The Neolithic Settlement of Knossos in Crete

New Evidence for the Early Occupation of Crete and the Aegean Islands

Frontispiece. The city, the fortifications, the harbor, and the hinterland of Khandax (Herakleion) in the first half of the 17th century. Map by unknown cartographer, 17th c., Collezione Museo Civico, Padua. Vikelaia Municipal Library, Herakleion.

PREHISTORY MONOGRAPHS 42

The Neolithic Settlement of Knossos in Crete

New Evidence for the Early Occupation of Crete and the Aegean Islands

edited by

Nikos Efstratiou, Alexandra Karetsou, and Maria Ntinou

Published by
INSTAP Academic Press
Philadelphia, Pennsylvania
2013

Design and Production
INSTAP Academic Press, Philadelphia, PA

Printing and Binding
Hoster Bindery, Inc., Ivyland, PA

Library of Congress Cataloging-in-Publication Data

The neolithic settlement of Knossos in Crete : new evidence for the early occupation of Crete and the Aegean islands / edited by Nikos Efstratiou, Alexandra Karetsou, and Maria Ntinou.
pages cm. -- (Prehistory monographs ; 42)
Includes bibliographical references and index.
ISBN 978-1-931534-72-7 (hardcover : alk. paper)
1. Knossos (Extinct city) 2. Neolithic period--Greece--Crete. 3. Land settlement patterns, Prehistoric--Greece--Crete. 4. Crete (Greece)--Antiquities. I. Efstratiou, Nicholas.
DF221.C8N46 2013
939'.18--dc23

2013016076

To the memory of Professor J.D. Evans, a gentleman of British Archaeology

–Nikos Efstratiou

Table of Contents

List of Tables in the Text

List of Figures in the Text

Preface

The site of Knossos on the Kephala hill in Crete is of great archaeological and historical importance for Greece and Europe. Dating back to 7000 B.C., it is the home of one of the earliest farming societies in southeastern Europe. In later Bronze Age periods, it developed into a remarkable center of economic and social organization within the island, enjoying extensive relations with the Aegean, the Greek mainland, the Near East, and Egypt. Arthur Evans excavated the site at the beginning of the 20th century, and through his extensive and spectacular restoration and reconstruction efforts, he transformed Knossos into one of the most popular archaeological sites in the Old World (Evans 1901, 1921–1935, 1927, 1928). Knossos is now best known among both specialists and the wider public for its unique central building, conventionally called a palace, which is one of the earliest archaeological monuments to have been restored on such a scale.

What was not apparent during the early archaeological research at the site was the impressive extent and depth of the earlier habitation that lies under the imposing palace, even though the laborious work of Arthur Evans and Duncan Mackenzie in the early 20th century had revealed considerable amounts of Neolithic material (Mackenzie 1903). In 1953 Audrey Furness studied and published the Neolithic pottery from Evans's test soundings with the aim of testing the three "Stone Age" periods discussed by Mackenzie (Furness 1953). The successful work of Furness led the British School at Athens to launch a series of systematic investigations at Knossos, directed by Sinclair Hood and John D. Evans, from 1956 to 1971 (Evans 1964, 1971, 1994; Warren et al. 1968). The well-known Trenches A to C, which were opened in the area of the Central Court of the palace, together with the peripheral soundings X and ZE, confirmed a chronological sequence of 10 strata representing at least 4,000 years of Neolithic occupation, including the still-disputed Aceramic phase. Looking back at the announcement by J.D. Evans (1971) of the first and very early radiocarbon dates for the founding of Knossos (7000 B.C.), I cannot forget the welcome surprise with which these dates were received, and I am very happy to see that our recent radiocarbon dates, published in this volume, confirm Evans's early chronology that was attained without the benefit of our modern technology.

Other contributions to our knowledge of the Neolithic of Crete include the work of Richard M. Dawkins at Magasa in eastern Crete in 1905 (Dawkins 1905), the investigations of Angelo Mosso and Doro Levi at Phaistos (Mosso 1908), the publication of the Phaistos material by Lucia Vagnetti (Vagnetti 1972–1973), and the pioneering research at Katsambas by Stylianos Alexiou (1953, 1954). The forthcoming publication of Katsambas by Nena Galanidou and her associates (Galanidou, ed., forthcoming) and the study of the material from older fieldwork at Gerani and Pelekita in the Zakros area, carried out by Yiannis Tzedakis and Costis Davaras, respectively (Tzedakis 1970; Davaras 1979), are expected to offer more data regarding the early occupational horizon of Crete. The recent publication by Valasia Isaakidou and Peter Tomkins of *The Cretan Neolithic in Context* (Isaakidou and Tomkins, eds., 2008), the latest rescue excavations carried out by the Ephorate of Central Crete in the vicinity of Katsambas, and, most importantly, the announced presence of Mesolithic material on the islands of Crete and Gavdos, show that early prehistoric research in Crete and its immediate environs is a dynamic field of investigation.

A series of archaeological test soundings was opened in February 1997 in conjunction with the planning of the course of the main and secondary visitors' routes through the palace, a process that involved widening the existing paths, establishing new ones, and examining the state of the building's foundations. The south and east slopes of the Kephala hill were the main focus of investigation (Karetsou 2004; Ioannidou-Karetsou 2006). This research was prompted by the architect Clairy Palyvou's suggestion to double the width of the modern narrow stone stair leading from this part of the Central Court to the first level of the Grand Staircase, where A. Evans made his last attempt to restore the Medallion Pithoi. The investigation, which lasted five weeks, was carried out under difficult weather conditions and according to a very strict timetable.

We were all happily surprised that in an area often disturbed for conservation work in the 1950s and 1960s, including the opening of rainwater channels, deep pre-Minoan deposits remained intact just a few centimeters under the visitors' feet. I took this to be a sign of good fortune, since, after three decades of personal, systematic involvement with Minoan archaeology, the dream of my youth to look down to the "Neolithic Cretan time" was becoming a reality.

A collaboration with colleagues familiar with the excavation of Neolithic sites and modern data collection and analysis methods was my next immediate concern. The chance to reexamine the succession of Neolithic occupation strata on the Kephala hilltop, some 50 years after the first such investigation at Knossos, presented me with great expectations and challenges. Professor Nikos Efstratiou of the Aristotle University of Thessaloniki contributed greatly to the success of the project, and I would like to take this opportunity to thank him. He was responsible both for the selection of the researchers who gathered at Knossos with very short notice that February and for the coordination of the project. In addition, Professor Giorgos Hourmouziadis, also of the Aristotle University of Thessaloniki, was very helpful.

Many thanks are due as well to my colleague Dr. Eleni Banou, who participated in the excavation on behalf of the Ephorate, to Nikos Daskalakis, the skilled foreman of the Knossos project, and to the late Andreas Klinis, also a Knossos foreman and a man of rare excavation experience.

The general aims of the investigation in the Central Court of Knossos in 1997 were (1) to readdress questions related to the old material and conclusions reached many years ago, and (2) to obtain new data, which, considering the nature of the archaeological site, with the palace standing on top of the Neolithic tell, would have been otherwise impossible. More specific objectives included the careful study of the stratigraphy for the confirmation or revision of the already established Neolithic sequence, the determination of whether the alleged Aceramic phase was represented, the collection of new evidence for the Neolithic ceramic sequence, and the recovery of new archaeozoological and archaeobotanical data and the analysis of their stratigraphic distribution (Efstratiou et al. 2004). Most importantly, the archaeological information was to be gathered and studied using methodologies that were not available in the past—sedimentological analyses, which might clarify the occupational gaps in the impressive Neolithic palimpsest, phytolith analyses, ceramic technological analyses, paleoenvironmental observations, and, most significantly, new radiocarbon analyses for the establishment of a reliable sequence of dates.

The many archaeological questions relating to the long Neolithic habitation of the Knossos tell had always intrigued me, especially during my 12 years of service (1992–2004) as head of the Knossos Conservation Project. I was impressed by the extent of the Neolithic settlement and the density of the scattered material, especially that of the Late and Final Neolithic periods (Fig. i). I was enormously pleased by the opportunity we had to investigate this early Cretan farming community, buried deep under the glorious Minoan palace, and to contribute to its understanding. There is no doubt that the Knossos Neolithic settlement—whether or not it was the first and only one in Crete—constitutes one of the earliest agricultural communities in Greece, and it is also surely the earliest in the Aegean islands.

Alexandra Karetsou
Honorary Ephor of Antiquities

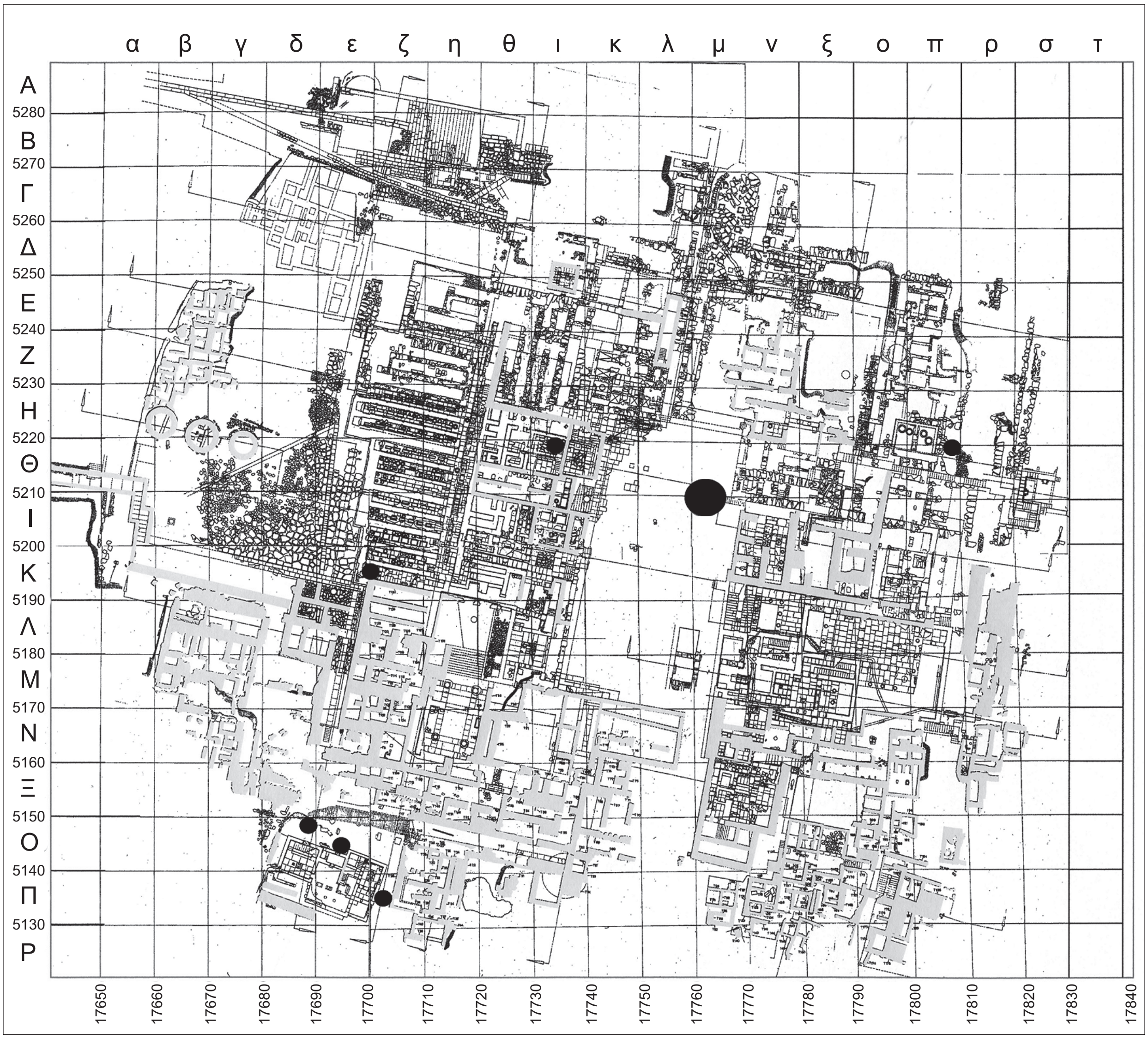


Figure i. The Minoan palace and its Neolithic past; areas where Neolithic deposits and ceramics are found are indicated with black dots (1997–2004).

References

Alexiou, S. 1953. "Ἀνασκαφὴ Κατσαμπᾶ Κρήτης," *Prakt* 108 [1956], pp. 299–308.

———. 1954. "Ἀνασκαφὴ Κατσαμπᾶ Κρήτης," *Prakt* 109 [1957], pp. 369–374.

Davaras, C. 1979. "Σπήλαιο Πελεκητών Ζάκρου," *ArchDelt* 34 (B', 2 Chronika), pp. 402–404.

Dawkins, R.M. 1905. "Excavations at Palaikastro. IV.2: Neolithic Settlement at Magasá," *BSA* 11, pp. 260–268.

Efstratiou, N., A. Karetsou, E. Banou, and D. Margomenou. 2004. "The Neolithic Settlement of Knossos: New Light on an Old Picture," in *Knossos: Palace, City, State. Proceedings of the Conference in Herakleion Organised by the British School of Athens and the 23rd Ephoreia of Prehistoric and Classical Antiquities, in November 2000, for the Centenary of Sir Arthur Evans's Excavations at Knossos* (*BSA Studies* 12), G. Cadogan, E. Hatzaki, and A. Vasilakis, eds., London, pp. 39–51.

Evans, A.J. 1901. "The Neolithic Settlement at Knossos and Its Place in the History of Early Aegean Culture," *Man* 1, pp. 184–186.

———. 1921–1935. *The Palace of Minos at Knossos* I–IV, London.

———. 1927. "Work of Reconstruction in the Palace of Knossos," *AntJ* 7, pp. 258–266.

———. 1928. "The Palace of Knossos and Its Dependencies in the Light of Recent Discoveries and Reconstructions," *Journal of the Royal Institute of British Architects* 36, pp. 90–102.

Evans, J.D. 1964. "Excavations in the Neolithic Settlement of Knossos, 1957–60: Part I," *BSA* 59, pp. 132–240.

———. 1971. "Neolithic Knossos: The Growth of a Settlement," *PPS* 37, pp. 95–117.

———. 1994. "The Early Millennia: Continuity and Change in a Farming Settlement," in *Knossos: A Labyrinth of History. Papers in Honour of S. Hood*, D. Evely, H. Hughes-Brock, and N. Momigliano, eds., Oxford, pp. 1–20.

