THE PALAEOETHNOBOTANY OF THE WEST HOUSE AKROTIRI, THERA

A CASE STUDY

Submitted in fulfillment of a
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Dedication

To my son,

Adonis.

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The Palaeoethnobotany of the West House: Akrotiri Thera: A Case Study

Anaya Anastasia Sarpaki

This study deals with the archaeobotany of the West House, a Late Bronze Age house at Akrotiri, on the island of Thera, Cyclades, Greece. The island is also known as Santorini.

Due to a volcanic eruption (c.1600 B.C.) which covered the whole town with ash, the settlement site of Akrotiri, has been preserved in its pristine state. This enables us to find all the storage contexts within the West House in an ash-sealed state, with absolute certainty of contemporaneity of contexts, structures and material culture. This thesis examines the results of archaeological contexts for botanical data, to provide information on agriculture, crop processing and storage. Preservation of seeds was in the form of charred, silicified, and mineralized material. Our spectrum of crops has increased with the addition of two species: cf.*Lathyrus clymenum* and *Lupinus cf.albus*, thus increasing the number of cultivated pulses known from the Late Bronze Age Aegean. Crops were *cf.Lathyrus clymenum* (a new find as a L.B.A. crop), *Lens culinaris*, *Pisum sativum*, *Hordeum vulgare*, *H.distichum*, *Triticum monococcum.* Other important crops included *Ficus carica*, *Vitis vinifera* and *Olea europaea.* A third group of possible crop plants included *Lathyrus cicera/L.sativus*, *Lupinus cf.albus*, *Vicia ervilia*, *Linum usitatissimum* and *Coriandrum sativum.* The find of crops in the latest stage just before consumption is unique for archaeobotanical material and includes split legumes, bulgur-type cracked barley, and flour. Work was also carried out on segetal and ruderal weed seeds to provide information on crop processing, field fragmentation, field contamination, and insect infestation.

Abbreviations

E.B.A.	Early Bronze Age
M.B.A.	Middle Bronze Age
L.B.A.	Late Bronze Age
E.M.	Early Minoan
M.M.	Middle Minoan
L.M.	Late Minoan
E.C.	Early Cycladic
M.C.	Middle Cycladic
L.C.	Late Cycladic
E.H.	Early Helladic
M.H.	Middle Helladic
L.H.	Late Helladic
W.H.	West House
L.	Length
B.	Breadth
T.	Thickness
L/B.	Length/breadth ratio
L/T.	Length/thickness ratio
S.E.M.	Scanning Electron Microscope

Preface

This thesis is about the palaeoethnobotany of Akrotiri on the island of Santorini, a comparatively recent name in its history. Classical authors knew the island as Thera, and it is this name that will be used when referring to the classical and prehistoric past of Santorini.

Before discussing the archaeobotanical evidence from Thera, it was felt necessary to place Thera in its wider physical and cultural context as part of the Aegean. For this reason, the first chapter presents an overview of the present environment of Greece and its islands, and the second, the evidence for environmental and climatic change in this region between the end of the last Ice Age some 10,000 years ago, and the destruction of Akrotiri in the second millennium B.C. The third chapter prefaces the archaeobotanical evidence from Akrotiri with an account of our present knowledge of prehistoric agriculture in the Aegean area, and a history of archaeobotanical research in this region. Current methodological developments in archaeobotany are also briefly reviewed, as these impinge directly upon the interpretation of the botanical data from Akrotiri itself.

The present day environment, agriculture and settlement of Santorini are discussed in chapter four, along with the evidence of what the island was like at the time of the volcanic eruption that destroyed Akrotiri (and much of Thera) in the Late Bronze Age.

Chapter five presents the archaeobotanical evidence from the recent excavations at Akrotiri, and the interpretation of this material is covered in chapter six. The study ends with a short concluding chapter which reviews what has been, and is still to be, achieved by archaeobotanical and related research into the evidence from this site.

Although this is the first systematic study of the archaeobotany of Thera, it must be regarded as only a preliminary attempt at what is undoubtedly a long-term and multi-facetted research programme. Akrotiri is unique in many ways as an archaeological site of its period. Like Pompeii, its destruction as a settlement was sudden and total, and the volcano that caused this destruction also ensured its preservation as an event frozen in time, and without the usual ravages of decay, erosion and dismantlement. As such, it gives us a unique insight into life in the Late Cycladic period. Fortunately for us, its history and importance at the time of its destruction also gives us a view of the Minoan World that a less influential site could not. As more material comes to light, we hope that the evidence from Akrotiri will continue to help us re-evaluate our understanding of not just the site itself, but of the Cycladic/Minoan world to which it belonged.

Chapter 1

The environment and agriculture of modern Greece

1.1 Introduction

Our main concern in this thesis is the island of Santorini or otherwise called Thera. It is situated in the middle of the Aegean Sea, amongst a group of islands known as the Cyclades. The present surface area of the island is 80.4 square kms. but before the L.B.A. eruption which destroyed the island and all its settlements it must have been close to 100 square kms.

In order to investigate the prehistoric agriculture of Santorini/Thera, we need to consider briefly the present environment of the Aegean. The constraints of geomorphology, drainage, climate, and soils should be assessed in order to understand the whole system of inter-relationships between what is possible within an environment, and what man has actually achieved at a given period. This interplay of the natural and the man-made environment should thus be understood, in order to be able to understand man 's decision-making as regards the variability of his agricultural systems.

1.1.1 Relief

Geologically speaking, the area has been, and still is, under much of stress. Ancient folding, probably of Carboniferous age (Palaeozoic) affected the whole area now occupied by the Balkan mountains and the Aegean Sea, and was followed by a period of comparative calm, forming what geographers term a 'mature'landscape. The final fracturing which gave shape to the present uplands and plains took place not earlier than the late Tertiary and even Quaternary period (c.7-10 million years B.P.). This fracturing and accompanying subsidence produced the Aegean Sea, and its islands, which are the fragmentary remains of a former land surface.

The Cyclades

The mountains of southern Euboea are continued through the chain of islands, i.e. Andros, Tinos, Mykonos, with Yiaros, Syros, and Delos, as the southerly fragments of this arc. Further south the mountains of Attica are continued seawards through Kea, Kythnos, Serifos, Sifnos, Amorgos, and Anaphi. Both chains are made up of very diverse material,but they are chiefly composed of ancient crystalline rocks such as marble, granite, gneiss, and schists.

Santorini - Thera

This is the most spectacular island in the Cyclades today (Fig.1.1). Together with the islets of Therasia, Aspro, and the two Kameni islands, they form the submerged crater of a volcano which is still far from extinct. It can be described as a hollow, truncated cone, which rises from an outer sandy beach of unusually regular form for the Cyclades, at first gently and afterwards more steeply, to an inner concentric rim which, though broken by large gaps, undulates between elevations of 170 and 600 m. However, I will not digress on description of the inner rim of this crater, as it is very different today from what it was before the great eruption of the L.B.A.

The outer surface of the cone, with its gradual slope, is on the whole regular, but is marked by numerous narrow and steep-sided ravines cut by erosion through the overlying pumice. At only two places is the uniformity of this outer front broken. Towards the south-east lies the rocky mass which represents the original pre-volcanic core. This was partly over-whelmed by volcanic deposits and rises to Profitis Ilias.

Along the coast on either side of the ridge are the plains, the only two on the island. They are largely covered with fertile soil washed down from the neighbouring heights. The southern plain has two small brooks, the only ones on the island, which descend from the slopes of Mt. Profitis Ilias. The narrow ravines referred to above are dry, except after rain, when they are filled with roaring torrents and carry down mud towards the coast, but few of them reach the sea. The scarcity of water today is one of the most striking features and serious problems of Thera.

The crater of Thera is a remnant of a volcano which was active since Tertiary times. Eruptions are known to have occurred in 193 B.C. (Pérrot & Chipiez 1894:142), 46 B.C., A.D. 19, 726, 1570, 165O, 1707-11, 1866-70 and in 1925-26, 1928, 1939-41, and 1950. In the eruption of 1925-26, there was a considerable time lag (c.two months) between the time when the magma welled up and the explosion of gas and ashes. Therefore, had it been similar in the past, the inhabitants could have been well aware of the events which were to follow and could have had plenty time to flee, when the need had arisen. Both the signs of the earthquake -evidence of which are visible in the present excavations- and the heating of sea water almost to boiling point, which occurred in the 1925 eruption might have happened and been recognised in the L.B.A. However, more needs to be studied on the pre-eruption topography of the island, and, although work is in progress, (McCoy,F. pers. comm.), nothing has been published so far. The conclusions, however, differ significantly from the previous suppositions about the shape of Thera before the eruption (e.g. Pichler & Friedrich 1980).

The geological stratigraphy of Thera (Fig.1.2) has been well studied. Under the L.B.A. layer of pumice and ash (Upper Pumice Series) which is up to 60-70 m. thick, there are 21 alternating pyroclastic strata totalling 35 m. in thickness (Doumas 1983:16). These rest on a 4 m. deep layer of pumice (Middle Pumice Series), dated to 37,000 B.P., which consist of dark ashes and other deposits. Lower down is the Lower Pumice Series. All three of the Pumice Series represent explosions, more or less, of the same kind and could be treated as a *terminus post quem* after which palaeosols developed, and over the Middle Pumice Series were the soils present and used by the L.B.A. farmers.

1.1.2 Water-drainage systems: the present

Due to the topography of Greece, it comes as no surprise to note that most of the major rivers have certain features in common; they are generally short and swift. The juxtaposition of uplifted areas and depressed basins, due to faulting, has given rise to many peculiarities of drainage, and abrupt bends, due to river capture, are characteristic. The presence of limestone has also caused sink-holes, underground streams, and bare waterless areas (Karst). However, here we shall only refer to the drainage system of the islands, and particularly of Thera.

The islands

Few of the islands of Greece have any rivers. The sources of water are springs, wells and cisterns which collect rain water. Even a large island like Crete has only one all-season river, the Mitropolipotamo, in the Mesara plain, the others are torrents which run after rain. The mountains, being composed mainly of limestone, have many features due to solution - caves of all sizes and shapes, unroofed, depressed, forming impassable ravines and enclosed depressions- that vary from small sink-holes to large flat-floored plains surrounded by high precipices. Examples of these circular depressions are the plain of Omalos (Levka Ori), and the plain of Lasithi.

Thera

The southern plain has two small brooks which descend from the slopes of the highest mountain, Profitis Ilias (565 m.). These are the only winter streams in the island which are filled with roaring torrents after rain and carry down much mud towards the coast, but they rarely reach the sea, as they have no water after rainy periods.

1.1.3 Climate

The Mediterranean climate and more specifically the climate in Greece is so extremely varied that no satisfactory single criterion has been found to define it. Rain falls during the months of October to April and the winters are cold and average over 4.3°C to above 10°C over much of the area during the coldest months. Frosts are infrequent along the coasts and on the islands. The summers are very hot and dry with mean temperatures over 21°C and rising to 40°C. In both north and south, an outstanding characteristic is the high amount of sunshine, averaging in the south 2,600-3,100 hours per year and in the north from 2,400-2,600 hours per year (Fellner 1951:211), with an average of over 10 hours per day during the months of June to August. This hot season, as well as the amount of sunshine, is ideal for ripening fruits of all kinds.

The overall pattern of the Greek climate is affected by the surrounding regions, and several meteorological stations have been set up (Table1.1) to monitor it. Moist air comes from the Atlantic, cold air from Central Europe and Turkey, and hot air from the Sahara. Thus, the western coasts have more rainfall than the corresponding eastern ones, while winds are many and varied and are of great importance locally to plant life. The cool 'mistral'and the 'bora'blowing from central Europe limits the extension of Mediterranean plants whilst the summer 'meltemi'winds of Greece bring down hot air from central Russia.

Temperature

Temperatures in Greece are rarely extreme except at high altitudes. Cold is modified by coastal effects, while summer heat is appeased by breezes or northerly winds (meltemia) (Table1.2). Monthly means of temperature do not vary as much as those from day to day and place to place (cf. two Athens temperatures) and even from day to night. Nevertheless, it would be safe to say that it is generally warmer in the south than in the north. Furthermore, the east of Greece suffers more extreme differences in temperature than the west, where the latter receives the cool wind from the Adriatic Sea. It is interesting to compare the monthly minima and maxima (Tables1.3 & 1.4). These variations of temperature cause great changes, and can affect agriculture beneficially, but, on the whole, should be treated as a hazardous factor when agricultural planning is concerned (see Tables1.5 & 1.6 for the highest and lowest temperature in C°).

In Greece rainfall decreases from west to east. Broadly speaking, it can be divided into 3 climatic zones:

1. western Greece with high rainfall, 800-1550 mm. precipitation, and a dry summer especially in the southwest;
2. transitional zone of central European climate in the mountainous parts of central Greece, where rain is perennial with a cold winter and a fairly warm

summer;

3. the Aegean Mediterranean zone (east Greece and coastal Macedonia/Thrace, islands) with 300-800 mm. precipitation, and a dry summer, especially in the southeast and the islands.

Wind

It is interesting to see wind direction statistics from three parts of Greece: Kythera island, Athens, and Samos, and though they belong geographically to a different area of Greece, the differences are more marked than one would expect from such a small country. One would expect that these differences would have major effects on the microclimate and consequently on the vegetation (Tables1.7, 1.8 & 1.9). At Kythera, the north and the west winds are the most prevalent. At Athens, the north-east winds are the strongest at all months, followed by a great number of calm days, while at Samos, the consistently prevalent winds are the north-west, followed also by calm days.

The summer 'meltemi'winds are also important, especially for navigation in the Cyclades, and consequently (Table1.10) have been included for the average number of days with high winds of gale force. It is interesting to note that Athens has, by far, the greatest number of days with gales (19.2 days per year) (Table1.11). This is another example of why one should be very wary of generalizations when one investigates primitive agricultural systems, where microclimate is much more relevant to agricultural produce than the regional macroclimate.

Precipitation

The importance of mountains in affecting the distribution of precipitation in Greece is very marked, for instance, the Rhodope Mountains in north Greece have very high precipitation, whilst there is a marked difference of precipitation between the drier east and the wetter west coasts where the Pindhos Mountains form the barrier (Tables1.12, 1.13 & 1.14). This east-west and north-south variation in precipitation is paralleled in the whole of the Mediterranean where the trends of rainfall decrease from west to east and north to south (Carapiperis 1960:205). However, Biel (1944:73) believes that there is no general rule as to the length of observations which will yield a reliable average. All depends upon the variability of the element under consideration which in turn depends upon the dynamics of the individual climates. He believes that approximately 80 years are necessary to secure an accuracy of ±2%. The kind of accuracy that Biel is referring to, I believe, is not needed in the present study as the minute differences of precipitation alone will not affect vegetation in any significant and detectable extent. We know that in cold climates relatively small amounts of precipitation are needed to support vegetation (i.e. the greatest forest belt, the Siberian taiga, does not receive more than 400 mm. which is comparable to the precipitation received in Athens and the Cyclades). On the other hand water requirements in warmer climates are much greater, and thus one ought to be very careful when using the terms 'arid'and 'semi-arid'when referring to rainfall alone. The duration of the dry season is four months in Greece (June to September), and it is important to bear in mind that most rainfall in Greece, and particularly those of the warmer half of the year, are short, heavy showers being swiftly followed by clear skies.

Two other climatological elements which affect vegetation are snow/frost and duration of sunshine.

Snow/frost

Throughout Greece the months of December to March are prone to snow (Table1.15). However, the areas of Greece which have the highest precipitation (i.e. Kerkyra and Zakynthos) have the lowest number of days with snow, even lower than the

Cyclades. Thucydides in his books on the Peloponessian War, mentioned that snow fell throughout the Greek mainland in most winters in the 5th century B.C. and even Attica is known to have had c. 45 cm. of snow on the ground on rare occasions (Meigs 1961:373).

Sunshine

We shall not elaborate on the 'sunshine'element of Greece (Table1.16), but as we have already mentioned it is important for the early flowering of plants and the ripening of fruits, and, therefore, affects harvesting time.

1.1.4 Greek soils

Two thirds of Greece is above c.215 m. and only one tenth of the country can be described as flat or gently undulating. The pressure, therefore, for flat land can lead to overuse of the soil. To counteract this disability, traditional Mediterranean farming practises a variety of systems to allow soil recovery, most notably alternate fallowing of arable land.

In sands, the trapping of water by colloidal action is impossible without calcium, and only very hardy plants survive into the dry part of the year on such soils. The heavy clays and silts keep their colloidal water into late spring, though the hotter weather leads to a deep arid crust in the clays by the summer. This prevents the upward migration of nutrients, water evaporation, and the parching of roots in perennials. In high summer, only the silty soils with high calcium remain moist and pliable at the surface.

South-east Greece and the Aegean islands

This area of Greece is the driest and hottest. What rainfall there is carries some nutrients down into the soil but the arid summer draws up the stored water with its load of nutrients to the surface by capillary action. Thus, an ABC (A=topsoil, B=zone of eluviation and modification and C=relatively unmodified rock material) profile does not develop but only an AC profile. The surface horizon, therefore, is very closely related to the bedrock from which it is derived. This ensures that most soils in the region are not acidic, since the main parent material is limestone, but the loss of water is damaging to the soil and any plant cover, as the surface nutrient concentration is unavailable without water transfer.

Clay formation is very low in arid climates (Bintliff 1977:90), and whenever it is formed, a dry summer destroys clay already in existence. Aridity also hampers the activity of micro-organisms which help the soil to have a good texture, aeration and nutrient retention (Anastassiades 1949:359). In the arid south-east of Greece, physical weathering predominates, and rocks are broken up and carried off, mostly by erosion, as smaller fragments. These are unable to release their minerals to plants because their weathering products remain undissolved by chemical breakdown.

One of the most important soil nutrients, nitrogen, is in very short supply in Greek soils. Normally, it would be concentrated in a humus surface layer, but humus has only slight development in Greek soils owing to the scant surface vegetation, the poverty of micro-organisms which break-down organic matter, and the slow general decomposition of organic material during the arid summer. An exception to this pattern are silts which have a strong calcium component, for they are able to break down organic material and incorporate it by colloidal action into their stored nutrients (Anastassiades 1949:359-60). In other soils of the drier parts of Greece, the low clay fraction and the limited organic component in the soil, leads to a very low exchange of cations (base exchange capacity) and, thus, the basic nutrients needed for plant growth are available in only small amounts. As we shall see later, this is especially evident on Thera.

Soil and archaeology

The interaction between the archaeologist and the soil scientist can solve only a few problems of the dating of sediments. Great care has to be exerted in the interpretation of pottery evidence from alluvial sections. Clearly, the deposition of such material can take place at some unknown time after the date of the youngest pottery. Also, for example, the great abundance of Classical sherds in alluvium could be the result of large numbers of widely distributed Classical sites rather than the sudden acceleration of erosion in post-Classical times. Broad patterns of sedimentation can be elucidated by sherd evidence, but more detailed investigations demand radio-carbon dates, and other forms of dating, especially when one is dealing with prehistoric data.

This point is clearly shown by the evidence from the Macedonian site of Sitagroi (Davidson 1980:149), occupied from c.5400-2200 B.C. In addition to an alluvium ascribed to the Younger Fill, there was an earlier alluvial phase during the 5th to the 3rd millennium B.C. Yet, the correlation of alluvial phases must be approached with great care as individual drainage basins will have varied in their alluvial histories. What was most interesting from the Sitagroi project was that it was possible to make some quantitative estimates of the extent to which the tell had been eroded since its abandonment in 2200 B.C. Measurements of the amount of remaining alluvial material indicated that the former summit area was a minimum of 0.49 ha compared with 0.25 ha today, and the former slope of the tell was at least 18° compared with 15° today. Such figures indicate the magnitude of erosion of unconsolidated material since the start of the first millennium B.C. All tells in eastern Macedonia have been very much degraded. For example, a rescue excavation by the German team was undertaken at the tell of Kastanas on the river Axios, which is being seriously eroded. This site, which was first occupied in the E.B.A. is on the floodplain of the Axios. The inference is of extensive alluvial deposits prior to the Bronze Age, but confirmation of the stratigraphy below the site must await further excavation. No evidence, however, in Macedonia is able to assist us with more precise dating of the initiation of this aggradation. It is possible that erosion of the Sitagroi tell was underway during the first millennium B.C., but any inference about general landscape erosion from this single observation would be very dangerous.

According to Davidson et al., (1976:223), the stratigraphy of a well which was found south of the site of Phylakopi on Melos (c.100 km.to west north west of Thera) indicates that the 'hillslope wash could have started in the Late Bronze Age, c.1600-1100 B.C.'. The early date was gained from a sample of organic material buried beneath 81-30 cm. of coarse hillslope deposits in a nearby valley, which was radiocarbon-dated to 2816±40 B.C. (Srr-793).

A good discussion on the interpretation of the Younger Fill is given in an article by Wagstaff (1981). The assumption in the work of both Vita-Finzi and Bintliff that the Younger Fill is synchronous and laid down in a single phase of alluviation lasting over 1000 years is overturned. Moreover, the climatic hypothesis for the aggradation is also refuted. On the contrary, it is believed that there are discrepancies in the chronology of the Younger Fill (Wagstaff 1981:253) in Greece, which might be accounted for by supposing that it was laid down in successive, discontinuous phases and the dating varied from place to place. Variations could result from differences in the location of the site studied, local topography, soil quality, vegetation, and climate, as well as from diachronic alterations in human activity (Wagstaff op.cit.).

Another complicating factor demonstrated by Wagstaff (1981:257,fig.5, see Fig.1.3) is the inter-annual variation in precipitation in Greece not only between regions but also within the same region.

Soils and agriculture

Soil fertility is affected by a number of factors, including chemical composition, particle size, moisture status, and ph. Population density and technological levels are two additional considerations which affect land use (Jarman et al.,1982:133).

Until World War II, the majority of Greek soils never received any commercial fertilizers or green manure and very little, if any, animal manure, because sheep and goat, the chief livestock, grazed most of the time on mountains, away from cultivated fields. Therefore, the only manure that agricultural land ever received until recently was a negligible amount from sheep and goat dung when grazed on stubble and fallow.

Hopkins and Bouyoucos (1922) analyzed 81 samples of soils from different parts of Greece representing nearly all of the most extensive and important soil types of the country, for the total elements of nitrogen, phosphorus, potassium, magnesium, and calcium, and also for limestone and acidity (Bouyoucos, 1922: Table 1.2:68-73). The samples were taken from fields which were used as following:

a)	grain	25
b)	grain and fallow/pasture/ idle/meadow/forage	33
c)	abandoned fields/partly abandoned	12
d)	grain and/or vines	2
e)	wasteland	4
f)	pasture	2
g)	cotton	1
h)	rice or corn	2
	TOTAL	81

These analyses showed that the soils of Greece differ greatly in fertility. Thus, nitrogen, in the ploughed soil, varies from 463 Kg. per acre to 2966 Kgs. It seems clear that most of the soils richest in nitrogen are found on mountain and piedmont slopes, while the soils poorest in nitrogen are located on plains and in the large valleys. However, most of the soils seemed either poor or very poor in nitrogen.

Only eight out of the 65 surface soils contain more than 907 Kgs. per acre of phosphorus. All of these are on mountain slopes or low mountain tops, or near the foot of mountains. Soils which have been formed from recent decomposition of limestone are either rich in phosphorus or moderately well supplied. These are found among the limestone rocks on the mountains, on some piedmont slopes and in some valley deposits washed from such mountain regions. However, most soils in Greece are poor in phosphorus. Of the five soils which contain less than 227 Kgs/acre of phosphorus, three are situated on level plains, one in a valley and one on a level ridge (Bouyoucos 1922:75). Potassium, though quite abundant in most soils, varies from 1134 Kg. to 29,020 Kgs/acre. Many soils seem to contain a large amount of magnesium, ranging from 792 to 20,767 Kgs/acre. Calcium seems to vary as well, but most Greek soils are abundantly supplied with this element.

Acid soils are scattered in many widely separated regions. They are usually found in plains, ridges, hills, or plateaux, which have lost their original supply of limestone and which cannot receive additional supplies from higher lying lands. Many soils were found to be acidic on the surface and adequately supplied with limestone at a depth of 0.9 m. and more.

Bouyoucos (1922:79) noted that plains with soils of good physical conditions were agriculturally abandoned because the new soils of the mountain slopes produced more profitable yields. Chemical examination showed that the soils of these mountain slopes are usually richer in both nitrogen and phosphorus than those of the plains. Therefore, the most primitive soils were on terraces of mountain slopes, on the sides and bottoms of small valleys between hills, ridges or mountains and in large valleys with perennial water.

Soils and arable agriculture

Soil fertility is only one of the several factors of importance for prehistoric arable farming. Jarman's (1982:133) field-work suggested that, in some cases at least, texture was more important than fertility in determining which soils were cultivated in prehistory. Generally speaking, the higher the clay content, the heavier it is, and thus the greater the force required to cultivate it. The physical difficulty of ploughing these clayey soils are combined with their poor drainage. When they are slightly damp, they offer less mechanical resistance to cultivation than when they are dry, but when they are wet, they become cohesive and sticky, and ploughing is either impossible or causes compaction. Moreover, as they retain cold winter rain and snow melt, the heavier soils are slow to warm up in spring and plant growth is delayed in relation to better drained soils. Therefore, fertility and tractability are to some extent inversely related to each other, as we know that the finer the soil particle, the more nutrients are released that could be absorbed by the plants but the other effects mentioned above counteract these benefits. Although these heavy soils are not impossible to till even with technologically simple tools, their cultivation would have been restricted to ideal weather conditions, for example little rain, no snow and so forth. Therefore, it is most unlikely that heavy loams and clayey soils were cultivated to any significant extent in prehistory. We can also assume that cultivation was restricted most of the time to light or medium-light soils (sandy and silty soils), the former being the easier to cultivate, the latter the most productive.

One can say that 'a system of agriculture is only "sensible"or "efficient "in terms of the natural environment in which it functions, the population level it supports, and the technological capability of its practitioners'(Jarman 1982:134). In Greece, due to environmental considerations, arable agriculture must be based for the most part upon autumn and winter-sown crops, as spring-sown crops receive insufficient rainfall to develop before summer drought halts plant growth. Cereal yields show a close correlation with spring rainfall, and total failure can sometimes occur in the not too infrequent years of spring drought.

Soils and crops

Cereals and in particular some primitive wheats are fairly tolerant in the range of soil conditions in which they mature, though, obviously, some soils are more productive than others. Thus, wheat will tolerate mildly acid soils, though barley prefers basic conditions (Bintliff 1977:105). Moreover, wheat does not grow well in a very low rainfall area such as the Cyclades and Crete. The rarity of wheat in these areas led, most probably, to its higher value and formed a status crop.

Broadly speaking, primitive wheats are hardy and well-adapted to both unfavourable climatic conditions and poor soils, but are low yielding compared to selectively bred yields of today (Jarman 1982:140). Percival (1979) noted that while *T.monococcum* was of poor quality, ripened late and had a low yield, compared to modern hexaploid wheats, it resisted frost and rust diseases better. Its awns and thick glumes also protected it from bird predation and it could be grown without manure on poor sandy, chalky, and rocky soils where higher quality wheats failed. *Hexaploid wheats* such as *T.aestivum* (bread wheat) are more productive than the previously mentioned wheat, but have the disadvantage of depleting soil nutrients at a greater rate, while *T.compactum* (club wheat) has a tolerance for cold and wet growing conditions. On the whole though, cereal crops, and especially wheat, are expensive in terms of their nitrogen requirements.

Barley is the most dependable cereal under a wide range of adverse conditions, and has a high productivity in good years. In general, under similar conditions, yields of barley are higher than wheat (Arnon 1972,Vol.II:89). However, wheat and barley do not generally prosper where annual rainfall exceeds 900 mm. (Jarman 1982:120), and are particularly susceptible to lodging on waterlogged ground. However, barley becomes more important than wheat as rainfall diminishes (Oram 1956:5), especially as its ripening period is shorter than wheat and therefore could be threshed before wheat and before the great heat of summer (especially applicable for the Mediterranean). Its greater tolerance to drought is a case in point when, during the drought year of 1870, barley roots went to a depth of 135 cm. at Rothamsted (Batey & Davies 1971:106), whilst in wheat 60% of the root is found in the upper c.30 cm. of soil and only occasionally some roots penetrate to c.100-150 cm. (Percival 1974:38).

Legumes seem to have been very important in the prehistoric diet and would have had the ability to restore nitrogen to a 'tired'soil. Had the legumes been pulled out by the roots, as was normally done before World War II, then the soil would have derived practically no benefit from them in the way of nitrogen enrichment. There are, however, growing on most of the agricultural land, different kinds of wild annual legumes, and, probably, the soils receive some nitrogen from these (Bouyoucos 1922:67). In poorly structured soils, legumes and peas respond to fertilizer nitrogen (Low 1973:256). The latter are quite sensitive to soil structural conditions. Peas, in particular, require a minimum precipitation of 300 mm. of rain and a light-to-medium soil with a high calcium content is desirable which means that neither sandy nor clay soils are chosen (Arnon 1972,II:232). Lentils are also not very hardy. They can be fairly heat resistant but they are grown exclusively on light-to-medium, well drained soils as they can suffer from excess soil moisture (Arnon 1972,II:239). *Lathyrus sativus* (grass pea) though is one of the hardiest legumes as it is drought-resistant and withstands waterlogging, totally contrary to lupins (*Lupinus sp.*) which are very sensitive to soil conditions such as texture, structure, moisture and particularly calcium content. They require a slightly acid soil, a ph of 5-6 as optimal for calcium-rich soils, otherwise the growth eventually slows down (Arnon 1972,II:242), but they are not sensitive to soil fertility.

Olives have been shown by agronomists to grow best on calcareous soils (basic calcium soils). They are also found on non-calcic soils but in no great density. On the clayey leached Older Fill that forms a common part of most Greek plains, olive trees are very scattered or absent.

Both vines and olives can survive the summer dry season and are harvested in the autumn and early winter. Because of their tolerance of relatively infertile soil, they can be cultivated in marginal areas and could occupy the poorer arable soils. Large scale olive and vine production is of interest in Greece and the latter especially in Santorini, as it represents a way of extracting a cultivated crop from areas unsuited to cereals and which would have been given over to rough grazing. This is due to their deep rooting systems and tolerance of poor and stony soils.

1.1.5 Plant communities

In the Balkan peninsula, Turrill (1929) divided plant-forms according to their life-form into five distinct categories:

	Category	Species
a)	trees	114
b)	shrubs	443
c)	perennial herbs	4181
d)	biennial herbs	481
e)	annuals	1486

The numbers and distribution of species in each area of Greece are shown in Fig.1.4. Although these numbers should be treated as approximate, for several more species have been discovered since, and more probably await discovery, the general trends must be correct and it is interesting to note that the most numerous species are perennial herbs followed by annuals. Biennials and shrubs are close in numbers, while trees are the least numerous. His study of flowering periods is also very interesting where we noted that the month of June is the period with most flowers (3,481), followed closely by July (3,401) and the months with the least flowers are

December (49) and January (59). He also noted (Turrill 1929) that the largest number of monocotyledons are in flower in June and dicotyledons in July.

The richness of the Mediterranean flora is due in part to the great variations in climate and habitat and also to its early history. The last Ice age which eliminated most of the north-west European species as recently as 10,000 B.P. did not have such an effect on Mediterranean species. There must have been plenty of scattered pockets where temperate plants could survive. Thus, there exist many 'old'species which survived the Ice ages from Tertiary times such as the carob *Ceratonia siliqua L.*, myrtle *Myrtus communis L.*, vine *Vitis sylvestris*, oleander *Nerium oleander L.*, plane *Platanus orientalis L.*, wild olive *Olea europaea ssp.oleaster*, lentisk *Pistacia lentiscus*, and the judas tree *Cercis siliquastrum L.*.

The Mediterranean flora is also rich in endemic species. Isolated species on islands or mountain tops have developed along different lines from their relatives on the mainland, and as they remained separated have developed quite distinct characteristics. Thus, peninsular Greece (excluding Macedonia) has 323 endemic species, Crete 131, Cyprus 69, the Athos peninsula 16 and Mt.Olympus 16, and they are continuously being discovered (Polunin & Huxley 1972:5) (Fig 1.4).

It is impossible in this study to go into intricate detail about the various habitats of plants in Greece. Even the fairly general classification of Turrill (1929:105) into 16 habitats is too detailed for the present study, although very useful. Here we will deal with the four very broad plant communities encountered:

1. evergreen forests (also named sclerophyllous forest);
2. maquis;
3. pseudomaquis;
4. garrigue (named 'phrygana'in Greece).

The climax plant community in a Mediterranean climate is a forest of evergreen trees with leathery leaves. Degradation of the forest, due mainly to man, follows the path shown below:

Evergreen forest—¿ maquis —¿ garrigue —¿ steppe
(see Fig 1.5, Polunin & Huxley 1972:7).

Altitude zonation of vegetation

The true Mediterranean vegetation of evergreen forests forms a broad or narrow zone around the Mediterranean littoral. In open and sunny valleys, it may penetrate inland or cover the whole of a peninsula such as the Peloponnese, or an island like Crete. The altitude range of the evergreen forest may reach 500 m. or more depending on the local climate.

Above the evergreen forest lies a deciduous forest zone of deciduous oaks *Quercus sp.*, ash *Fraxinus sp.*, hornbeam *Carpinus sp.*, sweet chestnut *Castanea sp.*, beech *Fagus sp.*, from altitudes of 800-1,800 m. and above there is a sub-alpine coniferous forest zone of silver fir *Abies sp.*, pines *Pinus sp.*, and in certain places cedar *Cedrus sp.*.

Evergreen forests

Only 15% of Greece is officially classified as forested (Pepelasis & Thompson 1960:148) although Semple (1931:282) put the figure at 9.3%. In the Mediterranean, the forests are defined by the distribution of the following species:

1)	wild olive	*Olea europaea L.ssp.oleaster*
2)	holm oak	*Quercus ilex L.*
3)	kermes oak	*Quercus coccifera L.*
4)	wild carob	*Ceratonia siliqua L.*
5)	poplar	*Populus sp.*
6)	laurel	*Laurus nobilis L.*
7)	pine	*Pinus sp.*
8)	aleppo pine	*Pinus halepensis L.*
9)	cypress	*Cypressus sp.*

The wild olive will not tolerate an average temperature below 3°C during the coldest winter months but could grow to altitudes of 600-800 m., while the second *Q.ilex* can tolerate an annual rainfall as low as 380 mm. and up to 4 months of drought, but neither form forests except in Crete and in the Peloponnese (Polunin & Huxley 1972:8). In particular, in the Hellenistic and Roman period a considerable oak forest near the town of Yithion in the Mani was removed (Wagstaff 1967:259). However, whenever one sees any two or more of these species growing together one can be reasonably certain one is within a Mediterranean climate zone. The distribution of small fragmentary stands of forest in Crete (Zohary & Orsham 1966:42) testify to former continuous forest areas. The trees that remained are the ones which withstood fire, axe and erosion, and regenerate vigorously, while less resistant trees have no doubt vanished.

