Science and Technology in Homeric Epics
Aims and Scope of the Series

This book series aims to establish a well defined forum for Monographs and Proceedings on the History of Mechanism and Machine Science (MMS). The series publishes works that give an overview of the historical developments, from the earliest times up to and including the recent past, of MMS in all its technical aspects.

This technical approach is an essential characteristic of the series. By discussing technical details and formulations and even reformulating those in terms of modern formalisms the possibility is created not only to track the historical technical developments but also to use past experiences in technical teaching and research today. In order to do so, the emphasis must be on technical aspects rather than a purely historical focus, although the latter has its place too.

Furthermore, the series will consider the republication of out-of-print older works with English translation and comments.

The book series is intended to collect technical views on historical developments of the broad field of MMS in a unique frame that can be seen in its totality as an Encyclopaedia of the History of MMS but with the additional purpose of archiving and teaching the History of MMS. Therefore the book series is intended not only for researchers of the History of Engineering but also for professionals and students who are interested in obtaining a clear perspective of the past for their future technical works. The books will be written in general by engineers but not only for engineers.

Prospective authors and editors can contact the series editor, Professor M. Ceccarelli, about future publications within the series at:

LARM: Laboratory of Robotics and Mechatronics
DiMSAT – University of Cassino
Via Di Biasio 43, 03043 Cassino (Fr)
Italy
E-mail: ceccarelli@unicas.it

For other titles published in this series, go to
www.springer.com/series/7481
# Table of Contents

Preface ix
Acknowledgements xiii
List of Contributors xv

## Part 1: General Themes

Mycenaen Technology 3
* T.P. Tassios

Autagreton 35
* E. Mikrogiannakis

## Part 2: Mathematics and Physics

Archimedes’ Count of Homer’s Cattle of the Sun 43
* C. Rorres

Vortices in Homer’s Odyssey – A Scientific Approach 67
* G.H. Vatistas

The Homeric Automata and Their Implementation 77
* D. Kalligeropoulos and S. Vasileiadou

The River Ocean: Homer’s Cosmogony 85
* T. Showleh

The Laws of Curvilinear Motion in the Iliad 93
* S.A. Paipetis

## Part 3: Materials

Iron in the Homeric Epics & Homer, A Sensible Ecologist 103
* G. Varoufakis
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Bronze Technology at Land’s End, North Western Iberia</td>
<td>113</td>
</tr>
<tr>
<td>B. Comendador-Rey, S. Reboreda-Morillo, W. Kockelmann, M. Macdonald, T. Bell and M. Pantos</td>
<td></td>
</tr>
<tr>
<td>Porphyra: In Search of Dyeing Methods in Ancient Greece</td>
<td>133</td>
</tr>
<tr>
<td>W. Nishiyama</td>
<td></td>
</tr>
<tr>
<td>Technology Transfer in the Bronze Age: The Case of a Faience-Like Blue Glaze Produced at Bread-Oven Temperatures</td>
<td>139</td>
</tr>
<tr>
<td>E. Pantos, J. Davidovits, M. Gelfi, G. Cornacchia, E. Bontempi, P. Colombi and L. Depero</td>
<td></td>
</tr>
<tr>
<td><strong>Part 4: Defensive Weapons</strong></td>
<td></td>
</tr>
<tr>
<td>From Homer to Hoplite: Scientific Investigations of Greek Copper Alloy Helmets</td>
<td>167</td>
</tr>
<tr>
<td>P. Manti and D. Watkinson</td>
<td></td>
</tr>
<tr>
<td>Defensive Weapons in Homer</td>
<td>181</td>
</tr>
<tr>
<td>S.A. Paipetis and V. Kostopoulos</td>
<td></td>
</tr>
<tr>
<td>How the Greeks Got Ahead: Technological Aspects of Manufacture of a Corinthian Type Hoplite Bronze Helmet from Olympia</td>
<td>205</td>
</tr>
<tr>
<td><strong>Part 5: Telecommunications</strong></td>
<td></td>
</tr>
<tr>
<td>Theoretical Analysis of Telecommunication through “Friktories”</td>
<td>223</td>
</tr>
<tr>
<td>N. Uzunoglu</td>
<td></td>
</tr>
<tr>
<td><strong>Part 6: Geology – Geomechanics</strong></td>
<td></td>
</tr>
<tr>
<td>Elements of Engineering Geology and Geotechnical Engineering in the Homeric Poems</td>
<td>233</td>
</tr>
<tr>
<td>D. Zekkos, G. Athanasopoulos, A. Athanasopoulos Zekkos and I. Manousakis</td>
<td></td>
</tr>
<tr>
<td>Geological Knowledge of Greeks in the Era of Trojan War</td>
<td>243</td>
</tr>
<tr>
<td>I.D. Mariolakos</td>
<td></td>
</tr>
<tr>
<td>Static and Dynamic Analysis of the Atreus Vaulted Tomb in Mycenae</td>
<td>257</td>
</tr>
<tr>
<td>P.K. Askouni, H.A. Agelopoulos, M.G. Sfakianakis and D.E. Beskos</td>
<td></td>
</tr>
</tbody>
</table>
### Part 7: Medicine