Furness, A. 1953. "The Neolithic Pottery of Knossos," *BSA* 48, pp. 94–134.

Galanidou, N., ed. Forthcoming. *The Neolithic Settlement by the River Kairatos: The Alexiou Excavations at Katsamba*.

Ioannidou-Karetsou, A. 2006 "Από την Κνωσό μέχρι τη Ζάκρο: Η περιπέτεια της προστασίας των ιστορικών αρχαιολογικών χώρων στην κεντρική και ανατολική Κρήτη," in *Conservation and Preservation of the Cultural and Natural Heritage of the Large Islands of the Mediterranean*, V. Karageorghis and A. Giannikouri, eds., Athens, pp. 61–76.

Isaakidou, V., and P. Tomkins, eds. 2008. *Escaping the Labyrinth: The Cretan Neolithic in Context* (*Sheffield Studies in Aegean Archaeology* 8), Oxford.

Karetsou, A. 2004. "Knossos after Evans: Past Interventions, Present State and Future Solutions", in *Knossos: Palace, City, State. Proceedings of the Conference in Herakleion Organised by the British School of Athens and the 23rd Ephoreia of Prehistoric and Classical Antiquities, in November 2000, for the Centenary of Sir Arthur Evans's Excavations at Knossos* (*BSA Studies* 12), G. Cadogan, E. Hatzaki, and A. Vasilakis, eds., London, pp. 547–555.

Mackenzie, D. 1903. "The Pottery of Knossos," *JHS* 23, pp. 157–205.

Mosso A. 1908 "Ceramica neolitica di Phaestos e vasi dell'epoca minoica primitiva," *MonAnt* 19, pp. 142–228.

Tzedakis, I. 1970. "Ἀρχαιλογική Ἐρεύνε Ἀνασκαφί Σπήλαιο Γερανίου," *ArchDelt* 25 (B', 2 Chronika), pp. 474–476.

Vagnetti, L. 1972–1973. "L'insediamento neolitico di Festòs," *ASAtene* 34–35, pp. 7–138.

Warren, P., M.R. Jarman, H.M. Jarman, N.J. Shackleton, and J.D. Evans. 1968. "Knossos Neolithic, Part II," *BSA* 63, pp. 239–276.

Acknowledgments

The excavators are grateful to all the people who made this publication possible. First and foremost, we would like to express our thanks to Dr. Iordanis Dimakopoulos, former Director of the Conservation and Restoration of Monuments Service of the Greek Ministry of Culture and Tourism. He fully understood the need for the rescue excavation to be carried out, at a time when the visitors' walkway project at the palace of Knossos was already under way with a tight deadline.

Our warmest thanks are also due to the technical staff of the 23rd Ephorate of Prehistoric and Classical Antiquities and the Knossos Conservation Office, who worked through the particularly cold February of 2011. We would especially like to thank Nikos Daskalakis, Stavros Mavrakis, and Michalis Tzobanakis, who constructed a small shelter to protect both staff and trenches from the rain, since the excavation ran from sunrise to sunset. The late Andreas Klinis, a foreman of special skill and astuteness, was the person whom we entrusted with the stratigraphy; he was the only one to work at a depth of four to eight meters. We must also thank Konstantinos Ktistakis for his accurate plans, elevations, and sections of the trenches; Dr. Don Evely, former Knossos curator for the British School at Athens, for his help during the study of the material; and archaeologist Maria Kelaidi, who spent an entire summer in the courtyard of the Villa Ariadne, meticulously sieving the huge amount of soil from the excavation. Vital assistance was also provided by the head guard of the palace of Knossos, Manolis Apostolakis, and the rest of the guard staff. The Ephorate accountants Evangelia Fotaki and Litsa Kafousi also provided their services, without which the project would not have been possible.

Finally, we would like to express our particular thanks for the generosity of Professor Philip Betancourt, who enthusiastically supported the publication of this volume by the INSTAP Academic Press, and to the Director of Publications, Susan Ferrence, for all her efforts in ensuring that the resulting publication was of the highest possible standard. Our warmest gratitude is also, of course, due to all the contributors to the volume.

Introduction

Nikos Efstratiou

The construction of a staircase extension in the northeastern part of the Central Court of the Palace of Minos at Knossos prompted the opening of a new excavation trench in 1997. After the systematic excavation of the deep Neolithic occupation levels by J.D. Evans in the late 1950s (1964, 132) and later, more limited investigations of the Prepalatial deposits undertaken primarily during restoration work, no thorough exploration of the earliest occupation of the mound had been attempted. Although our operation was to be swift and limited in extent, we knew that the opening of a trench destined to reach the basal layers of the settlement offered us the opportunity to address many old and new research questions concerning the chronological, socioeconomic, and spatial aspects of Cretan Neolithic society (Evans 1994, 1).

Since the time of Evans's research, excavation techniques and field methods have developed rapidly, and a new, more complex picture of late Pleistocene and early Holocene developments in the Aegean and the eastern Mediterranean has emerged. The chance to reexamine the important but inconspicuous Neolithic deposits of the Knossos tell afforded both an appealing and a demanding challenge.

While the Bronze Age palace dominates the historiography of the site and its archaeological image, the Neolithic settlement at Knossos does not hold the position it deserves in discussions of the early prehistory of the eastern Mediterranean, in part because of the limited research directed toward the early prehistory of Crete and the other Aegean islands. Moreover, the publication of the Neolithic settlement has been confined to a few preliminary though excellent field reports and short studies produced by Professor J.D. Evans and his collaborators (1964, 132; 1971, 95; Warren et al. 1968, 239). When attempted, previous syntheses of this material have been either very cautious analyses of the limited data (Evans 1994, 1) or provocative interpretations containing attractive but ill-founded speculations (Broodbank 1992, 39; Whitelaw 1992, 225). Additional Neolithic material recovered from later small field investigations focusing on Bronze Age deposits has been welcome, but because such information is scarce, it cannot provide the answers to many open questions (Manteli and Evely 1995, 1).

It is fortunate that certain categories of the archaeological material from Evans's investigations have recently undergone detailed reexamination with respect to issues of spatial organization, ceramic typology and technology, lithics, and faunal remains (Isaakidou and Tomkins, eds., 2008).

Despite these new and interesting studies, however, the need for a better understanding of the foundation and development of Neolithic Knossos continues. This impressive and long-lived settlement—one of the very few tells in Greece—is of paramount importance to the history of the eastern Mediterranean and the Near East (Berger and Guilaine 2009). Recent developments in the archaeology of Cyprus and the Aegean islands make the reevaluation of long-held concepts about this region and time period all the more urgent, as discussed in Chapter 11.

Although a number of rigorous surface reconnaissance projects have been undertaken in Crete in the past decades, Knossos remains the only early settlement known on the island (Manning 1999, 469). The methodology employed in these all-period surveys was not specifically designed to locate early sites, however. In the last few years field researchers have become increasingly critical of older methods used to identify traces of early habitation sites, especially in view of the geomorphological complexity of coastal and island areas (Runnels 2003, 121; Ammerman et al. 2006, 1). Until specially designed surface reconnaissance projects are carried out in various coastal areas, the presence of other early occupation sites in Crete remains an open possibility. Thus, the recently reported results of the Plakias Mesolithic Survey in Crete, in which a number of pre-Neolithic sites rich in lithic scatters were identified along the southern coast of the island, do not come as a surprise (Strasser et al. 2010). Indeed, current research in Cyprus indicates that we may encounter more new and unexpected late Pleistocene and early Holocene finds in the eastern Mediterranean (Ammerman 2011). Many older views of early habitation patterns in the Aegean islands should now be treated with skepticism (Cherry 1990, 145).

The newly found Mesolithic habitation remains along the south coast of the island may ultimately support claims of a missing Early Neolithic (EN) horizon in Crete. In the meantime, the apparent uniqueness of Knossos within the island is hard to accept in cultural terms, and as we shall see in later chapters, such a perception is undermined, albeit indirectly, by the material remains (pottery, subsistence) from Knossos, along with other evidence. The key importance of Knossos, however, for documenting the beginning of farming in the Aegean and mainland Greece, whether as a distinctive stage within a westward mobility pattern of human groups or as a well-planned colonization episode involving specific Aegean islands, remains undiminished. At present the notion of a local transition to farming in Crete undertaken by a dynamic Mesolithic population seems improbable, as is the case in continental Greece, where the archaeological evidence for the arrival of new farming groups seems overwhelming (Perlès 2001).

Neolithic Knossos is also important, as suggested above, in the wider geographic context of the early island prehistory of the eastern Mediterranean. Recent discoveries on the island of Cyprus have revealed the presence of a number of pre-Neolithic inland and coastal sites, triggering an interesting debate about a possibly early date for the occupation of the largest eastern Mediterranean islands and the interpretation of this phenomenon as a historical process with its own distinctive cultural, technological, and ideological characteristics (Broodbank 2006; Ammerman 2010). Mounting archaeological evidence from the Aegean either supports or at least allows us to entertain a new picture of early island settlement (Sampson 2006). In this context, the founding of the early seventh millennium B.C. farming village of Knossos on the Kephala hill may still be viewed either as the result of a long pre-Neolithic process of development on the island or as the start of an intrusive occupation by farmers from the east. Archaeological evidence from the long stratigraphic sequence of the Knossos tell may be called upon to interpret this ambiguous cultural process. Indeed, in relation to mainland Greece, specific material evidence from Knossos, such as the EN sequence of pottery (fabric types, surface treatment), attests to idiosyncratic elements of a local island development (see Dimitriadis, this vol., Ch. 3). It is still too early to argue whether these characteristics should be interpreted as the outcome of island isolationism and endogenous developments in Crete or as the manifestation of a more generalized and long-standing Aegean island cultural tradition. The former would undoubtedly have resulted in a number of other distinctive material features and perhaps oddities that we may search for in the archaeological record.

Both in terms of a pre-"historical" reconstruction and as far as the archaeology of the site itself is concerned, our endeavor entails a constant shift between different scales ("macro," "micro") and genres of field inquiry (e.g., use of space, radiocarbon dating, abandonment phases, faunal changes, pottery changes). The small size of our 1997 dig admittedly limits the overall representational validity of our findings at the site, but this does not deter us from addressing some of the broader issues mentioned above. We are particularly hopeful that the new studies presented here—sedimentology, phytoliths, anthracology, ceramic technology—together with the critical reevaluation of the other categories of material remains, such as the fauna and archaeobotany, will provide new and meaningful insights into the cultural sequence of the Knossos settlement. The documentation of the tell's stratigraphic sequence, which has a depth of more than 8 m, along with its comparison to the old and well-established succession of Evans's strata (Efstratiou, this vol., Ch. 2), also contributes to these insights, as does the the newly obtained series of radiocarbon dates from accelerator mass spectrometry (AMS), which seems to corroborate the existing chronological framework (Facorellis and Maniatis, this vol., Ch. 10).

All of the categories of material remains with the exception of the pottery are analyzed and presented in the following chapters of the monograph. The detailed study of the ceramics is still in progress and will appear in a separate volume. The contributors wish to underline the contingent nature of their results and syntheses, which are constrained by the limited area of the field investigation. Nevertheless, we hope that the rigor employed in the data collection, the meticulous study of the finds, the constant cross-checking with J.D. Evans's record, and our final synthesis will balance this unavoidable difficulty.

References

Ammerman, A.J. 2010. "The First Argonauts: Towards the Study of the Earliest Seafaring in the Mediterranean," in *Global Origins (and Development) of Seafaring*, A. Anderson, J. Barrett, and K. Boyle, eds., Cambridge, pp. 81–92.

———. 2011. "The Paradox of Early Voyaging in the Mediterranean and the Slowness of the Neolithic Transition between Cyprus and Italy," in *The Seascape in Aegean Prehistory* (*Monograph of the Danish Institute at Athens* 14), G. Vavouranakis, ed., Athens.

Ammerman, A.J., P. Flourentzos, C. McCartney, J. Noller, and D. Sorabji. 2006. "Two New Early Sites on Cyprus," *RDAC* 2006, pp. 1–22.

Berger, J-F., and J. Guilaine. 2009. "The 8200 cal BP Abrupt Environmental Change and the Neolithic Transition: A Mediterranean Perspective," *Quaternary International* 200, pp. 31–49.

Broodbank, C. 1992. "The Neolithic Labyrinth: Social Change at Knossos before the Bronze Age," *JMA* 5, pp. 39–75.

———. 2006. "The Origins and Early Development of Mediterranean Maritime Activity," *JMA* 19, pp. 199–230.

Cherry, J.F. 1990. "The First Colonization of the Mediterranean Islands: A Review of Recent Research," *JMA* 3, pp. 145–221.

Evans, J.D. 1964. "Excavations in the Neolithic Settlement of Knossos, 1957–60: Part I," *BSA* 59, pp. 132–240.

———. 1971. "Neolithic Knossos: The Growth of a Settlement," *PPS* 37, pp. 95–117.

———. 1994. "The Early Millennia: Continuity and Change in a Farming Settlement," in *Knossos: A Labyrinth of History. Papers in Honour of S. Hood*, D. Evely, H. Hughes-Brock, and N. Momigliano, eds., Oxford, pp. 1–20.

Isaakidou, V., and P. Tomkins, eds. 2008. *Escaping the Labyrinth: The Cretan Neolithic in Context* (*Sheffield Studies in Aegean Archaeology* 8), Oxford.

Manning, S.W. 1999. “Knossos and the Limits of Settlement Growth,” in *MELETEMATA: Studies in Aegean Archaeology Presented to Malcolm H. Wiener on the Occasion of His 65th Birthday* (*Aegeum* 20), P. Betancourt, V. Karageorghis, R. Laffineur, and W.-D. Niemeier, eds., Liège, pp. 469–482.

Manteli, K., and D. Evely. 1995. “The Neolithic Levels from the Throne Room System, Knossos,” *BSA* 90, pp. 1–16.

Perlès, C. 2001. *The Early Neolithic in Greece: The First Farming Communities in Europe*, Cambridge.

Runnels, C. 2003. “The Origins of the Greek Neolithic: A Personal View,” in *The Widening Harvest: The Neolithic Transition in Europe. Looking Back, Looking Forward* (*Colloquia and Conference Papers* 6), A.J. Ammerman and P. Biagi, eds., Boston, pp. 121–133.

Sampson, A. 2006. *Προϊστορία του Αιγαίου*, Athens.