The Aleppo pine *Pinus halepensis Mill.* forests dominate large areas of the warmer regions of the Mediterranean. They form the climax community particularly on limestone and on littoral sands. Dense forests are rare and they are usually scattered trees with a thick layer of maquis. Since the pine is unable to regenerate in the maquis owing to lack of light, such woodlands can regenerate only after forest fires (Walter 1973:119). Sometimes more open and degraded forests may have many plants of the garrique with low bushes of Lavander *Lavandula stoechas L.*, Rosemary *Rosmarinus officinalis L.*, Thyme *Thymus sp.*, Rock rose *Cistus sp.*, and herbaceous species in the more open places.

Stone or Umbrella pine woods *Pinus pinea L.* have a wide distribution but are restricted to the sands and dunes of the littoral and have undergrowth of Phoenician Juniper *Juniperus phoenicea L.*, lentisk *Pistacia lentiscus L.*, Spanish broom *Spartium junceum L.*, Rosemary *Rosmarinus officinalis L.*, *Phillyrea*, *Cistus sp.*, and so forth.

Cypress and laurel woods are generally made up of scattered trees with an undergrowth of evergreen and deciduous shrubs and woolly-leaved members of the garrigue. They occur among others in Crete, Rhodes, Cyprus.

Maquis

Maquis (or macchie) is a very characteristic type of Mediterranean plant community. About 18% of Greece consists of this type of vegetation (Pepelasis & Thompson 1960:148). It forms very dense and sometimes impenetrable thickets of tall shrubs, 2 m. or higher. In spring the hills are brightened by the pink and white of the Rock Roses, the yellows of the brooms, and white to purple flowers of the heathers.

It is not always possible to know, whether the maquis is a climax vegetation. In some cases it probably is, and is consequently known as 'primary maquis'but in most cases it is undoubtedly the result of man's activity on the 'primaeval'evergreen forest, and is, therefore, called 'secondary maquis'.

High maquis includes vegetation as high as 4-5 m. and could include the: Strawberry Tree *Arbutus unedo L.*, Eastern strawberry tree *Arbutus andrachne L.*, Holm and Kermes oaks *Q.ilex L.*, *Q.coccifera L.*, Phoenician Juniper *Juniperus phoenicea L.* Judas Tree *Cercis siliquastrum L.*, Olive *Olea sp.*, Aleppo Pine *Pinus halepensis*, Myrtle *Myrtus communis L.*, Tree Heather *Erica arborea L.*, Wig Tree *Cotinus coggygria Scop.*, *Phillyrea media*, and Spanish broom *Spartium junceum L.*. There are several gradations between this and low maquis where bushes are 1.5-2 m. high and there are no tree-forming species. The common species are: Lentisk *Pistacia Lentiscus L.*, *Phillyrea media*, Rosemary *Rosmarinus officinalis L.*, Jerusalem sage *Phlomis fruticosa L.*, Butcher's Broom *Ruscus aculeatus L.*, heathers *Erica sp.*, Christ's thorn *Paliurus spina-christi*, rock roses *Cistus salviaefolius*, *C.monspeliensis*, and *C.villosus*. In open patches many herbaceous perennials grow, including bulbous, tuberous plants, and annuals.

The 'low macquis'is otherwise named 'cistus maquis'and is very widespread in hot dry localities where *Cistus villosus* is the dominant species. It can stand very heavy grazing and often develops on abandoned cultivated areas.

The mixed lentisk-carob-myrtle maquis has many variations and occurs on hot dry lower hills and coastal regions. It contains Spiny Broom, Terebinth *Pistacia terebinthus L.*, common thorn *Rhamnus alaternus*, Kermes oak *Q. coccifera*, and Hawthorn *Ruscus aculeatus L.*. With excessive cutting and grazing it may be reduced to rounded scattered bushes which harbour many herbaceous species. Another type of maquis worth mentioning is the pseudomaquis.

Pseudomaquis

The 'Pseudomaquis'is a xerophyllous evergreen brushwood which inhabits submontane and montane regions (Turrill 1929:151). As it can withstand lower temperatures and a shorter growing season, it can extend farther north, farther inland, and to higher altitudes than maquis. One species is often dominant (cf. maquis which is floristically a mixed community) over a wide area but the dominant species varies. The species are: *Juniperus excelsa Bieb.*, *Q.macedonica*, *Buxus sempervirens L.*, *Prunus laurocerasus L.*, *Pistacia terebinthus*, and *Jasminum fructicans L.*. The dominant species are: junipers *Juniperus oxycedrus L.*, *J.drupacea L.*, (only in Greece and Thessaly), and the Kermes oak *Q.coccifera L.*. Pseudomaquis is not a degenerate form of maquis but are brushwoods of evergreen species.

Garrigue or Phrygana

Phrygana was the name given to a further vegetational stage of degeneration by Theophrastus. It is easily distinguished by its low scattered xerophytic bushes, rarely exceeding 50 cm. in height, and it is the most widespread type of vegetation in Greece. It is a vegetational zone developed a stage further after fires and intensive pasture (Debazac & Mavrommatis 1971:443). The name itself comes from an ancient Greek verb 'phrygo', to burn, which confirms the use made of these bushes by the ancient Greeks. On Thera and other south Aegean islands, phrygana is the dominating vegetational type on uncultivated ground.

The species inhabiting the phrygana are very numerous, and their main distribution coincides with the driest part of Greece. There are woody and herbaceous perennials, biennials, and annuals, in abundance, for example the Attic phrygana has over 200 different species (Turrill 1929:152). Typical plants are: *Corydothymus capitatus, Satureia thymbra, Anthyllis hermaniae, Thymelaea tartonraira, T.hirsuta, Genista acanthoclados, Euphorbia acanthothamnos, Hypericum empetrifolium, Phlomis fructicosa*, and some maquis shrubs such as *Q.coccifera* and *Cistus sp.*. Altitude, on the other hand, is not a limiting factor and phrygana could be found up to altitudes of 800 m. and sometimes even higher (Economidou 1976:48). It seems to have even invaded habitats of the sublitoral flora (Runemark 1969:128). However, in the central Aegean and particularly on small islands, it may represent the natural vegetation on dry habitats (Runemark 1969:98) (cf. section on past vegetation), while on the larger islands like Naxos, Andros and Kea, the phrygana has been greatly extended as a result of human activity. On the latter islands, small patches of forest still exists, *Q.coccifera L.* mainly and *Pinus halepensis Willd.*.

In Crete it is believed (Zohary & Orsham 1966:4) that the present phrygana consists of residual populations which gained high survival value from their antipastoral properties. The predominance of *Euphorbia characias, E. acanthoclados*, species of *Phlomis*, and many other *Labiatae*, as well as some thorny species of *Poterium*, *Cytisus*, *Anthyllis*, *Genista*, *Calycotome*, and *Ononis* is the result of a change in vegetation caused by excessive and very long lasting grazing (Fig.1.6).

Conclusions on the flora

The richness of floristic species (over 6,000 species) in the Balkans is due, as mentioned above, to geological factors and the refuge of plants to areas which were not covered in snow in the Pleistocene. Furthermore, this is an extra factor, which makes the study of Mediterranean and Balkan flora in particular, more difficult, as new species are being added to this list.

However, there are mainly two climatic constraints that affect Mediterranean plant life, these are summer drought and winter cold stress (Mitrakos 1980:245), and these opposing variables never occur in the same areas in Greece (Mitrakos 1980:249).

1.1.6 Present-day agricultural systems

It is important to understand present-day agricultural systems of Greece in order to interpret the palaeoethnobotanical evidence of Akrotiri. We need not imply, of course, that past agricultural systems had to be the same in all their details as today's, but a knowledge of current agricultural systems, enables us to formulate hypotheses about prehistoric ones.

Greece is a land of small family holdings which have been perpetuated by the rule of inheritance. Each child, whether male or female, inherits his/her share of the parents'land. Even the measure of land, the stremma (1 stremma = 0.1 hectare or 0.247 acres), brings out this intricate system of very small plots. In Greece, 81% of the farms are less than 5 hectares, and understandably land, especially these small holdings, is laboured exclusively by the members of the family, men, women, and older children.

Medium-sized farms are absent in Greece and in those farms where tenancy exists, and tenancy seems to have increased enormously since rural depopulation and increased urbanization, the prevailing method of payment is by share-cropping rather than cash rents.

Greece, is a land of small farms, with an agricultural economy, although not more than 22.2% of the land is under cultivation, (Fellner 1951:211) or 25% according to other sources (Newmeyer 1947:85). In 1939, wheat occupied 42% of the arable area. The other cereals, barley, oats, rye, maize, rice and a mixture of wheat and barley or wheat and rye occupied a further 32%.

Dry-farming is one of the dominant types of farming in the Mediterranean and particularly in Greece. Even cereal crops are grown under such a system together with vines and olive trees. Vegetables, some of which are also grown by dry-farming, account for 28% of the Greek farm income (Grigg 1974:127). This justifies scholars who claim that in the Mediterranean 'the garden rather than the field is the focus of the farmer's attention'(Grigg op. cit.).

Crops

The most important products of Greek agriculture and occupying 74% of land are cereal crops, namely, wheat, barley, rye, oats, maize, and rice.

The total area of leguminous or forage crops is only 11% of the total cultivated area (Fellner 1951:211), a handicap when soils are poor and rotation is the only way of replenishing crop nutrients. On Thera at present, they account for only 7% of the crops grown. However, see Table 1.17 for data on the cultivated area of Santorini and the area devoted to each crop.

Olive and vine production

In a good harvest year, the amount of olives produced per tree would be:

a)	large mature tree	50 kg.
b)	a medium tree (30-50 years old)	15-20 kg.
c)	a small tree (15-30 years old)	7-15 kg.

These yields would be approximately halved in bad years, which normally occur every second year. In the press, 4-6 kg. of fruit produce 1 kg. of oil, but this ratio varies according to the variety of olive. The percentage of fruit to oil can vary between 28% of oil down to 10% depending on the variety and the year (Pondikis 1981). Most farmers claim that a greater yield is produced from trees that are pruned regularly, once or more very 5 years. Pruning can probably be traced back to Minoan times (Melena 1983:104), and at Myrtos abundant findings of olive wood were attributed to intensive pruning (Rackham 1972:295). In the old days, even the fruit of the wild olive was exploited, for it provided soap oil (Forbes 1976:131). It could also provide as much as 10-20% oil and the kernels could be used for fuel. The olive grows well on rocky soil (Wagstaff 1965:277) and because of the summer aridity it yields some of the finest oil in the world. Together with the laurel, (*Laurus nobilis*), it belongs to a highly resistant group of plants that retain their leaves for a long time without a water supply and are thus highly drought-resistant (Oppenheimer 1960:130). As regards the spacing required, modern evidence concerning Crete supports a mean of 15-18 trees per stremma, or about 150-180 trees per hectare. Whilst the annual intake per person in modern Greece is 80 litres (van Leuven 1980:130), although others (Forbes & Foxhall 1978:46) suggest a lower figure of about 50 litres.

Viticulture in Greece in 1939 occupied 7% of arable land or about 590,799 acres (Caldis & Roy 1947:125). In 1916, the grape yield of vines was 1220 Kg.per hectare (10 stremmata) in Greece (Wagstaff & Gamble 1982:174) but grapes are relatively unimportant in the modern Greek diet. However, in Santorini the situation is reversed whereby vines occupy approximately 30% of cultivated area and are grown as a cash crop. In Santorini in the end of the 18th century, they already manufactured very good wine, which was exported to Russia. And yearly, they had a production of c. 1,000,000 okades of wine (where 1 oka=1.280 Kg.) which would be equivalent to c. 1,280,000 Kg. of wine (Logothetis 1977:33). The yield in Crete in 1948 was c. 5,000 Kg. of unprocessed grapes per ha and the production of 1 litre of wine requires some 1.5 Kg. of grapes (Wagstaff & Augustson 1982:129). Therefore, on Santorini in order to produce c. 1,280,000 Kgs. of wine, c. 1,920,000 Kgs. of grapes were necessary, which was requiring c. 384 ha of land to be planted with vines. In the 1960's Santorini cultivated c. 25,000 stremmata (2,500 ha) of vines of various cultivar subspecies. The commonest (65-70%) was devoted to the 'asyrtiko'which is resistant to iodine and 'peronosporos'and has also a great deal of tannine (Logothetis 1980:235).

The usage of Greek grapes in 1938:

Major use	Area (acres) 1938	Production(Tons)
currants	161,855	150,135
raisins	35,059	32,078
wine	389,110	463,577
Table grapes	51,252	150,728

Fruits and nuts

Other fruits include oranges, lemons, tangerines, bitter oranges, pears, apples, cherries, sour cherries, bananas, figs, pomegranates, almonds, walnuts, pistachios, chestnuts, and carobs. Olive and citrus trees were usually inter-planted with cereals, edible legumes and tomatoes (Caldis & Roy 1947:129).

The principal industrial crops in 1938 were tobacco and cotton which occupied only 3.7 and 3.0% of arable land respectively.

Traditional mixed farming

In this type of farming, field crops are grown in balance with tree crops. Vines generally play a secondary role, although on Thera it is of primary importance, and there is no grazing land on the farm. In Messenia (van Wersch 1969:133) field crops consisted of fodder crops (vetch, lupine, alfalfa, oats), winter vegetables (potatoes, cabbage, onions, etc.), food grain (wheat and barley) and edible pulses including beans and lentils. Among tree crops, olive trees were the most important, followed by figs, apricots, peaches and various nut trees. About half of the olive and fig trees and a large majority of the other trees were not grown in regular orchards but were scattered throughout the fields. Where olives were present, one often found them inter-cultivated with winter crops.

This is a semi-subsistence type of farming where cash income would derive from olive-oil, currants, dried figs and vegetables, while the other crops would be for household and livestock consumption. This type of land use system is found in most parts of Greece with the exception of mountainous areas where animal husbandry is of primary importance and those areas of predominant specialization like the plains of Thessaly and Macedonia.

Land preparation

In Classical antiquity repeated ploughing of fallow land was recommended, and three ploughings seem to have been standard (Forbes 1976:9). The purpose must have been to ensure that land retained as much moisture as possible, as well as to eradicate weeds before they flowered. It is important to clarify the type of fallow, for there are three main types:

1. *Uncultivated fallow* which has been mostly proved to be detrimental to soils of arid regions like Greece;
2. *Worked fallow* where the soil is cultivated between one cereal crop and the next;
3. *Summer fallow* which seems to be the most popular in Greece, especially in the Cyclades.

It is revealing to note the order of economic return from rotations (Oram 1956:21 and see Table1.18).

Currently fallow land is generally not ploughed as it is an important grazing resource for sheep, goats, and draft animals. Stubble grazing represents 16-21% of the total fodder supply (Oram 1956:1). Also, animals grazing on fallow leave their droppings to fertilize the ground. This seems to be more beneficial than the harm done to the soil by sheep treading, which can be very deleterious to soil and vegetation alike (Witschi & Michalk 1979:741). However, some believe that by ploughing fallow land, weeds would be reduced and moisture retention encouraged. By exterminating the weeds before seeding, the farmer would have reduced the amount of weed growth in the following year. However, different weed species have varying responses to fallowing, because of their variation in the period of dormancy (Brenchley, 1940:128). This can range between 4-9 years for most species but for *Aethusa cynapium*, *Anagallis arvensis*, *Medicago lupulina*, and *Polygonum aviculare*, the period may exceed 10 years (idem:134). Recently, on Methana, Forbes (1976:11) saw a number of women out in the fields weeding the wheat by hand, a long and tedious job. However, from experiments conducted in Minnesota (Robinson 1949:517), crops with moderate infestations of annual weeds sometimes yielded more than crops grown under weed free conditions. This could be due to creating a more aerated soil and hence greater soil moisture content. As the subject is inconclusive at the moment, more experiments need to be conducted on that matter, especially in the Mediterranean.

In Methana, a single ploughing suffices for cereal crops, as the main growth occurs in winter and spring, while for the preparation of the ground for summer dry-farmed vegetables, three ploughings seem to be necessary, starting in late winter (generally late January or February). The ground is ploughed and the lumps of earth are broken up using a harrow made from a board on which the farmer stands or places rocks for added weight. This is done three times (alternate ploughing and harrowing) with a final ploughing and harrowing immediately before the sowing of the crop, sometime in mid to late April, depending on the weather. This produces finely broken soil, four to six inches in depth. The seeds are sown in shallow pits, roughly one pace apart with a pint or so of water poured into each pit before sowing the seed. When the plants have sprung up, they are given another pint or so of water. This is the only watering the plants receive.

Rotation

Until the early 1950's cereals tended to be cropped continuously, and crop rotation was in evidence to only a minor degree (Fellner 1951:211). As we have seen cereals occupied 74% of land as bread is the staple of Greek diet, while legumes and forage crops occupied only 11%. In later years cotton also played an important role.

In the villages of Aithaia, Exochorion, Kalochorion, and Phinikous, in Messenia, where cereals occupied 27.1% of arable land, and pulses and fodder crops 8.5% (van Wersch 1969:131), the pattern mentioned above seems to be very similar in that very few legumes are available for crop-rotation. When crop rotation is available, sometimes simple biennial sequences are applied, and triennial rotations are rare. The most common rotations in dry land farming in Messenia were:

- wheat/fallow
- fodder crop (vetch, lupine, alfalfa, oats)/fallow)

- feed-grain (wheat and barley)/hay crop)
- fodder-crop/wheat
- wheat/pulse
- and pulse/fallow

A few cases of wheat/fodder-crop/fallow were found and several triennial rotations including:

- wheat/feed grain/hay
- peas/fodder-crop/peas
- wheat/fallow/vegetables

The same rotations are practised wherever tree crops are inter-cultivated with dry field crops. Rotations on irrigated fields are usually more complex, including:

- clover/tomatoes/melons/maize;
- and irrigated pasture/maize/vegetables.

No less than 30% of all arable land was being fallowed in 1950 in Greece (Pepelasis & Thompson 1960:149), although it has been shown from reports from Cyprus and Greece that fallow offers little or no advantage for moisture conservation where annual rainfall exceeds 500 mm. (Oram 1956:11). Experiments have also indicated that, under conditions of extreme aridity, around 300mm., there is no effective carry-over of moisture from year to year, and crops depend entirely on the rainfall of the current year (Oram 1956:12). Furthermore it was claimed in the past that uncultivated fallow could be detrimental to the structure of light soils by exposing them to wind and sun. Some investigations in Greece, in a clay soil with a rainfall of 550 mm., gave the following results (Oram 1956:14):

1. Comparison of ploughing to 35 cm. with ploughing to 10 cm. and subsoiling to 55 cm. showed no significant difference in either soil moisture or yield of wheat.

2. Comparison of ploughing fallow in autumn or in spring showed no significant differences in yield of wheat (9.6 and 9.62 quintals per hectare) (960-962 Kgs. per hectare/ 96 Kgs. per stremma).

3. Comparison of ploughing stubble in July, November, or March showed no significant differences in yield (20.1, 19.4, and 19.6 quintals per hectare) (201, 194, and 196 Kgs. per stremma)

4. Comparison of ploughing to 18 cm. in autumn or to 12 cm. in spring showed no significant differences in yield (20.1 and 19.6 quintals per hectare) (201 & 196 Kgs. per stremma).

In Israel, on the other hand, it was noted that the effect of annual legumes harvested for forage on the succeeding crop of cereal was more beneficial than that of fallow (Oram 1956:15). In Greece, experiments on the effects of rotation and fertilizers on wheat yields have been conducted (see Tables1.19 & 1.20, after Oram 1956:16) and it seems reasonable that in Greece an autumn-sown forage crop cut in good time and followed by spring ploughing and summer fallow, does not reduce cereal yields and may help to reduce the cost of cereal production (for rainfall zones 300-600 mm.) (Oram 1956:17). The value of leguminous species grown in rotation with cereals is apparent, though it seems that the effect of legumes on cereals still seems to depend on the way in which the legumes are harvested (Oram 1956:23).

In the mountainous region of Mani, in the Peloponnese, wheat was grown in tiny patches of cleared ground on a two year rotation which included beans and/ or lupins and/ or fallow. Lupins were important in the region and have been called 'the grapes of Mani'because they flourished under adverse conditions, with an annual precipitation of c.400 mm., and were a safeguard against starvation when the wheat crop failed (Wagstaff 1965:277).

Dry-farming is believed by some (Grigg 1974:21) to have developed in the Aegean by the first millennium B.C., and although there is a shortage of data it is believed to have been practised much earlier. Palaeoethnobotany, as well as soil studies, will have a lot to say on that matter.

It is believed (Grigg 1974:133) that well before the first centuries of the Christian era, the basic features of traditional Mediterranean agriculture were well established. The ard or scratch plough was used to cross-plough, and the fallow was worked 2-3 times. Wheat and barley were main crops, invariably grown with a fallow, due to the fact that cereals deplete the soil of nutrients and the fallow year helps to convert nutrients to an available form and/or conserves them for the succeeding crop. Wheat grown after fallow should yield twice as much as wheat following wheat (Staple 1960:205). Yet, the strongest deterrent to the use of fallow has been severe winds and water erosion. In winter rainfall areas, fallow can be replaced by crop rotations with grasses and legumes (Staple 1960:212). In Cyprus, it has been observed (Loizides 1949:213, 214) that ammonia, nitrate, nitrogen, and phosphorus content is greater after fallow than on stubble or after cropping.

Manure

Only 3.7% of cultivated acreage, received animal manure in 1950 (Pepelasis & Thompson 1960:149), and 13% of cultivated acreage received chemical fertilizers. It was calculated that 9 million tons of manure was produced, which corresponds to 765 Kgs. per year per acre of arable land, a very small amount (Caldis 1947:135). In effect, this reduces the already inadequate arable area. However, chemical and organic manuring, affects the weed flora quantitatively and qualitatively. A list of the association of weeds with specific manures was tabulated by Brenchley (1940:136), and it was interesting to note that dung did not increase the weed flora but weeds were affected positively by other chemical manures, i.e. the greatest encouragement was offered by a combination of minerals and nitrogen presented as sulphate of ammonia (idem:135). Yet, as we have seen, livestock is limited in number due to the vegetation, and as technological advances influence the spread of agriculture, they also have spatial constraints. Manure in Greece was also used as fuel, although it was found that people were very reluctant to speak on this subject.

Burning

Burning is used at present as a management tool and wheat farmers all over Greece consider stubble burning a good technique for increasing wheat production (Liacos 1974:72). Shepherds also use burning in many districts for range improvement especially in annual species of plants, and more specifically grasses (Gramineae). The farmers specifically observed the following after burning:

1. Ploughing of the field and soil preparation for reseeding was much easier and secured better germination of seeds and better development of seedlings.
2. Wheat seedlings showed no chlorotic (i.e. absence of green pigments in plants owing to lack of light or magnesium or iron) phenomena in spring as is the case when no burning was applied,
3. The season following stubble burning, insect and disease attacks were reduced.
4. Weeds were less abundant in season after stubble burning.

Shepherds use burning every four to five years to control undesirable invaders and weeds and they have noticed the following:

1. It controls weeds and other undesirable plants.

2. It stimulates the growth of dormant plants and provides green forage in small quantities, when vegetation is completely dry.

3. It secures a relatively higher quantity of forage for at least the next 2 years.

Liacos (1974:87) conducted some experiments in burning *Pinus halepensis* forests, and found that after a fire, orchard grass *Dactylis glomerata* became established. Legumes also colonised the soil to a satisfactory degree. The main species were: *Festuca ovina*, *Aristella bromoides*, *Andropogon ischaemum*, *Koeleria cristata*, *Phleum ssp.*, *Trifolium purpureum*, *T.angustifolium L.*, *T.arvense*, *Vicia ssp.*, and *Poterium sanguisorba*.

Human labour

In 1960, the available farm land in the north of Greece was estimated to require 86.9 million 'man productive days'in the busiest three months of the year, while 84.7 million was available, a deficiency of 2.6%. These calculations assumed a working year of only 255 days, and omitted males below 19 and over 65 (females were included in the count). The resulting estimate indicated something very close to full employment (Clark & Haswell 1967:145), but a slight shortage of labour at the peak period (idem:148).

Women play an important role in Greek agriculture. It had been calculated (Table1.22) that 38% of able-bodied women were occupied in domestic work, and the remainder was available for farm work. In the busy summer months women defer a certain amount of domestic work until the winter. Children work 16 hours in May, 18 hours in June, 36 hours in July, 50 hours in August, and 22 hours in September. Sundays and public holidays are excluded, and 5 hours per day is considered possible in the winter months, and 12 hours a day in the summer months. On the other hand, we have very different estimates from Messinia (van Wersch 1969:75) where labour requirements for major land use categories estimated in 1966 are shown in Table 1.22. There the average farm size (van Wersch 1969:100) was 2.9 ha.(29 stremmata) (cf. 3.5 ha. per man in the north of Greece), much smaller than the approximate size of 14.0 ha in the north of Greece, if one estimates four people to a family. At Thera, it was calculated (Economic and Social Atlas 1964, map 302) at 4.92-6.72 stremmata per head which would make 20-27 stremmata to a family. However, if farmers in the north of Greece owned 3.5 ha per adult head, which meant employment for 255 days per head, the smaller farms of 2.9 ha per family must have demanded approximately 1/4 of the work, namely 64 days work per year (if one estimates four adults to a family). If one calculates that farmers must have had at least one of each land use category referred to above, the labour requirement for 5 stremmata per year would have been 53 days of labour per adult. But considering they had an average farm of approximately 29 stremmata, and the largest area would have been covered with dry field crops due to shortage of water, one could make a very approximate estimate of c.212 days of work per head (53X4=212). While the labour for olive, vine, and wine production, calculated for Messinia is shown in Table1.23 (Aschenbrenner 1972:55; 1976:163).

1.1.7 Thera: crop cultivation

The crops that grow today on Thera are of two kinds, the cash crops and those used for personal consumption. The former consist of vines, a legume named 'arakas'on Thera and saffron. 'Arakas'is named 'fava'after being split in half by rotary mills, and it has been identified as *Lathyrus clymenum* and includes *L.articulatus ssp.* 'Fava'is eaten widely in the Greek world but Santorini's one is the most renowned in Greece. Whereas elsewhere 'fava'is made from a variety of pulses, among others *Lathyrus sativus*, and *Pisum sativum*, on Santorini it is consistently made from *Lathyrus clymenum*. Vines are extensively cultivated on the island, and very good varieties of wine are made in family owned wine-presses and wine cellars, called 'canava'on Thera. These wines are exported to other parts of Greece.

The main crops cultivated today for domestic use are:

CROPS	GREEK NAME	LATIN NAME
Barley	Krithari	Hordeum vulgare
Wheat	Sitari	Triticum sp. (2 species)
Peas	Bizelia	Pisum sativum
Spanish vetchling	Arakas	Lathyrus clymenum
Sesame	Sousami	Sesamum indicum L.
Millet	Kechri	Panicum sp.
Fodder crop	Faki	Vicia articulata (?)
Tomatoes	Tomata	Lycopersicon lycopersicum
Olives	Elies	Olea europaea
Fig trees	Syka	Ficus carica
Grapes	Staphylia	Vitis vinifera

All my informants seemed to agree that in the pre-World War II period, and before the introduction of tomatoes, the range of crops grown was much greater than today. Barley, which is the most extensivly grown of the cereals, was of two varieties, compared to today

's one variety. The species grown then was described to me as belonging to a round-seeded variety (naked? barley) which ripened earlier than *Hordeum vulgare*, although the latter was also grown. It is notable too that barley today on Thera barely reaches 30-40 cm.

Other crops grown until approximately 50 years ago were:

CROPS	GREEK NAME	LATIN NAME
Bitter vetch	Rovi	Vicia ervilia(?)/Lathyrus cicera
Wheat	Sitari	Triticum sp. (primitive sp.?)
Cotton	Vambaki	Gossypium sp.
Beans	Koukia	Vicia faba
Millet	Kechri	Panicum sp.

Due to a total lack of water on the island, the only type of agriculture practised is *dry-farming*, and *intercropping* as is shown in the agricultural calendar of Santorini (Table1.24) where cereals and pulses were grown in vineyards. *Crop rotation* is frequently practised in fields on Thera where it was common to find a three-crop rotation of tomato/barley/'arakas'instead of leaving fields fallow (informer a: note that the details of the various informants are given in Table1.24). Mixed farming though was most common in the extensive vineyards of the island. 'Arakas'(*L.clymenum*) was planted no more than once consecutively, as it is considered harmful to the vineyard if grown in consecutive years(informer a). In fields, 'arakas'can be grown in two consecutive years without harm (informer b) and barley in five consecutive years.

Land measurement on Thera

The smallest field unit on Thera is the 'carto'which corresponds as following: 4 'carta'= 1 'zevgaria'= 3 stremmata. This may indicate that Thera is an island of very small farms requiring smaller spatial units than elsewhere in Greece. This was probably due to inheritance laws.

Ploughing

On Thera I have seen two types of plough, the ard or 'scratch'plough which is invariably made of wood (Fig.1.7), and the mouldboard plough made of iron. Three things determine the depth of ploughing, the height of the perpendicular piece of wood (adjuster), the holes (adjuster sockets), and the draught animal. The ox ploughs deeper than the mule, which in turn ploughs deeper than the donkey. The ard is used in vineyards as it does not go deep enough to destroy the roots and it is also used just before planting for opening up ridges (see Fig.1.7). If the front hole in the adjustment socket is used, then the plough goes deeper and the animals get more tired. The last hole of the 'adjustment socket'makes shallow ploughing and is easy on the animals, as well as rendering the plough more manoeuvrable. Some of the types of ploughing from Santorini are shown in Fig.1.8, especially when it means preparing the soil for summer vegetables, whereas when sowing cereals and pulses, a single ploughing is adequate. A well tended vineyard can yield almost twice as much as a poorly tended plot (Forbes 1976:9).

When we come to compare a plough which was extensively used on the island of Kerkyra (Sordinas 1976) with the one in use in Thera, the similarity of type is striking (cf. Fig.1.7a & b). Some experiments were done on depth of ploughing in southern England on a plot of land on top of Brendon Hill (Vaugham 1975:48), where the soil was quite light and had been lying fallow for two years, which is a situation similar to Thera. The ard worked well and produced furrows of between 12-18 cm. deep. Reynolds (1979:61) has experimented with reconstructed ards, and he believes that they are extremely efficient on all soil types including heavy clay, producing furrows of at least 15 cm.

The simple wooden plough (aratrum) drawn by two animals is still common on Thera. Although it is primitive, this implement is well adapted to the shallow, stony soil on which it is used. It scratches the surface just enough to plant the seed without causing erosion. Its lightness and manoeuvrability mean it is easily handled in the rocky fields and its iron share can easily be replaced or hammered straight when damaged. It is also easily carried from one distant plot to another, a not unimportant consideration when we think that in Greece, in general, holdings are very fragmented as a result of both the inheritance system and the broken relief.

Harvesting

The sickle, 'drepano'in Greek, comes from a Turkish word, which suggests perhaps, though unlikely, that its derivation is foreign. As recently as twenty years ago, the sickle was introduced to Thera. Previously, they uprooted crops (informant b) (Table 1.24), just as they did in Israel for all pulses, wheat, barley, and sesame (Avitsur 1967:1). It was calculated that a man could uproot 80-100 sq.m. per hour (approximately 1000 sq.m. per working day), and a woman 60-75 sq.m.

On Thera sickles are all of one shape but have different numbers (Nos 1,2,3) according to their size. The reason for their introduction in Thera is manifold, I believe. Thera, in the 1950's was one of the poorest islands in the Cyclades, considered even poorer than its neighbour, Anaphi. The only crops that could be grown were those mentioned above, and the inhabitants so poor that they had to eat barley bread, whilst wheat bread was considered a luxury. Wood for cooking was practically non-existent, as the area of ground covered with fuel producing garrigue, is very limited, and whatever was present was needed for grazing for the few sheep and goats kept for the domestic production of cheese, milk, and very occasionally meat. Even staples like fruits, olives and olive oil were extremely scarce, the former due to a lack of water such that irrigation of even small orchards was impossible. Olive trees were also very few in number and certainly did not produce enough oil for the domestic consumption of the islanders. Therefore, agriculturally, Thera was considered a doomed island which only produced good wine and 'fava'(split 'arakas'). Since the late 1960's, Thera has become a centre of tourism and the economy is now totally dependent on it. Therefore, this influx of cash made it possible for farmers to invest in metal items like sickles, in order to speed up the harvesting. Time was becoming a variable which needed to be considered as it could be invested in tourism. This hypothesis explains the late re-introduction of the sickle to Thera whilst all the other islands around it used it much earlier, including the desolate island of Anaphi. At present, they cut the barley fairly near the ear and leave sheep and goats to graze the stubble, as grazing is scarce. This need to harvest near the ear is well portrayed by the sickles which have a very small handle (10 cm. long). It is very interesting to note the different sickles used on nearby Anaphi (called 'leleki'in other parts of Greece, but 'drepano'on Anaphi) which have a small wooden handle (c.10 cm. long) but a long neck and seem to be for harvesting cereals from nearer the base, so that the labourer would not need to bend very low. On Anaphi the time variable is not important yet, due to the island's isolation and lack of tourism. They also need straw for the stables as these islanders keep a fair number of sheep and goats, while there is no need for stubble as the garrigue can sustain the flocks and the islanders claim it makes the meat tastier.

Threshing

Threshing is performed on a threshing floor which is paved with stones, or more recently concrete. The crop is placed on the threshing floor and trampled only by animals (donkey, mule, and rarely oxen). A threshing sledge is not used in Thera. However, it is considered (Bordaz 1965) slower than treading by animals (idem:29) but can be used where there is a shortage of animal and/or man-power, the reason being that older people as well as children can perform these activities. A few animals are attached in a row, the quickest on the outside of the circle and the slowest on the inside. The smallest threshing floors can take 4-5 animals and others can take 9-10 animals. However, if a farmer does not have several animals, he might use only two, and I have seen this done on the island of Anaphi, just east of Thera. The threshing floors are situated in sunny locations with a breeze so that the sun will dry and make the crop more brittle in order to free the seed from the husk, and the breeze will help to separate the seed from unwanted chaff and other residues.

