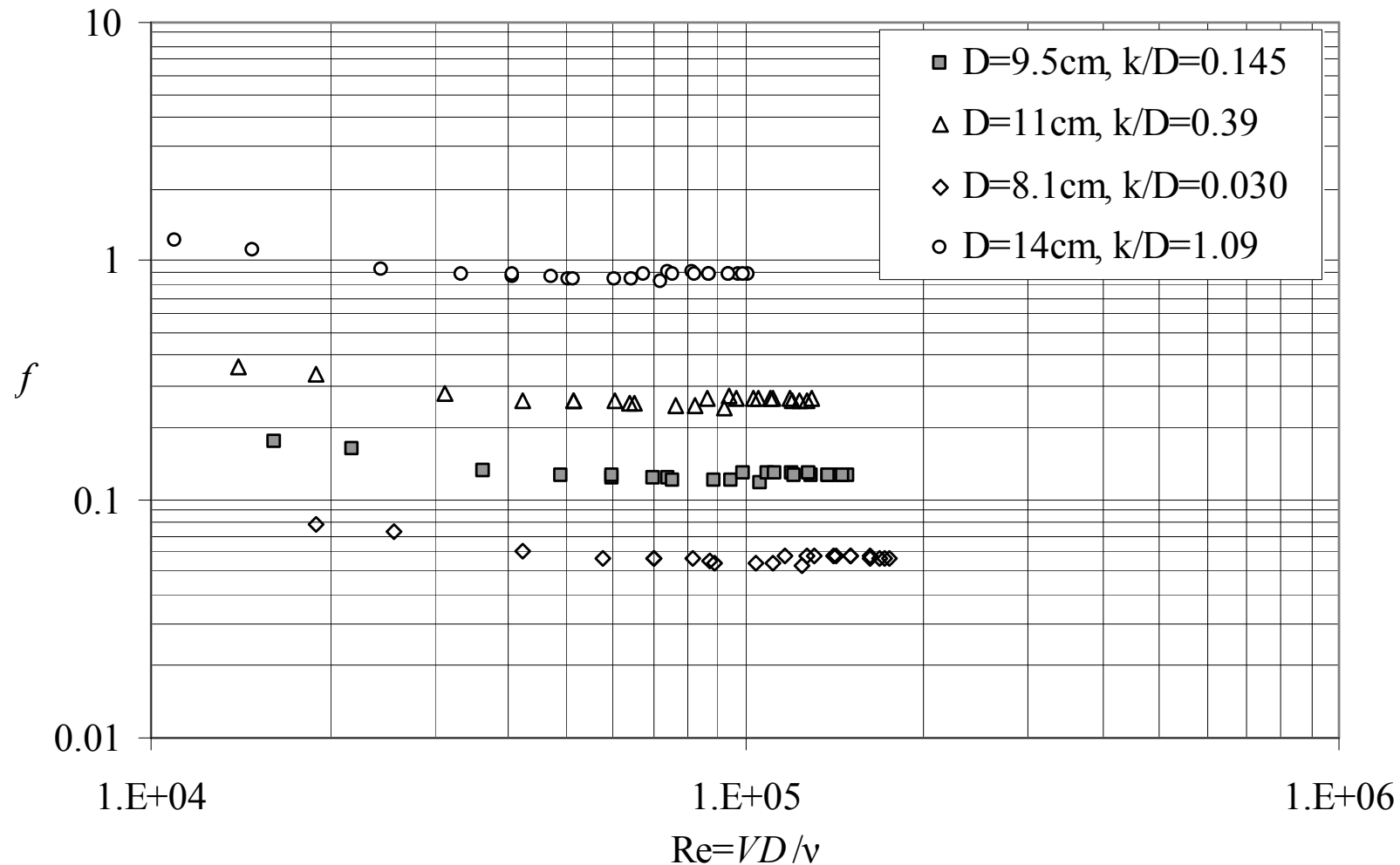


Modern hydraulic research for the Minoan conically-shaped pipes

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First experimental results



**6 pipe segments; $L=4.05$ m
 $D=8.1$ cm smallest diameter; $D = 14.0$ cm largest diameter; $D = 9.5$ cm estimated average diameter**

Interpretation of first experimental results

- **The smallest diameter (8.1 cm) should be regarded as the effective hydraulic diameter**
- **Even in this case, the hydraulic losses are too high as indicated by the high value of roughness $k = 2.4$ mm**
- **The high losses make these conical pipes ideal for mountainous terrains with high available slopes**
- **The high losses suggest development of secondary (non-axial) flows that will prevent deposition of sediments**
- **This was more or less understood by Sir Arthur Evans, who wrote:**
The tapering form of each section gave the water a shooting motion well adapted to prevent the accumulation of sediment

Presentation topics

- **Closing thoughts**

Closing Thoughts

- ✓ **Minoan aqueducts and sewerage and drainage systems consisted of open channels, closed conduits or combinations.**
- ✓ **The open channels were typically rectangular made of stone, or U-shaped made of stones or terracotta.**
- ✓ **Among the terracotta pipes, most interesting were those with truncated conic shape, manufactured in sections 70-75 cm long.**
- ✓ **Terracotta Minoan pipes of conic geometry differs notably from later Greek and Roman cylindrical.**
- ✓ **Both theoretical and experimental research, with terracotta pipes reconstructed recently resembling, the original Minoan pipes is carried out in order to answer several questions and possible advantages.**
- ✓ **The high losses make these conical pipes ideal for mountainous terrains with high available slopes**

More

IWA-Publishing Book:

***Evolution of Water Supply
Through the Millennia***

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Thank you for listening
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