Strasser T.F., E. Panagopoulou, C.N. Runnels, P.M. Murray, N. Thompson, P. Karkanas, F.W. McCoy, and K.W. Wegmann. 2010. “Stone Age Seafaring in the Mediterranean: Evidence from the Plakias Region for Lower Palaeolithic and Mesolithic Habitation of Crete,” *Hesperia* 79, pp. 145–190.

Warren, P., M.R. Jarman, H.N. Jarman, N.J. Shackleton, and J.D. Evans. 1968. “Knossos Neolithic, Part II,” *BSA* 63, pp. 239–276.

Whitelaw, T.M. 1992. “Lost in the Labyrinth? Comments on Broodbank’s Social Change at Knossos before the Bronze Age,” *JMA* 5, pp. 225–238.

6

Wood Charcoal Analysis: The Local Vegetation

Ernestina Badal and Maria Ntinou

The excavation of a small trench in the Central Court area at Knossos in 1997 explored the Neolithic sequence of the site. Previous excavations of the Neolithic deposits (Evans 1964) had already established the prominent role of Knossos in the early spread of agriculture in the Mediterranean. New excavations at the site, although much more limited in scale, presented us with the opportunity to add complementary information on various aspects of the process of neolithization.

One of the aims of the 1997 excavation was to undertake paleoenvironmental research at the site.* Charcoal analysis, or anthracology, has proven to be a valuable tool for paleoecological and paleoethnographic reconnaissance at many archaeological sites (Vernet, ed., 1992; Chabal et al. 1999; Thiébault, ed., 2002; Dufraisse, ed., 2006; Fiorentino and Magri, eds., 2008). The study of the charcoal from the 1997 Knossos excavation has helped us to reconstruct both the plant formations that prevailed in the Knossos area during the Neolithic and the ways in which they were used and modified by the first Neolithic settlers. The results of our analyses are presented in this chapter.

*Abbreviations used in this chapter are:

AN	Aceramic Neolithic
C	Celsius, Centigrade
cal.	calibrated or calendar years
cf.	compare
Ch(s).	Chapter(s)
EM	Early Minoan
EN	Early Neolithic
km	kilometers
LN	Late Neolithic
m	meters
m asl	meters above sea level
mm	millimeters
MN	Middle Neolithic
Mt.	Mount
no.	number
sp.	species

Physical Background

Location and Geology

The site of Knossos in Crete lies in the valley of the Kairatos River, which runs along the east side of the site. The Vlychia, a tributary of the Kairatos, borders the site to the south (Fig. 6.1). The river flows south from Mt. Juktas to the Aegean in the Nea Alikarnassos area, approximately 5 km to the north of Knossos. It carries a low volume of water and occasionally dries up in the summer. The Kairatos valley is narrow and gorge-like in its upper part, south of Knossos, and becomes slightly wider downstream. The terrain is higher to the south. The area around Knossos is surrounded by hills lower than 300 m, including a limestone ridge to the east and the "Acropolis" hill to the west (Roberts 1979).

The geology of the area is characterized by Cretaceous limestone overlain in places by *kouskouras,* a soft white marl of Pliocene age. Related gypsum deposits form the low hills of Gypsades south of Knossos. Debris fans of Plio-Pleistocene age surround the hills and the higher elevations to the south of the site (Roberts 1979).

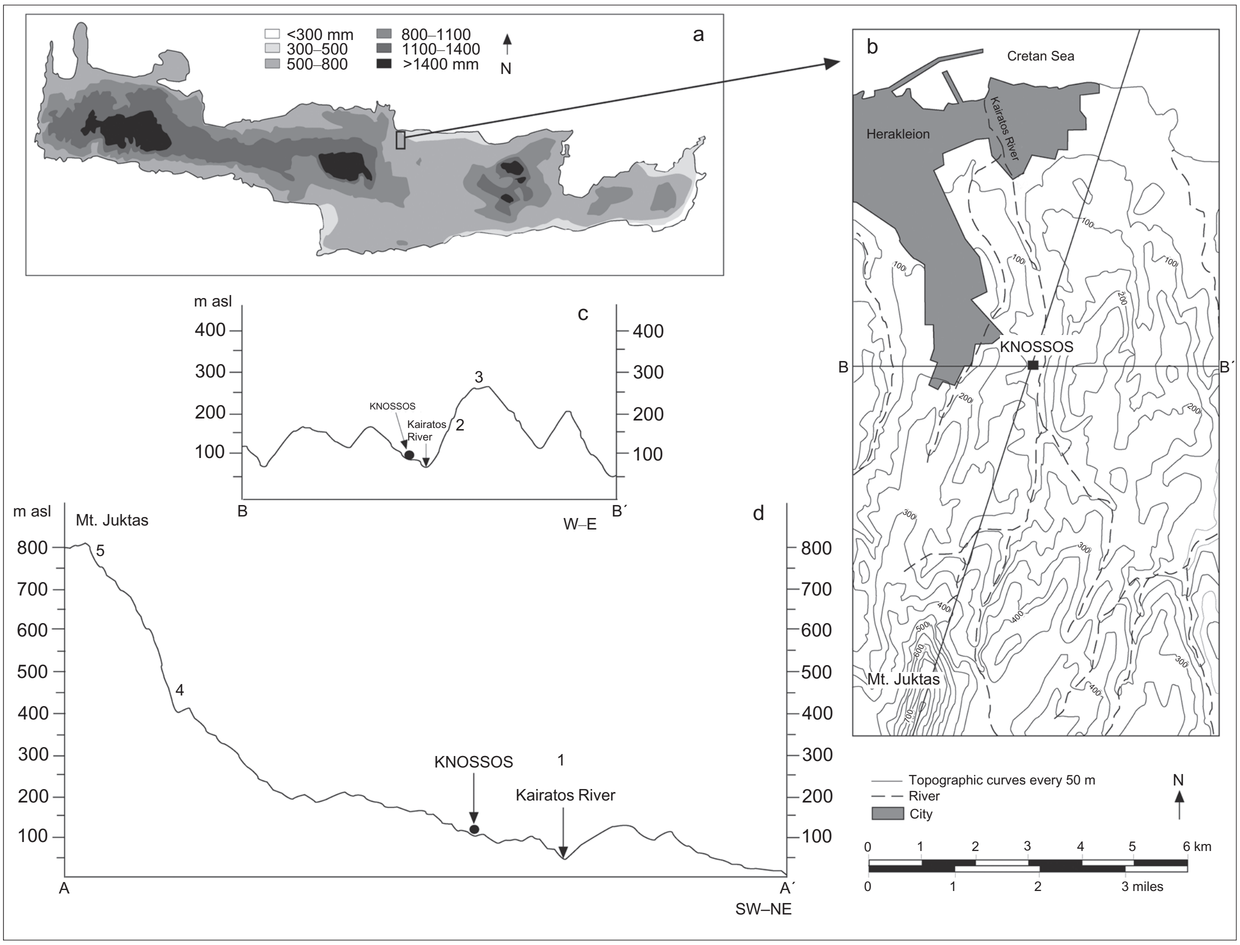


Figure 6.1. Climate and topography of Knossos: (a) mean annual precipitation in Crete (after Rackham and Moody 1996); (b) topographic map of the area around Knossos; (c) west–east topographic section; (d) southwest–northeast topographic section. The numbers on topographic sections correspond to plant inventories (see Table 6.1).

Climate

The climate in the Knossos area is typically Mediterranean, and the bioclimatic conditions are of the thermomediterranean type. The area is warm throughout the year with the average annual temperature estimated between 17°C and 19°C. January is the coldest month, with an average temperature of 11°C. Lower temperatures are experienced inland and at higher altitudes. Frosts, though rare, can occur from December to February. Maximum summer temperatures often exceed 35°C. Winter is the wettest season, and summers are dry and hot. Mean annual precipitation at the station of Herakleion has been estimated to be 476.5 mm by Roberts (1979). According to a map of Cretan precipitation in 1970–1982 drawn by Rackham and Moody (1996), the area of Knossos receives approximately 500 mm annually (Fig. 6.1:a). As in other Mediterranean areas, however, annual totals may vary considerably in consecutive years.

Flora and Vegetation

The vascular flora of Crete comprises 1,706 species. Many of these are widespread Mediterranean and Euro-Siberian plants, but some special elements associated with the historical geography of the area also exist. Certain habitats, particularly calcareous cliffs and naturally treeless mountain summits, are very rich in relict endemic species (Turland, Chilton, and Press 1993). The island's natural vegetation is typically Mediterranean. Zohary and Orshan (1966, cited in Roberts 1979) offered the following scheme of the altitudinal zoning of climax communities:

a. Evergreen maquis, which includes wild olive, pistachio, carob, juniper, and oak (*Quercus coccifera*), prevailing in all lowland areas up to 300 m

b. Evergreen oak forest extending between 300 m and 800 m of altitude, with pine forests partly substituting on rendzina soils

c. *Cupresso-Aceretum orientale* covering the zone above 800–1000 m, which corresponds to the oromediterranean zone in Crete

The Cretan landscape presents a variety of vegetation types, and occasionally altitudinal zoning is difficult to distinguish, in part due to intense use of the vegetation over the millennia, which has caused different plant formations such as maquis, phrygana, and pastureland to intermingle and fade into one another. Wooded areas exist in the great mountain ranges as well as at lower elevations. During the last decades and especially since the number of livestock has decreased and agriculture has retreated to the best land, the Cretan vegetation is recovering fast.

Agriculture is practiced extensively in the Kairatos valley around Knossos (Figs. 6.2, 6.3). The major crops are olive trees and vines, and there are also irrigated areas where vegetable orchards and orange plantations are located. Natural vegetation is restricted to small patches of the landscape. Thermomediterranean communities can be found from sea level to 600 m asl. They are very degraded by intense grazing. The elevations to the east of the site are covered with phrygana formations. Spiny shrubs such as *Sarcopoterium spinosum* and species of the Leguminosae, Labiatae, Cistaceae, and Compositae families are common components of these communities (Table 6.1; Figs. 6.1, 6.4). At higher elevations on the sides of Mt. Juktas (highest elevation 811 m) phrygana communities also dominate, but evergreen oak woodland in a degraded state is found in places. Conifers such as *Cupressus sempervirens* and *Pinus brutia* are rare. Scattered deciduous oaks grow on the western side of Mt. Juktas. Rich plant formations, which combine evergreen and deciduous species, are found on deeper soils and along watercourses (Figs. 6.1:d, 6.5). More detailed lists (inventories) of the plants growing in different parts of the study area are presented in Table 6.1.

Figure 6.2. View of the Knossos valley from Mt. Juktas showing present-day vegetation. Photo E. Badal.

Figure 6.3. Panoramic view of the site of Knossos showing present-day vegetation. Photo E. Badal.

Figure 6.4. Present-day phrygana vegetation on the hills in the study area. Photo E. Badal.

Figure 6.5. Present-day vegetation on deep soils in the study area. Photo E. Badal.

Inventory No. 1 River Kairatos 50–100 m asl	**Inventory No. 2 Eastern Hill 100–200 m asl**	**Inventory No. 3 Eastern Hill 200 m asl and up**	**Inventory No. 4 Juktas 400–425 m asl**	**Inventory No. 5 Juktas 700 m asl**
Platanus orientalis	*Pyrus* sp.	*Phlomis fruticosa*	*Quercus coccifera*	*Quercus coccifera*
Phragmites australis	*Salvia fruticosa*	*Cistus creticus*	*Cistus salvifolius*	*Quercus calliprinos*
Arundo donax	*Capparis* cf. *ovata*	*Calycotome villosa*	*Osyris alba*	*Cupressus sempervirens (horizontalis)*
Vinca sp.	*Sambucus ebulus*	*Asparagus* sp.	*Salvia fruticosa*	*Calycotome villosa*
Parietaria sp.	cf. *Asphodelus*	*Salvia fruticosa*	*Phlomis fruticosa*	*Cistus* cf. *crispus*
Ecbalium elaterium	*Thymus capitatus*	*Crocus* sp.	*Genista acanthoclada*	*Phlomis fruticosa*
Corylus avellana	*Satureja* sp.	*Lavatera* cf. *arborea*	*Calycotome villosa*	*Euphorbia* sp.
Morus sp.	*Lavatera* cf. *arborea*	*Thymus capitatus*	*Thymus capitatus*	*Sarcopoterium spinosum*
Ficus carica	*Calycotome villosa*	*Ebenus cretica*	*Hypericum empetrifolium*	*Phlomis lanata*
Hedera helix	*Ebenus cretica*	*Olea europaea*	*Pistacia lentiscus*	*Osyris alba*
—	*Asparagus* sp.	*Prunus amygdalus*	*Sarcopoterium spinosum*	*Spartium junceum*
—	*Pistacia terebinthus*	cf. *Asphodelus*	*Ebenus cretica*	*Pistacia terebinthus*
—	*Helichrysum* sp.	*Osyris alba*	*Erica multiflora*	*Hypericum empetrifolium*
—	*Crocus* sp.	*Ficus carica*	*Asphodelus* sp.	*Olea europaea*
—	*Phlomis fruticosa*	*Hypericum empetrifolium*	*Euphorbia* sp.	*Ranunculus* sp.
—	*Euphorbia* sp.	*Euphorbia* sp.	*Oreganum microphyllum*	*Asparagus* sp.
—	*Sarcopoterium spinosum*	*Capparis* cf. *ovata*	*Lavatera* cf. *arborea*	*Rhamnus oleoides*
—	*Rhamnus alaternus*	*Thymelea hirsuta*	*Asparagus* sp.	*Pinus brutia*
—	*Genista acanthoclada*	*Salicornia* sp.	*Phlomis lanata*	—
—	—	*Sarcopoterium spinosum*	*Ruscus aculeatus*	—
—	—	*Genista acanthoclada*	*Rubia peregrina*	—
—	—	—	*Fumana* sp.	—
—	—	—	*Oreganum vulgare*	—
—	—	—	*Quercus calliprinos*	
—	—	—	*Styrax officianalis*	—
	—	—	*Rhamnus oleoides*	—
—	—	—	*Cistus creticus*	
—	—	—	*Pyrus amygdaliformis*	—
—	—	—	*Crataegus* sp.	—
—	—	—	*Spartium junceum*	—
—	—	—	*Ficus carica*	—
—	—	—	*Thymelea hirsuta*	—
—	—	—	*Ephedra* cf. *fragilis*	—
—	—	—	*Pistacia terebinthus*	—
—	—	—	*Capparis spinosa*	—

Table 6.1. Inventories of plants growing in different parts of the study area. Plants are listed in the order of occurence as observed in each area.