- Homeric Injury Scenes on Ancient Greek Pottery Reveal Medical Knowledge
  - *S. Geroulanos, A. Tasouli, E. Lymberopoulou and K. Papadopoulos*
  - Page 269

- The Healing Art in the Iliad
  - *S.G. Marketos and G.J. Androutsos*
  - Page 275

- Medicinal Herbs and Plants in Homer
  - *G. Klimis*
  - Page 283

### Part 8: Flora and Fauna

- Agricultural Development in the Homeric Era
  - *C.C. Thanassoulopoulos*
  - Page 295

- The Fauna of Greece and Adjacent Areas in the Age of Homer
  - *E. Voultsiadou and A. Tatolos*
  - Page 303

### Part 9: Astronomy

- “Eneoros Minos” and the Minoan Calendrical Abacus
  - *P.D. Gregoriades*
  - Page 319

- The Divine Fires of Creation: Homeric Hephaestos as a Comet/Meteor God
  - *A. Laoupi*
  - Page 325

- A Comet during the Trojan War?
  - *S.P. Papamarinopoulos*
  - Page 341

- Homeric Calendar and Helios Charioteer
  - *M.K. Papathanassiou*
  - Page 357

- Homer and Orosius: A Key to Explain Deucalion’s Flood, Exodus and Other Tales
  - *E. Spedicato*
  - Page 369

### Part 10: Seafaring

- Homer at Sea
  - *M.T. Wright*
  - Page 377

- The Redness of Ulysses’ Ships
  - *T.Th. Katsaros*
  - Page 385
Part 11: Cultural Environment

Ambrosia, Nectar and Elaion in the Homeric Poems
D.G. Zanni

Dietary Habits in Homer
S.P. Christopoulou

Part 12: Geography

Trojan Plain and Homeric Topography
P. Malfas

Part 13: General Interest

Mētis and the Artificial
K.P. Anagnostopoulos and S. Chelidoni

Interpreting the Representations on the Shield of Achilles
D. Kalligeropoulos and S. Vasileiadou

Homer and the So-Called Homeric Questions
A. Tziropoulou-Efstathiou

Atlantis in Homer and Other Authors Prior to Plato
S.P. Papamarinopoulos

Did Ulysses Travel to Atlantis?
R.W. Kühne

Homer’s Reference to Writing in Proitos’ Era
E. Polygiannaki

Linguistic Science and Script Technology: The Homeric Evidence
A. Teffeteller

The Miraculous Homeric Metre
S.A. Paipetis
Preface

The present volume is based on papers presented at the international symposium “Science and Technology in Homeric Epics”, SPAP Conference Centre, Ancient Olympia, 27–30 August 2006. It includes a total of 41 contributions, mostly original research papers, covering diverse fields of science and technology, in the modern sense of these words.

The use of terms coined in relatively recent times (after the 15th century) to refer to situations from times so long ago as the Mycenaean Era, may sound inappropriate. However, careful studies of the Homeric Epics by specialists in the various scientific fields may convince the reader that the knowledge contained therein reflects a deep understanding of the science of nature and an ability to apply technological achievements and structures, strongly reminiscent of modern technology in its present evolution level.

The question of knowledge contained in the Homeric Epic had, until recently, received a negative answer. The seemingly scientific knowledge and admirable technological achievements presented have always been attributed to poetic inspiration rather than to a solid scientific mind. Of course, if the latter were true, which is likely to be sometimes, it is also true that the very conception of an idea can constitute a catalyst towards scientific development. For example, Isaac Asimov notices that the first reference to robots is found in the Iliad, i.e. to the golden girls of Hephaestus, who, although made of soulless matter, “were like real young women, with sense and reason, voice also and strength, and all the learning of the immortals” (Il. 18.419–420). The great dream of Man, i.e. the possession of fully rational, obedient and efficient mechanical servants, is about to be substantiated nowadays. On the other hand, the technical information given in the Iliad is not sufficient to reach a justified conclusion on whether such devices really existed in the Mycenaean era.

However, there are many more explicit cases, where the description of a structure provides sufficient data, from which, on the basis of fully realistic assumptions, it is possible to reconstruct it in the form of numerical models and/or experimental specimens and, consequently, to perform a theoretical and/or experimental analysis. Examples of such structures are the shields of Achilles and Ajax, which are laminated structures, of practically modern technology, exhibiting maximum penetration resistance. Their analysis confirmed their battle behaviour, as recounted in the Iliad, with surprising accuracy. The analysis of Circe’s instruction to Ulysses, on how to cross the fearful straits of Scylla and Charybdis safely, based on the hydrodynamic investigation of the problem, is another example of analytical approach.
It is, of course, clear that these instances have been pinpointed by science and technology specialists, whose broader interests have led them to study the Homeric Epics within the frame of their own scientific area. Thus, the conclusion is drawn that investigation of knowledge contained in the Epics cannot be but an interdisciplinary activity. It is further noted that many points of interest would not be recognizable a few decades ago even by competent scientists given the level of scientific and technological progress at the time. Accordingly, the next conclusion is that investigation of knowledge contained in the Epics is also a diachronic effort. In other words, a study of the Homeric Epics must be performed by the broadest possible circle of scientific specialists, but also on a continual basis, to account for new disciplines created as science is progressing.