The farmers begin by placing 4-5 'dematia'on an average threshing floor (two 'dematia'and three 'dematia'can be transported by a donkey and mule respectively). As the bulk lessens, several more 'dematia'are added to the floor, often as many as 5 at a time, and so forth, until the whole crop is threshed. There is a strict order in which crops are threshed. Firstly 'arakas'is threshed (*Lathyrus clymenum*), followed by 'faki'(*Vicia articulata*?) then wheat and lastly barley.

Winnowing

The winnowing implements were originally wooden, sometime rudimentally made and other times more elaborate (see the photograph in Theocharis 1973:Pl.160-

163). While the sieving was done with mainly two types of sieve, one with a large ($\simeq 7-8mm$) and the other with a fine mesh ($\simeq 3mm$). They use mainly goat's skin as it is thought to be stronger than sheep skin. The crop was cleaned and kept as seed in a wooden box often partitioned in two for two types of crop to be stored. The next crop processing stage, the splitting of legumes and the making of flour was done a little at a time as need arose, for, at that state, it is most vulnerable to weevil infestation. For this job, the rotary mill is still used (in action seen in Theocharis 1973:Pl.164). In the old days, still within living memory, it was said that barley flour was done in this manner but today the rotary mill is reserved for splitting the 'araka'*Lathyrus clymenum* and making the 'fava'.

Chapter 2

The environment of Greece in the past

2.1 Introduction

In this chapter I shall present and try to bring together all the data, on the climate, drainage, soils, and pollen, as well as archaeological evidence, in order to reconstruct, as best we can, the past environment of Greece.

2.1.1 The climate

'Annus fructum fert, non tellus'
'The season produces the crop not the soil'

Evidence suggests that the climate of Greece has remained unchanged during the last 4,000 years, while according to others (Greig & Turner 1974:193) there has been no major climatic change, since 7000 B.C. McCoy (1980:96) also claims that there were no significant climatic changes in the southern Aegean during the L.B.A.. From terrestial and oceanic oxygen-isotope measurements, one could suggest a possible warmer air temperature of c.1°C, at most, at c.3500 B.P. and he believes that generally in the L.B.A. there seems to have been a decreased river discharge but data are still conflicting. Minor climatic changes, however, are quite possible. For example the bird bones from Lerna (Gejvall 1969:49,59) indicate somewhat drier conditions from today's. Pollen data from Xinias indicates rather dry and hot summers around 6500 B.P., whilst the presence of *Pistacia* and *Poterium* point to winters with a Mediterranean character (Bottema 1974), whereby precipitation would have occurred mainly in late autumn, winter and early spring. This seems to be consistent with all Greek pollen diagrams. Temperatures in Greece seem to have been lower than today's ca. 4000 B.P., and it is thought that either sea temperatures were lower (Bintliff 1981:147) or precipitation was higher, resulting in an expansion of *Fagus* in the Ioannina area ca. 4535±40 b.c. (Bottema 1974).

We can be fairly positive, however, that the climate in the last 2500 years has not changed, although Rackham (1972:295) refers to it as slightly less arid in Crete (Fournou Korifi) but just as variable from year to year. The dates of planting wheat (October 20 to November 25) and harvesting it (c. May 15) in Boeotia have remained the same (Hesiod, Works & Days 385,614), as has the time of olive harvest and the degree of maturation of date fruits at Athens (Meigs 1961:374, Guinis 1976). Furthermore, evidence from historical data, pollen analysis and 'soil morphology of polygenetic profiles shows that changes in climatic conditions for at least the past 5,000 years were insignificant'(Yassoglou & Haidouti 1978:33). On the other hand, small abrupt climatic changes during the last centuries of the third millennium B.C. have been said to have affected the end of the Early Helladic II period in the Aegean area (Bell 1971). In the thirteenth century B.C. the widespread disturbances throughout the eastern Mediterranean and in Anatolia are 'suggestive of a cause more basic than local warfare or invasion, and climatic change may have been a factor which triggered the events seen in the archaeological record', notably references to the preparation for defence in tablets from Pylos, and the expansion of the fortifications in other Mycenaean cities (McGhee 1981:169).

The notion of the sudden decline of Mycenaean civilization c. 1200 B.C., triggered off by a drought was first put forward by Rhys Carpenter (1966), but was refuted later by Wright (1968). This argument was tackled again by three scholars (Bryson, Lamb & Donley:1974) who insisted that such a drought could have occurred, and they compared it to the climatic pattern of 1954-55. It seems that a drought could have occurred in Crete, the South Peloponnese, Boeotia, Euboea, and the Argolid, but not in Attica, Thessaly, and the rest of northern Greece. However, the problem has not yet been resolved for although it seems to have been a time of unrest, the reasons of it are still unclear. Possibly the climatic potential of dendrochronology might resolve this pertinent problem.

Another drought might have happened in the second half of the seventh century B.C. (Camp 1979:398), and Thera was said by Herodotus (IV.151) to have suffered a severe drought in c. 630 B.C. for seven years until every tree on the island but one had died, which indicates that Thera had trees at that time. An interesting argument which still waits to be tested (Camp 1979:410) is that colonization elsewhere was due to severe drought in parts of Greece and not to population growth as it has been suggested in the past.

2.1.2 The drainage

We can assume that drainage system changed during prehistory, perhaps not dramatically but enough to have affected settlements in their vicinity. For various reasons, the task of explaining changes in drainage basins during prehistory seems to be extremely difficult, given the problems in trying to account for erosional patterns even for the last 100 years. 'Indeed, it is very difficult to postulate the response of a river to a change in an environmental factor'(Davidson 1980: 146). Progress can be made only if a detailed chronology can be established for sedimentation, tectonic events, changes in climate, and vegetation as well as for the spread of man's activities. Therefore, one can only assume, that individual drainage basins in Greece will have varied markedly in their alluvial histories, and thus correlations of alluvial phases must be approached with great care.

2.1.3 Soils of Thera

Soil is clearly one of the key components of the physical environment affecting agriculture and they have been discussed in Chapter One. In Thera we are very fortunate to have the pumice and tephra of the c.1600 B.C. eruption 'sealing'the Late Bronze Age landscape.

The island prior to the eruption had been subjected to major earthquakes, which might have made the soil susceptible to erosion. Moreover, a few major storms could have caused large-scale soil erosion over a few months just before the eruption. However, the fact that no buried soil was found which exhibited any characteristic of a soil rich in humus, suggests that soil deterioration was underway well before c.1600 B.C. for better soil conditions must have existed before this, because there should have been a long period of soil formation after the Middle Pumice Series was formed ca. 37,000 B.P.. Such erosion can be postulated on the basis of the similarity between the tephra derived soils of today and the Minoan soils developed on the ignimbrites. Erosional processes are very apparent on Santorini today, and are reflected in the stone-dominated nature of the surface and the deposition of finer material against walls.

Davidson suggests (1980:155) that the inhabitants of Thera were already causing erosion through the intensification of arable cultivation and livestock herding. He reached his conclusions after studying the palaeosol under the Upper pumice series and dating to the L.B.A. This palaeosol, which reaches a thickness of 3-4 m. in Akrotiri (Davidson 1978b:243), varies in thickness over the island, and was formed from decomposed ignimbrites resulting from an earlier eruption, dated to c.15,000 B.P. When the volcano next erupted in c.1600 B.C. (although there is still a great deal of ongoing debate on the exact date (Warren 1987; Bruns et al., 1980; Cadogan 1987)), these soils were still poorly developed as shown by Davidson's analyses. He sampled this palaeosol at six exposures (Davidson, fig.1:243) for particle size, organic matter, and cation exchange capacity. Furthermore, as a test, two samples of present day topsoil derived from tephra were included. His results showed (Davidson 1978,table 1:243) that the palaeosols were composed predominantly of sands with only small quantities of silt and almost no clay. The organic content was negligible, demonstrating that there is no evidence in central and southern Thera for well-developed soils at the time of the eruption. On the steep slopes of the higher areas, there would have been either bare rock surfaces or poorly developed soils. The striking fact is the similarity in terms of particle size, cation exchange capacity, and organic matter between these Bronze Age soils and the present ones.

Therefore, it is very probable the L.B.A. farmers had to contend with serious soil moisture deficits, a soil low in organic matter, and sand resulting in poor water and nutrient storage, as well as a soil highly susceptible to erosion, all of which are still evident today.

2.1.4 Pollen analysis in Crete

There are two theories about the natural vegetation of Crete in prehistoric times. Some (Zohary & Orsham 1966) believe that deciduous broad-leaved species once played a major role in the forests of Crete, while others (Greuter 1971:337; Rackham 1972) believe that Crete was covered with evergreen forest. An evergreen woodland of oaks, *Q.coccifera* and *Q.ilex*, *Acer sempervirens L.*, was still present near Myrtos when Tournefort visited the island in 1717 (Rackham 1972:290).

Palaeobotanical evidence is very scarce and Rackham studied charcoal from a Bronze

Age settlement (2500 B.C.) near Myrtos, which yielded many remains of olive, and an oak that Rackham considered to have been evergreen. Charred pine also occurred but Bottema (1980a:197) believed that this was probably driftwood.

Recently (Bottema 1980a) four cores were sampled for pollen analysis from the south of the island, near Aghia Galini, and the radiocarbon dates of these span from 10090 to 4650 B.P. In the earliest zone (U), c.10000 B.P., *Pinus sp.* dominated the area (up to 70%) and xerophytic elements as *Q.coccifera* and *Pistacia* are hardly represented. From c.9500 to 8000 B.P., zone (V), there was an increase in oaks, deciduous as well as evergreen, but *Pinus* still remained important. *Vitis* was also present. On the whole there was more arboreal pollen than in the preceding level (Bottema 1980a:210) but open vegetation also occurred judging from the presence of *Asphodelus* pollen. It is possible that the increase of oaks, *Asphodelus* and the presence of pines indicates a pyrophytic vegetation (Naveh 1975:202), and a more widespread use of fires to control vegetation.

The zone (W) sample indicating that at around 7500 B.P. the oak forest expanded at the expense of *Pinus* and *Vitis* was still important. *Plantago lanceolata* type and Gramineae were also present, but had been previously, so it is not easy to draw conclusions about agriculture. Then, there was a short period of open vegetation and at c.7,300 B.P., zone (Y), a re-expansion of the oak took place. Therefore, we could conclude that the natural vegetation of Crete 'was dominated by deciduous broad-leaved species, especially oak'(Bottema 1980a:211), which supports the hypothesis of Zohary and Orsham (1966) mentioned above. At c.5000 B.P., zone (Z), the Aghia Galini area must have been devoid of trees, just like today, but Gramineae pollen was also very low.

The presence in Crete of *Olea* and *Ceratonia* is unclear, but the latter is hardly represented in pollen rain while the former, especially the wild olive, would have been either rare or absent from the island (Bottema 1980a:214). Therefore, it cannot be established palynologically that this tree occurred in Crete prior to the Bronze

Age. In the E.B.A. (2500 B.C.) at Myrtos the olive existed and was the most common charcoal (Rackham 1972:299-301), and elsewhere (i.e. Peloponnese) olive pollen is met with in considerable numbers. At Fournou Korifi the impressions of the following plants were discovered (Rackham 1972:295), barley and wheat, vine leaves, grape pips and skins, a stone of cultivated olive, and olive wood with evidence of pruning, *Q.ilex* (almost certainly), *Pinus brutia* (?) in small quantity, and reed which was probably *Phragmites communis*.

Pollen data suggests that the pine tree must have declined enormously between c.7500 and 7300 B.P.. It seems that even as late as 2500 B.C. the pine tree did not re-establish itself extensively, for had it been present in large numbers, Rackham (1972:295) presumes that it would have been preferred in carpentry to oak and olive. At Myrtos the great majority of charcoal studied, 16 of the 18 collections, was *Olea*. Oak occurred in only four collections, and pine only once, which re-enforces Rackham's (1972:302) thesis that the pine must have been rare in the area. The same seems to be true for Kommos (2000-1000 B.C.) where 38% of wood charcoal was *Olea*. The second commonest was *Quercus* with 29% while cypress came last with 4% (Shay & Shay 1983). It is also interesting to note that in the post-Bronze Age (1000-300 B.C.), cypress was the most common wood with 41% and olive came next with 20%, for we know that cypress is a plant of secondary climax vegetation, and might have occupied previous agricultural land, and be connected with the decline of Minoan and Mycenaean agricultural administration.

What seems to be a unanimous agreement is that Crete was wooded in E.Minoan times (Warren & Tzedhakis 1974:305). In classical texts, including Strabo and Theophrastus, Crete was not listed as a timber-producing region of Greece, but was still referred to as well-wooded (Strabo X.IV.4). With rather more mountain woodland than now but less pine in the lowlands, Rackham (1972:295) however claims that Crete appears to have been, in Classical times, much the same as today. Strabo (op.cit.) claims that it supported cypress and cedar. Pollen of the cedar was 3.3% in the deep-sea cores (core 24MO67, c.7900±170 B.P.) taken from the south and south-east of Crete, but Bottema claims that the source of this pollen is unlikely to have been from the island. This needs to be investigated more extensively and not be dismissed that light-heartedly. Judging from the Minoan 'thalassocracy', a navy would have been needed, and a large number of cedar and cypress trees would have been required, especially as the latter is proof against decay (Semple 1931:278). Dendrochronological studies of specimens of *Cypress cf.sempervirens* from Phaestos (ca. 2000 b.c.) show a time-span of 60 years, possibly indicative of mature trees in the area (Coccolini & Corona 1981:427-434). In the Khania region of west Crete, cypress wood was available in quantity in the fifteenth century A.D.(idem) and would have most certainly been numerous in earlier times. Roberts (1979:235) believes that rich evergreen maquis covered the Knossos area before 6000 B.C. and furthermore, he claims, although we have no undisputable proof, that sizeable forest stands would have provided the construction of the palace and might have existed about 20 km. from Knossos, throughout the life of the site.

Pollen analysis in the Cyclades

In 1964 five stics were bored in the Cyclades for pollen analytical studies (Turner 1968:112-113): Naxos, Melos, Antiparos, Saliagos, and Delos. Only the last site produced minute quantities of pollen, but they do not predate the construction of the Sacred Lake of the Archaic period. However, due to their uniqueness in the Cyclades, it is worth mentioning here the types of pollen which were found in the sample:

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2 grains of Pinus pollen
2 grains of Compositae
2 grains of Cyperaceae
2 grains of Plantago-lanceolata
5 grains of unknown type A
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5 grains of unknown type B

The vegetational history of Thera

Pollen studies have not so far been productive in the Cyclades because of the absence of water logged deposits. However, study of a sample of rodent coprolites from Akrotiri (Sample 77, chapter 5, Table 2.1) by G.M. Coles and C.O. Hunt (Unpublished) shows that pollen can be extracted from desiccated as well as water-logged material by using a new extraction technique (Hunt 1985). Meanwhile, reconstruction of the vegetation of bronze age Thera must be largely speculative.

Thera lies in the same climatic region of Greece as Athens and Lake Kopais with a mean annual temperature of 17-18°, and a mean annual rainfall of 350-450 mm. On climatic grounds, one would expect the vegetation of Thera to have been similar to the Kopais region, which would mean that the islands would have been originally covered with forest, at first open oak woods with *Juniperus* and *Pistacia*, and then, like Kopais, with more dense oak woods and having few other tree species.

According to phytosociological theory, the natural lowland vegetation in this climate ought to have been an evergreen forest dominated by *Q.ilex* L. and *Q.coccifera* (Rackham 1978:758). Both of these grow on the island of Naxos, though *Q.ilex* survives only at high altitudes. Rackham (1978:758) believes that deciduous trees might also have covered the top of the cone if it was high enough and also *Vitis vinifera ssp.sylvestris* could have been present. Yet, he believes, that due to its geological origin, severe wind exposure and periodic devastation by eruptions, the forest would have been patchy. On the nearby island of Ios, Rackham saw an old *Q.ilex* which was only 30 cm. high on the highest summit (Rackham op.cit.). Even though it is a single tree, Zohary (1962:71) (Rackham 1982) claims that one tree 'in a vast, desolated woodless area'can testify 'to the forests that previously existed in the area'. For example, Paros island (Cyclades) is a good example of forest destruction where forests existed during Byzantine times. Later, the Venetians destroyed the forests for timber (Economidou 1976:55). Therefore, by the 19th century, many of the Cycladic islands did not have wood even for domestic fuel. By 1836 phrygana was developing (Economidou 1976:55) where forests had once been.

Thera is mostly cultivated today. Vines occupy most of the area but legumes and other crops are also planted (see Thera agricultural section). On higher ground phrygana is present but this vegetational type is rather restricted on this island, unlike other Cycladic islands. Recently a few stands of *Juniperus phoenicea* were discovered on Thera at a site called 'vides'(unpublished Sampson Katsipis 1982).

In the Bronze Age settlement of Akrotiri, a moderate amount of structural timber existed in buildings, but as the evidence is all from casts, the species cannot usually be identified. Floors and flat roofs were supported by beams up to c.20 cm. thick. Therefore, this evidence suggests that the settlement was quite well off for timber. The question which arises, is how much, if any, of this timber was imported, and its source. But even if forest existed, due to the high population of the island and the need of agricultural land, one would presume forests would have been restricted to the high summits or steep slopes, which would have been difficult to cultivate.

The vegetational change from trees to minor plants (Friedrich 1980:126) is in agreement with various writers (including O.Rackham 1978 & J.Turner 1978) and it seems very likely. The need of great quantities of wood in the architecture of Akrotiri (timber reinforcements were used in walls, as the walls were encased in a series of horizontal frames built at intervals up the wall and connected by vertical timbers) could have been supplied by imports but the possibility of finding it, partially at least, locally should not be totally rejected.

I cannot resist from including the 'romantic description'of Thera given by Pichler and Friedrich (1980:15) who claim that 'the remnant of an old crater most probably formed a flat and wide depression covered by bushes and small trees forming a rather patchy forest. The central region as a whole was destined for wild-life, which is shown by the findings of the bones of red deer and hares'. The fact that Davidson (1978b) claims that soils of L.B.A. Thera were very poor in humus, immature and shallow, still make Rackham (1980:290-1) believe that it does not necessarily cause a serious limitation on agriculture or on natural vegetation. One could demonstrate that cereals, legumes and vines are not necessarily dependent on well-developed soils. Although Thera could be characterized as sub-arid on temperature and precipitation criteria, yet it is not entirely so if the relative humidity is taken into account (Marinos & Marinos 1978:297, 300). Relative humidity is rather high even during the summer, i.e. 60%, and is greater than in regions of Greece where rainfall is higher. They (Marinos & Marinos 1978:304) also believe that the overall water situation of the island was much better in Minoan times which would have had beneficial effects on agriculture and, perhaps, even garden agriculture. Even today Santorini has poor soils with a low nutrient content but it is still the most highly cultivated and the second most densely populated of the Cyclades.

Therefore, we can conclude, I believe, that the Cyclades were not as devoid of forest as today, but, on land which was not used agriculturally, forests of oak and olive and, perhaps in the higher summits, forests of deciduous woods might have existed throughout the Early, Middle and perhaps part of the Late Bronze Age. The existence of an olive press (a beam press) found on the island of Therasia (now off Thera proper but in the L.B.A. it was part of the same island) (Fouqué 1879:96,99,104,106), and an olive trunk discovered 2 m. in length (Fouqué 1879:120), all indicate much more forested vegetation than the nude landscape of today. However, the analysis of soils (Davidson 1978) indicate erosional processes existing just before the eruption of Santorini in the 15th century B.C. Could these have been the symptoms of deforestation in the L.B.A.?

2.1.5 Deforestation

Deforestation in a grand scale has occurred in Greece ever since the Bronze Age. The effect of man on the landscape, at least as far as we can conclude from pollen in Greece, seemed to have been minimal in earlier prehistory and especially in the Neolithic. Therefore, the impact of cultivation and livestock alone was not so great on the natural vegetation as to cause a lack of equilibrium. The animal considered the fruit of evil, the goat, could not have contributed to any significant degree to deforestation, even if one does not take into account the defense put forward for the goat (Hughes 1983:446, Kolars 1966). What seems far more likely to have contributed is what Wertime (1983:445) called the 'pyrotechnologic industries'of the Mediterranean, namely pottery, metalworking, and lime-making. We must not forget that a traditional limekiln for one burn in the highlands of Greece required 1,000 donkey loads of juniper wood (Wertime 1983:450), and 50 kilns requiring 6,000 metric tons of wood yearly (Wertime 1983:452). However, the most recent destructions of the forests occurred during Ottoman rule of the Balkans.

Up to the sixteenth century A.D., Attica had vast forests which covered Mt. Hymettos, Mt. Parnitha, Mt. Pendeli, and Philopappous Hill (Economidou 1976:54). The destruction of vegetation in this area took place in 1770-79 by the fires lit during the wars of Greeks and Turkish-Albanian populations. Forests, according to the same author, also existed in Euboea, Akarnania, the Peloponnese, the Dodecanese, and the Cyclades.

To sum up, we can say that the beginning of the end of forests seem to have started at the final stages of the Neolithic (Kopais) whereby burning of forest would have taken place to expand cultivated land and improve browse production for livestock depending on the needs and population growth. This forest destruction was intensified in the M.B.A.-L.B.A. especially in the south of Greece with the expansion of industries which needed the cutting down of wood: pottery, lime, architecture and bronze, especially as bronze working is extremely energy-inefficient and needing large quantities of wood (Wertime 1983:452). Following all this destruction, it was easy for livestock, especially the goat, to stop the forest regenerating.

However, it seems to have been noted early on that deforestation was a negative process and some favoured afforestation (Hughes 1983:441), but the measures were sporadic. Wise administrators limited the timber harvest. Theophrastus recorded that in Cyprus the kings used to take great care of the forests. Tree plantations were fostered, for example the Ptolemies in Egypt initiated a major afforestation program (Hughes 1983:442).

If we look closely at the impact of man on vegetation based on our present evidence from pollen, the results make more sense when observed side by side with the settlement density. Renfrew (1972a:230), in his ranking of regions of Greece, found out that the largest numbers of settlement occur in Crete in the Neolithic and Mycenaean period, followed by central Greece in the Neolithic, and the Peloponnese in the Mycenaean period. The only pollen diagram from Aghia Galini tells us that the area was devoid of trees as early as 5000 B.P. and Boeotia had signs of erosion beginning in the Final Neolithic and reduced forest by the E.B.A.

2.1.6 Architectural evidence

From the very little evidence that is available, it seems that in the Early Minoan period (c.2800 2000 B.C.) the use of wood was very tentative, confined to short lengths of small dimension, whose only usefulness could have been to prevent vertical cracks in walls (Meiggs 1982:89), but later, long horizontal beams were used which served a double purpose, in helping to consolidate the walls, and absorbing the shock of earthquakes. They could also serve as sills and lintels for doors and window frames.

In the later phases, the use of horizontal and vertical timbers developed into a genuine half-timber construction in which strong timbers provided a framework for panels of masonry (Meiggs 1982:90), but there was no standard treatment of timbers. Sometimes, the timbers used were in the round, or cut longitudinally down the middle leaving one side round, while in other walls the timbers were squared. The intervals between verticals and horizontals tended to be irregular.

The weight-carrying beams had to be strong and long, and some covered spans of up to 5.50 m. (Meiggs 1982:90). In the Pillar Crypt of the Royal Villa at Knossos, the span was 4.20 m. In the Temple Tomb at Knossos there were two main beams, both squared, on the east-west axis and measuring 8.10 m. and 5.60 m. in length and 53 cm square in cross section (Meiggs 1982:91). In some rooms there were larger spans to be covered. However, it is unlikely that any of the beams used were much over 8 metres. The use of wooden columns as weight-carriers was often encountered in Minoan architecture where the diameter varied from roughly 30-60 m. according to the weight they had to support.

A few carbonized fragments of columns have survived but the main evidence for their use and size comes from the stone bases on which they were set to protect them from damp. Almost all bases are rounded but there are a few at Phaestos which were oval and would imply oval columns. It is uncertain whether they were fluted but in three cases imprints on plaster suggested 16, 24 and 28 flutings (Knossos) (Meiggs 1982:93). One column at Knossos, in which 3 m. of carbonized wood survived, was taken to be cypress (Meiggs 1982:99), but when examined microscopically and was found to be fir *Abies cephalonica* (Meiggs 1982:99). Netolitzsky (1934), moreover, examined wood from Knossos and identified the following species: spruce *Picea orientalis*, fir *Abies cephalonica*, holly oak *Q.ilex*, cedar of Lebanon *Cedrus libani*, and common juniper *Juniperus communis*.

The other need for timber was the large Minoan navy. A good illustration of ships of the period comes from a fresco found at Akrotiri in 1973. However, Meiggs (1982) has good reasons to believe that all the timber needed for Minoan shipping could have been provided from the Cretan forests (Meiggs 1982:97). In sheer quantity, the amount of wood needed for domestic cooking, heating and metallurgy, in particular for fusing copper with tin to make bronze, must have been enormous (Meiggs 1982:97).

It is also very difficult to visualize today the use of wood in the kitchen for the sheer quantity of pottery obscures this point, so the dividing line between wood and pottery in household utensils such as bowls, dishes, trays, has remained obscure. Only from excavations at the temple of Hera at Samos, which was built on marshy ground, are there reminders that in the archaic period, craftsmen took pride in making their wooden bowls, plates and other vessels beautiful as well as useful.

Evans believed that at Knossos he could see changes in building practice from a period of an adequate amount of wood to a period in the Late Minoan era, c. 1550 B.C., where there seems to have been an increasing shortage of timber. At Kato Zakro, the extensive use of wood in the MMIIIB-LMIB periods implies rich local supply of timber (Shaw 1973:144). This is something which will need to be considered for Akrotiri where ideal conditions of preservation prevail. The new features were the increasing use of gypsum in places where timber had previously been used and a decrease in the use of vertical timbers in the walls as well as a reduction in the use of horizontal timbers (Meiggs 1982:98). Evans had suggested that a reason for the downfall of Minoan dominion was a shortage of timber. However, comparison with the palaces of Phaestos and Zakro suggests that there was no shortage of timber. At Zakro no fewer than 10 saws were found.

What we know of later history of Cretan forests point to no acute shortage of timber in the Bronze Age. Strabo described the island as 'mountainous and well-wooded'(Strabo 475). An Athenian comedy produced during the early stages of the Peloponnesian War (431-421 B.C.) included cypress from Crete in a list of Athenian imports (Meiggs 1982:99). Theophrastus says that Rhodos also has cypress (Theophrastus 4.5.2). Pliny accepts Crete as the original home of the cypress tree

(Pliny,Nat.Hist. 16.141-2) and the tree grew there even in the Middle ages and was much appreciated by the Venetians for their fleets. Fir also seems to have been available. Also miniature axe-handles from the cave of Arkolantiri were examined and five were made of fir and two, almost certainly, of Lebanon cedar (Meiggs 1982:99), which was a surprise as no cedar had been recorded on Crete in modern times. Moreover, one would not have expected a handle to have been made of an imported wood when cypress was plentifully available. Vitruvius, however, says that cedrus grew particularly well on Crete, Syria, and Africa (Vitruvius 2.9.13; Pliny NH 16.197). The tree was also recorded by a seventeenth century traveller who visited Crete (Meiggs 1982:100).

Quercus ilex (Holm oak) has been identified microscopically from Amnissos, Knossos, and Myrtos (Netolitzky), olive and pine from Myrtos (Rackham 1972:302) and cypress as well as olive from Phaistos (Follieri & Coccolini 1986). Chariot-wheels of elm wood and willow are included in a palace inventory from Knossos and Cretan willow is referred to by Pliny (NH 16.110). We can also add oaks, ash, maple, black mulberry, tamarisk, beech, spruce, and larch by inference from the modern distribution of these species.

At Pylos (Meiggs 1982:103) there is evidence of timbers used to frame the walls. In both sides of the walls there were verticals with irregular intervals varying from 55-80 cm. Evidence for horizontals is less good. There seem normally to have been one row at floor level, another c.70 cm higher, and roofs must have been flat and therefore supported by beams. There is evidence from other palaces and particularly Tiryns, to show that with minor variants, timber usage at Pylos was typical and very similar to the Minoan form (Meiggs 1982:104).

2.1.7 Documentary evidence

The flora of Messenia was studied in detail at Pylos (McDonald & Rapp 1972) (Wright 1972) and it was found that oak was, by far, the most widespread tree on the plains and lower slopes, fir forests at higher altitudes, and pine forests along the coast. Alder and poplar were also growing on the more marshy areas and some cypress existed, reflected in the name Kyparissia (Ku-pa-ri-so in the Linear B from Pylos, McDonald & Rapp 1972:106) which already existed at that time. Pollen analysis showed that in L.B.A. a pine forest near modern Kalamata was destroyed.

Clay tablets from Pylos show that, as at Knossos, chariots were made and one tablet shows that cypress was used (Meiggs 1982:105), and possibly also chestnut (*Castanea sativa*), as it yielded a high class hard wood for making axles of chariots (Levy 1961:85). Moreover, the bronze industry at Pylos sustained 400 workers, well beyond the needs of the community and these would have needed large quantities of wood (Chadwick 1976:156) (see pollen diagrams of Osmanaga).

According to Homer the following trees were used: fir, ash, oak, poplar, cornel, pine, and olive (Meiggs 1982:106,107). In both epics, ash is the tree most commonly mentioned, even though they may have been written by different poets, as they supposedly portray different environments (Levy 1961:85). Although it is only a botanical hypothesis, oak might have been the most widely distributed of trees up to a height of c.800 m. As a strong wood, it was used for the threshold in the palace of Odysseus (Meiggs 1982:109). The spear of Achilles in Homer was made of ash from Mt.Pelion (Iliad XIX: 390-392). The wood of cornel (*Cornus mas*) is especially suitable for a spear for it is strong, but flexible and withstands the shock of impact (Meiggs 1982:110), which is why it is still often used for oars. Cornel wood was regarded by Xenophon and many others as superior to ash for spears, but it is mentioned only once in the Iliad. The commonest use of olive in Homer was in tool-handles (Meiggs 1982:111). It was also used for furniture, as when Odyssey made his bed from olive wood (idem:165, Daremberg & Saglio 1905:163).

A bed made of olive wood was also discovered at Thera, Room D2 (Thera IV,1971). Strangely enough, however, olive culture is not mentioned by Hesiod (idem:163). Fir is the most prominent wood in both Iliad and Odyssey. Theophrastus (5.7.1 and 4-5) (4th century B.C.) gave it pride of place among ship-builders and for general construction, and he claimed it is the best wood for oars, for it is strong, light and durable (Semple 1931:277). Pine is fairly inconspicuous in Homer (Meiggs 1982:112). It is once referred to together with juniper and cedar as being cut down to provide ship-timbers. Keels of ships are often mentioned as being reinforced with oak or beech (Semple 1931:270). Box is only mentioned once, for a yoke used by mules, (Meiggs 1982:112), and also in tablets (Chadwick 1976:148). There is no mention in Homer of live cedars. Beech is not mentioned but it is not surprising as it is not found south of Thessaly. *Callitris quadrivalvis* (citrus) is mentioned in Homer (Meiggs 1982:112), but its home is in north Africa and it is an aromatic wood.

Tree-trunks would be squared and either split in half with wedges, or saws were used to transform the squarred trunk into beams, boards and batterys (Meiggs 1982:346-7). More than 20 examples of these have been found in palaces and royal villas which could cross-cut large tree trunks, and the biggest is 1.70 m long and 0.28 m wide and was found in the Palace of Zakro (Shaw 1971:55-58). Small saws were important for furniture makers. Woods used for carpentry and cabinet work were cypress, laurel, box, olive, poplar, maple, wild fig, larch, chestnut, walnut, beech, oak, elm, ash, mulberry, plane, Thya *Callitris quadrivalvis* and holly (Semple 1931:270).

The Classical Greeks had found a means of conserving forests by dedicating them to a god(s), and it was found to be a way to deter people from cutting down these sacred forests (Chloros 1890:40, Hughes 1983:438). This habit of protecting forests seems to have existed from very early times. This testimony comes down to us with Homer, where a hymn to Aphrodite talks of nymphs and grove of Crete's Mt. Ida whose 'trees no mortal fells with iron'(Dicks 1980:6). This custom seems to have been present in the Near East as well, where Zohary (1962:72) claims that the 'sacred wood'is a very common occurrence which acts as a 'reliable landmark in the reconstruction of a ruined environment'. This habit of sanctifying a forest was continued until the nineteenth century (1890) and the forest was named 'hypsopeno'meaning 'heightened'(Chloros 1890:44). The precincts of these forests were consecrated with marked boundaries. Some were quite large. One near Lerna in the Argolid extended the whole length of a mountain side to the sea and another at Daphne was 10 miles in circumference (Pausanias 7.22.1, Hughes 1983:442). Theories of ecology seem to have been already well on the way, some 2000 years ago and perhaps even earlier. We know from the laws they enacted that, not only were the forests protected against felling, but even the removal of branches, fallen wood, and leaves, was forbidden, as well as the setting of fire, disturbance of springs, hunting, fishing, the bringing of dogs, horses, or grazing of animals, tilling the soil and sowing grain (Hughes 1983:442). Theophrastus also mentioned how the Athenians, still forbade the cutting of wood, and they imported wood from Macedonia, although they had large forests in Attica. Even in the Iliad (IV.482-487), deforestation is seen as destructive and a felling tree became a simile for a warrior's death (Hughes 1983:438). Tree-cutting in the Classical period and perhaps even earlier was a specialized task and loggers (hylotomon) took pride in their work (Hughes 1983:439). These forests were also taken care by the 'custodians of forests'the 'hyloroi'(mentioned by Aristotle for some Greek states, Hughes 1983:441).

From the Pylos tablets, it is evident that some forest work was done, as there are tradesmen classed as ship-builders and carpenters, and one class of agricultural worker is that of wood-cutter (Ventris & Chadwick 1956:123). No estimates of the numbers of these tradesmen and workers are made. They used cypress and box and if identification is correct, willow, ebony and yew for building timbers, chariot axels, and furniture (idem:135).

Aside from the effects of fire and use of timber, some vegetational changes could be expected from domesticated animals. The partial inventory of flocks and herds recorded in the surviving Pylos tablets list 10,157 sheep, 1,825 goats and 540 pigs (Idem:198). The sheep and goats were apparently herded in several dozen flocks of under 200 animals, each in places away from the palace. The pigs could have foraged well on the acorns of an oak forest, as they do today in Portugal and Corsica, but burning would have enhanced the grazing of the sheep and, to a lesser degree, of the goats.