Wood Charcoal Analysis: Methodology and Fieldwork

Daily human activities are reflected in the cultural remains at archaeological sites. Wood charcoal is a category of such remains. It originates either from firewood or from timber and plants used for various purposes and burned deliberately or accidentally at some point during a site's history. Although wood charcoal has been employed mainly for ^{14}C dating, it can also be used for the identification of plant taxa, thus providing ethnobotanical and paleoenvironmental information. Wood charcoal analysis requires detailed sampling of all the excavated deposits and precise information concerning the state of deposition and origin of the remains. The woody plant species can be identified by using a metallurgical microscope. The results provide information on the types of vegetation that existed in an area in the past, the climate regime under which they grew, and, most importantly, how they were used by the human groups visiting or settling in an area (Chabal 1988; 1997; Badal 1990; Vernet, ed., 1992; Chabal et al. 1999; Thiébault, ed., 2002; Dufraisse, ed., 2006; Fiorentino and Magri, eds., 2008).

Excavation in the Central Court of the palace of Knossos was carried out in 1997 jointly by the 23rd Ephorate of Classical and Prehistoric Antiquities of the Ministry of Culture and the Department of History and Archaeology of the University of Thessaloniki. A 3 x 2 m trench was opened in the eastern part of the Central Court, and 39 archaeological levels were excavated. The study of the material culture and pottery typology, together with radiocarbon dating, have established the sequence of archaeological levels and phases of the Neolithic as follows:

Aceramic Neolithic: levels 39–38
Early Neolithic I (EN I): levels 37–30
Early Neolithic II (EN II): levels 29–14
Middle Neolithic (MN): levels 13–4
Late Neolithic (LN): levels 3–1

Because the paleoenvironmental study of the site was one of the main aims of the 1997 excavation campaign, sediment samples were taken from every archaeological level and subsequently dry-sieved and floated. Wood charcoal was extracted from the samples, and this material was analyzed to obtain information on the vegetation surrounding the site and its use by the Neolithic settlers of the area.

In general, the wood charcoal was dispersed but not abundant in the sediment. Its relatively low frequency may be explained by the characteristics of the physical site, which is an open-air settlement exposed to wind, rain, and other erosive agents that may have caused the displacement and loss of remains not concentrated in closed features. Some levels did not provide any wood charcoal at all. Material was recovered from 25 archaeological levels altogether, and these fortunately correspond to all of the Neolithic phases listed above (Table 6.2). The wood charcoal assemblage from each archaeological level comprises the material recovered from both dry-sieving and flotation.

Results

The Plant List

A total of 29 taxa have been identified. These include evergreen broad-leaved species, deciduous species, and conifers (Table 6.3). The identified taxa are *Acer* sp. (maple), Anacardiaceae, *Arbutus* sp. (strawberry tree), *Cistus* sp. (rockrose), Conifer, *Cupressus sempervirens* (cypress; Fig. 6.6:a, b), *Daphne* sp. (garland flower), *Erica* sp. (heather), *Fraxinus* sp. (ash), *Ficus carica* (fig tree), *Juniperus* sp. (juniper), cf. *Laurus nobilis* (laurel), Leguminosae (the pea family), Monocotyledons, cf. *Oreganum* (marjoram), *Phillyrea/Rhamnus* (mock privet/buckthorn), *Pinus brutia* (the Cretan pine; Fig. 6.6:c, d), *Pinus* sp., *Pistacia lentiscus* (lentisk; Fig. 6.6:e), *Pistacia* sp., *Pistacia terebinthus* (turpentine), *Platanus orientalis* (oriental plane; Fig. 6.6:f, g), *Prunus amygdalus* (almond tree; Fig. 6.6:h, i), *Prunus* sp., *Quercus* sp. evergreen type (prickly and/or Holm oak), *Quercus* sp., *Quercus* sp. deciduous type (deciduous oak), Rosaceae/Maloideae (the apple tree family), and *Tamarix* sp. (tamarisk). Five fragments were not identified because their small size did not permit observation of all three anatomical sections.

Overall, both the plant list and individual assemblages are rich in taxa. The taxon *Quercus* sp. evergreen type includes the species *Quercus coccifera* (prickly oak) and *Quercus ilex* (Holm oak), which are undifferentiated on the basis of their anatomy. Prickly oak is the most common tree in Crete and can grow at sea level as well as on the highest Cretan mountains (up to 1,780 m in the White Mountains). It grows on any type of substrate, although preferably on limestone (Turland, Chilton, and Press 1993, 5; Rackham and Moody 1996, 64). Holm oak is rather uncommon in Crete and is usually restricted to crevices of calcareous cliffs where it is protected from browsing, wood cutting, and burning. It usually forms thickets with the strawberry tree (*Arbutus unedo*) and turpentine (*Pistacia terebinthus*) on noncalcareous soils. It also occurs in open woodland on calcareous soils and rocky ground together with *Acer sempervirens, Crataegus, Phillyrea, Pistacia terebinthus, Prunus spinosa*, and *Quercus pubescens* (Turland, Chilton, and Press 1993, 5). In the assemblages from Neolithic Knossos both species, namely prickly oak and Holm oak, might be represented as components of various plant formations since all other participants of present-day communities are also included.

The taxon *Quercus* sp. deciduous type may include different deciduous oak species that cannot be differentiated by their xylem anatomy. For Crete the species *Q. pubescens* and *Q. brachyphylla* are mentioned as native (Turland, Chilton, and Press 1993, 6; Rackham and Moody 1996, 65). As discussed by Bottema and Sarpaki (2003), there are different opinions concerning the taxonomic status of deciduous oak in Crete. Some experts accept the presence of only one of the two species mentioned above or consider them synonymous; some even describe *Q. brachyphylla* as a subspecies of *Q. pubescens.*

The taxon *Phillyrea*/*Rhamnus* includes two different genera, *Phillyrea* and *Rhamnus*, belonging to different families. Due to their anatomical similarity they cannot be differentiated. Both are quite common in the Cretan landscape and participate in various sclerophyllous communities.

Arbutus sp. as a single taxon includes two species both native to Crete: *Arbutus unedo* (strawberry tree) is the more common, while *Arbutus andrachne* (andrachne) has a relatively limited distribution, especially on limestone substrate (Rackham and Moody 1996, 70). Anatomical distinction between the two species is impossible, however, and therefore we present the taxon at the genus level.

The taxon *Erica* sp. may include the tree heather *E. arborea* and other smaller species. The anatomical distinction is based on the width of the rays in the tangential section (Schweingruber 1990, 367, 369). The preservation of anatomical characteristics of wood charcoal fragments is not always optimal for the anatomical distinction of different species. For this reason we use a single taxon, but we can confirm the existence of fragments with ray widths of five cells or more, and these could be attributed to *E. arborea.*

Acer sp. (maple) is a taxon that includes many species, which, as far as their xylem anatomical characteristics are concerned, cannot be differentiated except in a few cases (*Acer platanoides*/*Acer pseudoplatanus*; Schweingruber 1990, 175, 177). In the Cretan landscape the most common *Acer* species is *A. sempervirens*, the Cretan maple, a small deciduous tree or shrub that forms thickets in the mountains and may descend gorges almost to sea level (Rackham and Moody 1996, 70). In this presentation, we use the taxon *Acer* sp. due to the limitations of xylem anatomy.

A few wood charcoal fragments were identified as *Platanus orientalis* (plane). In general the taxon is rare in pollen cores from pre-Neolithic mainland Greece, but it appears early in pollen cores from Crete (Bottema and Sarpaki 2003). The species

Level	**39**	**37**	**35**	**34**	**33**	**32**	**31**	**30**	**29, 28**	**24**
Taxa	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**
Acer sp.	—	—	—	—	—	—	—	—	1 (0.5)	—
Anacardiaceae	—	—	—	—	—	1 (0.4)	—	—	—	—
Arbutus sp.	—	—	1 (1.3)	4 (2.5)	2 (1.1)	9 (3.2)	3 (16.7)	—	5 (2.5)	3 (2.8)
Cistus sp.	—	5 (5.2)	—	6 (3.7)	—	1 (0.4)	—	—	2 (1.0)	—
Conifer	—	—	—	1 (0.6)	—	3 (1.1)	—	—	2 (1.0)	3 (2.8)
Cupressus sempervirens	—	2 (2.1)	—	6 (3.7)	2 (1.1)	1 (0.4)	—	—	7 (3.4)	—
Daphne sp.	—	—	—	—	—	—	—	—	—	1 (0.9)
Erica sp.	—	16 (16.7)	5 (6.4)	19 (11.7)	31 (16.6)	22 (7.8)	—	—	11 (5.4)	4 (3.7)
Ficus carica	—	4 (4.2)	—	—	1 (0.5)	—	—	—	1 (0.5)	2 (1.8)
Fraxinus sp.	—	1 (1.0)	—	—	—	—	—	—	—	—
Juniperus sp.	—	—	—	5 (3.1)	—	2 (0.7)	—	—	1 (0.5)	2 (1.8)
Laurus nobilis	—	—	—	—	—	—	—	—	1 (0.5)	—
Leguminosae	—	1 (1.0)	—	6 (3.7)	2 (1.1)	—	—	—	—	1 (0.9)
Monocotyledons	—	—	1 (1.3)	—	—	—	—	—	—	—
cf. *Oreganum* sp.	—	1 (1.0)	—	—	—	—	—	—	—	—
Phillyrea/ *Rhamnus*	—	13 (13.5)	12 (15.4)	12 (7.4)	5 (2.7)	33 (11.7)	—	2 (16.7)	14 (6.9)	6 (5.5)
Pinus sp.	—	—	—	—	—	—	—	—	—	—
Pinus brutia	—	1 (1.0)	2 (2.6)	4 (2.5)	7 (3.7)	1 (0.4)	—	—	10 (4.9)	1 (0.9)
Pistacia lentiscus	—	3 (3.1)	—	4 (2.5)	5 (2.7)	5 (1.8)	—	—	—	2 (1.8)
Pistacia terebinthus	—	1 (1.0)	—	5 (3.1)	4 (2.1)	3 (1.1)	1 (5.6)	—	17 (8.4)	1 (0.9)
Pistacia sp.	—	8 (8.3)	—	10 (6.2)	40 (21.4)	57 (20.2)	—	4 (33.3)	4 (2.0)	3 (2.8)
Platanus orientalis	—	—	—	—	—	—	—	—	—	—
Prunus amygdalus	—	—	—	1 (0.6)	5 (2.7)	12 (4.3)	—	—	3 (1.5)	9 (8.3)
Prunus sp.	—	4 (4.2)	3 (3.8)	1 (0.6)	7 (3.7)	11 (3.9)	—	—	29 (14.3)	10 (9.2)
Quercus sp. deciduous type	20 (66.7)	2 (2.1)	—	—	7 (3.7)	1 (0.4)	—	—	4 (2,0)	—
Quercus sp. evergreen type	7 (23.3)	24 (25.0)	32 (41.0)	65 (40.1)	46 (24.6)	116 (41.1)	10 (55.6)	5 (41.7)	73 (36.0)	52 (47.7)
Quercus sp.	3 (10.0)	8 (8.3)	22 (28.2)	5 (3.1)	10 (5.3)	4 (1.4)	4 (22.2)	—	13 (6.4)	3 (2.8)
Rosaceae	—	2 (2.1)	—	6 (3.7)	13 (7.0)	—	—	—	2 (1.0)	1 (0.9)
Tamarix sp.	—	—	—	1 (0.6)	—	—	—	—	2 (1.0)	1 (0.9)
Indeterminate	—	—	—	1 (0.6)	—	—	—	1 (8.3)	—	1 (0.9)
Nutshell fragment	—	—	—	—	—	—	—	—	1 (0.5)	—
Parenchymatous tissue	—	—	—	—	—	—	—	—	—	3 (2.8)
Subtotal	30 (100)	96 (100)	78 (100)	162 (100)	187 (100)	282 (100)	18 (100)	12 (100)	202 (100)	106 (97)
Unidentifiable	1 (3.2)	15 (13.5)	15 (16.1)	46 (22.1)	31 (14.2)	34 (10.8)	—	2 (14.3)	27 (11.7)	29 (21.0)
Total	**31 (100)**	**111 (100)**	**93 (100)**	**208 (100)**	**218 (100)**	**316 (100)**	**18 (100)**	**14 (100)**	**229 (100)**	**138 (100)**

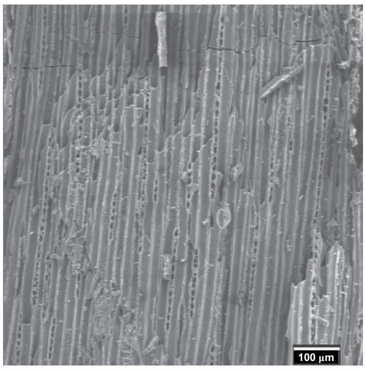
Table 6.2. Absolute and relative frequencies of taxa identified in the wood charcoal assemblages from Neolithic Knossos. Relative frequency of taxa has not been calculated for levels 20 and 7 due to the scarcity of wood charcoal.