The idea of organizing an international symposium on Homer’s science and technology was born during the study of the monumental monograph by Constantine Zeggelis “The science of nature in Homer”,\(^1\) a 1891 publication. The initial thought was “to rewrite” Zeggelis’ book by a team of experts, each one a specialist in the respective area. However, from the end of 19th century to the present day both the classification and the number of established sciences, as well as the knowledge they included, has changed dramatically. In other words, the scope was so much enlarged that only an invitation to those members of the international scientific community, who are dealing with the Homeric Epics from all possible aspects, was found appropriate to guarantee a satisfactory outcome.

This choice was fully justified by the highly enthusiastic response of the academic community, as well as of independent researchers, both in Greece and internationally, and of the mass media, and last but not least of lay people, justifying the title awarded to the Epics as “The Gospel of the Hellenic Nation”. Finally, besides the fact that numerous subjects remain unexplored, several distinguished scientists sent regrets for not being able to attend. This called for the preparation of a second symposium with the same theme in the near future.

The contents of the present volume are classified in 13 parts: Out of two general lectures, one in-depth presentation of Mycenaean Technology, covering all classes of activities, was delivered by Professor Theodossios P. Tassios, Greece. In this lecture, the sometimes inexplicable tendency of certain researchers to undermine the scientific and/or technological achievements of Ancient Greeks, as based on knowledge originating from the Orient or on imported know-how, and in fact by arguments unsupported or irrelevant, is addressed. This opposes long-held tendencies, which, with equally extreme attitude, used to express probably disproportionate admiration for the Greek achievements: unprejudiced research is, of course, the answer, which is greatly facilitated by the modern scientific research means available. The second lecture by Professor Emmanuel Mikroyannakis, Greece, deals with the interpretation of the term “autagreton”, as it appears in the Epics, which reaches the astonishing conclusion that it refers to technical devices not just automated but “intelligent”, i.e. capable of autonomous action, making decisions after a proper assessment of external excitations.

---

In Part 2, Mathematics and Physics, a variety of subjects is presented. Such as the Archimedean problem of counting Helios’ cattle, as described by Homer (Chris Rorres, US), a Fluid Dynamics approach to water vortices accounted for in the Odyssey (G.H. Vatistas, Canada), the implementation of Homeric automata in the ensuing centuries (D. Kalligeropoulos and S. Vasilieiadou, Greece), the creation of the world and the appearance of Man according to Homeric Cosmogony (Taha Showleh, Canada) and finally the excellent formulation of the laws of curvilinear motion by King Nestor of Pylos in the *Iliad* (S.A. Paipetis, Greece).

Part 3 deals with materials, a subject for which Homeric accounts abound. The importance of iron in the Epics is presented along with the ecological sensitivity of Homer (G. Varoufakis, Greece). Two important works come from Emmanuel Pantos (UK) and his associates, dealing with early bronze technology in the Iberian Peninsula and the production of faience-like blue glaze at low temperatures. Finally, a dyeing method based on porphyra is presented, inspired by a reference in the *Iliad* “to dye ivory-made horse cheek ornament in reddish purple” (W. Nishiyama, Japan).

Part 4 deals with the development of defensive weapons as depicted in the Homeric Epics, such as helmets of copper alloys (P. Manti et al., UK), a numerical and experimental analysis of the famous shields of Achilles and Ajax (S.A. Paipetis and V. Kostopoulos, Greece) and finally an analysis of the structural details of a Corinthian-type bronze helmet from Olympia, also by E. Pantos and his associates.

Telecommunication through “frikories”, i.e. huge pyres lit at specific geographical positions to transmit important messages at great distances in relatively short time, are analyzed by the propagation theory of electromagnetic radiation (N. Uzunoglu, Greece) in Part 5.

Part 6 deals with geological and geotechnical knowledge of the Greeks of the Mycenaean period, which is covered by two works (D. Zekkos et al. and I. Mariolakos, Greece). In addition, a complete dynamic analysis of the Atreus vaulted tomb in Mycenae is given (P.K. Askouni et al., Greece), revealing the amazing anti-seismic properties of the structure.

Part 7 covers the issue of medical knowledge of Homeric times, as depicted on vases of the time. It contains two papers (S. Geroulanos et al. and S. Marketos et al., Greece).

Part 8 deals with Homeric flora and fauna, subjects covered by two contributions (C. Thanassoulopoulos and E. Voultsiadou et al., Greece).