Strabo refers to very dense forests in Cyprus which were an obstacle to agriculture and as consumption of wood did not keep pace with the rate of regrowth of the forests, there were legal enactments, which stated that whoever cleared the land was made to convey title to it (Strabo XIV.VI.5, Semple 1931:272), but this description could have been based to 'folk'memory and perhaps referred more to the situation existing in the Bronze Age.

Western Greece and the Ionian islands are also said to have had considerable forests (Semple 1931:279,281). Even the plain of Elis had oak groves and pine (Pausanias V.VI.4), as well as the low hill near Olympia (Xenophon, Anabassis V.III.9-12). In Achaia all the mountains were well-wooded even a century ago (Semple 1931:280). In Messologgi, they used dug-out boats in the sea-lake. Pitch and tar was procurred from the pine and fir, while cedar oil was used as medicine and was considered to have antiseptic qualities (Semple 1931:282). Moreover, olive oil was sometimes compounded with oil of sesame or almonds and added to alum, sulphur, salt or tar as curative element to make healing salve (Semple 1931:673).

Analysis of a text (Aghia Triada 101) has yielded information as to the payment of labourers and supervisors with a ration of oil or olives. Labourers were entitled to a daily payment of 3 'kyathoi'of olive oil while supervisors received 4 'kyathoi'(Was 1975:15). It was also suggested that the price of plain olives was 20% of that of oil for the same capacity. They also refer to another quality of olives (TU) which were 30% of that of oil. Therefore, it is an early attestation of different types of olive-oil (HT 116) (Chadwick 1976:122), for we know that olives, depending on their time of harvesting and quality yield 20-30% of their weight in olive oil (see section on crops), so the findings are in accordance to what we presently know about the trees.

At Knossos a group of tablets (Fs) (Chadwick 1976:101) which may be offerings, refer to, among others, to olive oil (often, if not always, perfumed). At Pylos a tablet (Un2) (Chadwick 1976:100) lists for offerings 307 litres of olives. From Knossos we also have reference to some towns in Crete as producing olives as well as grain (Chadwick 1976:117), and this combination may reflect the practice still existing in Greece, of growing grain on land between olive-trees.

2.1.8 Archaeological data

At Mycenae, Wace (1979) examined the house of an oil merchant where it was claimed that stirrup jars (L.H.IIIb) were found 'impregnated'with oil (Wace 1979:13), but he did not state any chromatographic examination. Therefore, we cannot be sure that the oil was vegetable and not animal fat. Nor can we be certain of the type of oil. Could it have been another type of vegetable oil? However, macroscopic remains of olives have been found in Mycenae (Wace 1921-23:48), and olive was mentioned in the Mycenaean tablets (Wace 1979:189) (Chadwick 1973:476ff.). Although logs of wood were found in the hearth of the West House (Mycenae) (Chadwick 1963:23), as far as I could trace, none was analyzed to find any more information on the type of wood used. From Akrotiri we have the following identified woods: olive (sample P-1601), pine (several samples) (Weinstein & Betancourt 1978:810), and tamarisk (Ch.Doumas, pers.comm.).

There is evidence from Egyptian texts that Crete was exporting oil to Egypt in 1500 B.C. (Anagnostopoulos 1951:225) and that later it was considered a sacred tree for both Minoans and Greeks (idem:226,230). The species of olive discovered at Knossos was tentatively identified as 'myrtolia'(Anagnostopoulos 1951:228). During Classical times, the same author claims that the main varieties planted in Attica were 'throubolia'and 'kolymbada'and this conclusion was reached after studying the varieties of trees which still exist at the Academy of Plato. At Knossos, in the West magazine alone, 16,000 gallons of oil might have been stored, which represents the produce of an average of 7,270 trees. If there was a density of about 10 trees per stremma (Aschenbrenner 1972:54), an area of 727 stremmata would have been devoted to olive-culture (cf. next page where densities as far apart as 12 and 36 trees are mentioned in the Linear B tablets of Knossos).

The earliest find of olive is from the fourth millennium site of Teleilat Ghassul in the east of Jordan. There, stone-lined silos were excavated, and in several of them stones of olives and dates were found (Boardman 1977:194). They have also been found on the Neolithic site of El Garcel in Spain. In Greece, one olive stone, believed to be of the wild variety was studied by J.Renfrew (1966) from Thessaly, at the aceramic site of Soufli, but due to its uniqueness, it is still early to voice a judgement from this single find, especially as no olives were found at Franchthi (Hansen 1980).

However, there are indications that the cultivation of olive was already under way in the E.B.A. although some scholars (Runnels & Hansen 1986:299) dispute this thesis, and would rather date it to the L.B.A. or later. Early remains of olive oil were reported to have been found in a jug in an Early Cycladic grave on the island of Naxos (Vickery 1936:51) but, of course, this needs to be verified for it was a find made in the beginning of the century. Moreover, archaeologists have always viewed the appearance of lamps as an indication of olive oil (E.Cycladic and E.M.) (Vickery 1936:58), although this conclusion should be scrutinized more. The other source of evidence are, of course, structures which have been identified by various archaeologists as being olive presses or pertaining to olive oil extraction. Very interesting E.M. finds were made at Myrtos (Warren 1972) of possible areas of olive oil extraction and olive pruning (Greig & Warren 1974:131), as well as four oil separators, 'lekanai', and also from Thermi (Lesvos) (Lamb 1936; Bancroft 1938-39:88-89). What is surprising from these items is that they are fairly small, as if the extraction of oil was not done on an industrial scale, but rather on a household one. This makes sense if it is viewed from the ancient writers viewpoint: they state that olive oil quickly turned bad and it was recommended that a store of olives be kept handy so that the oil needed for the table could be produced immediately before use (Brothwell & Brothwell 1969:156). In this case, there would be no need for large containers, or of buildings to accommodate special areas of oil production. Moreover, the utensils used for oil, and the crushing or pressing of olives, could have been done with multi-purpose implements (cf.Runnels 1981:149), and would have left no immediately visible clues. Furthermore, the olive oil tablets of Pylos refer to oil as intended to make clothing fragrant. Most of the tablets explicitly describe the use of oil as scented or as ointment (Bennett 1958:37), which seem to coincide appropriately with the results of pollen analysis from the same area, especially the results from Osmanaga (Wright 1972) where the olive maximum falls between 1100-700 B.C., although it appeared for the first time c.1990 B.C. but was followed by a blank and a reappearance c.1270 B.C. In the other pollen core from the Peloponnese, Franchthi, *Olea* pollen makes a 'tentative'appearance in the M.N., although this early appearance of olive in Greece is still problematic, and it only reappeared in the Dark Ages after c.2700 B.P.

An indirect evidence of the production of oil and/or wine in the centre of Crete and the Peloponnese in the thirteenth century B.C. is a recent thesis by Haskell (1983:238) of export of these commodities to Cyprus. Coarse ware stirrup-jars were found on this island and after subjecting these jars to fabric analysis at the Fitch laboratory of the British School (Athens), the source of origin was determined and fell into two distinct groups, one closely matching the Central Cretan group and the other the Peloponnesian. However, the use itself of stirrup-jars is not yet conclusive. As they have a very narrow neck, whatever liquid was inside would have poured in dribbles and could have been tightly stoppered. Therefore, it might have been used to hold a liquid that was carefully and sparingly used, such as oil or unguents (Stubbings 1947:24) or even wine (Wace 1979:17, Melena 1976:161). If stirrup-jars held unguents, the reference of Haskell (1983) to the Peloponnese would agree with the tablets of Pylos, and the Peloponnese could well have been a centre of unguent preparation.

As for the reference of the second centre of oil production, Crete, and especially central Crete, Forbes (Vol.III,1955:101) claimed that the archaeological evidence pointed to the fact that the wealth of the 'kings'of Crete was 'certainly partly based on export of olive oil to Egypt and other Mediterranean countries'(i.e. Cyprus). Chadwick (1976:156) referred to evidence of stirrup-jars made in Crete and found on the mainland which, he believed, might have been containers for the export of olive oil. In some tablets from Knossos (Evans 1952:60) there is mention of 405 olive trees planted 20 feet apart, which would have occupied slightly more than an acre. Another tablet refers to 1,780 trees occupying an area of about 16 acres. Therefore, the tree densities would have been between 12 and 36 trees to the stremma. The earliest stage of extraction of oil would have been the bruising of olives which could have been done by pounding (Runnels 1981:243), or treading where wooden 'cloggs'used in treading olives existed in Boeotia. The practice seems to have persisted in other parts of the world, e.g. Corsica, until the early part of the 20th century (Amouretti 1984:268). The next stage would have been done by water-separation. The oil separators would have been used to separate the water contained in the olives as well as the boiling water poured on them, and the oil which would have floated and could have been scooped off with a triton shell or any other scoop. However, after the bruising, whether it was pounding and/or treading, the next stage, extraction, would have been 'pressing'which could have been done with stones (Fig.4.10), a beam press, like the one found at Therasia, or perhaps with so-called anchors used as weights. This is especially interesting in the context of Akrotiri, where several of these 'anchors'have been found within the site itself.

2.1.9 Discussion

If Greece was left untouched by man, we can be sure that the climax vegetation would have been some kind of forest (Rackham 1982:177), evergreen and sclerophyllous in low rainfall areas with *Q.coccifera*, *Pinus sp.* and *Ceratonia siliqua*. Some would have called it a Quercetum-ilicis (Walter 1973:116), while in higher altitudes more cold loving species of *Quercus*, *Pinus*, and *Abies* would have existed. The belief shared by most scholars (Renfrew 1972a:267; Liacos 1974:65; Economidou 1976:52) that Greece was once totally covered with thick forests, with the summits of high mountains the only exception, seems fair. However, unfortunately, all the pollen data cannot be easily compared to other different pollen sites because the approach of each researcher is different, and, thus, the cores do not refer to the same periods as elsewhere and, of course, the data is of unequal quality. It constitutes merely a small part of a jigsaw puzzle and it would still be unwise to voice generalizations. However, a few points stand out:

1. The Bronze Age appears to have been a time of maximum human impact on the vegetation. There seems to have been extensive forest clearance, which had begun as early as the Final Neolithic in the Kopais area (Turner 1978:772), and in northern Greece, there was more human activity within the forests than either before or immediately after.

2. In some northern areas (Ioannina and Philippi) where settlements were present, there is little sign that people were having an impact on the natural vegetation (Turner 1978:772).

3. Therefore, the pattern in northern Greece seems to have been different from that of the south. The vegetation in the north, although influenced by man, was basically woodland throughout prehistoric times, whereas in the south extensive tracts of arable land were formed from the Bronze Age onwards, and the impact of it was visible on the landscape.

Chapter 3

Archaeobotanical studies

3.1 Introduction

Until recently, the attention of most archaeologists was fully occupied in developing and explaining typologies of art-cum-utilitarian objects such as pottery, weapons, tools. These typological exercises provided a chronological framework, and enabled archaeologists to define cultures in space and time. One consequence of this preoccupation with cultural remains was that other types of evidence were not collected, unless they were well preserved and quite spectacular in themselves. Plant remains were particularly neglected. It had to be finds from tombs of ancient Egypt that captured the interest of botanists beginning with C.Kunth in 1826. Later, O.Heer (1866) examined plant material of a different nature but just as spectacular from the waterlogged prehistoric villages of Switzerland which were discovered by chance in the dry winters of 1853-54. Once it became clear that plant material could survive from remote periods of the past, more studies were undertaken, even if sporadically, in various areas of Europe and elsewhere. These took two forms, as either (and most frequently) reports (catalogue) on the species present at a particular site and these were by no means exhaustive studies, or they were studies of the evolution of a particular species in time. This possibility of being able to use palaeoethnobotanical finds in the study of the origins of crop plants was realized in the 1880's by A. de Candolle in his *Origine des Plantes Cultivées* (1883).

In the first half of this century, the number of archaeobotanists working in Europe continued to grow but it would be too lengthy to mention all of them here. A large amount of their research was summarized in the comparative works by K. and F.Bertsch (1949) and Renfrew (1973a). However, an important development in the studies of palaeoethnobotany and an indication that it was becoming a discipline in its own right, was the setting up of the International Work Group for Palaeoethnobotany at Kacina Castle (Prague) in October 1968. Seven meetings have been held since, every three years, at various places. This has fulfilled an important need in bringing together various archaeobotanists working in different countries and approaching the subject from various viewpoints. Here, however, the work of a few archaeobotanists will be mentioned whose work has an intrinsic value in the methodological breakthrough, who also, in some cases, included Greece in their studies. The ones we feel important to mention are Helbaek, van Zeist, Hopf, Renfrew, Willerding, Hubbard and more recently G. Jones, Hansen, Kroll, and Housley.

3.1.1 Archaeobotany in Greece - The early days

The earliest recorded finds of macrofossils from the Aegean area are those of Minos Kalokairinos (BSA, 6, 1899-1900:21) who, in 1878, discovered charred beans and peas in pithoi in the B.A. palace of Knossos on Crete (Evans 1899-1900). In 1879 M. Fouqué reported finding barley and peas from the B.A. site on Therasia in the Cyclades (Fouqué 1879). Professor H.Wittmack of Berlin identified in 1885 grape seeds found at Tiryns by H. Schliemann (1880:320-1). He continued to dominate palaeoethnobotany in Greece for a decade or so of the 20th century identifying remains from Tsountas'excavations at Sesklo, Dimini, and Marmariani (Tsountas 1908), and Bulle's excavations at Orchomenos (Bulle 1909). P. Newberry also identified wheat and two species of peas from the L.B.A. site of Palaikastro on Crete (Bosanquet 1901). In the next 20 years or so numerous finds are reported but no mention was made of any botanist studying the material. In 1926 Heurtley and Hutchinson mention the then Director of the Natural History Museum in London, for the identification of acorns, vetch, wheat and lentil from the B.A. site of Vardaroftsa in Macedonia. F. Netolitzsky (1931, 1934) also looked at material from Greece from the sites of Kephallonia and various sites from Crete. All the early archaeobotanical evidence from Greece was brought together by Vickery (1936). His data were based on chance finds in excavations in Greece mentioned in the reports, for example, large caches of charred material in pottery vessels, or heaps on floor surfaces.

3.1.2 Archaeobotany in Greece - The later days

In view of the recent methodological and theoretical approaches which were being investigated in western Europe, work in Greece changed as well and followed the more general trends of the times. The first innovation was the use of a sampling strategy as well as using a water flotation machine to retrieve the information. This was possible at Franchthi cave for three main reasons. Firstly, the excavator Professor Thomas Jacobsen had planned his excavation programme with environmental data-collecting in mind. Thus, a sampling strategy had been applied during excavation which enabled the retrieval of such information. Secondly, he used for the first time in Greece in 1971, the mechanical water separation device which made retrieval of such information possible. Unfortunately though, the mesh size was relatively large (1.5 mm.) (Hansen 1980:5), and some botanical and other bioarchaeological material would have been lost, especially seeds of weed/wild plants. Thirdly, the succession of periods at Franchthi ranging from the Upper Palaeolithic to the M.N. (c.25,000-3,400) present a diachronic view of the *environmental* and human constraints on the bioarchaeological flora and fauna that was not present on any site so far excavated.

A total of 40 Kg. of charred material, small shells and other float was water-sieved and from this bulk c.2 Kg. of identifiable seeds and plant material was recovered (Hansen 1980:9). Hansen, under Renfrew's supervision, was the first palaeoethnobotanist in Greece who studied fairly intensively several samples from one particular site. Franchthi is one of the first sites in the Aegean to portray the transition from a hunter/gatherer way of life to an agricultural one. Other sites where incipient domestication was sited by Renfrew (pers.comm.) was of *Vitis* at Dhimitra, Sitagroi, Dikili Tash and Lerna (Hopf 1962b). Stummer (1911) had pointed out that *Vitis sylvestris* had small, short and broad pips, whereas *Vitis vinifera* had pips with longer stalks and are narrower in relation to their length. They were distinguished from each other on the basis of their L/B indices. However, the problem of identifying cultivated from wild grapes remains still unresolved, especially after the study of some cultivated pips by Smith (forthcoming) who charred cultivated grapes and found that the L/B indices were not helpful in identifying wild from cultivated grapes. She found that measurements, after charring, overlapped with wild grapes, and that the ratio of the length of the stalk (measured from the base of the chalaza) to the length of the seed was more useful. At Franchthi we might be seeing incipient domestication of *Lens* (Hansen 1980:208). As we know, *Lens nigricans* is indigenous to the Balkan peninsula. Such a process would have had to begin as early as the Mesolithic for selection to have become apparent on them (Hansen 1980). Figs.3.1a & b, taken from Hansen (1980:402-3, figs. 57a & b), show a regression analysis of the *Lens sp.* measurements from two trenches F/AS and F/AN. In the former, the diameter of lentils starts at 2.1mm. in the Upper Palaeolithic and reaches c.3.2mm. in the Neolithic period, while in the latter, the diameter starts at c.2.1mm. in the Mesolithic and is c.3.2mm. again in the Neolithic. This should be compared with Nea Nikomedeia where 93% of the *Lens culinaris* seeds varied from 2.6 to 3.8mm, and the minimum and maximum diameters are 1.9 and 4.6mm. respectively (van Zeist & Bottema 1971:534). Unfortunately, there are no morphological differences between the wild lentil (whether *L.orientalis* or *L.nigricans*) wid the domesticated *Lens culinaris.* Moreover S.E.M. work is presently under way by Ann Butler of the

Institute of Archaeology, London. She has accumulated a vast supply of different populations of all wild species and of as many varieties of *L. culinaris* from as many strategic places as possible (pers.comm. 17.5.85). Pending the completion of her Ph.D. thesis, at present, we can rely only on diameter measurements for differentiating between wild and cultivated seeds.

The presence of wild peas and large seeds of *Hordeum cf.spontaneum* in the Mesolithic layers at Franchthi is very important. If the identification is correct, and badly preserved grains as well as the absence of other glume parts cast doubt upon this, it could have been an indication of a phase in between cultivation and domestication of these plants. Whether these species were just being collected from the wild or were already being experimented with as a source of food and being brought into cultivation at this early date, is not clear, but the possibility of incipient cultivation must remain open pending further finds from sites dating to this period in Greece. However, other evidence in favour of incipient cultivation is the indication of increased intensity of habitation at Franchthi, although it is not yet certain (Hansen 1980:36) whether this represents a more prolonged seasonal occupation or year-round settlement. The botanical evidence though suggests a seasonal occupation (idem:fig.99) (as the seeding plants at Franchthi flower from April to November), but arguments against it are also presented (Hansen 1980:207). Another question which arises from the evidence and that is why, if there was incipient cultivation, are there no signs of early domestication? However, cultivation of cereals would not necessarily leave any visible evidence in the archaeological record, if it resulted in no selective pressure for domesticated characteristics such as tough rachis. Those ears with a tough rachis and greater number of ripe grains will be unconsciously or consciously collected with a knife or sickle or pulling by hand in preference to ears that have brittle rachis or that have partially shattered and lost some of their grain. If, as would be natural in incipient agriculture, some of the harvested grain was then saved for future planting, a greater proportion of the sown grain would have the genotype of tough rachis, and this would predominate in the other generation of sowing. This would eventually eliminate the dominant brittle-rachis character.

If, on the other hand, one uses a harvesting method such as beating the grains into a basket with a stick, the brittle rachis, easily shattering inflorescences would be favoured over the tough rachis inflorescences. This would have been a more efficient means of harvesting wild oat especially, since it has a panicle inflorescence with widely spread florets. This is the way wild rice is still harvested today (Wilke et al.,1972:206; Hansen 1980:173). If the wild oats and wild barley were growing together, this would have been the most efficient way of gathering both cereals at once (Hansen 1980:209). We should not be unduly surprised that there is no clear archaeological evidence for the domestication of these plants at Franchthi, but we must stress that cultivation cannot be disproved at present.

Again under the supervision of J.Renfrew, Rupert Housley (1981) studied part of the material of the new excavation (1971-73) at Servia. There, at the same time as at Franchthi, water flotation was systematically introduced by Richard Hubbard and a sampling strategy was employed, where a constant amount of 10 sq.cm. of charred material was examined from each submitted sample. For large samples, this subsampling was increased to 20 sq.cm. and where the sample size was less than 10 sq.cm. all of the charred material was examined. Moreover, some samples were hand sampled from the contents of certain pottery vessels.

Since these first attempts at gathering bioarchaeological remains from Greek prehistoric and historic sites, there have been few excavations, whether Greek or non-Greek who were willing to spread into the field of environmental archaeology and more specifically plant macrofossils. Some attempts were made in:

Nichoria	(Shay & Shay 1978)
Dhimitra	(Renfrew unpublished)
Kommos	(Shay & Shay, unpublished)
Phylakopi	(Renfrew 1982; Renfrew et al. 1987)
Sparta	(Menelaion) (Jones, unpublished)
Knossos	(Jones 1984a)

Pseira	(Jones, unpublished)
Iolkos	(Jones 1982)

More recently work is in progress on material from Mandalo (Macedonia), Micro Vouni (Samothrace), and Toumba (Salonika) (G. Jones, pers.comm.). However, to date we only have four extensive palaeoethnobotanical studies from Greece, Franchthi (Hansen, 1980), Assiros (Jones 1979), Kastanas (Kroll 1983), and finally Servia (Housley 1981).

The site of Assiros Toumba was excavated in 1975-77, 1979-80 and 1986- by Ken Wardle and revealed Middle/Late B.A. and Early I.A. periods (early second millennium to c. 900 B.C.) (Wardle 1980). Jones (1983) was able, based on ethnoarchaeological work in Greece, to come to some conclusions as regards the ecology of the fields from Assiros. She concluded that soils cultivated were on average lighter, sandier and more easily workable than at Amorgos, suggesting that they possibly took advantage of these light soils on the fans or alluvium near the site. However, there is also evidence of usage of moister and more acid, loamy soils (hillslopes) behind the site where vetch was possibly grown, whilst in the former, cultivation of broomcorn millet may have been taking place.

She also found a low proportion of perennials and a high proportion of summer annuals, suggesting some spring sowing (millet) whilst the wheats were probably autumn sown. Other weed indicators were of compacted soils which could have resulted from frequent human treading in order to hoe and weed the crops. The nitrogenous nature of some weeds favouring sandy soils could have indicated manuring of the crops (G.Jones 1983). Other weed indicators are communities which have character-species of row crop alliances, which could be used as evidence to suggest that cereal and/or pulses were cultivated as row crops.

The excavation at the Toumba of Kastanas lasted from 1975-79 and included periods from E.B.A., L.B.A., I.A., archaic and classical periods. Kroll (1983) studied the plant remains and looked diachronically at the agriculture of these periods through his material. Apart from the usual plants one would expect for the E.B.A. i.e. *Hordeum vulgare*, *T.dicoccum*, *T.monococcum*, *Vicia ervilia*, *Lens culinaris*, *Vicia faba*, *Lathyrus sativus*, and *Pisum sativum*, it seems that *Linum usitatissimum* was cultivated. In the L.B.A. (the beginning) there seems to be intensified growing of *T.monococcum* (idem:244), which increased weeds, especially *Lolium temulentum*. Moreover, the size of crops decreases later in the L.B.A. At that period cultivation of *Panicum miliaceum* was intensified. The switch to this crop seems to have been to control darnel, as well as using it for crop rotation (idem:244). There was no sign though of intensive horticulture. He is convinced that from the L.B.A. agriculture was not only confined to fields but was also spread to gardens (cf.Assiros, where the same seems to have occurred but for different types of crops) (idem:245) where, he believes, fruit, vegetables, spices and herbs were planted. While in the Early.I.A. he sees a decrease in the number of species but production seems to have become more efficient (intensive). The presence, he believes, of Umbelliferae fruit as well as melon seeds might indicate some kind of horticulture. He bases his argument on the increased size of seeds and the decrease in weeds although the latter could happen because of more intensive crop cleaning and the former due to systematic manuring.

3.1.3 Approaches to archaeobotany - The early days

The interest in seed identification was tackled by some 'botanists'who happened to examine plant material from various excavations, usually without having participated. A list of plants identified would be sent to the relevant archaeologist who would insert these in their excavation reports. It just followed the philosophy of the time whereby objects, cultures, and all material things had to be classified in some typology, which revolved very much around the theory of evolution. Therefore, in these early days of 'timid'archaeobotany, we only encounter mention of seeds in footnotes and inserted within the archaeological publication with no reference to archaeobotany as a viable approach in its own right.

Only in the 1940's do we see major books in their own right emerging on archaeobotany (e.g. Bertsch & Bertsch 1949), and the first works of a palaeoethnobotanist, Hans Helbaek, who was going to leave a mark in his own field. In the 1950's, Helbaek, van Zeist, and Hopf were in the forefront of archaeobotany, and their interest lay mainly, as mentioned earlier, in the beginnings of agriculture and domestication in the Near East. On a techno-morphological level they mainly concentrated on the morphology of these proto-cereals, and the origin of their ancestors. However, they relied on excavators to provide them with archaeobotanical material. Therefore, they took little part in the decision-making of collection. What contexts to sample? How much to collect? How to process this material prior to laboratory investigation? How much to sample in the laboratory? Cases in point are the sites of Nea Nikomedeia (van Zeist 1971), Lerna (Hopf 1961 & 1962b), Argissa (Hopf 1962a), Athens (Hopf 1971), Iria and Synoro (Willerding 1973), where the flotation process had not been applied with the result of very poor samples with no segetal or ruderal plants. The introduction of 'seed machines'in the late sixties greatly improved the recoverability of plant species (Struever 1966, 1968; French 1971; Jarman et al., 1972). Moreover, there seems to be little consistency in the information given on the context, size or contents of samples. Even when Hopf examined seed impressions from pottery (Athens) there is no mention of how many sherds she examined, or which type of pottery contained grain impressions. When she refers to the weight of botanical samples (Lerna, Argissa), she never refers to the original sample size, so that it is impossible to estimate what the results mean in quantitative terms.

In the 1960's, Jane Renfrew collected material from previous excavations in Thessaly, and instead of reporting on each site separately, as had been the tradition so far in archaeobotanical reports, she tried to synthesize early agriculture of the whole area, as well as reporting on the individual sites (Renfrew 1966). She encountered, of course, many problems: some of the samples were small, or had been stored for a long time and thus could have deteriorated; some could have been mishandled or mislabelled before identification, and most were 'grab'samples of easily visible seeds and grains, and thus unlikely to contain large numbers of smaller seeds. This is reflected in the range of species that she found, as small weed seeds are almost absent. Moreover, material from Achilleion (unpublished, J.Renfrew), Phylakopi (Renfrew 1982), Kephala on Kea (Renfrew 1977), Myrtos (Renfrew 1972), Photolivos/Sitagroi (Renfrew 1969), Saliagos (Renfrew 1968a), and Dhimitra (unpublished, J.Renfrew) is said to have been water floated, but no information is given in the individual reports. Renfrew (1973:14-15) has described elsewhere, a technique of flotation, whereby dried soil was poured into water, sometimes after adding an amount of dilute hydrochloric acid (or carbon tetrachloride) to break up and release the charred material. The flot was then collected by a sieve (0.5 mm. mesh) but, this mesh was unlikely to be fine enough to capture most seeds of ruderal, and segetal plants. We, therefore, assume that this method was used at some, and perhaps all, the above-mentioned sites.

Therefore, archaeobotany, just like archaeology, itself evolved from the typological/infancy stage where lists of cultivated plants and numbers of seeds found were enumerated, and compared to finds from other sites. This building up of information was the basis for modelling the beginnings and spread of agriculture, from the Near East to south east Europe. Quantification of seeds was based on the principal that the main crop was the one with the highest number of seeds (Renfrew 1966:32). Eleven deposits from Iolkos in Thessaly were examined separately but finds from each deposit were lumped together in a single quantification unit. For illustration purposes, we shall mention here deposit 11, 61 T.601 2-9 SQ 4 A-B where 1 seed of *Hordeum hexastichum L.* and 1 stone of *Olea Europaea L.* made 50% each of the resources of this deposit (Renfrew 1966). The same author later (Renfrew 1973a:21) admits that 'samples of carbonized grain cannot be considered truly "random". They have become carbonized due to some accident in antiquity, being scorched in a parching oven, spilled by the hearth or singed in the conflagration of part of a building and are thus indicative of their own immediate circumstances and not even of the entire harvest of that season'.

After understanding the circumstances of accidental preservation, the next logical step was understanding what these accidentally preserved 'pockets'of charred material really meant. What was their 'cultural meaning'? As their presence mostly were attributed to human activity of some sort, crop processing was one possible factor contributing to the variation between samples.

Side by side with increasingly sophisticated questions, there grew a need for better retrieval methods which could provide samples of good enough quality and quantity which could be used as a basis for answering these questions. An early example of the use of water flotation was the excavation of the site of Ali Kosh in S.W. Iran (Helbaek 1960a). As early as the 1960's, Helbaek (1960a:99) believed in more active participation of natural scientists on archaeological excavations, in order to make their own professional assessments of prehistoric deposits *in situ*, and presumably to gather all the relevant information on the samples which would eventually influence the interpretive power of the data. His rigorous approach is also noted from the fact that he also advised scientists to make ecological observations of present conditions. Unfortunately, this advice seem to have remained largely unheeded until fairly recently, and even in the 1980's, this approach is considered *avant garde* in Aegean studies.

In this transitional period within palaeoethnobotanical history, several norms were set down. The distinction between macroscopic studies and microscopic ones in archaeobotany were also defined then (Helbaek idem:99). Helbaek's (1960e:196) intimate knowledge of cultivated cereals led him to experiment on the genetic constitution of plants where by submitting *Hordeum spontaneum* to X-ray treatment, he produced a six-row lax spike. Helbaek referred to 'cultivated wild barley'at Beidha, and drew attention to the fact that prehistoric farmers must have begun to raise wild species before the morphological characters of domesticates emerged. Therefore, he struck on the great theme of what is considered cultivated and what domesticated. In his view, some sort of proto-agriculture might have begun before permanent settlements occurred, just as is achieved by present-day nomads who wander through the same tracts a few times a year, and grow small plots of wheat and barley, seemingly not watching them until the time of ripening (Helbaek 1960a:100).

3.1.4 Approaches to archaeobotany - The loss of innocence

The major break-through occurred with the works of Dennell (1972; 1974; 1976) and Hillman (1972; 1973), who both suggested that archaeobotanical remains could be used to suggest various crop processing activities as it was believed they 'had discrete and predictable effects upon the type of plant samples recovered by excavation'(Dennell 1975:7:3). Quite rightly, it was suggested that crop processing was affecting 'the preservation and composition of macroscopic plant remains on archaeological sites'(Dennell 1978b:17). We should accept the truism that plant material on archaeological sites are often preserved by accident. Either the conditions of crop processing, e.g. parching, or drying in an oven or fire will favour the preservation of some crops and would eliminate the survival of others (e.g. brewing), or the circumstances of preservation would be such that the conflagration of a site would slightly reduce the bias of preservation and the relative proportions of seeds could inform us on the possible relative importance of stored crops. Nonetheless, we know very little on the effects of charring on various types of seeds. We also have to be very careful when making generalizations. Wilson (1984:205) concluded that 'the composition of a carbonised fossil assemblage is no indication of its composition before carbonisation', and that (idem:206) (Table 3.1 & 3.2) 'a predominance of cereal grains in a sample may often be solely the result of differential preservation'. Therefore, the difficulty of comparing assemblages, even from the same house, is obvious, as various microclimates during the fire might have existed which would have prevented uniformity of charring. However, even if there were uniform microclimates, from Wilson's (1984) study, it seems that seeds of different species need different temperatures and regimes to survive charring (Tables3.1). It also seems that wet seeds heated at c.350°C and above for 30 min. would be totally destroyed and leave no evidence of their existence (Table3.2). This is an area of research where it would be very important to experiment with various temperatures, regimes and seed species, for nothing seems to be conclusive at present.

Another method of quantification was used at Sitagroi (Renfrew 1969) where, in order to compensate for biases inherent in any one sample, the importance of each plant food was estimated from the percentage of samples in which it was the dominant plant. Thus emmer was estimated as comprising c.50% of the plant foods in the earliest settlement at Sitagroi on the basis that it was the commonest plant in 17 out of the 32 samples. But, here again we are faced with a serious problem as illustrated very well by Dennell (1978b:23-24) if one does not seriously take into account the characteristics of each individual sample, and especially try and understand the nature of the samples we are comparing. Firstly, they should be collected with the same method, and crop processing should be understood in order to avoid comparing a cleaned crop (food resource) with the by-products (accidental waste) of another. Differential preservation of some contexts (as mentioned) should be investigated, and the invisibility of some processes should not be ignored, as for example a wine production site could have very few visible plant remains, especially if the inhabitants used the by-products of wine production as manure. The fourth important point is understanding the nature of the site and variation in activity areas. Very often excavations uncover atypical parts of settlements, e.g. the excavation of a palace site in Greece, while humble country houses are rarely excavated. Therefore, the need is not only to increase the number of samples, but mainly to sample as much as possible from various contexts and understand their nature, so as to be able to compare results from similar type of activities.

A third method of quantification (Hubbard 1975:198) was used to estimate the importance of prehistoric plant resources, and that is 'presence analysis'. If, in other words, a plant species is represented in all the samples from a site, it is assigned a value of 100% and if in half the samples, then a value of 50% and so forth. However, we cannot always assume that the frequency of a plant in a group of samples is a direct reflection of its importance, nor that archaeobotanical evidence alone is directly representative of crop economics. Based on what we stated above, we cannot accept the argument that 'the frequency with which a plant is encountered in a group of samples will be proportional to the frequency of its use'(Hubbard 1975:198), since it allows the comparison of data of very different quality and heterogeneous material (Hubbard 1975:198 for more arguments, and opposing views in Dennell 1977).

Qualitative techniques were first noted by Helbaek (1970) but explored more fully by Dennell (1976a). He assumes that the economic status of a 'plant food should correspond to the range and type of food processing activities to which it was subjected'(Dennell 1978b:27). In other words, those plants that were economically important could be isolated from the 'incidental and casual foods'(Higgs & Vita-Finzi 1972:29), in that domestic processing activities would be performed in order to prepare these food plants for storage and consumption. This, of course, would be applicable in a sedentary-type economy but when it comes to examining Hunter/Gatherer - Gatherer/Hunter food plants a whole set of different rules would have to be applied.