23	21	20	18	17	14	12	10	9	8	7	4	3
No. (%)	**No. (%)**	**No.**	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**	**No.**	**No. (%)**	**No. (%)**
—	—	—	—	—	2 (1.1)	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
3 (5.4)	3 (13.6)	—	1 (2.9)	4 (5.4)	8 (4.4)	8 (8.6)	16 (18.0)	6 (7.8)	2 (3.8)	—	5 (16.1)	—
—	—	—	—	3 (4.1)	—	1 (1.1)	4 (4.5)	—	—	—	—	—
1 (1.8)	—	—	—	—	—	—	—	2 (2.6)	—	—	—	—
—	—	—	2 (5.7)	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	2 (2.6)	—	—	—	—
2 (3.6)	—	—	2 (5.7)	3 (4.1)	1 (0.6)	4 (4.3)	5 (5.6)	2 (2.6)	—	—	—	—
—	—	—	1 (2.9)		1 (0.6)	1 (1.1)	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
1 (1.8)	1 (4.5)	—	—	—	—	2 (2.2)	1 (1.1)	—	2 (3.8)	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	1 (2.9)	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	4 (18.2)	—	—	3 (4.1)	3 (1.7)	2 (2.2)	5 (5.6)	5 (6.5)	1 (1.9)	—	1 (3.2)	4 (14.3)
—	—	—	—	2 (2.7)	—	3 (3.2)	2 (2.2)	—	—	2	—	—
—	1 (4.5)	1	1 (2.9)	—	1 (0.6)	4 (4.3)	—	1 (1.3)	—	—	1 (3.2)	—
—	—	—	—	1 (1.4)	—	—	1 (1.1)	—	—	—	—	—
—	—	—	—	—	—	2 (2.2)	—	1 (1.3)	—	—	—	—
—	1 (4.5)	—	—	—	1 (0.6)	5 (5.4)	—	8 (10.4)	—	—	—	—
—	—	—	—	—	3 (1.7)	—	—	—	—	—	—	—
1 (1.8)	—	—	1 (2.9)	3 (4.1)	79 (43.9)	—	8 (9.0)	5 (6.5)	11 (21.2)	—	9 (29.0)	6 (21.4)
6 (10.7)	—	—	1 (2.9)	26 (35.1)	54 (30.0)	25 (26.9)	28 (31.5)	15 (19.5)	10 (19.2)	3	6 (19.4)	8 (28.6)
—	—	—	—	—	—	1 (1.1)	—	—	2 (3.8)	—	—	—
31 (55.4)	8 (36.4)	1	20 (57.1)	23 (31.1)	21 (11.7)	18 (19.4)	17 (19.1)	19 (24.7)	22 (42.3)	—	6 (19.4)	7 (25.0)
6 (10.7)	4 (18.2)	—	2 (5.7)	1 (1.4)	3 (1.7)	2 (2.2)	2 (2.2)	6 (7.8)	2 (3.8)	—	3 (9.7)	2 (7.1)
1 (1.8)	—	—	—	1 (1.4)	—	3 (3.2)	—	3 (3.9)	—	—	—	1 (3.6)
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	1 (0.6)	1 (1.1)	—	—	—	—	—	—
4 (7.1)	—	—	—	—	—	4 (4.3)	—	2 (2.6)	—	—	—	—
—	—	—	3 (8.6)	4 (5.4)	2 (1.1)	7 (7.5)	—	—	—	—	—	—
52 (93)	22 (100)	2	32 (91)	70 (95)	178 (99)	82 (88)	89 (100)	75 (97)	52 (100)	5	31 (100)	28 (100)
13 (18.8)	3 (12.0)	1	7 (16.7)	16 (17.8)	26 (12.6)	24 (20.5)	22 (19.8)	12 (13.5)	13 (20.0)	—	9 (22.5)	2 (6.7)
69 (100)	**25 (100)**	**3**	**42 (100)**	**90 (100)**	**206 (100)**	**117 (100)**	**111 (100)**	**89 (100)**	**65 (100)**	**5**	**40 (100)**	**30 (100)**

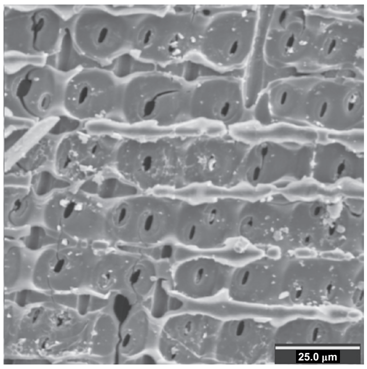
Cultural period	**AN**	**EN I**							**EN II**	
Calendar age years B.C. (95.4% probability)	7050–6690	5300–5000	5468–5228		5220–4950	5290–4960	5310–5000	5010–4350	5000–4730	5208–4936
Archaeological level	39	37	35	34	33	32	31	30	29–28	24
Number of charcoal fragments	31	111	93	208	218	316	18	14	230	138
Acer sp.									•	
Anacardiaceae						•				
Arbutus sp.			•	•	•	•	•		•	•
Cistus sp.		•		•		•			•	
Conifer				•		•			•	•
Cupressus sempervirens		•		•	•	•			•	
Daphne sp.										•
Erica sp.		•	•	•	•	•			•	•
Ficus carica		•			•				•	•
Fraxinus sp.		•								
Juniperus sp.				•		•			•	•
cf. *Laurus nobilis*									•	
Leguminosae		•		•	•					•
Monocotyledons			•							
cf. *Oreganum*		•								
Phillyrea/*Rhamnus*		•	•	•	•	•		•	•	•
Pinus brutia		•	•	•	•	•			•	•
Pinus sp.										
Pistacia lentiscus		•		•	•	•				•
Pistacia sp.		•		•	•	•		•	•	•
Pistacia terebinthus		•		•	•	•	•		•	•
Platanus orientalis										
Prunus amygdalus				•	•	•			•	•
Prunus sp.		•	•	•	•	•			•	•
Quercus sp.	•	•	•	•	•	•	•		•	•
Quercus sp. deciduous type	•	•			•	•			•	
Quercus sp. evergreen type	•	•	•	•	•	•	•	•	•	•
Rosaceae/ Maloideae		•		•	•				•	•
Tamarix sp.				•					•	•
Nutshell fragment									•	
Panenchymatous tissue										•
Indeterminate				•				•		•
Number of taxa	3	17	8	19	16	17	4	4	21	20

Table 6.3. Presence of plant taxa in wood charcoal assemblages from Neolithic Knossos, along with the total number of fragments analyzed and the total number of taxa identified in each level.

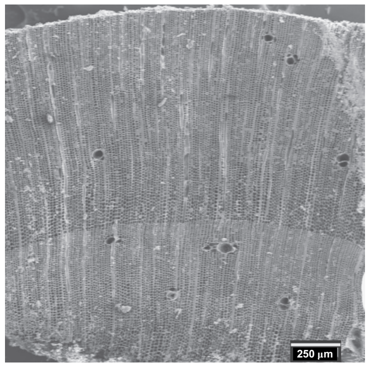
EN II, cont.						MN						LN
					4982–4774	4990–4731						
23	21	20	18	17	14	12	10	9	8	7	4	3
69	25	3	42	90	206	117	111	89	65	5	40	30
						•						
•	•		•	•	•	•	•	•	•		•	
				•		•	•					
•								•				
			•									
								•				
•			•	•	•	•	•	•				
			•		•	•						
•	•					•	•					
			•									
	•			•	•	•	•	•	•		•	•
	•	•	•		•	•		•			•	
			•	•	•	•	•	•	•	•	•	•
				•			•					
	•				•	•		•				
						•		•				
					•							
•			•	•	•		•	•	•		•	•
•				•		•	•			•		
•	•		•	•	•	•	•	•	•		•	•
						•			•			
•	•	•	•	•	•	•	•	•	•		•	•
•				•		•		•				•
•								•				
			•	•	•	•						
					•	•						
10	8	2	11	12	14	18	9	14	8	2	7	6



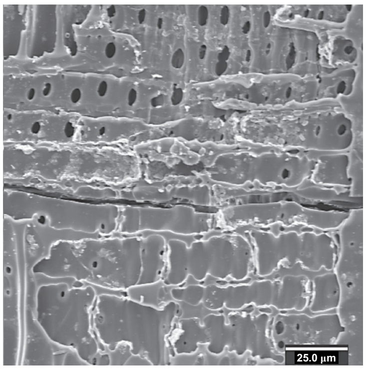
a. *Cupressus sempervirens*, tangential longitudinal section, x150.



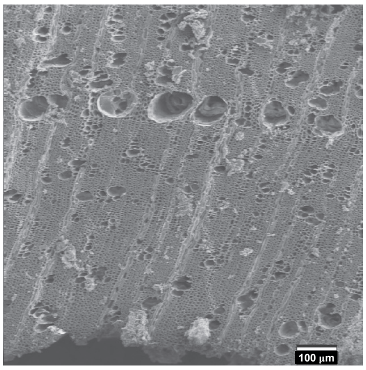
b. *Cupressus sempervirens*, radial longitudinal section, x1100.



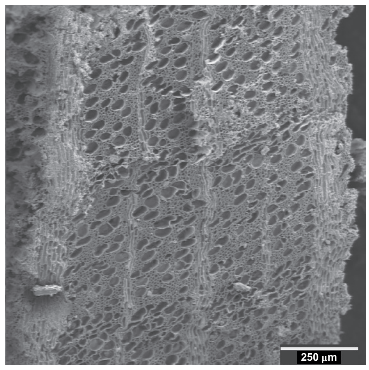
c. *Pinus brutia*, transverse section, x60.



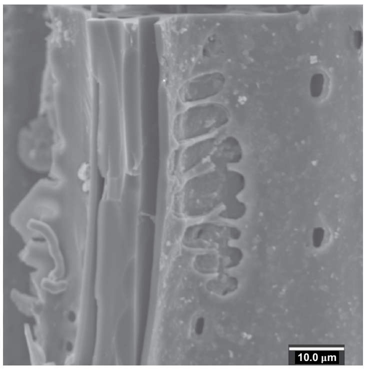
d. *Pinus brutia*, radial longitudinal section, x350.



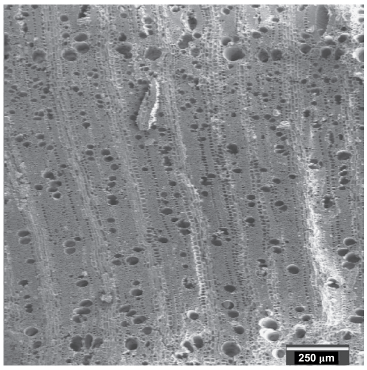
e. *Pistacia lentiscus*, transverse section, x130.



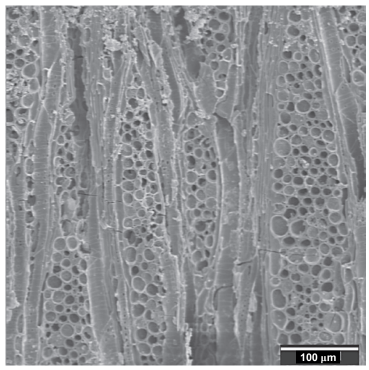
f. *Platanus orientalis*, transverse section, x100.



g. *Platanus orientalis*, tangential longitudinal section, x1800.



h. *Prunus amygdalus*, transverse section, x80.



i. *Prunus amygdalus*, tangential longitudinal section, x250.

Figure 6.6. Anatomy of plant taxa identified in wood charcoal assemblages from Neolithic Knossos. Photos M. Ntinou.

was probably native in Crete, and this corroborates its presence in the charcoal assemblages from Knossos.

The species *Pinus brutia* is anatomically similar to *P. halepensis*, and according to Schweingruber (1990, 121) the two are undifferentiated. In discussions of Cretan flora and vegetation *P. brutia* is considered the only native pine on the island (Turland, Chilton, and Press 1993, 34; Rackham and Moody 1996, 63), however, and we believe that this is the species represented in the wood charcoal assemblages.

Finally we should mention the presence of few small fragments of burned nutshell. Their presence in the assemblages may indicate the discard of food residues in domestic fires.

A general characteristic of the assemblages is their homogeneity in composition (Table 6.3); some of the taxa are constantly present. Evergreen oak (*Quercus* sp. evergreen type) is found in all assemblages, while mock privet/buckthorn (*Phillyrea*/*Rhamnus*), *Prunus* sp., the almond (*Prunus amygdalus*), strawberry tree (*Arbutus* sp.), *Pistacia* sp., the Cretan pine (*Pinus brutia*), and heather (*Erica* sp.) are present in most of them. Deciduous oak (*Quercus* deciduous type), members of the Rosaceae family, juniper (*Juniperus* sp.), cypress (*Cupressus sempervirens*), rockrose (*Cistus* sp.), and the pea family (Leguminosae) appear in many assemblages. The remaining taxa are rather infrequent.

The Charcoal Diagram

Combined qualitative and quantitative results (Table 6.2) for all the assemblages in chronological sequence are presented in a diagram that shows the representation of the taxa diachronically (Fig. 6.7). Comparison between successive assemblages allows us to distinguish vegetation types, their characteristics, and possible changes through time. The frequency of the taxa is shown for those assemblages that included enough fragments (over 70) for a coherent qualitative and quantitative study (i.e., the assemblages from levels 37, 35, 34, 33, 32, 29, 28, 24, 17, 14, 12, 10, and 9). For the remaining, charcoal-poor assemblages (those from levels 39, 31, 30, 21, 20, 18, 8, 7, 4, and 3), only the presence of taxa is indicated with a square black symbol.

The best represented taxon in the entire sequence is evergreen oak (*Quercus* sp. evergreen type). In assemblages 37–32, corresponding to the EN I period, the taxon's relative frequency increases from 25% to 41%. This frequency, with some fluctuations, is maintained or slightly higher in assemblages 29–24, ascribed to the EN II periods. The taxon's frequency decreases in assemblage 17 and reaches the lowest point in the sequence (11.7%) at the end of EN II in assemblage 14. The following assemblages 12, 10, and 9, corresponding to the MN period, document a slight increase in the taxon's frequency, which is maintained at approximately 20%.

Mock privet/buckthorn (*Phillyrea*/*Rhamnus*) shows a fluctuating tendency in assemblages 37–24, ascribed to EN I and part of EN II. The taxon's frequency clearly decreases in the following levels 17–9, that is, at the end of the EN II and in the MN period. The strawberry tree (*Arbutus* sp.) shows the opposite tendency, starting with low values in the older assemblages and increasing in frequency in assemblages 14–9. The frequencies of lentisk (*Pistacia lentiscus*) remain constantly below 5%. The lentisk might be partly represented under the taxon *Pistacia* sp., as is also the case with turpentine (*Pistacia terebinthus*). The frequency of *Pistacia* sp. fluctuates between 10% and 20% in the oldest part of the sequence. The taxon is very well represented in the EN I period (levels 37–32). If all three taxa—*Pistacia* sp., *P. lentiscus*, and *P. terebinthus*—are viewed together, they present similar trends as other evergreen taxa, namely *Quercus* evergreen and *Phillyrea*/*Rhamnus*. *Pistacia* appears to have been widely used for firewood in EN I and to some extent in EN II, but it was markedly abandoned as a source by the end of the EN II period. Some increase in the *Pistacia* sp. frequency is observed in level 9, where it reaches 10%.

A quite constant and frequent taxon is heather (*Erica* sp.). The taxon has its highest frequencies (16.7%) of occurrence in the first assemblage in which it appears, level 37, and in level 33, both of the EN I period, and its presence is also notable at the beginning of the EN II period. Its value decreases by the end of the EN II, but it is maintained at approximately 4%–5% thereafter. The frequency of rockrose (*Cistus* sp.) fluctuates between approximately 1% and 5% in some assemblages, and the leguminosae have a somewhat lower frequency (1%–3%). Other taxa such as *Daphne* sp., Monocotyledons, and cf. *Oreganum* are scarce.