Part 10 deals with seafaring in Homeric times (M.T. Wright, UK) and also with “The redness of Ulysses’ ships”, an issue that may reveal advanced shipbuilding knowledge (T.Th. Katsaros, Greece).

Part 11 describes the cultural environment of the Homeric era and consists of two interesting presentations: “Ambrosia, nectar and elaion in Homeric poetry”
“Geography of Trojan plane and Homeric topography” (P. Malfas, Greece) covers Part 12.

Finally, Part 13 comprises works of general and practical interest, both due to the information they provide and by being the object of vivid and fruitful discussions between scientists from theoretical and applied fields, namely the following presentations: “Mêîis and the artificial” (C.P. Anagnostopoulos et al., Greece), “The decorations on Achilles’ shield and their interpretation” (D. Kalligeropoulos et al., Greece), “The so-called Homeric problems” (A. Tziropoulou-Efstathiou, Greece), “Atlantis in Homer and other writers prior to Plato” (S.P. Papamarinopoulos), “Did Ulysses travel to Atlantis?” (R.W. Kühne, Germany), “The Homeric reference to writing in Proitos’ era” (E. Polygiannaki, Greece), “Linguistic science and script technology: The Homeric evidence” (A. Tefteteller, Canada) and finally “The miraculous Homeric metre” (S.A. Paipetis), a reference to recent research indicating that the metric recitation of Homeric Epics causes coordination of heart and respiration rates, similar to the effect obtained by religious meditation techniques, as practised by Eastern peoples.

Certainly, the above papers constitute substantial contributions towards uncovering knowledge found in the Epics, but the quest in the endless world of Homer does not stop. A few questions may have been answered, but only to reveal an enormous number of further questions, waiting to be answered by new, adventurous investigators, either specialists from practically all fields of science or even lay people who just happen to be sensitive towards beauty and, therefore, ready to partake of the hidden knowledge. The Hellenic gods would never reveal their mysteries to uninitiated ones, to those ignorant of geometry!

Prof. Emeritus S.A. Paipetis
Editor
Acknowledgements

The Symposium would have never been possible without the generous financial assistance of the West Greece Region and its then Secretary-General Mr. Pagiotis Kavadas, to whom grateful thanks by the Organizing Committee are expressed. Gratitude is also due to GEFYRA SA (Rion-Antirrion Bridge Company) and its top executives Mr. Nikos Harikiopoulos, Mr. G. Kalogerou, Mr. S. Stavris, Mrs. A. Sotiropoulou and Mr. I. Freris for material and moral support. Also, to the Central Archaeological Council of the Ministry of Culture of Greece for making available to the Organizers the SPAP Conference Centre gratis.

Enormous, and from every aspect invaluable, was the contribution of Mrs. Georgia Hatzi, Head of the 7th Ephorate of Prehistoric and Classical Antiquities and Director of the Olympia Museums. Not only was she close at hand providing support at every step to the Organizing Committee, but it was her idea for the Opening Ceremony to take place in the Hall of Freezes of the New Olympia Museum. This magnificent ceremony was honored by the presence of numerous important figures of the academic, archaeological and political community. Similarly, thanks are due to Mrs. V. Vasilopoulou, Head of the Directorate General of Antiquities of the Ministry of Culture, and practically to the whole of the community of archaeologists for receiving the idea with enthusiasm and positive attitude.

Several individuals and companies, in one way or another, provided assistance. Among them is the Research Committee of the University of Patras, the Technical Chamber of Greece, the Patras Agency of the Xerox Corporation and its executives Messr. N. Arvanitidis and G. Betsos, DYNACOMP Computer Company and many others.

Special thanks are due to the members of the Scientific Committee and to the invited speakers for the exceptionally high level of their presentations and also to the Greek and foreign referees of the works presented at the Symposium, a necessary procedure to ensure high quality before having them included in the Proceedings.

The contribution and the support team is greatly appreciated, namely that of Dr. John Lukas-Lekatsas, mathematician, Scientific Associate of Applied Mechanics Laboratory of the University of Patras, Mr George Mirotos, computer specialist, responsible for the digitization of the whole event, Mr. Babis and Ms. Dimitra Nika and also of Ms. Stella-Zaira Avloniti, distinguished philologist, MSc in Comparative Linguistics and Language Diversity, University of Patras, who provided excellent translations of a number of papers authored by English-speaking delegates into Greek. Finally, grateful thanks are due to Mrs. Teta Giannarou,
distinguished journalist and public relations officer of the Symposium, for the impeccably professional way she performed her duties, both during the preparation period, by organizing numerous press conferences in Athens and in the provinces, as well as during the Symposium by means of complete and detailed press releases on a daily basis and also by regular direct contacts with the Mass Media, who managed to supply this important event with the publicity it deserved.