Dennell isolated seven types of archaeological contexts: a) storage jars/areas; b) ovens and hearths; c) floor deposits; d) middens/ rubbish pits; e) fill deposits; f) faecal deposits; g) impressions in pottery, clay, adobe etc.(Dennell 1975:3:30-33; Dennell 1978:fig.2). This method has the advantage of integrating archaeobotanical and archaeological information providing, of course, there is close collaboration between archaeologist and archaeobotanist. The presence of several contexts could provide a variety of plant samples at different processing stages, but the absence of some plants would not in itself be interpreted as necessarily meaning that they were absent from the site/settlement. As whole sites are rarely totally excavated, the plant remains will be biased accordingly and relevant only to the excavated areas, not necessarily reflecting the conditions prevailing in the whole site. However, Dennell was very lucky in being able to detect three main crop processing stages at three Bulgarian sites, Kazanluk, Chevdar, and Ezero, as often evidence is not as clear cut as theoretical models claim (Dennell 1978b: fig.10 & 24; Dennell 1974b:283,fig.1). One reason why Dennell's sampling strategy, based on the known functions of structural contexts, does not always work, is demonstrated in the study of charred remains from a small Romano-British villa at Barton Court Farm in Oxfordshire (M.Jones 1985:111). As many of the structural contexts could be assigned to some type of function, a purposive sampling strategy was based on Dennell's predictive model, but the composition of the plant assemblages showed no relationship to the models of function. For example, a smithy oven yielded an assemblage of charred cereals, although that particular oven would have operated at too high temperatures for plant material to survive in any recognisable form. However, Dennell's major contribution was his behavioural approach to plant assemblages and his thesis that crop processing is a valid model for interpreting archaeobotanical remains. On the other hand, the methods used to arrive at this approach are somewhat unsystematic (see polemic, Hubbard 1975). He uses, as I understand it, three variables (including archaeological context) to arrive at his conclusions. One is his size of seed which is in itself a dubious matter and, secondly, the composition of the samples (Dennell 1974b:284). If we use as an example (Dennell 1978b:256, Fig.3.2a) the early Neolithic site of Kazanluk where crop processing was portrayed, and where weed species of these various stages are noted, we see that out of the 19 weed species mentioned, 14 seem to be present in more than one context, and 8 in more than three contexts. In another figure (Dennell 1978b:256, Fig.3.2b) we see that out of the 11 weed species, 5 appeared in both floor and oven context at Chevdar. Therefore, the argument in these particular examples of using weeds as indicators as well of context is just indicative and not conclusive. The number of seeds is important as well as the number of species for detecting crop processing stages, but no mention was made of those numbers. However, Dennell tried to show that:

1. Cleaned crops had some weed seeds from a very small range of species;
2. Cleaning residues had a higher percentage of weed seeds and from a wider range of species;

3. Possible threshing residues had even more weeds and species.

It is clear that Dennell used numbers and species of weeds as indicators of the crop processing stage but other factors had to be quantified before understanding the crop processing model. Therefore, it seems as if Dennell rushed prematurely to normative conclusions, through a behavioural approach, before developing a sound methodology for deciphering the signs of crop processing activities in archaeological material. However, this is not a totally negative criticism for somewhere theory-building is needed to generate a methodology to test it.

Hillman (1972) was working about the same time as Dennell but was trying to solve these problems by using ethnographic models, and tried to systematize information on crop processing (Hillman 1981). Although the theoretical aim of both was basically the same, the way they approached the subject was from two opposite directions. Hillman, unlike Dennell, believes that the composition of samples of plant remains is able 'to provide the basis for assigning past functions to the features, structures, or even whole sites from which the samples were recovered than it is for the excavator's identification of context-type to provide the basis for interpreting the composition of samples of plant remains'(Hillman 1981:125). Therefore, we can say that Dennell's crop processing was based on assumed past functions of the contexts, which he sampled, and his approach was principally archaeological and predictive, and owed much to speculation, whilst Hillman and G.Jones approached crop processing from 'explicitly defined ethnographic models'(Hillman 1984b:1). In order to understand the underlying meaning of the composition of archaeological samples, detailed observations are needed to understand present-day traditional agricultural practices and the composition of crop products and by-products. In other words it is believed that by observing and measuring crop products and by-products, interpretative models would be built based on ethnographic models which would help us analyse archaeological plant remains (Hillman 1981:126). From the ethnographic work that Hillman did in Turkey, he claimed that 'the broad correlations between crop processing practices and sample composition are sufficiently clear-cut to be definable in respect of the major categories of materials of the sort found in samples of prehistoric charred plant remains'(Hillman 1981:130 and flow diagrams Figs.5-7 our Fig.3.2; Hillman 1984). The classes of plant products that are likely to be preserved as charred remains from archaeological sites (marked F on his flow diagrams) are believed by Hillman (1981:139) to be slightly different from Dennell's classification (cf.above) and include a) crop products at a stage of processing (dried/parched in kilns, ovens, open fires etc.); b) diseased crop products disposed of in fires; c) crop processing 'waste'used as fuel and d) food products at the last stage of storage or cooking. These would be the stages observed in wet zones (cf.flow diagrams; Hillman 1981 for dry zones). Therefore, our need of ethnographic models and research in weed ecology is crucial in our understanding of the composition of archaeological plant remains, and would yield information on the methods of reaping and cleaning the grain as well as providing clues to other husbandry practices such as ploughing, manuring etc. Based on his models from ethnographic work in Turkey (Hillman 1973a), he claims to be able to classify plant material and assign them a crop processing stage (Hillman 1984). However, his observations are based on 'qualitative assessments of equivalent ratios in present-day product types'(Hillman 1984). The completion of his quantitative study from Turkey is pending, but G.Jones's work on Amorgos and Karpathos in Greece (G.Jones 1983a & b, 1984a &b), has tested quantitatively the discrimination of these crop processing stages, and is convincing enough as regards identifying products and by-products of particular stages of crop processing. This would help us identify the various types of activity areas in a site, and, therefore, contribute to the interpretation of the functions of buildings, and consequently, help us understand the role of the site in relation to other sites and more generally within its environment.

3.1.5 Models of crop-processing and beyond

Fortunately for us, crop processing has an international language in that cereal and legume crops have to go through various procedures from the time of harvest to storage and food, which do not differ a great deal between different cultures. However, there is a dichotomy between the procedures used in dry and wet environments for dealing with free-threshing cereals (including barley and rye), pulses and glume wheats. In the dry habitats, the main crop processing stages are done in the open-air and mostly in bulk, while in the latter, jobs are done on a day-to-day basis as need may arise, especially as cereal spikelets keep better and have a lesser chance of being attacked by weevils than the naked grain. However, not only are the procedures the same in large geographical areas independently of the culture and time-period, but also the stages are fairly strictly laid out in a logical order. The winnowing, for example, cannot be done after sieving, nor the threshing after winnowing, which makes the study of traditional present-day agricultural systems even more relevant to prehistory. The maturity of this approach came with Hillman's and Jones'work in Turkey and Greece respectively, and the following questions became answerable:

1. What is the function of rooms/structures in terms of the activities concerned with the processing of plant products? (e.g. models Hillman 1972, 1973, 1984; G.Jones et al.,1986; G.Jones & Rowley-Conwy 1985; Buurman,J.1979).

2. What were the crop processing stages and in which stage were crops stored? (e.g. Dennell 1974; Jones 1981a; G.Jones et al.,1986; M.Jones 1984).

3. The harvesting methods? (e.g. van Zeist & Bottema 1971)

   These are questions which can be answered if plant products come from various contexts, as the main variable one contests with are man and his effects after the harvesting of the plant. When one comes to dealing with the following questions:

4. Sowing times, e.g. sown in autumn or spring? (M.Jones,1983; P.Reynolds 1981a & b; Hillman 1981);

5. Did they till with ards or mouldboard ploughs (not relevant for Greece until possibly the Byzantine period)?;

6. Did they weed their crops?; and
7. Did they irrigate or manure any of their crop?;
8. What soil type do the weeds portray, and can anything be said on the location of fields?;

It is much more difficult to give answers as we are dealing with the whole agricultural ecosystem. Unfortunately, to date, very little is still known about phytoecology and more particularly, weed ecology and phytosociology. Nevertheless, studies have been conducted about present day phytoecology/weed ecology in the western Mediterranean and in temperate climates (e.g. Braun-Blanquet 1932; Brenchley & Warrington 1933; Holzner & Numata 1982) but for the Balkans many more studies are needed (Walter 1966, 1969; Oberdorfer 1953-54; Tuxen 1958; Ellenberg 1950, 1974) As we know that weeds have evolved a general purpose genotype (Jones 1983b:198) which gives them flexibility for growing in a wide range of anthropogenic environments, they can easily adapt to fairly flexible edaphic (moisture content, pH, and nitrogen content) and climatic factors (light, temperature, and continentality) (Ellenberg 1974), so that these factors combine to make their precise ecological classification difficult.

Our interests as archaeologists in the above questions, is to understand the relationship of weed species to their environment, and not so much to understand the mechanism of the relationship of one weed species to another, or one weed community to another. However, it is recognised by most phytosociologists (Tuxen 1950; Ellenberg 1950, 1974) that groups of species often give more effective indication of environmental factors than single species, so that in archaeological samples, if one found what one believed to be an 'indicator'weed (based on the single presence of that weed species), it would be very rash to opt for an ecological explanation. This caution is due to the fact that some weed species have a whole range of ecotypes adapted to different local environments, and while some species are more likely to have more flexible ecotypes than others, the combination of the various species would be a way of narrowing down the ecotype 'possibilities'.

To make matters even more complicated for the Balkans, the weed floras are much richer in species than in more northern regions and, whereas in central Europe a clear line can be drawn between natural and anthropogenic plant communities, this boundary is blurred in the Mediterranean (Zohary 1973; Oberdorfer 1954; Walter 1969). The greatest overlap seems to occur between communities on dry grassland and xerophytic pasture (mostly annual xerophytic species). It is believed that many of the weed species have their origins in this region and in the Middle East (Zohary 1973; Knapp 1964), as it is well known that many plant species 'have a narrower ecological amplitude towards the edges of their range than in its centre'(Holzner 1978:18).

In brief, whilst assigning weeds to particular ecotypes is not achievable universally, studies for interpreting archaeological weed material should be conducted in areas of well-defined climate, as this (using the term loosely) seems to be a determining factor of their existence (Holzner 1978:19). Edaphic requirements seem to vary, for in their optimal climate, weeds are often indifferent to soil factors, and in their northern border areas, species of southern origin are restricted to calcareous soils as well as to agrestal and ruderal communities. Also, some weeds may appear as being relatively calciphilous but genuinely calcifuge species, where the controlling factor is climatic in the former case and physiological in the second (Holzner 1978:19). Therefore, some of the studies conducted in northern Europe by scholars like Reynolds (1981a & b) at the Iron Age Farm at Butzer have a fairly limited applicability when one considers archaeological botanical material from Greece. One final caveat to be considered is the time span, and if we should automatically presume that the ecozones of weeds have changed diachronically.

Both experimental (Reynolds 1981a; 1981b; Dennell 1972;1975:7:10 fig.7.2 and table 7:4) and ethnographic models (Hillman; G.Jones) have helped to analyze archaeobotanical remains and discriminate between the different crop processing stages.

G.Jones (1981a; 1983a&b; 1984b) has used the data on six categories of weed seeds from Amorgos (e.g. small, headed, heavy: big, free, light etc., Jones 1983:24) to differentiate statistically different stages of crop processing. Thus, analytical theory, was taken a step further. One could perhaps use the analogy and claim that 'middle-range methodology'(Jones,G.1983a:17) could be used in this respect to build middle-range theory. Models of crop processing have been formulated and tested, and therefore, could be used for the third stage of analysis, the modelling of economic and social complexity.

Barker and Gamble (1985:6) believe that palaeoeconomic data (including palaeoethnobotany) could help in illuminating economic and social complexity problems as 'agricultural organization provides a comparative yardstick with which to measure variations in the socio-economic systems of prehistoric Europe'(idem:7), although, of course, different social systems and institutions can arise from the same set of plant/animal resources (cf. social systems believed to have operated in, for example, B.A. Greece). They believe that the social system is dominant over the ecological system in as far as the system dictates the exploitation of the environment, and though the ecological system imposes some constraints on the types of resources available, it cannot 'determine the level of appropriation of resources....or what is done with them'(idem).

This emphasis on the temporal variation of archaeobotanical investigations, has led some archaeobotanists to see the potential of studying other forms of variation in the plant record, beyond crop processing, in order to understand man-plant relationships in a socio-economic context. Korber-Grohne (1967, 1981), in her archaeobotanical investigations of Feddersen Wierde (1st-4th century A.D.) settlement mound on the north German coast, has investigated another dimension of archaeobotanical studies, namely the spatial variation of plant remains, in order to understand these intricacies of man-plant relationships, referred to above. In this study, where she had the good luck of finding both charred and waterlogged plant material preserved in an almost intact state, and used this data to study the spatial distribution of plant remains and their relation to structural features on the site. This provided information on processes of collecting, threshing, storing, and using crop plants. Her findings of whole plants (see above) resulted from the method of harvesting, and she concluded that it must have travelled only a short distance. The other main concern in palaeoethnobotanical studies, namely the differential preservation of plant assemblages at the intra-site and inter-site scale, was also discussed by her, but it is still an area about which we know very little, and where a great deal of experimental work still needs to be done.

In addition to interpretations of plant material on an intra-site level, and its implications for socio-economic articulation, and explanation of modes of production and consumption of crop plants, M.Jones (1978; 1985) has demonstrated how the same set of data, collected with a probabilistic sampling strategy (see below on sampling), can be 'aimed at relating assemblages to general zones of the site without reference to particular structural contexts'(Jones,M. 1985:112). Using this method, he was able to see patterns of landscape utilization, and used correlations of weeds, grain and chaff to show that crop-cleaning activities varied from five sites (M.Jones 1985:119, fig.4.5 scattergrams). The difference in topographic position of the two pairs of sites (Ashville and Mount Farm located on the second gravel terrace above the Thames where free-draining, level and fertile land is suited for cereal agriculture, and Smith's Field and Claydon Pike, closer to the river, and on the first gravel terrace) 'is mirrored by a difference in the general spread of assemblage composition'(M.Jones 1985:118). At the first two sites, at least 30% of all fragments in the majority of assemblages are cereal grains, and no sample has more than 70% weed seeds and more than 50% chaff fragments. The assemblages from the other two sites seemed to have been composed of up to 80% of chaff, 100% of weeds, and cereal grains made no more than 50% of any individual sample. Jones (1985:118), therefore, believes that 'the spread of assemblage compositions and the environmental settings of a site are clearly linked', where 'non-producer site receiving the harvest product through exchange is likely to allow only waste material from any final processing to be discarded into the settlement fires'(idem:120). Consumption on a non-producer site would, therefore, be expected to produce the kind of assemblage distribution found at the two sites on the first gravel terrace (Smith's Field and Claydon Pike). The fifth scatter-diagram (idem:fig 4.5) refers to the hillfort at Danebury (Jones,M.1984), where he detected a range of assemblages far greater than at any of the aforementioned sites, in terms both of composition and of fragment density within each deposit, and he interpreted this to mean a much broader range of agricultural activities within Danebury. A number of the weed species also belonged to riverside habitats which were presumed to lie at the edge of the site territory and, moreover, belonged to a mixture of ecological types, which suggest that the crops brought back to the site belonged to various 'territory-types'. Therefore, Danebury could be interpreted as receiving harvested crops from various parts of its 'territory'and was processing it in bulk within the hillfort. As regards consumption, what this meant is difficult to say, unless one has looked at the whole web of settlements within an area from a plant assemblage viewpoint. Cereals at Danebury could either have been consumed within the hillfort or 'passed out of the territory along a network of external exchange'(M.Jones 1985:122), or redistributed within the territory. (cf. possible communal storage at B.A. Assiros, G.Jones 1985, social storage from the Minoan palaces, Halstead,P.1981b). From the evidence of the Upper Thames valley, he (M.Jones 1985:122) suggested that cereals at the pastoral sites (Smith's Field & Claydon Pike) were in a semi-processed state, and had been when they left the arable sites (Ashville & Mount Farm), while he predicted that at Danebury they would have left in a fully processed state. From the above-mentioned model, it implies that the extracted cereals, were not redistributed within the system (unlike that which is modelled occasionally for Minoan palaces), but rather small consumer sites were receiving cereals directly from the producer sites, and that the cereals within hillforts were either consumed there, or possibly exchanged for goods from outside the system (Idem:122).

To be able to stretch the full potential of this 'landscape approach', there should be three basic prerequisites. Firstly, the sampling for plant remains within a given region should be using methods which make the results comparable. Secondly, excavations, following survey, within the given region would need to be exhaustive and last, but not least, an integrated approach would be essential between specialists studying various categories of material, be they bioarchaeological data or artifacts, and the whole sampling strategy within a given site would need to be geared around the questions asked by the excavator together with the other specialists.

3.1.6 Recovery methods and sampling

Here I will not deal with the intricacies of various sampling theories that exist nor with the discussion of the multitude of sieving machines, but with the bare practicality of sampling on-site where the questions which come to mind are: a) what sample size to collect from excavations?; b) what decisions should be taken when choosing these samples?; and c) subsampling in the laboratory?.

Sampling on site

The question which needs an answer is how big should soil samples be, and from where should they be taken? Here, optimization of time and resources should be considered, just as in every stage of the procedure. However, all that we know from this stage is untested, but qualitative suggestions have been proposed which have more of a heuristic than a scientific value.

The choice of sample size varies considerably between archaeologists and also between features/chronological periods on the same site. Some consider it necessary to sample whole deposits, while others, who are the majority, sample selected deposits, or even do a programme of random sampling. Choice of sample size ranges sometimes from 1-¿25 Kg. but there seems to be a preference for 5 Kg. samples (Keeley 1978:180). It is interesting to note that work at the York Environmental Archaeology Unit showed that wide variations in inter-sample results were obtained when a 10 Kg. sample was divided into 1 Kg. subsamples (idem:180), and it indicates without doubt the desirability of large samples (5-10 Kg. perhaps).

At Ashville (Oxfordshire) M.Jones (1978:97) normally took a known volume of soil (3 buckets) (c.40 litres) from each feature he wanted to sample, while at Danebury (M.Jones 1984:483) the sample size was 2 buckets (c.25 litres), but there is no explanation for the number of buckets taken.

However, the aim of the archaeologist should be an attempt to reconstruct *as complete* a picture as possible of agricultural practices, domestic/industrial activities, and help in solving the intra and inter-site economic webs which could subsequently give us a glimpse, perhaps, of social stratification. In order to approach as closely as possible these goals:

1. one should sample from as wide a range of contexts and features as possible, and
2. one should replicate this sampling in as many different contexts and features within and between occupation phases (Hillman 1981:141) so as to act as a test to a). Thirdly
3. each sample should be sufficiently large to be representative of the whole parent population, but not excessive so that optimization of time and money should be accounted for by higher degree of resolution of our data.

Hillman (idem:141) believes that 'the minimum acceptable sample size varies with the initial rate of deposition of charred remains and their state of preservation which is partially age-dependent'. At Tell Abu Hureyra (Syria) with deposits of 8,000-11,000 B.P., the average sample size was four barrow-loads of excavated earth, and at Neolithic Can Hasan III, the samples were even larger. In contrast, at Romano-British Cefn Graeanog II (Wales), four buckets per feature were considered enough for most interpretative needs.

From ethnoarchaeological studies of crop processing, G.Jones (1983b:3.3.6) took c.5 litres or 5 Kg. (cf. 2 Kg.taken by Hillman, 1973a:243) from the three products and by-products of crop processing at Amorgos, and this amount was proved to be enough to make statistically significant tests to assign them to some crop-processing group. How this observation can be transcribed when taking archaeological samples is difficult to estimate at present. However, G.Jones (unpublished manuscript) gives some sampling suggestions where she states that it would be advisable to process initially four buckets of soil, and if plant remains are visible in the flot sieve (1 mm. mesh), one should continue until one reaches a number of c. 100 seeds minimum or up to when the deposit is exhausted, and preferably up to 500-1000 seeds if possible. If, on the other hand, there are no plant remains visible, one should stop at four buckets and bag the sample.

However, all these statements are possible guidelines, and it is not yet possible to state a volume/weight of sample with assurance. It would only become possible if tests of subsamples would be taken of whatever amount one deemed appropriate, and the whole feature/layer floated in order to test the optimum amount, but this testing has a negative point in that it has an in-built mechanism to test within the feature sampled and not reflect what might be needed in a different feature of the same site and of the same period. Schaaf (1981:223) rightly states that 'archaeological features by the very nature of their deposition cannot be homogeneous and therefore random distribution cannot be claimed for them'. Therefore, probabilistic sampling seems best used in conjunction with purposive sampling strategies (Nance 1981:164).

An experiment was conducted by Schaaf (1981:224), where she took 124.5 litres of soil matrix which represented an entire pit content. Eighteen 1 litre samples (c.15% of the total) were randomly collected from the pile (124.5 litres) and these were analyzed individually in order to evaluate sample size and representiveness. However, by randomly was meant that the samples were taken from various locations in the pile of 124.5 litres to compensate for the effect that seeds have to sort themselves into categories, i.e. very heavy and very small would fall in the bottom of the pile. The remainder of the total was split into 25% sample using a riffle type sample splitter, and 18 one litre subsamples were selected from the 25%. These two groups of 18 litre samples were subjected to identical flotation processing and analysis.

The first and second groups of 18 litre samples show that assemblages of seeds recovered between the two trials are very consistent. If one compares the chi-squares of the genera, the results seem to be fairly consistent between subsamples, and it proves once more (see below) that the riffle splitter will produce more representative subsamples of the whole sample (Schaaf 1981:229). The graph which illustrates the relationship between the relative precision index, sample, and seed population size shows that the greater precision is proportional to larger sample size and larger seed population, while rarer components may be missed completely by subsampling (idem:232). However, she still does not recommend an optimum sample size but believes that a sample over 15% is recommendable (idem:230). Therefore, within-site sampling remains an unsolved problem, and concrete, objective criteria for a meaningful evaluation of sample size is still awaiting.

Subsampling in the laboratory

It seems better to take as large samples as possible for water flotation from archaeological sites and then subsample them in the workshop/laboratory, rather than find that samples, due to their small size, are unrepresentative and could not be used for the questions asked. In the latter case, there would often be no way of going back and retrieving information.

Experiments for subsampling in the laboratory were done by van der Veen and Fieller (1980, 1982), but the shortcoming is that they were done using a bag of charred material where modern seeds were added. Therefore, they were not using a real archaeological sample nor sampled from various feature compositions as, presumably, they would need a slightly different degree of sampling depending on the density of seeds per soil, and other variables whose nature would be closely connected to the use of a particular feature. One would expect, for example, that a floor covered by 1 cm. or more of pure charred seeds, representing the spill from storage, would need sampling at various sections of the spill rather than one large sample from a random area of the spill. Here one could argue that G.Jones'suggestions (see above) come nearer to solving this difficulty. However, for these experiments, van der Veen and Fieller (ibid) used five different sample compositions, each with varying numbers of species, and subsampled these with three methods, the spoon, the riffle, and the grid (for details see van der Veen 1980:12-13). Each of these three methods was applied five times on the five compositions, and resulted in 75 experiments. The five species involved were *Triticum aestivum*, *Lens culinaris*, *Hordeum hexastichum*, *Vicia sativa* and *Solanum nigra* and the five compositions were totals of 100, 250, 435, 1000 and 1025 seeds and respectively the sampling proportions were 37.5%, 25%, 25%, 10%, and 10%. The riffle method produced the best estimate of the true proportion, and it was closely followed by the grid-method, whilst the spoon-method produced the least accurate estimates of the true proportion.

Van der Veen and Fieller's next hypothesis assumed that the sampling method was producing random samples, and the question followed was what was the probability of getting the observed results? As expected the riffle-method produced random samples, whilst the grid-method produced few extreme results and 'could almost be said to be suspiciously accurate'(van der Veen 1980:17).

The sample size needed will be determined by several factors, but above all by the questions we are asking of our data. If we are just asking for a list about the most abundant species present in our sample, then our sample size need not be large, but again it might depend on the context. If, on the other hand, we need to know the proportion of the different species to each other for further interpretation of the plant assemblage, then, of course, our sample size will need to grow. However, the sampling paradox is that in order to calculate statistically the subsample which would be representative of our needs, we ideally need to know the total number of seeds and their proportions in our original sample, but in archaeology that is impossible and only enlighted guesses, most probably from previous experience, could be used. Having these guesses in mind, Fieller (van der Veen & Fieller 1982:295) have provided some formulas which could help us estimate the required sample size to take. Therefore, four variables are important to consider when we need to sample: a) the total number of seeds in the target population; b) the proportion of the different species to each other; c) the degree of accuracy that we require for our analysis; and d) a measure of chance of obtaining the accuracy demanded.

3.1.7 Interpretation

In this chapter, I have tried to bring out several points of weakness and gaps in archaeobotanical research but, on the other hand, I hope it has highlighted the potential and the challenge that archaeobotany has in playing a very substantial part in the study of the diet, the interpretation of contexts and use of rooms, the agricultural and industrial activities connected to plants, the whole organization of subsistence activities, and even beyond subsistence to explanations of economic ties within and between sites and the whole interplay of connections within a given landscape.

Beyond the vast literature and the mass of knowledge accumulated from very detailed studies of various cultivated and wild plants a great deal still needs to be learnt about other cultivated plants, weeds and wild plants. More detailed seed atlases need to be made with, amongst others, the problem of the archaeobotanist in mind. Needless to say, seed collections should be created on a national level, preferably connected to major botanical Herberia, i.e. Kew, Edinburgh, with computerized lists distributed to all major centres researching in palaeoethnobotany.

Another important point would be closer collaboration with botanists and botanical departments so that both parties would become aware of problems pertaining to each other's fields which could be relevant to either parties. Therefore, this collaboration could induce more botanists to pay more respect to this part of the plant, the seed. It is very frustrating to see that major botanical works like the Flora Europaea, very often ignore seeds altogether.

The other great gap in botanical studies is generally weed ecology, both segetal and ruderal. When it comes to weeds, botanists are more ready to study the effects of various weed killers and fertilizers, rather than treat these classes of plants as endangered species which need to be studied for their own right. This is especially true when studies of husbandry are undertaken, as weeds are such variable species and could adapt to various anthropogenic environments. There is a great need of more localised studies which could eventually be useful to archaeobotanists studying in the area. So far the study of prehistoric husbandry and its effects on vegetation has lagged far behind the crop processing studies of the latest years. Some studies have merely touched on the problem (Kroll 1984a&b; Jones 1983b; Jones 1984b) as its intricacies are attributed to the fact that the problems touch weed sociology/phytoecology, and the autecology of individual species (G.Jones, forthcoming), and the effects of cultivation on these species.

Recovery problems float on several levels. Firstly, on the basic problems of recovery which deal with machinery used to collect our data, and the sampling strategies which we use both on the site, when we select the soil samples that should be floated, and in the laboratory, when we decide how much of the material to submit to study. Here we have, as we saw above, a few problems still to resolve.

We also need more ethnoarchaeological research in various ecological zones and with agricultural economies that are still traditional in order to gather information on crop processing, storage habits, husbandry practices, and, in general, more information is needed on man-plant relationships under traditional systems of agriculture.

Chapter 4

Thera: The background

4.1 Introduction

This chapter discusses the island of Thera with particular reference to the site of Akrotiri in order to make inferences on possible settlement patterns and population estimates.

4.1.1 The macro-context: the island

The island of Thera is one of the live volcanoes in the Aegean region, the volcanic cones are mostly under the sea except for the two islands of Palaea Kameni and Nea Kameni (Fig.4.1). Thera is one of the largest calderas in the world. However, what we see today is unlike the L.B.A. island prior to the catastrophic eruption.

The present group of islands comprising Thera, Therasia and Aspronisi are the remnants of a former single island, which, because of its round form, was called 'Strongyle', meaning 'round'in Greek. Some classical Greek authors, including

Plato, referred to it as 'Kallisti'meaning 'the most beautiful one'. This island is the product of at least ten volcanoes, which became active about 1 million years ago (Pichler & Friedrich 1980:15), and thus it has undergone a great deal of transformation.

The Late Minoan eruption of the Thera volcano was preceded by a long period of volcanic quiescence which had lasted about 15,000 years. During this period, the same authors (Pichler & Friedrich 1980) believe that the central cone reached a height of 500-600 m., but another more generally accepted view was that it reached c.1500 m. (Hedervari 1978:155-156). More recent views, as yet unpublished (McCoy, pers.comm.), give the impression that it was not a single large cone in the centre of the island but a large number of smaller cones. This view is supported by the 'fleet fresco'on the south wall of the upper storey of room 5 in the West House. In this fresco the town on the right, which is recognized as being Akrotiri, does not have a single large volcano in the background but a series of smaller ones. To my knowledge, the latest published schematic representation of what could have been the phases of the island's development resulting from the Minoan eruption (c.1700 B.C.) and culminating in the present are shown in Fig.4.1.

Pichler and Friedrich *(1980) believe that the volcanic disaster followed an earth*quake, caused by volcano-tectonic events, and a pause of between a few months to two years. In contrast (D.A.Davidson 1978a:285) claims that there is no palaeopedological basis for postulating a gap between the earthquake and the eruption. The eruption itself is believed to have had three phases which lasted from a few hours to some weeks (Pichler & Friedrich 1980:16-23) and eventually the present shape of Thera emerged. The current surface area of Thera is 71.7 sq.kms., of Therasia and Aspronisi is 8.7 sq.kms., making a total of 80.4 sq.kms. However, the area of the caldera is 84.9 sq.kms. and, therefore, broadly speaking, the area of Thera before the collapse should have been in the range of 165.3 sq.kms. Yet, it would have been less as the area to the southeast of Profitis Ilias was, most probably, filled in with depositions of pumice and ash after the Minoan eruption. Therefore, a reasonable estimate would be that L.B.A. Thera was about 100 sq.kms.

4.1.2 Settlement pattern

At present there are nineteen settlements of ten or more houses on Thera and two on Therasia. Throughout their history the Cyclades seem to have been well peopled. This was also true during the Turkish period as their rule in the Cyclades was milder than other parts of Greece which often led people to flee to the islands. In a census of 1838, the islands had a density of 100 people per square mile (39 people per sq.km.), whilst before World War II Thera had 342 people per square mile (132 people per sq.km.) (Greece 1944:Vol.2:20). By way of comparison Classical Melos could support a density of 59 people per sq.km., but attained higher levels in the 19th and 20th centuries (Wagstaff and Cherry 1982:145). Even if we want to be cautious and use the population density figure of 1838, we are still speaking of about 4000 inhabitants, which could easily have lived on Thera in the L.B.A. If the number of settlements was doubled in pre-eruption Thera, then we could have about 38 settlements, whilst Wagstaff (1978:450) prefers a figure of 25-26 settlements. If we take the proximity of modern settlements as models for what might have happened in the L.B.A. we see that settlements are differentially spaced between each other. Some are only 200-300m apart, while others like Emporio and present-day Akrotiri village are 4 kms apart.

The trend in other Cycladic islands, where prehistoric settlement densities could be measured by surveys, shows that in the Cyclades there was an increase in population from the Neolithic to the E.B.A. (Table4.2) and the increase continued, except that the 'increase in size of individual settlements offsets the decrease in settlement numbers in the M.B.A.'(Renfrew 1972b:394, and also Cherry 1979:40). This seems to coincide with what was happening on Thera, especially when the settlement of Akrotiri seems to have grown and flourished towards the end of the M.B.A. As we see from the Tables4.3 and 4.4, the densities used by Renfrew are very conservative if compared to the 1838 census.

The available information on the settlements of Thera in the pre-eruption period is very summary, due to two principal causes:

1. Much of the original island has disappeared under the sea and been buried in such a way that recovery of underwater evidence within the caldera seems impossible to piece together, whilst some settlements would have been blown totally to dust.
2. Most of the island is covered with such thick layers of very fine ash and pumice, and hinders surface survey over most of the island.

The only possible source of evidence around the caldera are the quarries which report occasional archaeological finds. Therefore, most of the sites of pre-eruption Thera mentioned by Wagstaff (1978:451, map) have been found by pure chance in quarries or by farmers falling into holes when the ceilings of buried buildings collapse under the extra weight.

At present we know of seventeen L.B.A. sites (Table4.1; Fig.4.1) which are found in a comparatively small area mainly in the southwest of the island. Other authors mention eleven (Sperling 1973, fig.10b; Wagstaff 1978:450) whilst Doumas (1983:10, Map 1) gives thirteen. Six of these sites are near Akrotiri, but we should consider the available data as somewhat biased in its spatial distribution, although Doumas (1983:129) believes that the southwest was more densely populated than the north.

Based on what we know of the present lie of the land, Doumas believes that most of the northeast of the island was mountainous and perhaps unsuitable for agriculture, and that the region around Oia was the only flat area in the north. The mean spacing between known L.B.A. sites is of the order of 2.06 kms which could suggest a degree of concentration of settlement compared with the modern distances of 0.3-4.0 kms. What we see in the southwest of Thera is the pattern of a major centre (Akrotiri) and its possible satellites (Archangelos, Kokkino Vouno, Alaphouzos Quarry on Therasia and so forth), and this should not necessarily be taken as the norm for the entire island. Therefore, there is no way of knowing whether the other settlements were regularly spaced or randomly arranged; by comparison the L.B.A. settlement pattern on Melos seems to show extreme nucleation (Wagstaff and Cherry 1982:254). Spatial management and settlement patterns are influenced not only by environmental constraints of physical space but also by the organization of land use and resources. When we consider a site such as Akrotiri, we must assume, due to its urban character, that many inhabitants will not necessarily engage in agriculture and, therefore, the 'process of urbanization and aggregation should not be considered as equivalent to the patterning of small communities in the earlier stages of agricultural development' (Gamble 1982:164). Nucleated agricultural settlement patterns with a high concentration of people are inefficient in terms of productive capacity (idem:165) and although it might not affect the population as regards its ability to feed themselves, it would act as a check on urban development. This distinction between the agricultural settlement, where most of the inhabitants are farmers, and the developed urban community, is important, and we must understand the nature of this relationship in order to understand the position of the L.B.A. site of Akrotiri within its human and natural environment. With our present evidence, it is virtually impossible for us to say whether the site of Akrotiri was a town, inhabited by a totally urban population and depending on other agricultural sites for its needs, or whether it reflects a situation where the core of the town was urban and the periphery was agricultural providing the urban centre with its requirements.