Deciduous taxa are represented in the Neolithic Knossos diagram by deciduous oak (*Quercus* sp. deciduous type), almond (*Prunus amygdalus*), other *Prunus* species, maple (*Acer* sp.), ash (*Fraxinus* sp.), the fig tree (*Ficus carica*), turpentine (*Pistacia terebinthus*), and members of the

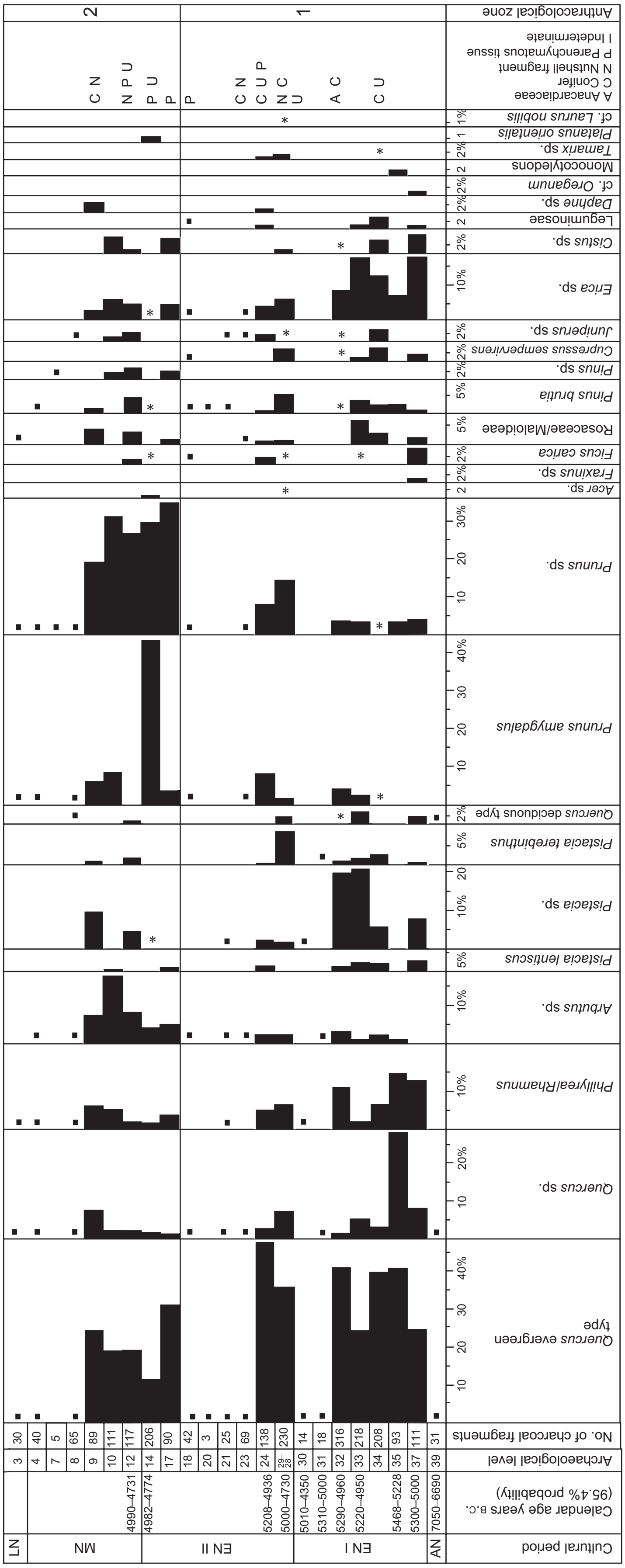


Figure 6.7. Wood charcoal diagram from Neolithic Knossos showing relative frequencies of taxa in successive excavation levels. Relative frequencies of taxa are calculated on the basis of the fragments identified. Black squares indicate presence of taxa in charcoal-poor assemblages; asterisks indicate taxa with frequencies lower than 0.8%.

Rosaceae/Maloideae family. With the exception of *Prunus* sp., the almond, and the turpentine, all the remaining deciduous taxa have a modest representation. Deciduous oak is present in some of the assemblages with low values overall. The presence of the taxon in the earliest occupation level of the sequence, the Aceramic Neolithic level 39, is interesting, however. Wood charcoal was very scarce in this level, and consequently qualitative and quantitative data are incomplete. Nevertheless, the absolute frequency of deciduous oak (Table 6.2) establishes it as the dominant taxon in this assemblage and clearly differentiates level 39 from the rest of the sequence (see discussion below).

Prunus sp. and the almond are regularly represented in EN I (assemblages 37–32) with values that approach 4% on average. The taxa show a stable increase during EN II (assemblages 29–23). The end of EN II, when the almond tree reaches 43.9% and *Prunus* sp. reaches 30%, is the culminating point for these taxa (especially assemblage 14 for both). High frequency of *Prunus* sp. is maintained in the MN period.

Other deciduous taxa are occasionally present with low values in the assemblages. Their mean relative frequency is around 2%, and only Rosaceae surpass this value once in level 33. Taxa associated with riversides and humid environments, such as the oriental plane (*Platanus orientalis*) and laurel (*Laurus nobilis*), are present in only one assemblage each. Tamarisk (*Tamarix* sp.) is present with low frequencies in three assemblages.

The conifers are represented by the Cretan pine (*Pinus brutia*), the cypress (*Cupressus sempervirens*), and juniper (*Juniperus* sp.). The Cretan pine is more constant than the other conifers, although its frequency hardly exceeds 5%. Only in level 29 does it reach 8%. The values of the cypress fluctuate between 2% and 5% and those of juniper between 2% and 4%.

Interpretation

The basal assemblage of the diagram and the sequence derives from level 39, the Aceramic Neolithic. Unfortunately, wood charcoal was scarce, and thus it does not allow for a good understanding of the vegetation characteristics of that period. Furthermore, the large chronological distance between this assemblage and the next one represented in the diagram (assemblage 37) makes the comparison between them difficult. Nevertheless, the main characteristic of assemblage 39, the abundance of deciduous oak—the dominant taxon—clearly distinguishes the earliest phase of habitation from the rest of the sequence. The other taxon represented in the assemblage is evergreen oak, and *Quercus* sp. might be either deciduous or evergreen oak. The abundance of the deciduous oak in this assemblage could be the result of environmental conditions that favored the growth of those trees in the surroundings of the settlement, conditions that changed sometime before EN I, and/or the selective use of these trees for purposes other than firewood.

According to the first hypothesis, during the Aceramic (dated to 7050–6690 B.C.), deciduous oaks prevailed in the vegetation around the site. A change took place between the first occupation and the beginning of EN I (level 37), dated to the late sixth millennium. Sclerophyllous woodland and evergreen oaks dominated the environment thereafter. It is difficult to say if this change occurred due to climatic reasons or because of human activities. There is a long period of time separating the AN occupation from what is considered to be the EN I occupation (almost 1,500 years). However, if human presence was constant in the area during this period of time, it might have affected the natural vegetation and caused the restriction of certain species to protected habitats. Deciduous oaks and humans compete for the same environments, valley bottoms, and in Crete's present-day vegetation these trees are frequently found growing in abandoned fields. It is possible that deciduous oak groves existed in the Kairatos valley, close to the first Neolithic settlement. If Neolithic farmers opened small plots for cultivation in the valley, the constant practice of mixed farming activities would eventually have caused the territory of deciduous oaks to shrink. Such a hypothesis seems to be supported by Isaakidou's (2008) modeling of the subsistence requirements of Neolithic

Knossos, which, according to the author, could have been easily accommodated in the valley alluvium throughout this period. The early human presence at Knossos and the constant use of the valley floor, possibly a favorable location for deciduous oaks, might have accounted for the reduction of the trees in the vegetation sometime after the first 1,000 years of occupation, especially if that occupation was continuous.

According to the second hypothesis, wood charcoals in assemblage 39 were not firewood remains. The presence of only two species in the assemblage might indicate that the remains originated from burned timber or wooden material associated with a structure not revealed in the limited excavation exposure. In general, assemblages with poor plant lists are typical of selective plant use or incidental, instantaneous use (Badal 1992; Chabal 1997; Chabal et al. 1999). The poor plant list of assemblage 39 contrasts with the rest of the sequence, in which a wide array of plants has been identified in individual levels (see Table 6.3). The dominance of deciduous oak in assemblage 39, therefore, would not reflect the characteristics of the vegetation but the selection of these trees for their timber. The discovery of post and stake holes in Evans's Aceramic Stratum X, along with the end of a burned stake identified as oak, probably of the deciduous type, supports this hypothesis (Evans 1964; Western 1964). The abundance of deciduous oak in the earliest occupation level would thus be a reflection of timber use rather than of the locally dominant vegetation. Even so, these trees were certainly growing in the vicinity of the settlement.

Following the Aceramic Neolithic assemblage 39, the diagram shows two anthracological zones that can be distinguished on the basis of the relative representation of the evergreen oak and the almond, *Prunus* sp. In the first zone, which includes the EN I and most of the EN II period, evergreen oak is dominant. In the second zone, corresponding to the end of the EN II and part of the MN period, the almond is the most abundant taxon.

The first anthracological zone is characterized by the dominance of evergreen oak accompanied by other sclerophyllous taxa, as well as deciduous species and conifers. This zone provides a good picture of the EN vegetation of the area and its different environments. The characteristics of the vegetation are typically Mediterranean. Prickly oak and the other evergreen species would have participated in Mediterranean sclerophyllous formations, which at present are found mostly in a shrub-like state, but may reach an arboreal state and form a dense canopy when left undisturbed by the pressure of coppicing or browsing by animals. Lentisk and juniper would have extended to the areas closer to the coast, giving way farther inland to evergreen oak woodland, in which mock privet/buckthorn would have played an important role. Evergreen woodland would have grown around the settlement, probably forming a noncontinuous mantle interrupted by more open space. Strawberry trees with tree heather might either have grown in separate formations, resembling their modern analogue on the phyllite areas of western Crete, or, most probably, they would have formed part of the understory of evergreen oak thickets. Deciduous species of the Rosaceae/Maloideae family-subfamily such as *Pyrus amygdaliformis* and species of the *Prunus* genus, which are sun-loving and resistant to drought and poor soils, might have occupied rocky areas with an open canopy or areas barren of other arboreal vegetation that were covered by phrygana, rockrose, *Daphne*, and members of the Leguminosae and Labiatae (such as cf. *Oreganum*) family.

Deciduous oaks would not have been abundant. They probably grew in more humid areas and in the deeper soils of the evergreen woodland. Holm oak might have been found in such places as well, as it demands more humid environments than the other evergreen species, the prickly oak.

Cretan pine and cypress are not abundant in the assemblages from Neolithic Knossos. The examples present might represent scattered individuals or, since both are gregarious species, they might have constituted limited inland groves in areas bordering the lower elevations of the mountains.

Laurel, plane tree, and probably monocotyledons and ash would have grown on riverbanks or slopes in the upper part of the Kairatos valley. Tamarisk might have grown either in sandy and coastal areas or along riverbanks. The low frequency of these taxa is indicative of the limited extension of riverine formations along the river course.

The first zone presents all the characteristics of an area ascribed to the thermomediterranean bioclimatic level, consistent with the lowland, almost coastal location of the site. The identified taxa could grow under dry (precipitation of 300–500 mm/year) or subhumid (precipitation of 500–700 mm/year) conditions. Neither precipitation nor temperatures would have been much different from the present. The natural plant cover surrounding the site of Knossos was probably a mosaic of formations, with dense woodland interspersed with open vegetation and small cultivated plots.

The evergreen formation components of the first anthracological zone persisted in the second zone observed at the end of EN II and into the MN period. The factor that defines the new anthracological zone is the high frequency of *Prunus* sp. (almond) in some assemblages, surpassing that of the evergreen oak, which is dominant in the rest of the sequence. The abundance of *Prunus* sp. could be due to a special use of these trees for their edible fruits and/or to a change in the vegetation.

The identification of the almond is well documented. The anatomy of this species (ring porous distribution and wide rays) clearly differentiates it from other *Prunus* species and from *P. webbii*, a wild almond with bitter and poisonous fruit. Many other small wood charcoal pieces, although they were identified as *Prunus* sp., could also correspond to the almond, but the identification was limited to the genus because, despite the large and wide rays, they did not preserve an entire growth ring. Therefore, at Neolithic Knossos people were using the almond for firewood and probably for the consumption of the edible fruits (see Sarpaki, this vol., Ch. 5) as early as EN I. These trees were probably part of the natural vegetation, as they occur in Greek mainland areas from the end of the Pleistocene (Ntinou 2002a). By the end of EN II the almond and *Prunus* in general became the most abundant taxa. This proliferation may reflect the managing of these trees. By this we mean planting with seeds and pruning or even grafting the wild trees, activities that could indicate proto-arboriculture. In the archaeobotanical record only the end products of tree tending (wood from pruning used for fuel) and fruit consumption (nutshells) are preserved to testify to such activities. Consequently, it is difficult to support the idea of either intensive fruit gathering or more sophisticated techniques of fruit tree management. Nevertheless, the end of the EN II period is characterized by a selective use of *Prunus* species, probably focused on the fruit of these trees.

Moreover, there is further evidence in the second zone to support the idea that a change in the vegetation was taking place. Evergreen oaks were still present, but their frequency was lower. In addition, all the other taxa composing previous assemblages also decreased in frequency, with the exception of strawberry tree (*Arbutus* sp.) and *Prunus* sp. In well-developed evergreen oak formations *Arbutus* forms part of the understory, but it tends to spread when the evergreen oak woodland is set on fire, for it benefits to a certain extent from the opening of the canopy; if the degradation is continuous and repetitive, however, it is also adversely affected, and the population diminishes (Braun-Blanquet 1936). The above succession has been observed at prehistoric sites in the western Mediterranean and is attributed to increasing human intervention from the Neolithic onward (Badal, Bernabeu, and Vernet 1994).