Prof. Emeritus S.A. Paipetis
Editor
List of Contributors

Agelopoulou, H.A., Department of Civil Engineering, University of Patras, 26001 Patras, Greece

Anagnostopoulos, K.P., Department of Production & Management Engineering, Democritus University of Thrace, 67100 Kimmeria-Xanthi, Greece
E-mail: kanagn@civil.duth.gr

Androutsos, G.J., Athens University Medical School, Athens, Greece
E-mail: lyon48@otenet.gr

Askouni, P.K., Department of Civil Engineering, University of Patras, 26001 Patras, Greece
E-mail: askounik@otenet.gr

Athanasopoulos Zekkos, A., 1316 Bonita Ave., Apt. 7, Berkeley, CA 94709, USA
E-mail: adda@berkeley.edu

Athanasopoulos, G., Department of Civil Engineering, University of Patras, 26500 Patras, Greece
E-mail: gaa@upatras.gr

Bell, T., CCLRC, Daresbury Laboratory, Keckwick Lane, Warrington WA4 4AD, UK

Bennett, S.L., CCLRC, Daresbury Laboratory, Keckwick Lane, Warrington WA4 4AD, UK

Beskos, D.E., Department of Civil Engineering, University of Patras, 26001 Patras, Greece
E-mail: d.e.beskos@upatras.gr

Bontempi, E., Laboratorio di Chimica per le Tecnologie, Dipartimento di Ingegneria Meccanica, Università di Brescia, Brescia, Italy
Chapon, L.C., CCLRC, Rutherford-Appleton Laboratory, ISIS Neutron Spallation Source, UK

Chelidoni, S., Department of Production & Management Engineering, Democritus University of Thrace, 67100 Kimmeria-Xanthi, Greece

Christopoulou, S.P., 3 Ypsilon Alonian, 26224 Patras, Greece
E-mail: schristo@otenet.gr

Colombi, P., Laboratorio di Chimica per le Tecnologie, Dipartimento di Ingegneria Meccanica, Università di Brescia, Brescia, Italy

Comendador-Rey, B., Department of History, Art and Geography, Faculty of History, University of Vigo, Spain

Cornacchia, G., Laboratorio di Metallurgia, Dipartimento di Ingegneria Meccanica, Università di Brescia, Brescia, Italy

Davidovits, J., Institut Géopolymère, Laboratoire de Recherche sur les Nouveaux Matériaux, Saint-Quentin, France

Depero, L., Laboratorio di Chimica per le Tecnologie, Dipartimento di Ingegneria Meccanica, Università di Brescia, Brescia, Italy

Garner, R., The Manchester Museum, The University of Manchester, Manchester, UK

Gelfi, M., Laboratorio di Metallurgia, Dipartimento di Ingegneria Meccanica, Università di Brescia, Brescia, Italy

Geroulanos, S., Onasseion Cardiac Surgery Centre, 356 Sygrou Ave., 17674 Athens, Greece
E-mail: sger@hol.gr

Gregoriades, P.D., 10 Aldou Manoutiou St., 11521 Athens, Greece
E-mail: griskman@otenet.gr

Kalligeropoulos, D., Department of Automation, TEI of Piraeus, Piraeus, Greece
E-mail: heron100@otenet.gr

Katsaros, T.Th., Faculty of Humanities, University of Aegean, Rhodes, Greece
E-mail: tkatsaros@rhodes.aegean.gr
Klimis, G., 32 Kaisareias St., 11527 Athens, Greece
E-mail: g_klim@yahoo.gr

Kockelmann, W., ISIS, Rutherford-Appleton Laboratory, Didcot OX11 0QX, UK

Kostopoulos, V., Department of Mechanical Engineering & Aeronautics, University of Patras, Patras, Greece
E-mail: kostopoulos@mech.upatras.gr

Kühne, R.W., Tuckermannstr. 35, 38118 Braunschweig, Germany
E-mail: kuehne70@gmx.de

Laoupi, A., 9 Heroon Polytechniou St., 15780 Athens, Greece
E-mail: alaoupi@otenet.gr

Lymberopoulou, E., Onasseion Cardiac Surgery Centre, 356 Sygrou Ave., 17674 Athens, Greece

Macdonald, M., CCLRC, Daresbury Laboratory, Keckwick Lane, Warrington WA4 4AD, UK

Malfas, P., 44 Lemesou St., 15669 Papagou, Greece
E-mail: hxografi@otenet.gr

Manousakis, I., Dromos Consulting, 27 Monemvasias St., 15125 Halandri, Greece
E-mail: jmanous@tee.gr

Manti, P., HISAR, Cardiff University, Humanities Building, Colum Drive, Cardiff CF10 3EU, UK
E-mail: mantip@cf.ac.uk

Mariolakos, I.D., National and Kapodistrian University of Athens, Panepistimiou-polì Zografou, 15784 Athens, Greece
E-mail: mariolakos@geol.uoa.gr

Marketos, S.G., Athens University Medical School, Athens, Greece

Mikrogianakis, E., School of Philosophy, University of Athens, Athens, Greece
E-mail: thmicrou@phil.uoa.gr