4.1.3 Agricultural production: past and present

It is assumed that agricultural production on Melos was enough to ensure self-sufficiency in all the critical subsistence needs throughout the prehistoric period (Gamble 1982:162). Phylakopi on Melos was in early studies thought to have relied to a large extent upon fishing as 40-50% of its potential catchment lies in the sea.

However, the fish bones recovered at Phylakopi (Gamble 1982:171), just like the ones that seem to come out of sieving at Akrotiri, are from very small fish, which could indicate that the marine resources were not contributing in any great extent to the diet of the town.

Gamble (1982:168) built a model whereby the majority of the population of Phylakopi would be engaged in agricultural activities and the immediate catchment of the site would be producing the food required for the town's inhabitants. This model could fit the site of Akrotiri, as it should not be considered sheer chance that the site lies on the largest plain of Thera. Prior to the eruption, Singer et al. (1980) and Doumas (1983:129) claim that the southwest of Thera was the flattest terrain on the island and would have been protected from the north winds (meltemia) by the volcanic cones, which would have made it very suitable for agriculture. On the west of the site and at a distance of about 1 Km. (approximately 10-12 minutes walking time), Mt.Loumaravi could provide good grazing ground for livestock and on the northeast side, Mt.Profitis Ilias, at a distance of 6 Kms (90 minutes walking) would also have provided grazing. Possibly, some good grazing ground could have been provided in the northeast of the island in late summer, as the north winds would have cooled the area to the extent that whilst everywhere else the 'phrygana'would have been dry, the vegetation on north-facing areas would have remained greener for longer periods. This is especially noticeable on the island of Anaphi to the east where 'phrygana'remains greener at least 1-2 months later than in the south of the island. These three areas could have provided Akrotiri's needs in animal produce fairly effectively (Table4.18 for resources needed). The plain could have been reserved for crops, which would have been more important in feeding the population and would have demanded a higher labour input than husbandry, and thus would need to have been in closer proximity. This could have been the case at Akrotiri in the L.B.A.

The crop yields for the Cyclades and Thera are shown in Table4.5, and the amount of land required to support 1 person at the subsistence levels in Crete and Greece in 1948 is shown in Tables4.6 and 4.7. Within Table4.7 the importance of barley in Crete is shown and interestingly the protein scores (Table 4.8 & 4.9) indicate its high nutritional value.

Proteins differ in nutritive value 'because of the differences in the kind and amount of constituent amino acids'(Keene 1985:171). There are eight amino acids essential to the human system and if the protein contains all of the amino acids it is termed a 'complete protein' (idem). Therefore, it is useful to have the constituent amino acids of the protein specified. The heating of foods could also produce changes in the chemical structure of the molecules of proteins and could reduce their nutritive value. For example, the effect of baking on the protein quality of cereal breads is somewhat negative. It seems that although protein digestibility is less in both barley flour and barley bread compared to wheat, the net protein utilization, as well as the net dietary protein calories (Table4.9), is higher. This leads one to the conclusion that barley, although lower in general calorific content, produces higher protein calories.

Wagstaff and Gamble's table (Table4.6) shows an overestimate of the level of consumption for wheat, especially when we know that in the Cyclades in general and Thera in particular, wheat was considered a luxury item and wheat bread was reserved for the wealthy or consumed at exceptional occasions. Until recently (1950's), barley bread seemed to have been the 'daily bread'consumed.

Keeping these figures in mind, we shall try to reconstruct the supportive capacity of the land at Thera and in particular near the site (Table4.13). However, these will only be estimates, as these tables are simplifications of real situations. Although crops mentioned in those tables (i.e. barley, wheat, vegetables) could be grown in between trees (poly-cropping/multi-cropping), the need to grow a wider variety of crops, for example, grapes, and other fruit as well as the need for herding would lead to a greater need of land than 1.23 hectares per person. Furthermore, Table4.7 is constructed with an overestimate in the consumption of meat, which would have been much less in the Cyclades both at present and in the past. Meat in most parts of Greece, up to the 1950's, was also considered a luxury food eaten at special occasions, and occasionally on Sundays. Therefore, for calorific requirements, one would have expected greater reliance on crops both at present and in the past. One would presume that these are the reasons Wagstaff and Gamble (1982:175) suggest more than the 1.23 ha suggested for Crete (Table4.6) and prefer a higher estimate of 1.5-2 ha of land per person for Melos.

4.1.4 Akrotiri: The micro-context

From the above it is possible to get an overall picture of Thera, but in the following sections I will concentrate upon the site of Akrotiri. In these sections the old and recent excavations are briefly discussed, and a general description of the site is provided.

History of the old excavations

Investigations had been conducted on Thera in the nineteenth century but they have left only a few records (Fouqué 1879), and all traces have been obliterated by ploughing and erosion. The only site which had been fairly straightforward to identify was Kamaras in the valley of Potamos to the east of the site. This was possible thanks to the photographic documentation which is kept of R.Zahn's 1899 excavations at the German Archaeological Institute of Athens, although his excavations remained unpublished. The site excavated by Zahn is only about 600m away from the present site of Akrotiri, but it was probably part of the town. Another point which supports this extension of the city is that the ground between the excavation and the Potamos valley 'does not follow the natural southward slope, although of the same volcanic ash, but rises towards the sea, thus creating a concave plateau inland. The plateau can be explained if one supposes that the ground has subsided over collapsed multi-storey houses'(Doumas 1983:45). Doumas believes that the town could have been in the order of 200,000 square metres. So far an area of c.12,000 square metres has been uncovered but not thoroughly excavated yet. However, there is no tangible evidence as to where the city might have stopped. Doumas believes (1983:45) that the sites of Balos and Mavromati Quarry may have been suburbs of the city but it is not confirmed yet (Fig.4.1). Balos was excavated by Gorceix and Mamet, and eventually published by Fouqué (1879:118-120; Pérrot & Chipiez 1894:150). It was mainly composed of a building of which three rooms were excavated, where a thick bed of straw was found in one room and some seeds of barley, lentils, 'arakas', aniseed and coriander were identified, as well as some chaff was found (Fouqué 1879:118-120). At Therasia the site of Alaphouzos Quarry was also excavated (Fouqué 1879:96-106; Pérrot & Chipiez 1894) where seeds of barley mostly, other cereals and peas were found as well as what he believes to have been a beam olive press. Renfrew (1973:171) refers to 'arakas', lentils, barley, aniseed and coriander to have been found but she does not refer to her sources.

Mamet's excavations at Akrotiri took place a few years before in 1867 but it has not been possible to locate the area exactly, except that it must have been in the general area of the Akrotiri excavations, possibly on the east side of the ravine at the site of Favatas. Therefore, as we see, the excavations and reports done in the 19th century were small and unsystematic, and in all cases not fully published.

History of the new excavations

Marinatos (1939) was the first to express the view that the Minoan civilization which seemed to have come to a halt around 1500 B.C. was due to the devastating effects of the volcanic eruption of Thera, and as he needed proof for this thesis, he began to excavate in 1967 at the present site. Excavations continued uninterrupted until 1974 when Marinatos died, and resumed in 1976 under the directorship of Professor Ch.Doumas. Excavations have continued ever since but not on the grand scale that

Marinatos had got the world accustomed to. He had excavated for long periods every season and with a very large team of workmen/diggers, which, of course, led to the uncovering of huge numbers of impressive finds. However, in order to pursue the new aims, the excavation every season is on a more modest scale, whereby the unskilled work force has diminished and has been replaced with archaeologists and other specialists. Presently the aim is not to produce spectacular finds, for these will come anyway, but to excavate in a way that will enable us to understand the underlying socio-economic structure of a prehistoric settlement. Akrotiri is totally unique because it preserves a sealed moment in time, and thus its cultural and bioarchaeological remains can be considered as entirely simultaneous.

Description of Akrotiri

There is evidence of a Neolithic presence at Akrotiri, but how extensive, it is currently impossible to determine as only a few sherds have been found. The E.B.A. (E.C.II & III) (Doumas 1983:42; Sotirakopoulou 1986) is much better attested, and the earliest certain evidence of habitation at Akrotiri goes back to the third millennium B.C. Due to the need to roof the excavation area, deep pits were often dug to bedrock and these have produced E.C.II and III pottery. (Fig 4.2 for Early Cycladic sites; Doumas 1978:779). In the summer of 1985 further evidence for an Early Cycladic presence was found northeast of building Delta and perhaps, though it is too early to say for sure, we might be seeing a rock-cut tomb which had been reduced to some secondary use either in the M.B.A. or L.B.A.

In the M.B.A. occupation seems to have been more extensive (Doumas 1983:42), and entire vases have already been found, which are often closely associated with architectural remains. In Doumas'opinion, life thrived in that period, and the transition from E.B.A. to M.B.A. was relatively smooth. Not only is there evidence of contact with Crete (some fine Kamares ware was found) but also contacts with mainland Greece seem to be apparent from finds of pottery of M.H. provenance

(Doumas 1978:782; Doumas 1983:42). When the first major destruction of the city occurred in M.C. (Palyvou 1984; 1986; Marthari 1984), a vast rebuilding operation took place (Palyvou 1984:147) in a short period of time, indicating that a well organized and prosperous community was established at the end of the M.B.A. It also seems that the town plan in M.C. was more or less the same as in L.C. (Doumas 1983:43). At some point in the early L.C.I (Marthari 1984:132) there was a destruction caused by earthquake(s), and rebuilding of some houses is apparent, especially rearrangements of upper floors (Palyvou 1984), before the final destruction late in the same period. One would have expected part of this community to have engaged in intensive agriculture and herding. This seems to have happened, as the L.B.A. soils, just before the eruption, exhibit intense soil erosion similar to Melos (Davidson 1978a:736). However, this picture is at odds with the geological evidence, since it has been suggested that a period of c.15,000 years without volcanic activity preceded the Minoan eruption which should have ensured some mature soils.

In the L.C.I another major destruction occurred and this thriving community rebuilt anew the destroyed city on an even grander scale (Fig.4.2). To date what seems to be only 10 buildings have been uncovered but, unfortunately, none of these have been fully explored. The only one which is nearing full investigation and which is going to be published first is the West House (Fig.4.3).

However, I will not go into any detail about the town plan as there are good descriptions already published (Palyvou 1982, 1984; Doumas 1983; Palyvou Ph.D. in progress). I will only say a few words about the feeling of continuity one gets from the L.B.A. town and the present-day villages of Santorini and the Cyclades in general. This sense of continuity ties in well with the archaeobotanical remains, that I will refer to in the next chapter. The narrow winding streets of L.B.A. Akrotiri compare well with the modern villages, and just like today, they were geared to accommodate pack animals (i.e. donkeys/mules), but not vehicles (i.e. chariots). These streets follow the natural contour of the landscape and would, most probably, have been traced since very early times. They would have checked violent winds (meltemia) in the summer and also could have been a way of trapping any enemies who would easily have been lost in such tortuous alleys.

The affluence and the high degree of organization and civilization can be seen in the condition of the streets which were paved with sizeable stones (somewhat flat on the upper surface), and the city sewers which ran beneath these streets and consisted of narrow stone-lined ditches covered with slabs (Doumas 1983:8). These sewers were connected to pits near the houses which received the effluent from domestic lavatories via clay pipes incorporated in the house walls (West House, Fig.4.3).

What is important for us to remember when we interpret plant remains is that the part of the city which has been uncovered (Fig.4.2) is considered to have been the wealthy part of the town. There seems to have been a private sector (area Beta, Gamma, Delta, the House of the Ladies, the West House) and a public sector (Xeste 2, 3). As yet, no palatial building has come to light, which could mean either that the present sample is unrepresentative and the palace will be uncovered in a different area of the town, or Theran society was of a much more egalitarian nature than Minoan or Helladic cultures.

Dating problems

The problem of dating at Akrotiri will just be touched upon and certainly not solved, as it has confused many scientists from several disciplines. These problems are illustrated in Table4.21 and Tables4.22. We now know that the site was destroyed twice by earthquake(s), one at the end of the M.C. period and the second at the beginning of the L.C.I, but the inhabitants came back and cleaned the rubble, repaired houses, and conducted an intense re-building activity (Palyvou 1984). The earthquake that occurred in L.C.I terrified the inhabitants who took with them their precious belongings, and it was followed by a time when they came back to start repairing the houses and streets, when the eruption took place. Yet, even then, they seem to have had time to flee, as no corpse has been found so far on the excavation. There seems to be no general agreement on how much time would have elapsed between the last earthquake(s) and the ash layer which covered the whole site. Since the site was sealed with this ash layer, it was believed to be an ideal source of information on radiocarbon dating, until the results of the two series (series I & II) came out and caused more confusion (Table4.22). The archaeological date proposed by Professor Marinatos was 1550-1500 B.C., and points to an L.C.I date as there is a lack of L.M.IB artifacts on Thera.

Radiocarbon dates The discrepancies in the radiocarbon dates from Akrotiri, especially from the short-lived samples, are puzzling and could have been perhaps the effects of gaseous emanations from the volcano (Michael 1978:791,794). Radiocarbon dates of plant material could give an old age due to 'photosynthesis of old CO^2 emanating from fissures in the ground in volcanic surroundings'(Friedrich et al.,1980:242). This mixing of 'dead'CO^2 may lead to pseudo-ages in archaeological samples of up to 1600 years (Bruns et al.,1980:532). Therefore, eight out of the 10 short-lived samples support an earlier chronology by some 100-150 years which gives us an average of c.1660 B.C. The discrepancy of the short-lived samples which will be mentioned below was particularly puzzling, as they derive from the same storage jars (Table4.22) and yet give different dates. Samples P-2560 and P-2791 are legumes from the same jar (sample 5/10, Room 5, West House). The same happens with P-2561 and P-2562 (sample 16, Room 5, West House). Samples P-2564 P-2566 P-2795 are cereals from the West House (sample 22) and should also have shown unambiguous dates, and last, the samples P-2794 P-3228 P-2559 are legumes from the West House deriving again from the same jar (sample 1) and should not have had these discrepancies. However, what we have to keep in mind is that most of the short-lived samples were undersize, and therefore, we cannot be certain of the indicated date. Michael's explanation (1978) was that perhaps grain stored from one jar came from a field affected more by gaseous emissions whereas those in another jar would have grown on, perhaps, unaffected fields. One could think of some arguments which would negate this assumption, as the seeds from one jar could have represented one year's crop or at most two, and most probably would have derived from either the same field, or perhaps adjacent fields. However, G.Jones (pers.comm.) claims that on Amorgos crops from distant fields were often processed and stored together but what the distances involved were is not known. It would be important to do some ethnographic work on storage patterns and find out which crops are stored together, the distances of fields of crops stored together, and also the distances of fields of crops threshed together. For threshing floors in the Cyclades are to be seen everywhere, and are fairly closely clustered, but the pattern of usage is still unknown.

Moreover, the effect of CO^2 on the C^{13} values of the plant samples seems also to be visible (Bruns et al.,1980:535). This is a valuable tool which would, perhaps, eventually make it possible for us to differentiate between the crops from other parts of Greece and Akrotiri itself, thus enabling us to source the material.

However, the Oxford Accelerator Unit has taken 17 samples, some of which are from the same samples that were already radiocarbon-dated in order to see discrepancies with previous dates. Moreover, the context of these samples has been well studied, so we now know which samples are from the same pots and which from different pots. Hopefully, we should have these results in 1988, and they would be a good control against the latest dates which have been published for Akrotiri.

Archaeomagnetic dates The dating was conducted on the Minoan ash horizons of the Thera volcano and of fired destruction levels at the Late Minoan sites in Crete. The results demonstrated by Downey and Tarling (1984) suggest that the Plinian air-fall ash of the first 'Minoan'pumice is contemporaneous with the destruction levels on central Crete (Malia, Gournia, Knossos, Sklavokambos, Phaestos and Agia Triada) and that the higher 'Minoan'ashes are not contemporaneous with the destruction levels in the extreme eastern Crete (Palaikastro, Kato Zakro, Makrygialos). They estimate that a time gap of c.10-20 years is a reasonable estimate for this interval (idem:522). Sparks (1985:74), on the other hand, claims that there is no geological and volcanological evidence supporting this thesis, and claims a single short eruption with no time gap.

Other dating evidence Recently, a date of 1645 B.C. has been published based on a totally different method, ice-core dating (Hammer et al. 1987). This method is based on variations in acid fallout in the annual ice layers and a core was drilled at a site in South Greenland. An acidity peak was spotted at 1645 B.C. (idem:519) with an estimated standard deviation of ± 7 years, and an estimated error limit of ± 20 years. This corresponds well with the tentative date given by the analyses of frost damages in tree rings (LaMarche et al.,1984). This method suggested a date for the Thera eruption of c.1628-1626 B.C. but Warren (1984:493) argues that the frost-rings are not caused only by volcanic eruptions but could be caused by other influences of the climate. *However, this is a question for scientists to answer.*

Population estimates for Akrotiri

There exist several ways of estimating population for an archaeological site and in the following sections three are used. Firstly, estimates are made using the size of the site and habitation density; secondly, using the floor space and the storage capacity of the West House; and finally, using the supportive capacity of the local area based upon site catchment analysis.

Population estimates for the whole site For Akrotiri, the calculation of the density of the population is riddled with unknown factors, as we still know very little about the nature of the settlement. Although the core of the settlement seems urban, at least from what we know from the present excavations, we do not know how far this urban 'core' extended. Here, we shall assume that the part of the settlement that has been uncovered is a representative sample of the rest of Akrotiri site.

In order to estimate the density of occupation of Akrotiri, the density of habitation versus open spaces (streets, courts, etc.) has been calculated in a section of the site (Fig.4.7). The area used comprises the West House, sectors Delta, Beta, and part of Gamma. The built area is estimated at 813 sq.m., while the open spaces (streets, courts, etc.,) are 912 sq.m., making a total area of 1725 sq.m. If we take into account that the whole settlement comprised at least two storeys (in the section sampled all houses were of two storeys, but some other houses indicate 3 storeys as in Xeste 3), then we should perhaps increase the built area by a factor of 2 (averaging for the houses which have one and three storeys), which makes it 1626 sq.m. (Table4.10).

So far an area of c.10,000 sq.m. (cf. 18,000 sq.m. estimate of settlement for Phylakopi, Renfrew 1972:237) has been partially excavated (Doumas 1983:45) and, based on the sampled area, we see that open spaces/public places, including squares and roads, took up more area than the buildings. But if we multiplied this built area by a factor of 2 we see that the built area increases more than the open places. Yet, from the indications of the West House, and if the West House is a typical house of the settlement, we believe that only the first floor could have been used as a living area. The ground floor would have been mainly workshops, shops, industrial areas of all kinds, storage or religious areas (e.g. Xeste 3 lustral basin, Delta 2) and so forth.

Therefore, if we use Narroll's theory (1962:587) that the population of a prehistoric settlement could be roughly estimated as of the order of one person for every ten square metres of the floor area, we can consequently assume the present excavated area to have housed 471 people as a minimum number (as we calculated only one floor for our population count). This assumption agrees well with the fieldwork done in Crete by Allbaugh (1953:89-90) who calculated about 9 sq.m. per person when living quarters only are considered and c.10-13 sq.m. including storage places.

If the area (Area A) of the settlement included Balos, Kamaras and up to the modern windmills (Fig.4.1), the surface area would have been 1,720,000 sq.m. (or 172 ha), and if the density of habitation in the uncovered part of the site was the same as the presently excavated area (Akrotiri), we could then assume that the built area would have been 810,643 square m. and the population would have been c.81,064 people (Table4.11). However, there are indications (Doumas 1983:45) that the settlement area could have been even larger and extended in the same area (Area A) eastwards beyond the present-day windmills to Mavromati Quarry (Area A+B). This whole area would have been in the order of 2,740,000 sq.m. (274 ha.). If so, it would have meant that the built area would have been 1,291,373 sq.m. (Table4.10) and could have represented a population of about 129,137 people (Table4.11), which compares with the 1923 census figure of 129,702 people for the whole of the Cyclades (Naval Intelligence Division 1944:477). If these numbers were valid, which seems extremely unlikely, Akrotiri would have represented a huge settlement even as regards present island towns and cities. In large towns and cities we would expect to find less space devoted exclusively to habitation and more space devoted to 'administrative, commercial, industrial, religious, and other public functions'(Sumner 1979:167). One could also suggest that the range of living space per person would be greater in towns, possibly reflecting the greater range in status, and, therefore, we would expect a lower density in towns than villages. This is what one seems to see at Akrotiri, although the evidence is not totally conclusive yet. Firstly, the argument of more space for public spaces is vindicated by the sample of the settlement we used to find the ratio of inhabited to public spaces. Secondly, the lower population density of perhaps c.16 sq.m. instead of Narroll's 10 square m. per person seems to be in accordance with the second of Sumner's arguments, as well as with some ethnographic studies. Consequently, the present excavated site of 10,000 sq.m. could have held between c.290-580 people (or between c.5,890-11,700 for the estimated 200,000 sq.m.).

On the other hand, if we use Sumner's estimates (1979:165), whereby he calculated 100-200 inhabitants per settlement ha (or 50-100 sq.m./person), the numbers drop dramatically with the size of the settlement compared to the two previous estimates. Sumner, however, drew his suggestions from recent work from Fars province in southwest Iran and the mean density suggested of c.147 people per hectare (Sumner 1979:172) was in part due to space reserved for animals in the modern villages. This is one suggestion which would definitely not stand for Akrotiri, at least from our experience of the excavated area, as the settlement seems to have been totally devoid of spaces reserved for animals. Stables seem *rather to have been possibly* reserved in the periphery (see Balos, where two rooms had been excavated. Beside these rooms another had a thick layer on the floor of what the author refers to as 'hay'and he presumes it to have been a stable, Fouqué 1879:118-120). However, more ethnographic work needs to be done to be able to find the differentiating elements for population estimates in villages versus towns and larger cities. One would need to be very cautious when applying ethnographic data to archaeological situations, and especially about giving absolute figures and applying them with complete confidence in archaeological contexts. An example from Tell-i Nun (Iran) shows us that 'the range of household size is so great, and household composition is so varied that one would hesitate to use an average figure in archaeological contexts' (Jacobs 1979:190). This was because there were c.30 sq.m. per person of living space in the old town and even more in the new town. Nevertheless, if we consider the area of the site to have been c.200,000 sq.m., as Professor Doumas claims, then the population estimate could have ranged from an improbable low of 2,000 to as high as 18,000, which is quite possible depending on the population model we use (Table4.11). Therefore, in archaeology, it would be far more sensible to reach estimates based on a combination of factors and these will be discussed below.

Population estimates based on the West House The West House had two storeys but the staircase (Fig.4.4) at its east end suggests the existence of a third storey or an attic on top of room six. In the basement there were seven rooms and the first floor comprised four rooms and a fifth corridor-cum-staircase-cum-storage. Part of this area was named the 'cupboard'when excavated in 1982. The whole area of the house, basement and first floor, is 146.95 sq.m., which according to Narroll's model (Table4.12) could accommodate 14 people. If, on the other hand, one calculated only the first floor as living space, i.e. 83.3 sq.m., the number of occupants would drop down to about 8 people. This number still seems larger than expected for both a nuclear and extended family. The estimate of 3.5 people per household in ancient populations is considered realistic (Sumner 1979:170) as one would have expected a low rate of population growth in prehistoric times. In M.B.A. Lerna the population growth seems to have been 0.4% annually (Angel 1971:109), which is rapid for a pre-industrial society, whilst she extrapolates that family size, including older relatives, would have been c.5.7 people (idem:110). Even for the Classical period, a population growth of between 0-1/2 per annum is extrapolated (Hansen 1986:11). Therefore, if we assume that 5-6 people corresponded to each household (cf. 5.9 people per household in Ilam, Iran, where the population growth is 2.5%), we can consequently calculate for the West House, using the area of the first floor only, 83.3 sq.m., a floor space of 16.6 sq.m. per person (cf. 30 sq.m. per person in the old town at Tell-i Nun). This falls within a well-accepted floor space per person for large towns/cities. The implications of these estimates are given in Table4.11. If we assume that the West House is a typical example of the home of a nuclear family, we could come closer to estimating a population perhaps between c.5,800 and 11,700, and somewhere in the middle of these for the entire settlement.

In order to calculate the storage capacity of the West House we used only large pottery jars, 65cm in height or above, as the problem of simultaneous use of other small types of pottery is debatable. The chosen height should be considered arbitrary, and based only on empirical knowledge that smaller pots could be stored empty. In these calculations, all the pottery which fell within this definition is included, both decorated and undecorated. Unfortunately however, the study of the pottery of the West House is still in progress (M. Marthari), but as most of the pottery which could be restored has already been completed, it was possible to trace all of the known 'large'pots and include them in our calculations.

In our study, the following pots were included, and are grouped under their room numbers:

Room 5	(ground floor):	5779, 4918, 4673, 4671,
		4672, 4922, 4354, 4747, 3489.
Room 6	(ground & 1st):	5392, 5386, 5156, 5275,
	(floors)	5660, 4857, 2496, 5390
Room 7	(first floor):	5992, 6000
Room 3C	(ground floor):	5668
Room 4	(ground floor):	5664
Unlocated West House	:	3211

In order to calculate the volume of those pots we could not go into fine detail as too many measurements had to be taken. Therefore, for this exercise their volume has been roughly estimated using the following formula:

$$VOLUME = \frac{\pi r1^2 * h + \pi r2^2 * h}{2}$$

As the radii included the base (r1) and the mouth (r2) of the pot, and as most of these pots tend to bulge somewhere in the middle, we should treat these calculations as minimum capacity. Perhaps a third should be included for this loss. After applying this formula, the minimum storage capacities of the rooms were calculated and they are the following (in litres): Room (5) 1098, Room (6) 570, Room (7) 84, Room (3C) 22, Room (4) 105 and Room (?) (pots which have not been allocated to room) 562. This would be in the range of c.2441 litres, and if 1/3 is added for the loss which was mentioned above, the storage capacity would be increased to c.3300 litres. If we consult Table4.16, we note that this is the storage needed for about seven adults

(3300 litres). However, we have to remember that storage for some products might well have covered longer periods than one year, for example oil, wine and perhaps even cereals and pulses, and therefore it could keep seven adults for only one year or five adults for one and a half years.

In agreement with our findings of seeds from room 5 (ground flour), our impression that this room seemed to be the main storage room was verified by our volumetric exercise whereby it was found to hold the largest volume capacity (1098 litres) as well as the largest (¿ 65 cm) pots. Second in storage capacity is Room 6 (570 litres) (ground and first floor), but, unfortunately, for this room we cannot yet tell whether the first or ground floor had most pots. This, too, agrees with our findings of palaeoethnobotanical material, i.e., that both ground and first floors were storage rooms. Furthermore, we are struck by the large numbers of one-lugged cups from these rooms (although, at this stage, it is impossible to say whether they belonged to the ground or first floor), which must imply the use of liquids (e.g. wine, beer, oil), and provides a possible explanation as to why we find so little botanical material on the first floor. The evidence from Area 7, and Rooms 4 and 3C does not contradict the seed finds. Area 7 (84 litres) could have been reserved for some kind of temporary storage, e.g. reserves stored in the stage previous to cooking or ready to be eaten. The imprints of pulses of, possibly, spanish vetchling make us wonder whether these were preserved in this state because of their being in some kind of liquid, as the imprints are in very fine ash which could have filtered through the liquid medium and settled around the seeds, thus making a perfect imprint. Rooms 4 and 3C (105 and 22 litres respectively) also coincide with our few finds of botanical material from these rooms. Therefore, the lack of palaeoethnobotanical samples should be treated as, perhaps, reflecting a real situation. The absence of large pots from the other rooms,i.e. 3 (first floor), 3A, 3B (no pottery was found in that room) reinforces our belief that the lack of botanical remains from these rooms does not reflect a fortuitous recovery pattern, but rather reflects a real lack of storage.

Population estimates based on site catchment Here two approaches will be tried to estimate the supportive capacity of a given territory. Firstly, we will use site catchment analysis (Higgs & Vita-Finzi 1972), and secondly, we will use the reverse method of estimating the population and working out the area needed. In the first instance, the area of the 'site territory' of L.B.A. Akrotiri is c.5,891 ha (Fig.4.1).

Within this area, potentially arable and grazing land covers 3,756 ha (if the town covered only area A, as shown on Fig.4.1), which could have fed a population of c.1,878 people (2 ha per person). This is much lower than the population of Akrotiri (Table4.11). However, the whole island, i.e. 10,000 ha, could have supported c.5,000 people, which is close to the estimates made by using the one person to 16 sq.m. formula for the West House (Table4.11). By comparison, the proposed population of Melos in the L.B.A. was c.2,000-3,000 (Wagstaff & Cherry 1982:140), because they suggest (1982:174) that 'each individual would necessitate the cropping of perhaps 1.5-2.0 ha of land'. The land required for each population is shown in Tables4.14 and 4.15. It could well be that at Akrotiri, just as at Phylakopi, the population was dependent upon much of the arable land on the island for its subsistence, and it is difficult to believe that another extensive settlement was supported by the island. By looking at the map (Fig.4.1) we realize the great advantages of Akrotiri compared to other settlements. Besides being sheltered on the north by the volcanic cones (we do not know the number yet), which would have rendered the plain less windy, and having a more beneficial microclimate perhaps than the rest of island, it seems that the site catchment included, in its 'territory', both the western and southern harbours. The implications of such an advantageous geographical position cannot be stressed too much.

Archaeozoological studies

Gamble divided animal products into two convenient groups, recurrent and non-recurrent resources (Table4.18). The nearby hills of Mt.Loumaravi and Profitis Elias would have provided adequate grazing, and thus indirectly, the animal products which Akrotiri required. The nearest would provide some of the recurrent resources needed on a daily basis on the site, for example traction, milk, and other dairy products, while the furthest would have provided the other needs of the site but not on a daily basis. In addition, the manure and traction would be available to the agricultural land, and perhaps for the plain to the east and west. This system compares well with the animal management seen in the southern Argolid where these two opposed areas would have provided different systems of flock management, as seen by Koster and Koster (1976:277-9). These could have been small numbers of ovicaprids grazing near the settlement, and larger numbers grazing at up to 12 hours from the settlement. However, the current crater area north of Akrotiri may have had a few volcanic cones with (like Vesuvius) vegetation near the peaks. Whatever could not be terraced and used as agricultural land could have been used for grazing.

Akrotiri, like Melos, should have thrived in the Aegean through a system of exchange, but the question arises of what? Gamble (1982:170) believes that Melos could have provided wool, although the archaeological visibility of such a product is nil. Yet, he believes that the conditions in M.B.A. and L.B.A. Melos were 'suitable for extensive management of sheep for such a product'(*idem:170*). *This could be* achieved without putting at risk the production of subsistence resources for the inhabitants. This extensive management could have been happening as well on Thera, but it seems rather unlikely.

From a social point of view, Akrotiri, seen through its architectural remains, seems to have been a much more decentralized and egalitarian society than Minoan Crete or even Phylakopi. Of course, this is mentioned with caution, since only just a fraction of the site has been uncovered. However, at least we know that the area excavated represents a wealthy section of the settlement, even though there is no evidence of any extravagantly wealthy house, nor any structure which reminds us of a palace. The West House, which seems to be an 'urban'house, probably of a fairly wealthy family (see quality of wall-paintings, water-closet, and topographical position on a main alley-way), is fairly modest compared to palatial houses in Crete. The wealth of the 'middle classes'must have come from somewhere outside Thera. Theran agriculture and husbandry could have provided them with self-sufficiency, but where did the surplus come from? Agricultural products have a very low exchange value and, therefore, the model of agricultural surplus being exchanged for other commodities would not work on Thera. At best, it would not have provided the general prosperity we seem to see on the site from the M.B.A. onwards. Another model is one whereby archaeologically invisible products like cloth (e.g. linen, wool), perfumery, dyes (both 'saffron'and purple dye *Murex sp.*) and wine could have been traded in exchange for precious metals and other commodities. However, I believe that the most plausible model is one in which Thera would have been an entrepot site. It is the nearest Cycladic island to Crete and seems to hold a geographically central position in the south Aegean. Its inhabitants would have had two very protected ports (Fig.4.1), one to the south facing Crete, and the other to the west facing the Peloponnese and Kythera. Due to their geographical position and the Cycladic tradition, and, above all, the need for survival in the middle of the sea, one would also assume, that the Therans were good sailors. Therefore, it seems fairly reasonable to assume that they could have acted as the 'middlemen'in the sea for the Minoans and traded for them in return for some 'pay', or even accepted a percentage of the goods traded; or perhaps they were employed as mercenaries, sailors or captains by the Cretans, or provided manual labour for them as 'Gastarbeiter'. Van Leuven (1980:131) tried to explain the early Mycenaean presence in Crete in terms of the contacts that Thera might have had with Crete and he goes on to say that 'emigrants'(either Mycenaeans or Therans in our case) 'were too poor and adaptable to bring substantial traits, and as individuals they stayed only long enough to earn the means of prospering at home'(see Mycenaean pottery found in the West House). In the case of the Therans, the 'Gastarbeiter'could have been sailors.

Of the 7,155 animal bones studied from Akrotiri, 2,845 could be identified and were ascribed to the four main species: sheep, goat (Table4.19), pig, and cow (Gamble

1978:746). Of these only 5% of ovicaprids, 4% of pig, and 1.2% of cattle bones had traces of cut marks.

Gamble concluded that the rarity of butchery marks indicated a 'non-intensive attitude to processing the animal carcasses' and possibly also indicated 'that meat was an occasional resource butchered by the household rather than an economic staple that was centrally processed by a specialist'(Gamble 1978:747). One can argue that if meat was highly in demand, people would have 'bought'(exchanged) small pieces of meat as well as large carcasses, and cut marks would thus have been more abundant. Another case in point is the age of pigs where a few survive past the age of 3-3.5 years, and could represent a similar attitude to the one in Greece today, where one young pig is kept per household in or out of the settlement and provides the sausages, fat, and skin but rarely bred intensively or kept in large numbers.

The cattle data too indicate that they were not bred intensively (Table4.19) and this small number, together with the rarity of juvenile specimens, indicates 'its use for draught purposes where milk would have been a useful bonus'(Gamble 1978:750).

The age structure (Gamble 1978:fig.1:749; this thesis Table4.20) and the dominance of sheep in the fauna suggest that it might have been a mixed management strategy 'with the accent being on dairy products, together with the removal of surplus lambs'(probably mostly the males) 'for meat and the retention of small wether flocks for wool'(Gamble 1978:750). An emphasis on sheep could have reflected the management of garrigue/maquis vegetation, especially as the goat is a 'plant scavenger'eating just about anything. Possibly some sort of plant management was envisaged. Furthermore, if forests were present, goats would have been a negative factor in forest rejuvenation and timber producing strategy (cf. opposite claimed for the goat by Wertime 1983:446).