In the case of Knossos the opposing tendencies of evergreen oak and *Arbutus* might be related to changes in the density of the evergreen formations caused by human activities. The increase in *Prunus* sp. (almond) would be in line with this change, especially given that these taxa thrive in open formations and are favored by solar radiation. Changes in the composition and density of the sclerophyllous woodland might have occurred after more than 1,000 years of human presence in the area. Farming, herding, and burning would have affected the fragile equilibrium of evergreen Mediterranean formations, and the evergreen oak woodland surrounding the site would have become less dense. As reported elsewhere (Efstratiou et al. 2004), after a long period (more than 1,000 years) the occupation of the site became more solid with substantial architecture by the end of EN II. In the light of this information, we could explain the increase of *Prunus* sp. in conjunction with changes in the vegetation and adaptations of subsistence strategies to local resources.

The Olive

The wood charcoal results from Neolithic Knossos show that typically Mediterranean formations were growing around the site. These would ordinarily include components of thermomediterranean vegetation characteristic of the coastal areas of Crete such as evergreen oaks, lentisk, Cretan pine, laurel, and wild olive (Quézel and Barbéro 1985). The olive in its wild state is the indicator of the thermomediterranean bioclimatic level (Ozenda 1982), and at present the olive is a major crop in Crete. It is, however, remarkably absent from the entire charcoal sequence of Knossos.

The absence of the olive from the charcoal assemblages of Knossos might indicate that: (a) the species was not native to the island, or at least it did not grow along this part of the northern coast; (b) the species was very rare in the landscape, and it was not gathered for firewood or other purposes; or (c) the species grew around the site, but for cultural reasons it was not used for fuel. The third hypothesis is difficult to evaluate given that the selection or avoidance of plants varies considerably in relation to ideologies and taboos. Therefore, it remains a possible explanation for the absence of the olive from the Neolithic sequence of Knossos. The other two hypotheses can be checked in relation to relevant information from Crete and adjacent areas.

The olive appears in the pollen record of Crete late in the Holocene. During the early part of the Holocene the taxon is absent from the Hagia Galini core in South-Central Crete, and Bottema suggests that "the wild olive must have been either rare or even absent from the island" (Bottema 1980, 214). The olive is also absent in the lower spectra of the pollen diagrams from Delphinos (Bottema and Sarpaki 2003) and Tersana (Moody, Rackham, and Rapp 1996), northwestern Crete. It appears for the first time at 6200 B.P. (around 5000 cal. B.C.) in the Delphinos diagram and presents a continuous closed curve after 5700 B.P. (ca. 4700 cal. B.C.). In the Tersana diagram the olive appears at 6000 B.P. According to Bottema and Sarpaki (2003), olives were introduced to the island through overseas contacts, and they were certainly grown before Early Minoan (EM) I, although cultivation and oil production on a larger scale is not documented until the Middle Minoan I period. Moody, Rackham, and Rapp (1996) have argued, however, that the olive was a natural element of the Pleistocene vegetation of Crete. During that period it survived in *refugia* somewhere on the island and spread with the onset of the Holocene. The authors attribute its presence during the MN (4750 B.C.) to a native origin, being "a natural part of the oak woodland" (Moody, Rackham, and Rapp 1996, 286). The abundance of the taxon thereafter is an indication of the manipulation of the vegetation by humans and of local cultivation, which could have been an imported practice or a local development (Moody, Rackham, and Rapp 1996; Rackham and Moody 1996, 20).

The pollen record is inconclusive regarding the Holocene presence and natural growth of *Olea* in Crete. Moreover, the oldest olive archaeobotanical remnant, namely an olive stone from the site of Myrtos, dates to the Early Bronze Age (Rackham 1972; Renfrew 1972), millennia after the first Neolithic settlements were established on the island. The only Neolithic charcoal evidence comes from Knossos, and the EN I charcoal results are in agreement with the pollen record regarding the absence of the olive. Furthermore, although the species appears in the pollen record after 5000 B.C., it continues to be absent from the charcoal sequence.

According to Moody, Rackham, and Rapp (1996), the olive might have grown naturally in small numbers in the oak woodland of Crete. In the case of Knossos, if the wild olive was a rare element of the natural vegetation, it might have escaped being collected for firewood. The plant list from the site is very rich in taxa, however, and although some of them are scarcely represented, they appear nonetheless, reflecting the use of a variety of environments. Therefore, we would expect the olive to appear at least once, as is the case with other rare taxa like the plane, the tamarisk, and the laurel.

The early presence of the wild olive in Neolithic contexts in other parts of the Mediterranean contrasts with the wood charcoal results from the site of Knossos. If the olive grew naturally in the environment, it would probably have been used. In Cyprus the olive is well documented both in the form of wood charcoal and archaeobotanical remains in the earliest Neolithic settlements of Shillourokambos, Khirokitia, Cape Andreas–*Kastros*, and Ayios Epiktitos–*Vrysi* (Thiébault 2003). The analysis of wood charcoal from the site of Shillourokambos shows that the olive became very abundant already by 7500 B.C. Similarly, in the southern latitudes and coastal areas (the thermomediterranean bioclimatic level) of the eastern, central, and western Mediterranean, the olive was already present in Epipaleolithic, Mesolithic, and Early Neolithic contexts, mainly in the form of charcoal remains rather than olive stones (Galili, Weinstein-Evron, and Zohary 1989; Liphschitz et al. 1991; Bernabeu and Badal 1992; Galili et al. 1993; Badal, Bernabeu, and Vernet 1994; Liphschitz 1997; Colledge 2001; Badal 2002; Aura et al. 2005; Rodríguez-Ariza and Montes Moya 2005). The presence of an olive stone (dated to 6415–6089 B.C.) from a Mesolithic context at El Abric de la Falguera, Spain (García Puchol and Aura Tortosa, eds., 2006, 115) corroborates the idea that the species was growing spontaneously in certain places and was used by pre-Neolithic populations. The olive was a native element of the vegetation in these areas, and while the fruit might not have been extensively used, at least during the Neolithic, the wild plants were used for fuel and fodder (Badal 1999, 2002).

In mainland Greece the olive does not appear in wood charcoal samples from Neolithic sites, although most of these are located in the northern part of the country, which probably did not offer the optimum conditions for the natural growth of the species. The olive is absent from the Neolithic levels of the site of Limenaria on Thassos (Ntinou 2012), and it only appears in small numbers in LN assemblages from the Cave of the Cyclops on the island of Youra (Ntinou 2002b, 2011). In view of the information about the taxon in the archaeobotanical remains from Neolithic sites in Greece, questions concerning the native origin and use of the species remain open.

The early presence of the wild olive in Neolithic contexts in other parts of the Mediterranean contrasts with the wood charcoal results from the site of Knossos. Thus, it seems probable that the olive either was not native to Crete or did not grow in the wider area of Knossos. Moreover, even if the plant was grown locally in western Crete before EM I, as the pollen results indicate (Moody, Rackham, and Rapp 1996; Bottema and Sarpaki 2003), this activity probably did not take place at Neolithic Knossos. If it had been grown there, we would expect to find olive wood charcoal remains among the other archaeobotanical material. The pruning of olive trees would provide wood that could be used for fuel and would eventually be represented, even in small numbers, in the charcoal assemblages. Whether the species was introduced to Crete relatively late in the Neolithic as Bottema and Sarpaki (2003) postulate or was present on the island during the EN period but did not grow/was not grown in the wider area of Knossos will remain an open question until more charcoal results are available from early contexts and from different locations on the island.

Discussion

The wood charcoal data from Neolithic Knossos offer information regarding the history of Mediterranean plant formations and their use by the first settlers of the island from the Aceramic to the Late Neolithic.

The vegetation around Knossos was typically Mediterranean, presenting a mosaic of evergreen oak woodland and open xerophytic formations. The conifers associated with the vegetation of Crete, namely *Pinus brutia* and *Cupressus sempervirens*, probably grew at some distance from the site at higher altitudes. Riverine and estuarine environments were only used sporadically by the settlers of Knossos, but the existence of such habitats is documented in the charcoal results and points to the biodiversity of the area.

The wood charcoal data from Neolithic Knossos can be compared to the Holocene pollen record. The pollen record for Crete starts during the early Holocene, in pre-Neolithic times, with the pollen core from Hagia Galini (Bottema 1980) on the southern coast. This shows a relatively high pine frequency at first, after which the pine decreases rapidly and is replaced by oak as the main arboreal species. During pre-Neolithic times woodland was relatively abundant. Plants characteristic of dry open conditions such as Leguminosae, Compositae, Umbelliferae, and *Asphodelus* existed as well. The absence of wild olive pollen suggests that the olive might not have been present on Crete in early Holocene times. According to the Hagia Galini diagram (Bottema 1980), throughout the Neolithic the southern coast continued to be a mosaic of open formations and woodland dominated by deciduous oak. Other pollen types included evergreen oak and pine. These characteristics prevailed until 4300 B.C., when a decline in the woodland vegetation is documented.

Two more pollen diagrams from northwestern Crete, Delphinos and Kournas, add information concerning the Holocene vegetation of the island (Bottema and Sarpaki 2003). The percentages of nonarboreal pollen are higher than arboreal pollen until 6300 B.C., the beginning of EN I, indicating that climatic conditions were dryer and that the forest near the coast was sparser than today. Deciduous and evergreen oaks could have grown in a few places near the coast, or, alternatively, the observed arboreal pollen might represent the vegetation at higher elevations. According to Bottema and Sarpaki, the presence of central European taxa (lime, hazel, hornbeam) in these two cores, as well as in others from northwestern Crete (see below for Tersana), is due to long-distance transport.

After 6300 B.C. and during the EN I period, there is an increase in both evergreen and deciduous oaks. *Pistacia* and *Phillyrea* start forming continuous curves. The landscape included all the typical Mediterranean components. The main cause for the spread of oak forest appears to have been an increase in winter precipitation that might have brought about a shift from the previous dry conditions to the modern situation. Changes in the vegetation are observed around 5000 B.C., that is, at the end of EN I and the beginning of EN II. *Quercus* decreases slightly, Ericaceae increase, the olive appears for the first time, and indicators of crop cultivation and animal husbandry appear or increase. The indicators of human activity increase considerably after 4870 B.C., the end of EN II, and the anthropogenic impact becomes apparent in the fifth millennium.

Complementary information for the Neolithic period comes from the Tersana core in northwestern Crete, which documents the existence of mosaic vegetation of phrygana and woodland at the beginning of the Neolithic (Moody 1987; Moody, Rackham, and Rapp 1996). The woodland included Mediterranean and central European taxa, namely evergreen and deciduous oaks, lime, hazel, and hornbeam. The Central European taxa would indicate that the climate was moister than today. During the MN, ca. 4750 B.C., olive pollen that was not present earlier begins to appear in small quantities and indicates human manipulation of the local vegetation. By the LN it is abundant enough to indicate local cultivation (Rackham and Moody 1996). From this time onward the decrease in oak woodland and the increase in phrygana and steppe taxa suggest a modification of the natural plant environment due to human activities, especially land clearance for agriculture.

The pollen cores and the wood charcoal diagram from Knossos show similarities both in the components of the vegetation of successive periods and in the timing of the changes that took place in the plant formations. The different locations of the study areas may account for the discrepancies between them. The pollen cores are from western Crete, which is considerably moister and presents more microenvironments than Central Crete, where Knossos is located.

The vegetation that the first settlers of Knossos encountered around 7000 B.C. is difficult to describe in detail because of the scarcity of charcoal from the earliest occupation level. Even so, deciduous and evergreen oaks grew in proximity to the site. The arboreal pollen of the same period is composed mainly of the same species. The extraordinary presence of central European taxa is interpreted by Bottema and Sarpaki (2003) as an effect of long-distance transport during drier conditions in the first three millennia of the Holocene, while others (Moody 1987; Moody, Rackham, and Rapp 1996) interpret these taxa as evidence of moister conditions. Although the charcoal evidence cannot resolve this question, since only oaks are represented in the earliest level, it shows clearly that deciduous species grew in lowland areas and near the coast.

Later on, during the sixth millennium, the pollen cores show that the vegetation in western Crete was characterized by an expansion of woodland in which deciduous oaks played an important role. Typical Mediterranean elements, namely evergreen oaks, mock privet, and *Pistacia* expanded as well. According to the wood charcoal results, approximately at the same time in EN I and II, a typically Mediterranean woodland of evergreen oaks grew around Knossos. Woodland or more open formations are documented in the wood charcoal assemblages, and their components are the same as those found in the pollen cores. Deciduous oaks are not so important in the vegetation around Knossos, unlike the situation in western Crete. This is probably due to differences in the precipitation and topography of these two regions. Western Crete is rainier, and within a few kilometers of the coast mountain peaks rise to more than 1,000 m of altitude, a situation that favors the existence of different microclimates and microenvironments with diverse vegetation and plant formations. These conditions probably contributed to the proliferation of deciduous oak in the western parts of the island. As one moves to the east the conditions become relatively drier, perhaps accounting for the lower representation of deciduous oak in the wood charcoal diagram from Knossos. Moreover, early and continuous human presence at Knossos might also have restricted the growth of deciduous oak, especially if Neolithic farmers competed with these trees for the deeper soils of the valley bottoms.

Drier conditions around Knossos probably favored the growth of evergreen oaks and xerophytic formations. Cretan pines, cypresses, and maples might have grown in the nearby low mountains. In general terms, both the pollen cores and the charcoal diagram attest to the existence of a mosaic of woodland and open vegetation areas.

Evidence for changes in the vegetation appears and increases during the fifth millennium. In the pollen cores, the decrease of oak, the increase of Ericaceae and plants associated with farming activities, and, most importantly, the first appearance of the olive are prominent indicators of human activities that would have caused changes in the vegetation. By the end of EN II the charcoal diagram from Knossos shows similar characteristics. Evergreen oaks decrease, while strawberry trees (a member of the Ericaceae) and *Prunus* increase, probably as a result of the opening of the woodland caused by human activities. Contrary to what is observed in the pollen cores, the olive is absent from the whole Neolithic sequence of Knossos. Other indications of tree management and early arboriculture, however, may be seen in the abundance of *Prunus* sp. (almond) from the end of EN II onward, consistent with the proposed use of the olive based on the pollen evidence. Members of Rosaceae such as *Prunus* are usually absent from pollen cores because they are pollinated by insects. Their presence and abundance in the charcoal diagram might be an effect of clearance of the woodland caused by human activities and/or special treatment of these trees with an emphasis on fruit collection. Changes in the vegetation and evidence for the intensification of farming practices at Knossos occurred after more than 1,000 years of Neolithic presence at the site, when, according to all the archaeological information, the consolidation of the settlement took place.