Mosselmans, J.F.W., CCLRC, Daresbury Laboratory, Keckwick Lane, Warrington WA4 4AD, UK
Nishiyama, W., 530 Ishki, Yaizou-City, Shzuoka, 425-0054 Japan
E-mail: wako-n@nifty.com

Paipetis, S.A., Department of Mechanical Engineering & Aeronautics, University of Patras, Patras, Greece
E-mail: paipetis@mech.upatras.gr

Pantos, M., CCLRC, Daresbury Laboratory, Keckwick Lane, Warrington WA4 4AD, UK
E-mail: e.pantos@dl.ac.uk

Papadopoulos, K., Onasseion Cardiac Surgery Centre, 356 Sygrou Ave., 17674 Athens, Greece

Papamarinopoulos, S.P., Department of Geology, University of Patras, 26500 Patras, Greece
E-mail: papamari1@otenet.gr

Papathanassiou, M.K., Faculty of Mathematics, National and Kapodistrian University of Athens, Panepistimioupolis, 15784 Athens, Greece
E-mail: mpapatha@math.uoa.gr

Polygiannaki, E., Athens, Greece
E-mail: efipolyg@otenet.gr

Pradell, T., Departament d’Enginyeria Quimica, EPSEVG Universitat Politècnica de Catalunya, Vilanova, Spain

Prag, A.J.N.W., The Manchester Museum, The University of Manchester, Manchester, UK

Reboreda-Morillo, S., Department of History, Art and Geography, Faculty of History, University of Vigo, Spain

Rorres, C., School of Veterinary Medicine, University of Pennsylvania, 3800 Spruce St., Philadelphia, PA 19104, USA
E-mail: rorres@vet.upenn.edu

Salvado, N., Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya, Barcelona, Spain

Showleh, T., Department of Mechanical Engineering, Concordia University, Montreal, Canada H3G 1M8
E-mail: tahashowleh@gmail.com
List of Contributors

Sfakianakis, M.G., Department of Civil Engineering, University of Patras, 26001 Patras, Greece
E-mail: mgs@upatras.gr

Spedicato, E., University of Bergamo, Italy
E-mail: spedicato@cypher.a-technet.com

Tasouli, A., Onasseion Cardiac Surgery Centre, 356 Sygrou Ave., 17674 Athens, Greece

Tassios, T.P., Professor Emeritus, National Technical University of Athens, 42 Patission St., Athens, Greece
E-mail: tassiost@central.ntua.gr

Tatolas, A., Department of Zoology, School of Biology, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

Teffeteller, A., Linguistics, Concordia University, Montreal, Quebec, Canada H3G 1M8
E-mail: teffet@vax2.concordia.ca

Thanassoulopoulos, C.C., Department of Plant Pathology, Aristotelian University of Thessaloniki, Thessaloniki, Greece
E-mail: ktl@otenet.gr

Tobin, M.J., CCLRC, Daresbury Laboratory, Keckwick Lane, Warrington WA4 4AD, UK

Tziropoulou-Efstathiou, A., “Helleniki Agoghi”, School of Ancient Greek, Athens, Greece

Uzunoglu, N., National Technical University of Athens, 15773 Athens, Greece
E-mail: mnap@otenet.gr

Varoufakis, G., Halyvourghiki SA, 3 Dragatsaniou St., Athens, Greece
E-mail: georgevaroufakis@yahoo.gr

Vasileiadou, S., Department of Automation, TEI of Piraeus, Piraeus, Greece

Vatistas, G.H., Department of Mechanical Engineering, Concordia University, Montreal, Canada H3G 1M8
E-mail: vatistas@encs.concordia.ca
Voultiadou, E., Department of Zoology, School of Biology, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece
E-mail: elvoults@bio.auth.gr

Watkinson, D., HISAR, Cardiff University, Humanities Building, Colum Drive, Cardiff CF10 3EU, UK
E-mail: watkinson@cf.ac.uk

Wright, M.T., Centre for the History of Science, Technology & Medicine, Imperial College, London SW7 2AZ, UK
E-mail: m.t.wright@imperial.ac.uk

Zanni, D.G., Vas. Olgas 145, 54645 Thessaloniki, Greece
E-mail: zannidoukaina@hotmail.com

Zekkos, D., GeoSyntec Consultants, 475 14th Street, Suite 450, Oakland, CA 94612, USA
E-mail: zekkos@geoengineer.org
Part 1

GENERAL THEMES
Mycenaean Technology

T.P. Tassios

National Technical University of Athens, Greece

Abstract. We should not be surprised at the great significance of Technology during the prehistoric period in Greece; or indeed in any other part of the world of those times: Technology was already possessed by several animals; it was a natural supplement to Nature, so to say. By analogy, it was, therefore, all too obvious for humans to consider that Technology was “donated” to them by the gods. In other words, it was expected that humans were admiring Technology as much as a fundamental means for their survival and their well-being, that have attributed it to a religious Heaven. This general attitude of humankind being observed, I will maintain that the level of technological development of the Greeks during the second millennium BCE, was expectedly high. The aim of this paper is to summarize the main technical achievements of that period in Mycenaean Greece. To this end, I will first take that the writings of Hesiod and Homer are reflecting, to a certain extent, facts and beliefs during the Mycenaean period as well.