Gamble (1978:752), therefore, believes that the pattern of island animal economies in the prehistoric Aegean is consistent with Akrotiri's findings. The ovicaprids would have been kept mainly for their milk and wool, and pig would have been an easily husbanded source of meat, fed on low quality diet and left overs from human meals. On the other hand, cattle were not adapted to the small island environments of the Cyclades and would have been mainly important for their traction as well as incidentally providing meat and milk. Unless equids were rare, they could have fulfilled the needs of traction as the soils of Thera are not heavy and can be ploughed with lighter animals. Therefore, the fact of finding only one equid bone could be indicative of the low numbers of these animals on the site, but there is another option. If equid meat was not eaten in the L.B.A site just like today in Greece, one would have expected them to dispose of their dead animals outside the settlement, and consequently their bones would not be present in the bone assemblage recovered. Traditionally, villagers in the Cyclades drown their animals in the sea when they become too old or ill to be used efficiently. In this case all the bone evidence would have disappeared without trace. However, the incomplete faunal studies at Akrotiri are not yet conclusive.

The other identified species at Akrotiri are dog, red deer (Cervus elaphus), small equid (Equus sp., possibly a donkey (Gamble 1978:752)), hare, fish, birds, and two Homo sapiens bones (Table4.19). Apart from the small numbers of dog bones which could be attributed to differential disposal patterns, there is little evidence of bone gnawing indicating that it could have been rare. Due to the lack of wet sieving and sometimes even dry sieving in certain areas of the site at the time when Gamble studied this material, small bones and in particular microfauna, birds, and fish were under-represented. This is particularly obvious in Gamble's 1978 publication. However, since 1981, we have started operating the 'Ankara'type of watei sieving machine and many small bones have come to light, and these should eventually form the basis of bird, fish, rodent, and reptile studies. It is interesting to note the presence of very small fish bones, which seems to parallel the finds at Melos. Therefore, there is some indication at Thera that fishing might have been conducted on a small scale, and would have been incidental in the diet, perhaps conducted as a side-line by each family or some families.

Coprolite remains As mentioned earlier, Akrotiri had a very extensive network of sewage under the streets which gathered the waste from water-closets and other sources. The information that such a context can provide as regards plant remains is very varied and include the types of plants that were eaten. Coprolites and sewer contexts could also indicate plants that would not normally be stored as seeds. These could include plants collected in the wild (e.g. *Rubus sp.*), medicinal plants, or even industrial plants (e.g. *Rose sp.*) used for perfumery, and so forth. It could also provide information on some industrial quarters when used for plant processing. Besides botanical information, it could also provide evidence of faunal remains but, most important of all, I believe, it would be used for an extensive palaeopathological study. This could include studies on the presence of bacteria, rickettsiae, and parasites, including fleas, lice, and ticks.

Potential for other bioarchaeological studies A large number of further studies are required including:

1. *Nematodes* The study of these would be the first to tell us about plant diseases (especially diseases of crop plants)

2. *Phytoliths* To give us information on plants which have no preservable parts (i.e. bulbs, tubers, etc.,) (Pearsall 1980) and whose visibility is not possible in the archaeological record. Phytoliths would be particularly useful in the interpretation of the use of pots which were used for storage or processing of plants or parts of plants which produced no seeds (e.g. *C.cartwrightianus*).

3. *Insect remains* These could impart information about the conditions of light, dirt, humidity and so forth; it would be important for us to note crop infestations.

4. *Molluscs/ snails* These are also collected at Akrotiri and are being studied by L.Karali whose work is still in progress. From the amount of Prophyra murex (*Murex sp.*) used at Akrotiri, there is some indication that the production of

this red/purple dye was conducted at the site but the industrial sectors would probably have been outside the town due to the odour that such an industry would have produced.

5. *Ostracods/foraminifera* Due to the fact that the material has not been weathered nor redeposited (Shackley 1981:62), these are well preserved at Akrotiri. Some specimens are even larger than 1 mm. Although they provide no archaeological information, they are important for palaeoecological studies and the possible locations of ancient coastlines, estuarine clays and so forth, and would be of indirect importance to the study of the settlement of Akrotiri.

Indirect evidence for plant use

Here I will only refer to the broad classes of objects which are associated with plant remains and evidence for plant processing, which might give us some indication of the plants used. In most cases, the conclusions must be tentative because the study of the site is still in progress.

Frescoes The frescoes depict plant life in three main ways. These are representions of wild plants (e.g. flowers in vases), those cultivated by man or depicted in geometric motifs (e.g. rosettes). It is often difficult to discern what was imagination, or what reflected landscapes of other areas (Room 5, West House, 'the river landscape'), or local ones (Room Delta 2, 'the spring fresco'where swallows and lilies are present in a rocky landscape. There are no exceptional plants depicted on the Theran frescoes, which is very much in line with the Cretan ones. One plant which has aroused controversy is the Papyrus plant in Room 1 of the House of the Ladies. Whether Papyrus could have grown on Thera is still debatable. Some scholars prefer to identify this plant as the sea-lily *Pancratium maritimum* (Diapoulis 1980:138) but others (cf.P.Warren 1976:91) believe not, and prefer to identify this plant as *Cyperus papyrus*. Although the latter does not grow naturally in the Aegean, it seems to be able to survive the climatic conditions there, as shown by examples of *Cyperus papyrus* growing in the Archaeological Museums at Khania and Rhodes today.

Another plant which seems to have had an exceptional role in Theran life is the 'saffron'crocus *Crocus cartwrightianus* (Douskos 1980), a multi-purpose plant, depicted in a fresco of Xeste 3, in the lustral chamber, 'Ladies gathering the saffron'. This plant grows wild even today on the mountains to the west of the site of Akrotiri, and is still gathered by local women. The stigmas produce the saffron and 4,000 stigmas are required to produce an ounce of dye (Polunin & Huxley 1972:223). This dye can be used in foods, like cakes and cheese, for dyeing cloth, and perhaps perfumes. It is also believed to have medicinal (idem:223) properties as well as narcotic effects (Landerer 1854:363). Other intriguing plants are depicted on two more groups of frescoes one of which have not been cleaned and restored yet, so identification is impossible at this stage. The plants on the other group, the 'micrographies'of Room 5 of the West House, are so small and, in some cases, drawn in such an abstract way that identification would be totally arbitrary. However, *Vitex agnus-castus L.* (chaste tree), reeds, myrtle, and date trees (upper frieze of east wall of room 5, West House), seem to occur time and time again in these intricate floral compositions. The popularity of the chaste tree could be connected to its usefulness for making perfume from its leaves (Pliny, Nat.Hist.XIII:14). It also cured a multitude of ailments (Pliny, Nat.Hist.XXIV:59-63), and its economic importance in making wickerwork (Pliny, Nat.Hist.XXIV:59) is known even today on the island of Thera, where plants are collected only after permission from the landowner.

Plants on pottery Here again we have a whole repertoire of floral designs. Most of the plants are so schematic that identification would be hazardous. In some representations we may be able to identify crocuses of various species and even 'saffron'crocus, but whether it refers to *Crocus sativus* or *C.cartwrightianus* is difficult to say at this stage. *Vitex agnus-castus* is again depicted on pottery and would have been a useful plant for basketry. On Thera today, they still use this plant to make strong baskets which are mainly used for grape collecting ('vendema'as they call it). The palm *Phoenix dactylifera* is also depicted and could have been present on Thera just as it is still present today on many Cycladic islands. Caper, *Capparis spinosa*, is also represented and must have been thriving on hanging cliffs protected from grazing animals. At present, the women of Thera collect both the buds and the leaves (especially young leaves) and put them in brine to preserve them for use in salads as a condiment. The myrtle *Myrtus communis L.* seems to have been depicted as well.

Of the cultivated fruit plants, we have the olive *Olea europaea L.*, the pomegranate *Punica granatum L.*, and the grape *Vitis sp.* - probably *V.vinifera*- all of which might have been cultivated on the island, but the absence of documentation of the apple, pear, fig, and almond (although imprints of almond are said to have been found) is intriguing as these could easily have grown on the island in the L.B.A.

Of the other cultivated crops, we seem to recognize several species of legumes but none can be identified to genus. Cereals and possibly two species of barley might also have been drawn.

Wood It has been mentioned already that the use of wood in architecture at Akrotiri was very extensive. In order to strengthen buildings against earthquakes, timber reinforcements were used in the walls. The walls were encased in a series of horizontal frames built at intervals up the wall and connected by vertical timbers (Doumas 1983:51). Wood, of course, was also used for doors, windows, and even wooden grille (Doumas 1983:52) on smaller windows. A few staircases were made entirely of wood, although most were stone-built with wooden reinforcements. Floors of upper storeys were also supported by wooden beams and branches. Reeds or rubble were laid on top of these beams and then covered with a layer of earth which was sometimes covered by flagstones. It is impossible at present to know which was the most common wood used for these architectural needs, the reason being that these have mostly disappeared leaving behind a hollow space showing the presence of wood. According to impressions of barks on jambs and sills, it seems that olive wood or oleaster was used in most cases (Marinatos 1970:10). However, it is very probable that beams of oak, pine, juniper, cypress and olive could have been used (Rackham 1978:758) all of which could have grown on Thera in the L.B.A.

Furniture impressions As the volcanic ash penetrated the houses and reached c.300-350°C (Tarling 1982, pers.comm.), the temperature must not have been high enough to burn/char the wood, so that we rarely find charred wood, except for small pieces, and these with time have rotted away leaving impressions of wooden objects (e.g. furniture, structural beams) some of which are well preserved. Using these impressions as moulds, liquid plaster-of-Paris was poured in to produce casts (Doumas 1983:116). One was a wooden bed (1.60m. X 0.68m.) from Room Delta 2, as well as a wooden stool, and the veining of the wood was so well preserved that it was recognised as olive. Casts of parts of stools and a chair have also been salvaged from other areas of the excavation, but a remarkable piece was recovered from the ground floor of Room Delta 1. This was a round table with carved decorative legs.

Charcoal The pieces of charcoal generally found at Akrotiri are small and only a few pieces have been identified. These are pine, cypress, olive, vine, and tamarix. Unfortunately, although several pieces have been recovered from the excavation, no extensive study has yet been conducted on the wood and shrubs. Therefore, although we know which types of wood were used, there is no way of knowing whether there was any pattern in wood utilization, i.e. if certain species were consistently used for certain jobs, as beams, furniture, doors and so forth. There is still a great deal to be learnt about wood working techniques and woodland management in Minoan times. There are also numerous impressions of the giant reed *Arundo donax*, used in some areas in architecture (i.e. shelves), which seem to have been used in order to economize on wood.

Harvesting implements All the stone implements are currently being studied by Antiklea Agraphioti and Tania Devetzi, and we must await their results. The ones which interest us in this section are the sickles. From discussions with Antiklea Agraphioti, it seems that there are very few flint sickle tools of the type that we encounter in other cultures as 'composite'tools. The flint sickle blades so far found at Akrotiri were probably inserted in wood, as there is no evidence that bone was used for hafting purposes. Most of the flint seems to have been locally mined from a site west of modern Akrotiri.

Bronze objects are being studied by Anni Michaelidou. A few bronze sickles have been found on Akrotiri, but bronze is scarce on the site. This may account for the fact that the inhabitants had time to take with them objects of value. The scarcity of these objects on the site need not be indicative of their absence in the L.B.A. What should be taken as indicative is the small number in flint, as these would surely have been left behind. This picture will become clearer when we deal with the plant remains of Akrotiri.

The six bronze 'sickles'found at Akrotiri are serrated, and it seemed at first from their shape (cf. modern sickle from Thera) that they were small saws. However, they are too small, the longest is c.25 cm., to have been proper saws (unless they were used for shrubs) and it would be safer to assume that they were 'sickles'. Their shape is strikingly similar to Iranian examples described by Lerche (1968:35-36; see Fig.4.8). These also give us some indication of how these implements might have been hafted, probably with wooden handles as no bone has survived.

No other harvesting implements seem to have survived. Some baskets and other wicker objects have survived. Some could have been sowing baskets, sieves and winnowing baskets. Unfortunately, no conclusions have yet been reached by Iris Tzahili who is studying them.

Milling installations and grinding implements In most of the houses discovered so far, there is a mill installation. Its main feature is a heavy grinding stone fixed to a bench accompanied by mortars, pestles, and grinders. In Delta 15 the mill installation also had a jar incorporated in the same bench as the millstone but at a lower level to collect the flour (Doumas 1983:pl.25). Another installation was in Sector A, where flour seems to have been collected in portable containers placed in a niche beneath the small stone beams on which the millstone rested (Doumas 1983:54). Another is found in Room 3A of the West House (Pl. 2) resting on the west wall. Therefore, it seems clear that each household made its own flour when it so needed, and that the products were not traded (at least not on a large scale). As grain stores longer in the husks (e.g. barley) and probably less vulnerable than flour to weevils, this method of storage might have been a strategy for preserving foodstuffs for longer periods. It is also interesting to note that ethnographic literature shows that grinding at the household level was done every day, even in ancient commercial bakeries like Pompeii (Runnels 1981:244).

The most common querns at Akrotiri are the 'saddle'querns (studied by A. Agraphioti), made of basaltic andesite. Wulff (1966:277) claims that they are still used today for small household tasks in Iran in the province of Khuzistan. These basaltic andesite outcrops occur to the west of the site on Mavrorakhidi hill (Fig.4.1), but no sign of quarrying has been found yet (Runnels 1981). Querns would have been used for grinding substances that mortars could not do well, and as they are often found, in the same contexts, they must have been used for complementary jobs. White (1984:64) claims that naked grains were rubbed (cf. hulled grains which might have been processed with pestle and mortar). Experiments with querns have shown that dried and roasted wheat may be ground at a rate of a pound in a few minutes (Runnels 1981:244, for other uses see Runnels & Murray 1983:62). From excavations at Halieis (Runnels 1981:149) three millstones were found, one in association with a triton shell (*Tonna sp.*), used today in olive oil extraction as scoops, and two others with charred olive pits. As no other tool/machine has been found for crushing olives in L.B.A. Greece, it seems probable that the querns could have been used for this purpose as well. An exception to this might be the beam press from Therasia (Fouqué 1879). Pressing of olives should not necessarily leave any traces archaeologically, although what have been termed 'presses'have been found in many Minoan sites but to my knowledge, no crushing tools connected to olive crushing have been found. Presumably, the actual breakage of the pulp (crushing) could be done with any heavy stone, perhaps, even on milling installations. The actual pressing of olives would leave no trace if a press was used, and it seems that twisting exerts more pressure than weight alone (Fig.4.9). Therefore, Melena (1983:107) believes that the Mycenaeans used a 'twisting'as well as a beam press. Similarly, at Akrotiri, the combination of querns, crushed olive pits, and the presence of objects which have been termed 'anchors'induce me to believe that olive oil was extracted at Akrotiri. The 'anchors'could have been used as presses for extracting oil once the olive stones had been crushed (Fig.4.10). Therefore, we need not expect sophisticated installations for the crushing and extraction of oil at Akrotiri. We might only have expected a specialized area for this extraction. This is because, firstly, a great amount of water would have been needed for the extraction of oil, and secondly, olives would have had to be crushed all at once and temporary storage facilities would have been needed hampering other house chores. These speculations should be considered as being at a preliminary stage, and more associations of querns and botanical material have to be studied before the results become more conclusive about the use and production of olive oil at Akrotiri.

At Kerkyra, some old informants told Sordinas (1971:8) that two natural slabs were used for crushing and pressing simultaneously, but the information remains otherwise undocumented. Vickery (1936:52) mentions another method still used in Crete whereby the fruit is drenched in hot water and then crushed and later placed in a settling vat. In that case, he claims that the oil floats on the surface of the water while the water is drawn off through a spout in the bottom of the vat. However, it seems more likely that the olives were crushed first, and then drenched in boiling water for oil extraction. One should also note Godart (1967:605) who believes that this process was reserved only for the second pressing. Vats of this type are found at Akrotiri but they have been named 'bath-tubs' and have a hole in the side at the very bottom. These are sometimes associated with the industrial quarters of a house and very often with sewage channels (i.e. Xeste 3, Room 2), demonstrating that, whatever they were used for, they had to do with the use of a great quantity of water and possibly other detritus substances. They might also have been multipurpose objects, possibly used at different times of the year for different jobs, for example olive oil extraction in the autumn/winter, perfumery in the spring, and maybe even dyeing at other times of the year, but this hypothesis still awaits documentation. Even though pottery gets imbibed with the substances it contains, the same pot could still be used for each of these purposes, as presumably they would not adversely affect each other. Moreover, our more or less sterile environment has made us less tolerant of natural smells, and artificial odours are becoming more and more the only smells tolerated by modern society.

The mortars (studied by Tania Devetzi) have a different use from the saddle querns. Whilst the latter rubs (Moritz 1958:21) and produces fine flour, the former is used for pounding or 'bruising'especially husked grain (e.g. barley, Hillman 1984:8) and possibly condiments as well (e.g. coriander). An example is in Room 8 of the house of the Sphinxes, at Mycenae, where debris of spices were found in association with pestle and mortar (Bennett 1958:13). However, I did some experiments in pounding unprocessed hulled barley in order to see the breakage points in the seeds, but the results proved different from the 'crushed barley'I found archaeologically at Akrotiri (Pl. 4 and Fig.5.2b). In the archaeological samples, the breakage, in most cases, is transverse to the seed but in the modern sample it is erratic. This could mean one or all of three things. The tool used (mortar) was not the correct one, or the pounding motion I was using was not correct, and another hand movement should have been used, or else the grain in the archaeological sample had undergone some form of processing before being pounded such as drying and/or roasting (cf.Runnels 1981:244, Moritz 1958:23). K.White (1984:63) claims that the ancient Greeks roasted barley before hulling, and then pounding with pestle and mortar. In Turkey, Weistein (1973:275) observed that they make bulgur by pounding it in stone bowls with wooden mallets.

In the northwest of Anatolia, at Kizilcahamam, mortars and mallets are used for de-husking rice. What is interesting is that all the mortars have curved inside sections which resemble an open parabola (Hillman 1984b:130). Pliny (18.105ff) explains that the hulled grain is pounded in a wooden mortar to avoid pulverizing the grain, and after the grain was stripped of its husk the naked grain was broken up by the same instrument (White 1984:64). It is also interesting to note that the pestle heads are of two types. One type has rounded ends and is used for de-husking and removing some of the bran, while the other type is flatter and broader and removes all the reddish fibrous bran and the proteinaceous aleurone layer of the seed (idem:130).

As regards the size of the mortars for de-husking, it reflects the quantities needed to be processed at any one time. Small mortars with diameters of c.10 cm are adequate for processing grain every few days for a small family (idem:130). However, mortars were also used for perfumery (Foster 1974:161) for pounding aromatics with wine or water, as well as for preparing spices and other condiments.

Pottery Most of the pottery must have been used to process or store various types of food, mostly plant based, and some were even used as flower-pots, but no systematic study has been conducted at Akrotiri. Gas chromatography has been used in some cases on other sites (e.g. Myrtos) for analyzing the 'odd'pot, but Akrotiri might prove to be ideal for such a study due to the preservation conditions. Cooking pots, in addition to the other daily functions of cooking plant and animal foods, could have been used for perfumery, and Foster (1974:171) believes that perfume equipment throughout antiquity was 'essentially the same as that used for the preparation of food'. Other equipments used for perfumery would have been strainers, stirring ladles, measuring vessels, and a pressing vat. Stirrup jars, among other uses, would also have been closely connected to perfume industry. This connection is clear from Pylos tablet (PY Fr 1184) where a perfume maker receives

38 stirrup jars (Foster 1974:88). As for the 'bath-tubs', mentioned above, they could also have been used for several functions including the extraction of natural oils from flowers.

Weights and measures At Akrotiri we have one of the largest and most important collections of prehistoric balance weights in the Aegean (Petruso 1978:547). They are important indicators of the manner in which merchants and craftsmen 'perceived, evaluated and dispensed some commodities'(idem:547), and, therefore, they have the potential of providing information about the economic interconnections taking place at inter and intra-site level. Most probably some of the goods weighed and sold must have been plant material sold as cloth (linen, Robkin 1979:470), for food, condiment, medicine and dye plants. One of the plants of which we have strong indirect evidence is the 'saffron' crocus *Crocus cartwrightianus* or *C.sativus* and although no direct evidence has yet been found of this plant on the site, it does not surprise us. The reason is that parts of the plant collected would have been either stamens or the whole flower before the seeds matured (only in the case of *C.cartwrightianus* as *C.sativus* does not produce seed). We can be certain that it was collected for some purpose/s as for dyeing cloth or food. This type of plant commodity would, most probably, have been sold in very small quantities due to its value, and balance weights might have been used with very low denominations (i.e. 30 gms). Petruso (1978:547) has argued that the system of the site of Akrotiri was scaled on a system of weight whose main denominations were in the vicinity of 60-64 gms and 480-510 gms (the latter being the Minoan mina and equivalent to eight of the former), and corresponded to the Minoan system. It was also suggested that a very thick lead disk with a bronze handle which weighs approximately 15 Kg. could have functioned as a half-talent weight (a talent being c.29-30 Kg.). Yet some of the lead weights do not seem to fit the Minoan system (Petruso 1978:553) but the exegesis of this phenomenon is still obscure and it seems as if two systems were in use at the same time at L.C.I Akrotiri. It is interesting to note that two sites in the Cyclades, Ayia Irini and Akrotiri, have produced two thirds of the total number of known Minoan balance weights (Petruso 1979:138). Because the indigenous system of weights was so common in the L.B.A. in the Cyclades and Crete in comparison with the foreign systems, some scholars claim that trade with foreign lands would have been comparatively insignificant compared with the internal flow of goods (Petruso 1979:138).

Besides commodities that were exchanged by weight, there must have been a volume measure which would have been used for liquids (e.g. olive oil, wine and so forth) and the same or another used for the exchange of cheaper foodstuffs (e.g. barley, legumes etc.,). Lang (1964:99) claims that the smaller dry and wet units were represented by the same symbol in Linear B, but that different symbols were used for the larger units. After measuring 778 pots from Pylos, Lang (1964:105) concluded that the discrepant range was greater than expected.

Let us turn now to what the Linear B tablets have to say on this matter. Other products that were probably weighed would have been cloth, wool (Melena 1975:95) and other material such as linen. In the Theban tablets (Melena 1975:95) wool is dealt with in relatively small quantities and the largest figure is 10 units (where 1 unit= c.30 Kg.), which would have corresponded to a Minoan talent and, it seems, would have been weighed with balance weights of the type found at Akrotiri. However, a study of mass produced vessels used for both storage and export of liquids (e.g. stirrup jars) needs to be made and would provide more information on metrology.

Dry measures were used for wheat, barley, olives, figs, flour, and condiments (Bennett et al.,1956) like cumin *Cuminum cyminum* (recorded at Mycenae) (Bennett 1958:101), sesame *Sesamum indicum* (idem), fennel *Foeniculum vulgare* (idem:108), celery *Apium graveolens*, aniseed *Pimpinella anisum*, and hoary pepperwort *Cardaria draba L. Lepidium draba L.* (idem:100). The last was possibly used as pepper, although all the condiments sold in seed would have most probably been weighed, as they would have been sold in very small quantities. It is recorded that dry products were weighed in a measure of a medimnoi of 120 Khoinikes. By contrast liquid products (e.g. olive oil) would have been measured in 12 khowes, each of 60 kyathoi (dry measure: 120 Khoinikes= 1 medimnoi; 12 khowes= 60 kyathoi; 60 kyathoi= 3/10 medimnoi) (Was 1975:7). Normal Mycenaean pay allocation is shown in Table4.17.

Ventris and Chadwick (1956:132) record from Pylos E-tablets c.720 dry units of wheat which seem to be 6 times 120 khoinikes and presume that to be 86,400 litres, which they think could have been sufficient for an arable area of approximately 1730 hectares.

4.1.5 Discussion

The whole problem of the sources of wealth of Akrotiri are still shrouded in obscurity. Yet, for a settlement to have reached this size and this level of social complexity, a self-sufficiency strategy on its own would not have worked, although self-sufficiency in food products could have been achieved. A detailed survey of Melos showed that distance from fields is not a constraint on present settlement location (Gamble 1982:127), and that the present centres are not positioned so as to utilize the most productive resources in a most efficient manner. Therefore, there must be other factors apart from subsistence concerns, which govern the decision of settlement locations. The need to understand the decision-making processes in present day settlement locations on the Cycladic islands would, perhaps, provide some insight of prehistoric 'logic'.

Beyond the motives of settlement location, it is worth investigating whether agricultural surplus in the Aegean could have led to the social developments and complexity we see, for example, at Akrotiri. If self-sufficiency existed on large settlements (Phylakopi, Akrotiri), then we should presume smaller settlements were like-wise self-sufficient and, therefore, where would agricultural surplus be traded/exchanged? It is because of this that the whole role of agricultural surplus in the Aegean needs to be investigated (Gamble 1979:130). The needs of other areas and islands acquiring more of what they already produce is not an alternative explanation, for such commodities as wine, oil, olives, cereals and wool would have existed on a self-sufficiency basis in the Aegean World. Therefore, could it be that Akrotiri, just like Knossos in Crete or Danebury in Iron Age Britain, would have acted as a redistribution centre, but whereas Danebury was a redistributive centre of subsistence commodities Akrotiri was of manufactured commodities, especially commodities in their final stage of refinement such as cloth, perfumes, soap, or dyes. They could also have encouraged surplus production of small communities by repaying them with a variety of benefits such as high status, ceremonial participation, and luxury items. This surplus production would have led to some type of subsistence specialization (Gamble 1979:131) which is encouraged by the great diversity of the Greek landscape, and could have encouraged the intensification of production/collection of some crops, such as saffron, the production of which, on Thera today, is centred on Akrotiri.

Halstead (1981b:189) rightly claims that the interannual variations in crop yields are of considerably greater impact the smaller the island and/or the smaller the area. Therefore it seems a likely assumption (Halstead 1981b:192) that the 'advantage of exchange to food-producing communities is that surplus for good years may be exchanged with needy neighbours in the expectation of reciprocation when circumstances are reversed'. In this case, exchange will take the form of 'social storage'. Therefore, 'social storage may be a factor favouring the concentration of population or the development of centralized redistribution under a managerial elite'(idem:192). Perhaps it is no coincidence that the largest collection of balance weights comes from the Cycladic islands, Keos and Thera, as these would have been possible candidates for central redistribution points, and, perhaps, were areas which represented accumulation of 'social storage'.

Chapter 5

Akrotiri: The palaeoethnobotany

5.1 Introduction

The site of Akrotiri lends itself to the study of bio-archaeological remains and particularly to palaeoethnobotany. Besides being one of the most extensive L.B.A. site in the Cyclades, the volcanic disaster of Thera sealed one particular period of the settlement's life and, therefore, the contemporaneity of contexts and structures within the site is assured. However, as seen already, the volcanic disaster followed several stages. Sometime at the beginning of the LM1a/LC1 period an earthquake took place which may have warned the inhabitants of the coming volcanic danger and they, therefore, had time to take their valuables with them and flee. Very few gold, silver, and metal objects have been found to date. After this initial disaster, there was a period of quiescence, which, according to the excavator and other authorities (Pichler & Friedrich 1980:16), could have lasted for some months and up to two years, at the utmost. This instigated some inhabitants to come back to the settlement (the so-called 'troglodytes'as coined by Prof. S. Marinatos), clear the rubble and reuse some of the rooms of some houses. The period of re-habitation was not long, especially as the rebuilding work was not completed (e.g. the unfinished plastering of room 4 (first floor) of the West House) before the second and final disaster occurred. Even then the inhabitants must have had some warning, as no victims have been found so far at Akrotiri, and doors were found closed (i.e. the door of the West House) denoting that the inhabitants hoped to return after the passage of volcanic paroxysms. Subsequently, the whole city was sealed by a thick layer of pumice and ash which not only covered it totally but buried it to oblivion.

The contemporaneity of contexts and structures solves one of the biggest problems faced elsewhere by archaeologists, and provides us with the potential and the security of contemporaneity of data. We can be sure that structures, movable objects and organic remains had an inter-related existence. However, to date, we have just 'scratched the surface'in understanding the dynamics of such an important settlement. A multitude of questions remain unanswered but, knowing the main stages of the disaster, some questions are closely relevant to our interpretation of plant remains. One question would be related to the period after the first earthquake when the inhabitants (all or some) came back: which houses did they re-use and which rooms were cleared? Although we know that they came back for a short time, this duration is impossible to estimate. Was it a month, a year or even longer? Are the crops which are stored in the houses representative of the first disaster, or do they represent crops collected in-between the two disasters? There is no single answer to these questions. Each house/room should be interpreted separately. However, the West House seems to have been re-used for a short time between the two disasters, and most of the seeds from here probably represent crops from this interlude. Later, The reasons for this last statement will be explained later.

5.1.1 Choice of area studied

Because of the impossibility of investigating all the material from Akrotiri for a thesis it was necessary to decide which material was going to be studied first.

As Akrotiri is a site which was preserved in its 'pristine' state by pumice and ash falls, it provides the possibility of finding all the crops *in situ* in their original containers/pots, thus providing even more possibilities for an economic and social assessment. Therefore, we decided on the choice of area with the following criteria in mind. Firstly, our consideration was to find a building which was nearing total excavation, and where all the plant remains had been collected. It also had to be a complete building -a functional whole- which could eventually give us information on its functioning parts. The obvious choice was the West House. Unfortunately, however, the West House (especially the levels of the L.B.A.) had been excavated before the full application of water flotation on the site, and all of the botanical material was collected by eye from, mainly, pots, or where it was found en masse *in situ*. However, the nature of the samples from the West House was such that it constrained us and curtailed *the applicability of the crop processing models we had in* mind (Hillman 1981; 1984b; Jones 1984b). The macroscopic plant material we had from the West House represented crops at the very last stage of processing, just before storage, or even having undergone secondary and even tertiary processing. We, therefore, felt we had also to look at material from floor as well as storage contexts in order to obtain complementary data on crop processing activities. Unfortunately, we could not use material from the West House for this purpose as it had already been excavated before the application of the water-flotation technique on the site. Xeste 3 was, therefore, chosen for this exercise because it was being excavated at the time, and we thought we could collect floor samples from the excavated rooms and thus compare the stored material of the West House with floor material of the same period. Another obvious question which then arose was how representative the West House was within Akrotiri, and whether general statements about the settlement would be misplaced at this stage. We were later vindicated in believing that the West House is not representative of the rest of the settlement, and might not even be representative of what existed before the first major earthquake in the L.C.1.

In order to highlight some of the differences of the West House with the rest of the settlement, we took 'grab'samples from the rest of the site which were available at the time and included these samples as exhibiting a different spectrum of plant remains (cf. samples 36, 46, 40-44, 48, 49).

Two samples which would be grouped under a fourth type of sample are samples 81/11 and 81/13. These should be included here for two reasons. From an archaeobotanical point of view, they are the only samples which come from a drainage pit from Greece and have intrinsically valuable information. The other reason is that they will contribute to our understanding of the function(s) of the West House.

As far as the rest of the site is concerned, very little material has been collected so far. Much of the plant material found by Prof. S. Marinatos has been left *in situ* in the pots in the partly excavated areas of the site. An indication of how little material was collected from the rest of the site, versus what has probably been missed during excavation, can be seen from the following list of material collected and stored in the site laboratory (Table5.1). Whereas 62 samples were collected in the West House, only 2 were collected from the House of the Ladies, which is a building even larger than the West House. A vast amount of material is thus likely to have been lost or most probably have been left *in situ* in the pots/containers within the house.

5.1.2 Choice of samples

The samples studied here are of four types. First, there are samples found in pots during excavation and, obviously, representing the contents of pots. Most of the West House samples are of this type. The second type of sample were seen and collected from other contexts during excavation but were not water-floated. A few of this type were collected from the West House but most did not produce seeds (Fig.5.1). These two types of samples were collected whole and stored in the site laboratory in glass jars or plastic bags. The third and fourth types of sample were introduced in 1981 when an 'Ankara'(French 1971; Williams 1973) machine was put into full use. These were 'grab samples'from floors of rooms 7 and 10 of Xeste 3, whereas the fourth was all of the soil that had remained in the clay pipe and sewer pit of the West House (most of it, unfortunately, had already been dug by Marinatos) (Table5.1; Table5.2).

5.1.3 Sampling methods

Sampling at Akrotiri was conducted on two levels. The first was on site while the excavation was taking place, and the second was in the laboratory once the samples had been retrieved. My belief is that as much material as possible should be sampled on the excavation and from as many contexts as possible, but due to a lack of efficient staff in the field it was sometimes impossible to adhere to these aims. However, from the summer of 1988, the whole structure of the excavation will change so that, in the future, this aim will be our priority.

Sampling on site

Due to the shortage of funds and to the small spectrum of contexts excavated, our samples were limited in scope. As there seems to be no agreement yet on the size of samples to be taken on site and only rooms 7 and 10 of Xeste 3 were excavated in 1981, it was decided to take large samples from these.

For the processing of these samples an 'Ankara'machine was used (Pl. 5.1) which had been built of concrete in 1976 but had not yet been systematically used. The reason was that Prof. Ch.Doumas (1983:31) had found dry sieving to be adequate. He claimed that 'water sieving is slow, the plant remains it produces are often duplicated by remains in pots, and objects of any size are in fact recovered more effectively by dry sieving'. These observations seem unjustified now that we have studied the plant remains, but at that time seemed entirely reasonable. In the first place, the mesh size of the residue trays was 1 sq.cm., the same as that used in dry sieving, and thus the retaining capacity of both were duplicated. Secondly, the flot tray had a mesh size of 0.5 cm., which is unjustifiably large, and retained, of course, only the largest remains, such as legumes, cereals, and fruit stones.

The water used to water-sieve is brackish, which creates even more buoyancy than fresh water. The mesh size of the residue tray is 1mm. and of the flot trays 1mm., 500 and 300 microns.

Sampling and sorting the water floated samples

Residue from the coarse tray was sorted at the time *in toto* for these samples with the help of students, *mainly from Athens University.* As the sorting took a considerable amount of time, a different system has since been applied, whereby 25% was subsampled using a riffle box and was totally sorted, and the remaining 75% was just screened for material.