Concerning the olive tree, the pollen record from Crete diverges from the wood charcoal results from Knossos. The earliest appearance of the olive is in the Delphinos pollen diagram, around 5000 B.C. (Bottema and Sarpaki 2003), and after approximately 4500 B.C. it shows continuous curves in all pollen cores. The Tersana pollen diagram documents the appearance and increase of olive pollen grains from the MN onward. Rackham and Moody (1996) argue that the wild olive is native to Crete, having survived glaciations in warm gorges and expanding later to the coastal areas. At Neolithic Knossos the olive is completely lacking, probably because it did not grow spontaneously in the area, nor was it deliberately grown by humans.

Wood charcoal analysis results from other Neolithic sites in Crete are not available, and therefore the data from Knossos can only be compared to relevant information from a few other coastal areas and islands in the Aegean. Information for the vegetation during the second half of the sixth millennium comes from two sites in the northern Aegean, the coastal site of Makri, Thrace, and the settlement of Limenaria on the island of Thassos (Ntinou 2002a, 2012). Both these areas are located at a long distance from Crete and at a higher latitude, which may explain the importance of deciduous oaks in their natural vegetation, contrasting with the dominance of evergreen oak woodland

and xerophytic formations at Knossos. At Makri, evergreen oaks, lentisk, strawberry tree, and other thermophilous plants are absent. On the island of Thassos all of the above-mentioned species are present, along with deciduous oaks. Farther to the south on the island of Youra, the Mesolithic hunter-gatherers used the evergreen formations with *Phillyrea*/*Rhamnus* and evergreen oaks early in the Holocene, and the same vegetation thrived during the Neolithic (Ntinou 2011). These vegetational characteristics are quite similar to the ones from Knossos and contrast with those from the northern latitudes. Thus, we can see a north–south transect along which Mediterranean deciduous formations give way to evergreen formations in response to latitude, temperature, and moisture. The present-day evergreen maquis and the shiblyak formations (associations of deciduous scrubs and short trees as a result of the degradation of oak forests) of the northern areas may be interpreted as the result of human activities that caused the substitution or modification of the Holocene deciduous woodland through the millennia. At sites in the southern latitudes such as those in the Sporades and Crete, a mosaic of evergreen oak woodland and xerophytic formations formed the natural vegetation used by the human groups, who gradually transformed the landscape through their agricultural practices.

Conclusions

Wood charcoal analysis of the Neolithic deposits at Knossos was undertaken in order to describe the local vegetation and the way it was used by the first settlers of the area. Although the small size of the excavation placed limitations on sampling and recovery of detailed paleoenvironmental information, we believe that the charcoal results for the Neolithic sequence are coherent and in agreement with other lines of paleoenvironmental evidence.

The area around the Neolithic settlement presented a variety of environments that are reflected in the identified plant taxa. A mosaic of evergreen oak woodland and open plant formations was the most common plant cover in the area and the most extensively used by Neolithic people. Deciduous oaks were a rare component, probably associated with mature evergreen woodland and growing in favorable places with deeper soils also used by Neolithic farmers. These deciduous trees were widely used in the first Aceramic settlement. Cretan pines and cypresses, characteristic species of the Cretan flora, would have grown in the nearby mountains. The riverside and saline environments were seldom used for the gathering of firewood, although the valley of the river Kairatos would have been the main area of farming activity.

Throughout the Neolithic, the Knossos settlers made use of the local vegetation for firewood. Changes relating to the density of the plant formations, especially the oak woodland, become evident by the end of the EN II period, and they should be interpreted in conjunction with the consolidation of the settlement and human activities in the area. Among other farming activities, tree management or arboriculture of the almond/*Prunus* sp. is reflected in the abundant remains of these taxa. Such activities would have been the result of a longer process involving the adoption of local resources in the diet.

It is remarkable that the olive, a typical component of the Mediterranean sclerophyllous formations, is absent from the wood charcoal of Neolithic Knossos. Without other charcoal or archaeobotanical data from relevant chronological contexts, and given the late appearance of the olive in the pollen cores from Crete, we are inclined to believe that the species did not grow and/or was not purposely grown in the area.

References

Aura, J.E., Y. Carrión, E. Estelles, and G. Pérez. 2005. "Plant Economy of Hunter-Gatherer Groups at the End of the Last Ice Age: Plant Macroremains from the Cave Santa Maira (Alacant, Spain) ca. 12,000–9000 B.P.," *Vegetation History and Archaeobotany* 14, pp. 542–550.

Badal, E. 1990. *Aportaciones de la antracología al estudio del paisaje vegetal y su evolución en el cuaternario reciente, en la costa mediterránea del País Valenciano y Andalucía (18.000–3000 B.P.)*, Ph.D. diss., Universitat de València.

———. 1992. "L'anthracologie préhistorique: À propos de certains problèmes mèthodologiques," in *Les charbons de bois, les anciens écosystèmes et le rôle de l'homme* (*Bulletin de la Société Botanique de France* 139, *Actualités botaniques* 1992 [2/3/4]), Paris, pp. 167–189.

———. 1999. "El potencial pecuario de la vegetación mediterránea: Las cuevas redil," in *Actes del II Congrés del Neolític a la Península Ibérica* (*Saguntum-PLAV* Extra 2), J. Bernabeu and T. Orozco, eds., Valencia, pp. 69–75.

———. 2002. "Bosques, campos y pastos: El potencial económico de la vegetación mediterránea," in *Neolithic Landscapes of the Mediterranean* (*Saguntum-PLAV* Extra 5), E. Badal, J. Bernabeu, and B. Martí, eds., Valencia, pp. 129–146.

Badal, E., J. Bernabeu, and J.-L. Vernet. 1994. "Vegetation Changes and Human Action from the Neolithic to the Bronze Age (7.000–4.000 B.P.) in Alicante, Based on Charcoal Analysis," *Vegetation History and Arcaeobotany* 3, pp. 155–166.

Bernabeu, J., and E. Badal. 1992. "A View of the Vegetation and Economic Explotation of the Forest in the Late Neolithic Sites of Les Jovades and Niuet (Alicante, Spain)," in *Les charbons de bois, les anciens écosystèmes et le rôle de l'homme. Colloque organisé à Montpellier du 10 au 13 septembre 1991* (*Bulletin de la Société Botanique de France* 139; *Actualités botaniques* 1992 [2/3/4]), Paris, pp. 697–714.

Bottema, S. 1980. "Palynological Investigation on Crete," *Review of Palaeobotany and Palynology* 31, pp. 193–217.

Bottema, S., and A. Sarpaki. 2003. "Environmental Change in Crete: A 9000-Year Record of Holocene Vegetation History and the Effect of the Santorini Eruption," *The Holocene* 13, pp. 733–749.

Braun-Blanquet, J. 1936. "La forêt d'yeuse languedocienne," *Memoire de la Société de Sciences Naturelles de Nîmes* 5, pp. 1–47.

Chabal, L. 1988. "Pourquoi et comment prélever les charbons de bois pour la période antique: Les méthodes utilisées sur le site de Lattes (Hérault)," *Lattara* 1, pp. 187–222.

———. 1997. *Forêts et sociétés en Languedoc (Néolithique final, Antiquité tardive): L'anthracologie, méthode et paléoécologie* (*Documents d'Archéologie Française* 63), Paris.

Chabal, L., L. Fabre, J.-F. Terral, and I. Théry-Parisot. 1999. "L'Anthracologie," in *La Botanique*, C. Bourquin-Mignot, J.-É. Brochier, L. Chabal, S. Crozat, L. Fabre, F. Guibal, P. Marinval, H. Richard, J.-F. Terral, and I. Rhéry, Paris, pp. 43–104.

Colledge, S. 2001. *Plant Exploitation on Epipalaeolithic and Early Neolithic Sites in the Levant* (*BAR-IS* 986), Oxford.

Dufraisse, A., ed., 2006. *Charcoal Analysis: New Analytical Tools and Methods for Archaeology. Papers from the Table-Ronde Held in Basel 2004* (*BAR-IS* S1483), Oxford.

Efstratiou, N., A. Karetsou, E. Banou, and D. Margomenou. 2004. "The Neolithic Settlement of Knossos: New Light on an Old Picture," in *Knossos: Palace, City, State. Proceedings of the Conference in Herakleion Organised by the British School at Athens and the 23rd Ephoreia of Prehistoric and Classical Antiquities of Heraklion, in November 2000, for the Centenary of Sir Arthur Evans's Excavations at Knossos* (*BSA Studies* 12), G. Cadogan, E. Hatzaki, and A. Vasilakis, eds., London, pp. 39–51.

Evans, J.D. 1964. "Excavations in the Neolithic Settlement of Knossos, 1957–60. Part I," *BSA* 59, pp. 132–240.

Fiorentino, G., and D. Magri, eds. 2008. *Charcoals from the Past: Cultural and Palaeoenvironmental Implications. Proceedings of the Third International Meeting of Anthracology, Cavallino, Lecce (Italy), June 28th—July 1st, 2004* (*BAR-IS* 1807), Oxford.

Galili, E., M. Weinstein-Evron, and D. Zohary. 1989. "Appearance of Olives in Submerged Neolithic Sites along the Carmel Coast," *Mitekufat Haeven* 22, pp. 95–97.

Galili, E., A. Hershkowitz, A. Gopher, M. Weinstein-Evron, O. Lernau, M. Kislev, and L. Horwitz. 1993.

"Atlit-Yam: A Prehistoric Site on the Sea Floor of the Israeli Coast," *JFA* 20, pp. 133–157.

García Puchol, O., and E. Aura Tortosa, eds. 2006. *El abric de la Falguera (Alcoi, Alacant): 8000 años de ocupación humana en la cabecera del río de Alcoi*, Alcoi.

Isaakidou, V. 2008. "The Fauna and Economy of Neolithic Knossos Revisited," in *Escaping the Labyrinth: The Cretan Neolithic in Context* (*Sheffield Studies in Aegean Archaeology* 8), V. Isaakidou and P. Tomkins, eds., Oxford, pp. 9–114.

Liphschitz, N. 1997. "Wood Remains from Two PPNB Sites: Horvat Galil and Nahal Beset," *Tel Aviv* 24, pp. 237–239.

Liphschitz, N., R. Gophna, M. Hartman, and G. Biger. 1991. "The Beginning of Olive (*Olea europaea*) Cultivation in the Old World: A Reassessment," *JAS* 18, pp. 441–453.

Moody, J. 1987. *The Environmental and Cultural Prehistory of the Khania Region of West Crete*, Ph.D. diss., University of Minnesota, Minneapolis.

Moody, J., O. Rackham, and G. Rapp. 1996. "Environmental Archaeology of Prehistoric NW Crete," *JFA* 23, pp. 273–297.

Ntinou, M. 2002a. *El paisaje en el norte de Grecia desde el Tardiglaciar al Atlantico: Formaciones vegetales, recursos y usos* (*BAR-IS* 1038), Oxford.

———. 2002b. "Vegetation and Human Communities in Prehistoric Greece," in *Neolithic Landscapes of the Mediterranean* (*Saguntum-PLAV* Extra 5), E. Badal, J. Bernabeu, and B. Martí, eds., Valencia, pp. 91–103.

———. 2011. "Charcoal Analysis at the Cave of the Cyclops, Youra, Northern Sporades," in *The Cave of the Cyclops: Mesolithic and Neolithic Networks in the Northern Aegean, Greece*. Vol. II: *Bone Tool Industries, Dietery Resources, and the Paleoenvironment and Archaeometrical Studies* (*Prehistory Monographs* 31), A. Sampson, ed., Philadelphia, pp. 297–314.

———. 2012. "Anthracological Analysis at the Neolithic Settlement of Limenaria, Thassos," in *Δέκα Χρόνια Ανασκαφικής Έρευνας στον Προϊστορικό Οικισμό Λιμεναρίων Θάσου*, S. Papadopoulos and D. Malamidou, eds., Thessaloniki, pp. 77–93.

Ozenda, P. 1982. *Les végétaux dans la biosphère*, Paris.

Quézel, P., and M. Barbéro. 1985. *Carte de la végétation potentielle de la région méditerranéenne*, Paris.

Rackham, O. 1972. "Appendix III: Charcoal and Plaster Impressions," in *Myrtos: An Early Bronze Age Settlement in Crete* (*BSA Suppl.* 7), P. Warren, London, pp. 299–304.

Rackham, O., and J. Moody. 1996. *The Making of the Cretan Landscap*e, Manchester.

Renfrew, J. 1972. "Appendix V: The Plant Remains," in *Myrtos: An Early Bronze Age Settlement in Crete* (*BSA Suppl.* 7), P. Warren, London, pp. 315–317.

Roberts, N. 1979. "The Location and Environment of Knossos," *BSA* 74, pp. 231–240.

Rodríguez-Ariza, M.O., and E. Montes Moya. 2005. "On the Origin and Domestication of *Olea europaea* L. (Olive) in Andalucia, Spain, Based on the Biogeographical Distribution of Its Finds," *Vegetation History and Archaeobotany* 14, pp. 551–561.

Schweingruber, F.H. 1990. *Anatomy of European Woods*, Bern.

Thiébault, S. 2003. "Les paysages végétaux de Chypre au néolithique: Premières données anthracologiques," in *Le Néolithique de Chypre. Actes du colloque international organisé par le Département des Antiquités de Chypre et l'École Française d'Athènes, Nicosie 17–19 mai 2001* (*BCH Suppl.* 43), J. Guilaine and A. Le Brun, eds., Athens, pp. 221–230.

Thiébault, S., ed. 2002. *Charcoal Analysis: Methodological Approaches, Palaeoecological Results and Wood Uses. Proceedings of the Second International Meeting of Anthracology, Paris, September 2000* (*BAR-IS* 1063), Oxford.

Turland, N.J., L. Chilton, and J.R. Press. 1993. *Flora of the Cretan Area*: *Annotated Checklist and Atlas*, London.

Vernet, J-L., ed. 1992. *Les charbons de bois: Les anciens écosystèmes et le rôle de l'homme. Colloque International, Montpellier du 10 au 13 septembre 1991* (*Bulletin de la Société Botanique de France* 139; *Actualité botanique* 1992-2/3/4), Paris.

Western, A.C. 1964. "Appendix 2: Timber from Neolithic Knossos, Pit F, Stratum X, Area AC, 1960," in "Excavations in the Neolithic Settlement of Knossos. Part I," J.D. Evans, *BSA* 59, pp. 240–241.

Zohary, D., and G. Orshan. 1966. *An Outline of the Geobotany of Crete* (*Israel Journal of Botany* 14, Suppl. 5), Jerusalem.