1 Technology in Hesiod

It is important to note that in Hesiod, the equilateral triangle of the manifested deity is formed with Titans at one summit, and the Hekatoncheires and the Cyclopes at the other two: Thus, the Greeks recognized the synthesis of (i) the spiritual element, (ii) the natural forces and (iii) Technology (as a “natural” supplement to Nature). In fact, Cyclopes were conceived as God-smiths. The same place will be kept for Technology in the tripartite deity during the subsequent reign of the Olympians who have replaced the Titans. Besides, the victory of Zeus against the Cronides was only achieved when the “inventors-Cyclopes” offered to him the absolute weapon of lightning – another proof of the significance of Technology for the Greeks. Thus, the fundamental importance of Technology for the early Greek tribes is clearly reflected in their basic Myths. And this will be presented in more detail in the Homeric Epics.
2 Technology in Homer

After the “happy end” of Theomachy, the Greeks continued to nourish their myths with technological details reflecting to a certain extent their own technical development, as well as their technological dreams (the concept of automats, for instance). It is accepted that a considerable part of these facts and beliefs are portrayed in the Homeric Epics. Therefore, it is interesting to revisit the Iliad and the Odyssey, searching for technical stories – although very briefly.

(a) Metals: Besides gold and silver, bronze (copper + tin) was the basic metallic material in Iliad (Il. 15.309). Iron will furiously invade Odyssey – in the form of quenched steel as well (e.g. Od. 9.391). Metal workshops are vividly described (Il. 18.412, Od. 8.274).

Weapons: The significance of this basic subject of fabrication of weapons is shown by the fact that almost the entire rhapsody 18 is devoted to this technology. Besides, weaponry is a frequent subject of Homeric Epics: Arrows (Il. 4.105), shields (Il. 15.308), cuirasses (Il. 8.195), chariots (Il. 5.722) – and above all, the famous weapons of Achilles (Il. 18.144). More specifically regarding the structural (not the artistic) aspect of shields, including that of Achilles (Il. 20.260, 22.290) and Ajax (Il. 6.219), I wish to refer to the original work of Paipetis et al. [1] who have reconstructed layer by layer these defensive weapons, and subjected them to rigorous testing – both experimental and analytical, concluding that the nature, the sequence and the number of these layers were in fact optimal for absorbing the piercing energy of a spear. These findings tend to belie Morris [2] stating that “no such shield ever protected a Mycenaean . . .”

(b) Buildings: It is worth noting that in Iliad, mainly the rich and complex palaces of gods are described (e.g. Il. 1.607, 5.167, 18.371 etc), whereas in Odyssey, building technology is landed on earth, describing human buildings (e.g. Od. 4.72). In the house (and ship) building technology, it is interesting to include also the structural miracle of the Wooden Horse (Od. 4.272, 8.493, 11.24) – that complex and solid artifact of chief-carpenter Epeios: A giant mobile work, with a body measuring something like 8 by 16 by 32 meters (in order to be able to accommodate three thousand well hidden hoplites, as it is said).

(c) Automats: Here we find ourselves in the summit of ancient Greeks’ technophilia. Such is their confidence of their technical knowledge, that they rush to the future of Technology (see [3]).

- Moving automats: self moving tripods, entering and leaving the Palaces (Il. 18.376), automatic bellows of metallurgical kilns (Il. 18.468), gates automatically opening when hearing a whip (Il. 5.749). This is an Epic of Technology . . .
Fig. 1 Achilles’ shield: After 1.5 sec the spear’s penetration is stopped, whereas after 3 sec, the spear tip moves backwards, outside of shield’s inner face [1]. Courtesy Professor S.A. Paipetis.

Fig. 2 Achilles’ shield: After 1 sec the shield repulses the spear, whereas after 2 sec it vibrates at velocities lower than the repulsed spear [1]. Courtesy Professor S.A. Paipetis.

- Animal and human-like automats: guardian dogs (made of gold and silver, Od. 7.91), live girls-robots (“in them is mind and wits, in them too a voice and strength”, II. 18.418), etc.
- Traps: elaborated grips, hidden above and underneath the bed, in order to catch the illegal lovers (Od. 8.274).
- Automat ships: the ships of the inhabitants of Scheria exceed the achievements of modern Automat Technology – they are “διανοούμενα” (intelligent) ships: They have no captains, but they conceive “what men have in mind”, and they
Fig. 3 Ajax’s shield: When the number of leather layers behind the number of bronze laminates is increased to seven, penetration is stopped and energy dissipation is ensured by maximization of the imprint of the bronze layer [1]. Courtesy Professor S.A. Paipetis.

travel them very rapidly across the clouds – and they are unsinkable (Od. 8.562). It is the first time that the techno-mythical thought of the Greeks dares to figure out human robotic achievements, whereas up to that moment automat were thought only in the service of Gods. Later on, I will reexamine this clearly humanistic attitude of the Greeks.

(d) Artifacts-artistic objects: in fact, the gods had initially taught humans the technical skill and crafts; Hephaestus himself ἐτεϕάνη (was manifested) to humans and lived nine years with them (see Homeric Hymn to Hephaestus, 20.3), whereas, later on, Prometheus (Plato, Protagoras, 321c) will take Technology from Athēna and Hephaestus, he will transfer it to humans, and thus will save mankind. Subsequently, a more specifically human characteristic will appear on human artifacts. In the Homeric Epics we observe that every technical object was an artistic object as well; after all, in Greek language, both are called “τεχνηματα”: the shield of Achilles, a perfect defensive weapon, was a densely ornamented work too (Il. 18.481) described in no less than 128 verses of Iliad!1

3 The Technology of Mycenaeans

Archaeological findings, throughout Greece and in numerous areas of Mediterranean Sea (from Syria to Sardenia), have confirmed a good part of the alleged

---

1 The sling of Hercules’ sword was also very richly decorated (Od. xi, 609).
technophilia of the Achaeans, i.e. the Mycenaean world. During the second half of the 2nd Millennium BCE, Mycenaean people have developed an advanced Technology, many centuries before the classical and Hellenistic times, which seem to be better studied from this point of view.

Fig. 4 Mycenaean settlements in the mainland during 14th and 13th centuries BCE (Ekdhotikē Athinōn).

Fig. 5 Mycenaean expansion during 14th and 13th centuries BCE (Ekdhotikē Athinōn).
3.1 Water Supply of Cities

First, I will briefly describe the underground well-houses, following the views of Knauss [4], and I will restrict this presentation only to those structures which are more characteristic to the building techniques of the Mycenaens, i.e. the vaulting of access tunnels and spring chambers. The main features of these structures are the following:

- A series of retaining walls (approx. 3.00 m high) are securing (i) the stability of the sloped hillsides and (ii) a better infiltration of surface waters.
- A small entrance is built on the ground, leading to the spring chamber via an inclined tunnel, stabilized by means of a corbelled strong-vault. Slope of the tunnel: 1 to 2 (up to 4), width: 0.8 to 1.4 m.
- An underground well-house(or spring chamber) stabilized by a bidimensional or three-dimensional stone-vault. Total depth of the installation: 5 to 15 m.

In this category of water facilities belong the finds of Tiryns and Ithaca (in the area of the so called "Homer School").

Another category of underground water-supply facilities are the highly sophisticated Mycenaen structures at the Acropolis of Mycenae and the Acropolis of
Fig. 8 The prehistoric underground well-house in Ithaca at the so-called “School of Homer”, L. Kontorli-Papadopoulou, Eranos and Corpus 2001 (supplemented by Knauss [5]). Courtesy Professor J. Knauss.

Fig. 9 The prehistoric underground well-houses of Ithaca at Mycenae, G. Karo, AJA 38 (1934), supplemented by Knauss. Courtesy Professor J. Knauss.

Athens: The access-tunnels are dug in the rock of the hill, and lead down to a depth up to 25.0 m. In Mycenae, the lowest flight of the tunnel is plastered with a waterproof lime mortar [6], still in place.
3.2 Dams

I will mention three characteristic cases of masonry dams used for three different purposes.

(a) A large artificial lake (30 × 100 m) was created just outside the city walls2 of Mycenae, by means of a masonry dam constructed at an appropriate point of Chavos torrent. Thickness 5 m, height 4.5 m, length 37 m. An efficient water-tight construction technique was used.

(b) An artificial waterfall was gradually constructed in Alyzeia (Acarnania) west-central Greece, apparently for fleece-washing in a region of intensive cattle-raising (actual Varnaka torrent). Height: initially 3.20 m, and after the natural

---

2 It is worth noting that, outside the walls, the king had installed several workshops and commercial facilities.
earth filling behind it, a second height (c. 2.70), and subsequently a third and a fourth (3.00 m and 1.50 m, respectively) were added during the years, summing up a today’s height of 10.50 m. Crest’s length: 25.0 m.

(c) A torrent deviation (still in use today) was constructed in order to protect Tiryns from very destructive floods, which were archaeologically identified. A masonry (clay infilled) dam was erected across the deep river-bed of Tiryns-torrent. Thickness: 3.5 to 4.0 m, height up to 10.0 m, length (at the crest) 70.0 m. A 1500 m long channel was dug in order to convey the torrent waters to the riverbed of another torrent (the actual Aghios Adrianos torrent) 3.0 km away from the Mycenaean city of Tiryns.