Amongst the various categories of organic and inorganic remains, we collected many large seeds (legumes, cereals, grape pips, olive stones etc.) which had not floated as expected, especially as we were using brackish water, but sank and were retained by the 1mm. mesh of the coarse residue sieve. This observation should make us reconsider the use of flotation machines which have no residue trays. The *flot* tends to be very bulky due to the accumulation of pumice particles and takes a long time to sort. Therefore, it was deemed necessary to subsample this to a quarter using a riffle box. This material was processed using a binocular stereoscopic microscope

(Zenith MBS-9) and using mainly magnifications from X8 to X56. The modern comparative seed material used was mainly from my own collection. The average processing time for sorting in the laboratory into broad categories of samples is shown in Table5.3. but it does not include time used on the field to collect the material, nor time for identification in the laboratory.

Sampling the other samples in the laboratory

The other two types of samples, i.e. the ones found in the pots and the others spotted by eye and collected en masse, had also to undergo a sampling procedure. Our intention was to process c.50 grams when available and to process the whole sample where the samples were smaller. All of the subsampling was conducted using a riffle box, unless otherwise stated. This subsample was dry-sieved using a 300 micron sieve.

5.1.4 Plant remains

Broadly speaking, the Akrotiri plant macrofossil remains can be divided into the following categories, depending on the contexts they were found in.

- *Storage contexts*:
    1. pure crops
    2. processed crops (i.e. legume fragments)
    3. contaminants
    4. residue from crops (i.e. chaff)
    5. ruderal/segetal plants
- *Fill contexts* (i.e. water-sieved samples from Xeste 3):

1. crops (these include contaminants which cannot be distinguished from crops)
2. processed crops (these would be detected only if found in large quantities 'en masse')
3. residue from crops or plant material brought on purpose for other uses, e.g. fuel, animal feed
4. ruderal/segetal plants

- *Sewage contexts* (from the West House):

1. crops
2. ruderal/segetal plants

Pure crop

The term 'crop'has often been used in a very arbitrary manner and hardly ever defined. What is termed a crop on one site can be termed a contaminant on another. Moreover, sometimes several cultivated species of cereals and/or legumes are grown together on the same field as mixed crop (maslin, dredge and in Greek 'mighadi'). Here for the sake of consistency, I will define a sample as being a 'crop'when it is made up of 75% or more of one species of cultivated plant. In 'maslin'crops, of course, the proportion would be smaller, as these are more difficult to identify as indicating one crop rather than a mixture of two or more.

At Akrotiri this first category derives from inside pots and pure crops were the following: a) *cf.Lathyrus clymenum*; b) *Lens culinaris*; c) *Pisum sativum*; d) *Hordeum vulgare*; e)*Hordeum distichum*; and f) *T. monococcum* (sample 78 -the maslin sample).

From the water-floated samples there are indications that these crops were also grown: g) *Ficus carica*; h) *Vitis vinifera*; i) *Olea europaea*.

cf.Lathyrus clymenum On morphological grounds, the seeds of a legume plant still grown on Thera today and considered a staple food by the inhabitants seemed to me to be the same species as the seeds I saw archaeologically. These are named 'arakas'but when split to make their staple dish, they are renamed 'fava'. Perhaps the term 'fava'misled Friedrich (1983:243) and Renfrew (1973:171) in identifying this crop as faba beans *Vicia faba ssp. minor.* Morphologically it looks very different from *Vicia faba L.*. In size, the seed, *Vicia faba ssp.minor* is still much larger, and most importantly, the hilum of the latter is on the shorter side of the seed while in *Lathyrus clymenum* (spanish vetchling) it is on the long side (Tables 5.4 and 5.4a, Fig.5.1a).

However, in order to be sure of the identification of the modern plant, seeds were collected from Thera and planted at Tapton Botanical Gardens of Sheffield University Botany Department. The grown plant was identified by G.Jones and myself and verified by C.D.Preston (pers.comm.), who claims that *L.clymenum* and *L.articulatus* could not be separated as different species in the Mediterranean. The same seems to be stated by Davis (Vol.3,1970:365) who added that it was difficult to discriminate them 'even at a varietal rank'. However, Tutin et al.,(Vol.2,1968:142) describe the pod of *L.clymenum* as 'channelled on the dorsal suture' and 'not torulose', whereas *L.articulatus* (idem) has a pod which is 'not channelled on the dorsal suture'and 'somewhat torulose'. The legume which is grown today on Santorini complies with the first description, i.e. *L.clymenum.* Furthermore, modern charred seeds and archaeological specimens were compared by Scanning Electron Microscope (S.E.M.). Although initially it was believed that a distinctive surface pattern of the testa (Pl. 5 and Pl. 6) could be identified, as we spotted regular, blunt, papillae on both the archaeological specimens and the modern charred seeds, Ann Butler (Ph.D. in progress at London University), who is presently studying surface sculpture of Viciaceae, claimed that our results could not yet be considered conclusive as these were not characteristic to species but could include other Viciaceae. Therefore, at present, the shape of the seed itself and the position and size of the hilum seem to be our only criteria for identification. The shape could be described as oblong with three rounded edges, except for the edge on which the hilum begins, which is situated on the long side of the seed. This last edge is mainly angular. This immediately excludes all archaeological examples of legumes identified to date in the Mediterranean, and it excludes, amongst others, *Vicia faba ssp. minor*, and *Lathyrus sativus*.

There are, in all, nine samples (Tables5.4 & 5.4a) which contain this legume crop, seven of which belong to the West House, and it seems to have been one of the most important crops in the samples studied here.

Because of the archaeological uniqueness of this crop, and its abundance in these samples, I wished to quantify whether there were significant differences between the sizes of seeds amongst the samples. Sixty seeds were measured from each sample and the 'Minitab'computer package (Ryan et al. 1982) was used for the calculations of the data. An analysis of variance was performed for the three measurements, length (L), breadth (B), thickness (T), and two ratios, length to breadth (L/B) and length to thickness (L/T) (Fig.5.4). An abbreviated version of these results is shown in Fig.5.5. It is interesting that for all the measurements and ratios, F is significant at the 0.01 confidence level, which means that there is 99% chance that the differences of measurements and ratios between samples are not the result of chance. The strongest similarities between the samples seem to be occurring in breadth measurements followed by length and thickness. However, in this chapter we shall only discuss the similarities and/or differences between samples, and explanations for them will be discussed in chapter 6.

It is interesting to note that the one sample that stands out as being very different in size, the largest, on all of the three measurements (L.B.T.) is sample 40 (Fig.5.5).

The other extreme in size is portrayed by sample 65 which seems to contain the smallest seeds of all samples. The weight of whole cf.*Lathyrus clymenum* seeds in this sample is 0.27 grams, less than the weight of legume fragments (cf.*L.clymenum* s.l.) (less than 1/2 the weight), probably indicating a partially processed crop.

The other sample which stands out is sample 20/29. It has smallish seeds compared to the other samples from the West House but has also three other distinguishing features: the presence of coriander fruits, legume fragments (more numerous than elsewhere, c.8.7 grams, but less than in sample 65), and a high presence of legume stems. In sample 20/29, coriander fruits are all broken in half, and the diameters of half the fruits are in the range of c.2mm., and could have passed through a sieve which might have separated samples 16 and 20/29, the former belonging to large seeds and the latter to smaller seeds (tail grains?). Moreover, in Table5.6 and especially in Table5.7, we see the similarity of these two samples, but the differences are shown in Fig.5.5. They are both quite large, over 50 grams each, and the percentages of the samples used are also comparable, 3.0% and 3.7% respectively. Therefore, the similarity of the percentage of crop to other plant material (81.5% and 81.2% respectively) and the three most abundant contaminants are comparable in both samples and the similarity in the three most abundant contaminants could not be seen as mere coincidence, where *L.cicera/sativus* is the most abundant with 11.0% and 12.0% respectively. It is followed by *Lens culinaris* at 2.6% and 2.7% respectively, and the weed with the highest presence is *Sherardia arvensis* with 1.5% and up to 2.0%.

The seeds closest in size in all three measurements are samples 9 and 14 (Fig.5.5). If we look at the level of contamination of the crop (Table5.6), the proportion of the crop to contaminants/weeds (Table5.7) is comparable in the two samples (94.7% for sample 9 and 95% for sample 14). Although it seems as if contaminants are more abundant in sample 9, the weed seeds are more numerous in both numbers and percentage of contamination in sample 14 (Tables5.4 & 5.6).

The other two samples of cf.*L.clymenum*, samples 1 and 5/10, as regards the measurements of length, breadth and thickness have no variant factor, but where we compare the ratios of L/B and L/T, there is no overlap of L/B and only a slight one of L/T. Therefore, this might imply a different shape. We note that the number of contaminants is the same (Table5.7) but have different proportions of contamination as well as different contaminants. However, weed species are more abundant in sample 1 than in most other samples (7.4%), and the percentage of contamination of the whole crop is as high as 28.5%. Moreover, infested crops have the highest number with 3.9%.

The purity of cf.*L.clymenum* crop, in general, is fairly high, as it ranges between 71.5% to 95% (Table5.7) but what is interesting is the persistence, in eight out of the nine samples, of one particular contaminant *Lathyrus cicera/L.sativus L.*. The one sample (sample 40) (M.B.A.) which does not include *L.cicera/L.sativus* has *Lupinus cf.albus L.* instead (Tables5.4 & 5.7, Fig.5.1d). To date there is no evidence that these latter contaminants were being cultivated in their own right, as no sample has been found with their prevalence, but we cannot rule out the possibility that they could be found as crops in other areas of the site, especially if they were used as animal fodder. In that case we would expect to find them in association with structures which have stables and/or stalls. However, these structures have not yet been found at Akrotiri, although they have been found at Balos (Fig.4.1).

Tables5.6 and 5.7 show the percentage of contaminants and weeds, and these will be discussed in chapter 6. It is noteworthy that the most frequent other contaminants are the cultigens *Lens culinaris*, and *Hordeum vulgare*, which are also grown as crops on the site. Moreover, in samples 40-44, which belong to Sector Delta, room D1a, are seeds of *Linum usitatissimum*, another contaminant, but we still do not know if it was grown at Akrotiri as a crop in its own right. The latter, although it can grow in dry-farming, thrives in irrigated fields.

Lens culinaris The lentils that we find at Akrotiri in the West House are very small (Table5.8) in accordance with the general size of all other macrofossil remains in the same house. According to size alone, they could be attributed to *Lens es-*

culenta microspermae Barul.. Renfrew (1973:115) has measured the diameters of seeds found at various archaeological contexts and sites in the Aegean, and attributes them to this variety. Yet, this division between microsperma and macrosperma is considered meaningless by others (Zeist & de Wet 1982:96). Van Zeist claims that if seeds have a diameter less than 3mm., it is likely that wild lentil is represented, but on morphology alone it is not possible to distinguish between cultivated and wild lentil. Ann Butler is at present trying to see if it is possible to distinguish between the two main varieties of wild lentil, *Lens orientalis* and *L.nigricans*, as well as to distinguish between the cultivated species and their wild progenitors, using the S.E.M. for isolating differences in cell structures.

Only three samples from the West House are a *L.culinaris* crop. Whether lentils were in the minority at Akrotiri remains to be seen. However, the crop purity is fairly high as two out of three samples have 84.3% to 95.7% of crop, whereas the third ('maslin'sample) has only 48.3% (Table5.9). The most abundant and ever-present contaminant is cf.*L.clymenum*. In two samples (37/61 and 13/73) cf.*L.clymenum* is dominant, whilst *L.cicera/sativus* predominates in sample 17 with a level 0.3% of contamination.

However, the contamination by these contaminants varies from very low (0.3% for sample 17) to quite high (20% for sample 37/61). The presence of other contaminants seems to follow the same pattern as cf.*L.clymenum*, with *L.cicera/sativus* and *Sherardia arvensis* being high on the list. The presence of *Pisum sativum* (9.2%) in sample 37/61 is an exception to this pattern.

The type and number of weeds are very variable (Tables5.8 and 5.9) as is the degree of contamination from as low as 1.9% in sample 17 to as high as 43.0% in sample 37/61. In this instance, this percentage is too high for my definition of crop, so could this sample represent a mixed crop of lentil, spanish vetchling and peas? Or could it be a later mixture, e.g. during destruction? In other words, it might represent a 'maslin'crop. This is definitely not a reflection of the sampling performed. The two samples represent 50% of the original samples and one sample (sample 37/61), which represents only 10% of the original sample, seems to have nearly half of the number of weed species when compared to sample 17 and approximately 1/3 of the number of weed seeds.

The presence of *Galium aparine* (cleavers) in fairly large numbers in two (17 and 37/61) out of the three lentil samples (Table5.8) is interesting as this weed is totally absent from the cf.*L.clymenum* samples. Some scholars (M.Jones 1984:489; Hillman 1981:146) would take it as an indication of an autumn-sown legume, as it is an autumn germinating weed in northern Europe. Yet, its presence in the Mediterranean would not automatically imply autumn-sowing, and spring-sowing could not be excluded. It is more possible that lentils would have been autumn-sown at Thera, although Theophrastus (H.P.VIII 1.3-4) assigns them to spring sowing in other parts of Greece. Due to the low rainfall at Thera, especially in the spring, and the dryness in the late spring/early summer (Table1.12) it is more likely that they would have been winter sown.

Pisum sativum There is only one sample (sample 31) of *Pisum sativum* in the West House (Table5.10) and it is in a very poor state of preservation. Therefore, very little can be said on the weeds of this sample.

Hordeum vulgare and Hordeum distichum There is evidence at Akrotiri for the cultivation of both *H.vulgare* and *H.distichum* (samples 2, 24 & 71) (Tables5.11 & 5.12). Sample 24 is a chaff sample but as lemmas and rachis internodes were preserved in larger numbers than in other samples, it gives us indications of the presence of *H.distichum*, which, however, was present in smaller numbers. Due to the fact that *H.distichum* is more water-resistant (Hubbard 1980:59) than *H.vulgare*, and that Thera is a waterless island, we would have expected it to have been more extensively cultivated.

It comes as a surprise to find just two samples of barley crops in the West House (samples 2 & 71) (Table5.11). These samples are very different in composition from one another. Sample 2 (room 6) has seeds which seem very small and deformed and, therefore, there was no possibility of telling whether the grain was symmetric or assymmetric in order to differentiate between *H.distichum* and *H.vulgare*. The smallness and deformity of these seeds could not be attributed to differing charring conditions but must have been an intrinsic difference in the seeds themselves. A possible explanation for their size could be that they represented what one can name a 'milk-ripe crop' (Hillman 1984:4; this thesis Fig.3.2; cf.also green cereals can be uprooted prematurely for fodder, in Hillman 1984:117), or 'tail grain'.

Most of the barley seeds in sample 71 are also very small like tail grain. Although barley grains are generally small at Akrotiri, those in samples on floors from Xeste 3 are not as small as these. Moreover, in sample 24 we found possible by-products of crop processing, that is, rachis segments and internodes (Table5.12), culm nodes, a few culm bases and, of course, the ever present awns as well as some lemmas. One should note that the presence of leaves of *Thymelaea hirsuta* (sample 2 and 71) could be indicative of a processing stage. This could also represent a semi-cleaned crop.

Triticum monococcum s.l. *T.monococcum s.l.* (sample 78, Table5.13) was found in some other crops at Akrotiri (Tables5.4, 5.11, and 5.14) but only as an intrusion/contaminant. Its status as a crop plant became evident only from the find of the 'maslin'remains (sample 78). What is peculiar is the mixture of the various crops i.e. *T.monococcum s.l.*, *Lens esculenta*, and *Hordeum sp.* (hulled), with lentils being the most abundant (62.4%), followed by einkorn (26.4%) and last by barley (11.2%).

It is hard to believe that these crops were grown together in the same field as a single crop. For the moment it can be classed under a tertiary processing stage, and will be discussed later.

Triticum dicoccum Against all expectations, only small quantities of emmer were found in the West House (Table5.8). More evidence of wheat in a 'middle-class' house of the L.B.A. was expected to be found due to the attribute of status of this crop, just as it was in Greece at the beginning of the 20th century. Yet, the preponderance of barley makes sense in terms of economic returns in that it is a more productive crop than wheat and costs less in terms of labour and seed to produce (Brumfield 1981:15). As we have seen from present-day cultivation (Table1.26) at Thera, barley is more adapted to the island's conditions of soil and climate. On a poor soil like Thera, barley could yield 50% more than wheat (Brumfield 1981:15) and it would ripen earlier, before the great heat of June.

Other crops

The following crops were found only incidentally in the samples collected without water-sieving, and then mainly from pots, and only systematically appeared in water-sieved samples of the third and fourth type described earlier.

Ficus carica Figs were found in pots of the West House in very small numbers. Only the sewer samples (81/11 and 81/13) understandably produced large numbers of these seeds (Table5.15), and nearly all were mineralized. Moreover, fig seeds are also represented in Xeste 3, in rooms 7 and 10. In room 7, the quantity of figs is very high (30.0%) as expected from a fruit that produces a very large number of seeds (1600 or more) (Renfrew 1973:135). Some figs which I had defleshed contained an average of c.1000 seeds.

Vitis vinifera As one would expect from an Aegean island, the presence of vine is no surprise to us. Its presence in the West House is incidental because of the nature of these samples. However, in Xeste 3, room 7, we have a presence of 2.9%, while in room 10, there seems to be just a 'timid'presence (Table5.15).

An unexpected find was the presence of a possible seed of *V.vinifera cf. ssp.sylvestris* (sample 81(7), room 10). The seed is small, short and broad with a short stalk. Because only one seed was found no secure calculations can be conducted on the length/breadth indices (Stummer 1911).

As both figs and grapes could be used as dried fruits, they should be ruled out from indicating a seasonal occupation of an archaeological context, as they can be stored and consumed all the year round. Yet, if the presence of wild vine is verified in the future, it could provide us with ecological 'clues'as to what could have been the vegetational cover in the high summits (mountains and cones) of Thera, provided, of course, the plants were not an import. However, it would be most unlikely that wild grapes were imports.

Logothetis (1975:50) mentions that wild vine 'grows in woods in humid places', and Davies (Vol.2:521) says that it is found in 'deciduous forests or climbing over trees near water'. Its presence should, perhaps, be considered fortuitous as it is most improbable that this wild vine would have been dried and kept for winter as the berry is sour.

Olea europaea The presence of olive in the archaeological samples from Thera is very important (Table5.15) as the tree is not extensively grown on the island today and the inhabitants have to rely on imports for their needs of olives and olive oil. Although the number of stones, five complete stones, are very few, and only two fragments were found in the West House (sample 2, room 6; Table5.11), the presence of fragments in all water-sieved samples and also in the West House sewer (Table 5.15), is some evidence, perhaps not conclusive, towards claiming local cultivation of the olive. Had the olive been imported from Crete or elsewhere, we would have found mainly whole stones. Secondly, the stones would have been of larger varieties. At Thera, the stones are of the small, olive-oil varieties, which, of course, could also have been eaten. It seems far fetched and uneconomical to assume that the Therans imported olives to make olive oil, for in that case, the import of oil itself would have been easier. It is also far fetched to assume that they imported the products of olive-crushing (i.e. broken stones and pulp) for some purpose as fuel. One could assume that, had they had no olive, they could have used other means of fuel, i.e. wood, failing that, bushes, vine prunings, dung.

Another point worth noting, in relation to the fragmentation of olive stones, is that the stones were not broken after charring. Had the latter been the case, we would have found stones mainly broken in half and not in small fragments. Therefore, for all these reasons, I believe, that there is good proof for local olive cultivation.

Processed crops

Here the term '*processed'is used to denote some kind of transformation which affects* the crop itself, a 'disfigurement', so to speak, of the crop. At Akrotiri I noted three 'processed'crops, a) legume fragments, b) bulgur-type cracked barley, c) flour.

Legume fragments There are eight samples containing legume fragments (Table5.16), out of which six belong to the West House: samples 7, 35, 47, 54, 55 belong to room 6 and sample 23/28 to room 5. Sample 36 belongs to Xeste 3, room 6, and sample 44 to Sector Delta, room D1a (Fig.4.2).

The weed population of these samples should be treated critically for two reasons. Firstly, even if a number of weeds remained in the samples after some crop processing stages, they would still not reflect the actual number of weeds present after the first processing stage, for example the splitting of the legume, as this could have crushed some weeds and seeds. Secondly, if they had fine-sieved the legumes before reducing them to fragments, we would expect a minimal number of weeds. Therefore, either way, what we are probably seeing is a residual number of weed seeds.

A further problem of these samples is the recognition of the initial crop plant. This disfigurement of the crop(s) makes their identification difficult and sometimes impossible, as well as complicates the quantification of crop(s) versus contaminants. Here, it has been decided to quantify the crop(s) that are identifiable, and on this basis work out the relative proportions of crop(s) to contaminant(s). For example, sample 7 has a predominance of cf.*L.clymenum* where the identifiable fragments represent 50% and, although the other fragments could also be cf.*L.clymenum*, we could not be totally confident that this sample represents a pure crop of spanish vetchling. Another example is sample 55 which includes cf.*L.clymenum* and cf. *Vicia ervilia* at 12%, whilst sample 35 has a predominance of *Lens* (35%). Further evidence for the predominance of this crop in this sample is the inclusion of *Galium aparine*, a weed which is consistently associated with lentil crops at Akrotiri. Probably, the inhabitants of Akrotiri were splitting all their legume species, but we still do not have fully conclusive evidence for this statement.

Moreover, other samples (23/28, 54, 55) seem to have more finely ground legumes than the rest of the samples, which induces us to believe that they might have represented some type of legume flour.

Sample 44 (Sector Delta, D1a) is very much in accordance with what has been found in this house: the presence of *Linum usitatissimum* and *Lupinus cf. albus*. As we have already mentioned, these two crops/contaminants have not been found in the West House, but are consistent with the finds of Sector Delta. However, there must have been some kind of mixing, as shell fragments, stalks of cf. *Vitis sp.* and even fig were included in it.

Sample 36, from Xeste 3, includes most species of legume in the 'meal'. Lentils, peas, spanish vetchling and dwarf chickling/grass pea (*L.cicera/L.sativus*) are present, but it is impossible to say which pulse predominated. It is surprising to see that the legumes were not well cleaned of their pods and some tendrils were still present. Could it have been remnants of unripe legumes? (cf. unripe legumes collected at Santorini today and eaten as greens, Table1.25).

Bulgur-type cracked barley From the few distinguishable fragments (Table5.17 and Fig.5.2b) it is possible to say that this 'bulgur-type meal'was made of hulled barley. It is referred to as bulgur-type as bulgur is made of wheat and not barley (Weinstein 1973:275). These fragments were selected as being the largest, and identifiable to genus. They do not reflect the quantity of finer 'bulgur'that might have been present originally in the sample. Therefore, out of quite large samples, we have collected only fractions of what was originally there (e.g. sample 75 where from over 100 grams, only about 0.22 gms. of fragments was collected).

There are eight relevant samples from the West House, of which 5 samples (4, 11, 15, 18, 22) are from room 5 (Fig.4.4), one from room 6 (32), another from the upper floor, Area 7 (75), and one from room 3C (34). What one can say with confidence about these samples is that they do not represent remnants that have trickled down from whole seed/crop storage, as the volume of these samples can sometimes be very large, but the grains must have been deliberately cracked to make this barley 'meal'. The breakage point of these fragments (Fig.5.2b) is very consistent and is transverse to the caryopse, as if some type of repeated perpendicular pressure was applied using, probably, a pestle and mortar.

As regards the weed population of these samples, it is not possible to estimate their exact numbers and variability. It seems logical to assume that barley crops would have been well sieved before cracking and, consequently, the weed population would have been further reduced by 'disfigurement'(cracking and breaking the crop as well as the weeds present). However, samples 22, 32, 34 and 75 have the largest numbers of weeds/contaminants (Table5.17) in total numbers and number of species. Samples 22, 34, and 75 have 18, 21, and 16 weed seeds respectively. The proportion of weed to crop cannot be estimated in these samples for cracked barley cannot be used as a comparative measure. However, it does not seem to be simply a reflection of sample size. The percentage of weed contamination (Table5.18) is probably not a reflection of its original extent, for the reasons stated above, and because some samples are too small (e.g. 11, 15 and 18). Sample 34 (room 3C), however, is the one sample with the highest number of weed seeds in both number of species (10 species) and actual number of weed seeds (21 seeds). This increase in weeds could, perhaps, represent a badly processed 'bulgur'sample or a by-product of several 'bulgur'samples.

What is puzzling at this stage is the presence of *Echium sp.* (14 seeds) in sample 75 (Table5.17), as we would have expected this seed to have been trapped by the second finer sieving. It is also 'timidly'present in sample 12 (Table5.12) where a very fine 'bulgur' seems to have been stored (cf. 20 seeds in sample 36 (legume fragments); Table5.16).

It is most intriguing to find cracked barley in all of the cf.*L.clymenum* crops of the West House (Table5.4), although it is present in very small quantities. An explanation could be that barley was stored in pots prior to the pulse, and that only small particles trickled down from the main crop and settled in the bottom of the pot. When Therans scooped off the rest of the barley, they could not extract these small fragments. Another explanation could be that they stored cracked barley in these pots prior to the pulse, and they did not completely empty out their pots before the change of crops. However, the broken fragments of barley seem to have a consistent breakage pattern transverse to the seed. Therefore, experiments need to be made or ethnoarchaeological material studied, to find out whether deliberate breakage through pounding has a consistent pattern which could be differentiated from natural breakage within storage.

Flour There are nine samples which could be classified as flour; samples 21(room 5), 33 and 38 (room 3C), samples 39, 54, 55, 58 and 59 (room 6) and sample 46 (Xeste 3) (Tables5.12 and 5.16). Macroscopic analysis indicates this grouping, although no chemical analysis has been done on the samples in order to analyse their fine particles. However, what is interesting is that several samples (e.g. 33, 38, 39, 58 and 59), seem to have held a high organic content as reflected in their dark colour.

We could be seeing three types of flour, *barley*, *wheat* and *legume*. Barley flour would be represented by samples 21, 33, 38, 46, 59, and wheat by samples 39 and 58, (identified on the basis of awns), whereas samples 54 and 55 could be legume flour. Just like in 'bulgur'samples, the discussion of weeds/intrusions is not useful as the product is extremely transformed by crop processing. What is puzzling at this stage is the presence of awns, of wheat in the former and barley in the latter, as one might have assumed that these awns would be screened out in previous crop processing stages.

However, we cannot be sure that all of the wheat/barley flour samples were collected, as their visibility is low and they *could easily have been mistaken for pure soil and* discarded. One could also assume that there might have been a limited need for flour due to the lack of gluten in barley and einkorn flour. Therefore, cereals might have been eaten more in the form of groats, porridge and soups. Perhaps this explains the lack of need for wheat in the L.C. period at Akrotiri, especially as bread was probably not of the kind we know. The high status attributed to wheat (Table4.17) could be a misconception triggered off by our familiarity of Linear B rather than Linear A texts.

Contaminants

Contaminants here will be defined as plants which seem to have contaminated pure crops and which do not seem to have been deliberately planted. However, they are plants that could have been cultivated in their own right, but evidence of their cultivation is so far lacking.

Lathyrus cicera/L.sativus It is impossible at this stage to differentiate between *L.cicera* (dwarf chickling) and *L.sativus* (grass pea) on seed morphology alone, but more emphasis is placed on *L.cicera* due to the small size of the archaeological specimens. Some S.E.M. work has already been done by Kislev (unpublished 1986), nothing seems conclusive so far. It seems that the size and shape of papillae are more variable in *L.sativus* than in *L.cicera.*

In the cf.*L.clymenum* samples of the West House (Table5.4), *L.cicera/sativus* occupies a prevalent position. It is the most abundant contaminant in all of the samples except for one, sample 40-43 (Table5.4a), where *Lupinus cf.albus* is the most abundant (7.3%). The degree of contamination varies from as high as 16.5% (sample 1) to as low as 2% (sample 9). In the *Lens culinaris*, samples *L.cicera/L.sativus* is the second most abundant contaminant in only one sample (13/73), representing 2.3% of contamination (Table5.8).

The measurements of *L.cicera/L.sativus* follow the same pattern as spanish vetchling (Table5.5) in that the seeds are smaller where spanish vetchling is small, and larger where the latter is large, but they are, by and large, small in the West House. The difference is apparent when one compares samples from Xeste 3 where legumes and cereals on average tend to be larger and, consequently, *L.cicera/sativus* tends to be larger too. However, it can be said from the samples in Xeste 3 that *L.cicera/ L.sativus* seems to have been much less common than in the West House in that it represents only 1.8% of contamination.

At the ends of the pod, seeds have one pointed end, whereas in the middle, they could be described as roughly oval and truncated at both ends. At one corner of the long end, in the middle, and when the hilum is preserved, it is small and oval in shape. *L.cicera* has 3-5 seeds per pod (Davis,P.H., Vol.3) and *L.sativus* has 3-5 seeds per pod. Therefore, quantitative study of the seeds which are at the end of the pod cannot inform us on either species, but they could give us indications of the proportion of seed per pod. From the Akrotiri samples of cf.*Lathyrus clymenum* where *L.cicera/sativus* is a high contaminant, it has been calculated in total that the 'end of pod' seeds total 27.7%. In other words, it coincides with the number of seeds attributed per pod (3-4 or 5) as given above (Fig.5.6).

Lupinus cf. albus Very little is known of lupin in ancient times and van Zeist (1985:36) claims that there is no archaeobotanical evidence of cultivation of this pulse in the ancient Near East. This is disputed by Gladstones (1970:123) who claims that cultivation was practised in Egypt in c.2000 B.C. At Akrotiri, so far, it was present in only one sample (sample 40, Sector Delta 1a) (Fig.4.2) and occurs as a contaminant in a cf.*L.clymenum* crop (7.3% contamination). Whether it was used as a fodder crop, for human consumption, or was simply present as a chance contaminant is still impossible to say, as no pure sample of this plant has yet been found at Akrotiri. Gladstones (1974:9), who has studied lupins extensively, mentions the use of this plant in Greece at the time of Theophrastus (c.3rd century B.C.) for green manure, and for its seeds as cattle feed as well as for human consumption after steeping to remove the dangerous water-soluble and bitter alkaloids. Various medicinal and cosmetic uses were also described (Gladstones 1970: 123). As regards its soil requirements, it is confined to well-drained soils of mostly light-medium texture (Gladstones 1974:11).

Linum usitatissimum The cultivation of flax dates back to the 7th millennium B.C. (Helbaek 1959b, van Zeist & Bakker-Heeres 1975) and it is frequently reported from archaeological sites in both the Near East and Europe and, therefore, it should not be surprising to find it at Akrotiri. Its total absence from the L.B.A. West House can be explained in that it is a species which can only be preserved in exceptional circumstances because of its use. Had it not been for the study of samples 41-43 (Sector Delta, D1a), the presence of flax would not have been documented on Akrotiri. However, at this stage, it is impossible to say whether flax is just a contaminant or was planted for linseed or linen production. The difference in the flax and linseed form is that the former is sown with a higher sowing rate and the plants grow in thick stands, and, therefore, are less branched and have a lower seed yield, whereas the latter is sown far apart and produce more green parts and grows less tall, and therefore produce more and larger seeds.

The plant is generally sown in late October and irrigated in dry spells, but can grow in dry-farming regimes. The harvesting takes place at different times but before the great heat of the summer, depending on whether it is grown for flax or linseed. Harvesting is performed by pulling for flax, so that the full length of the stem is saved, and by cutting for linseed (Charles 1985:48). The time of harvest is also affected by the kind of produce required. If good quality white silky flax is required, the plants are pulled up soon after the fall of the petals of the flowers when the stems are still green in their upper parts, although the lower parts are still yellow and have lost their leaves (Percival 1936:401). When both linseed and flax are wanted, the crop is harvested when the stem and capsules have turned yellow and the flax produced is greater in bulk and coarser. Where only linseed is needed, the plants are allowed to stand until totally ripe (Percival 1936:401). In areas of limited rainfall (as is the case for Thera), oil-seed varieties do better than those grown for their flax fibres; medium yields can be obtained with an annual rainfall of 300-350 mm. (Renfrew 1985:63, expected yields of c.897/2129 Kg./hectare for oil-linseed (Charles 1985:59)).

In modern times, the flax grown for its flax fibres has small seeds (Gill & Vear 1980:198) (c.190 Kg. of seed drilled per hectare), but should be planted on fertile land (cf. 90 Kg./ha drilled for linseed). One would presume that the same would have happened in the past. Light soils are unsuitable since the shallow root system make the plant rely on water supply in the top c.60 cm. of soil and it does not compete well with weeds (Renfrew 1973:124). On Thera, even the heaviest rains of winter do not penetrate more than 100-150 cm below the surface (Marinatos 1968:8).

If flax fibres were retted in the houses, seeds would be very rare as the immature capsules which hold the seeds would have been combed off before the straw was retted, thrown away, and found perhaps only sporadically in fire places, rubbish pits, etc.

Measurements of ancient flax seeds from various cultures and periods are given by Renfrew (1973:122), and it is interesting to note that the Akrotiri seeds are comparable to the smallest seeds, although one should add 12-15% for shrinkage (Helbaek 1959b).

Coriandrum sativum *Coriandrum sativum* has been found on various sites in Greece and from various periods, but *at Akrotiri it is rather rare except for the 46* seeds found in sample 20/29 of the West House (Table 5.4). All of the seeds were split in half and this number represents a minimum number.

Crop by-products

The chaff samples are defined here as those that were mostly composed of by-products of crop processing, although some of the samples are of an ambiguous nature (Table5.12) and hard to categorize.

There are five samples which could be loosely classed under this heading (3, 19, 24, 25 and 26), all from the West House. One explanation could be that they were by-products of barley processing, but they could also have been remnants of previously stored crops whereby the awns had filtered down and had not been scooped off the pot. In these samples, barley awns are always a major constituent, except for samples 24 and 25, which also contain what we would expect from a by-product of barley processing, namely rachis and culm internodes, and lemma bases.

Fill contexts: West House

These samples have been called 'fill contexts'as they cannot be classed under any other heading of crops and/or by-product, and could, perhaps, represent residues of mixed contexts. There are six samples, 8, 48, 49, 50, 70 and 77 (table 5.19). Samples 48, 49 and 50 were collected from fill and cannot be attributed to any archaeological feature, whilst sample 70 was collected from an area around pots and lamps, which may explain their lack of homogeneity. Samples 8 and 77 are difficult to interpret, and both belong to pots. The nature of plant inclusions which seem to be erratic make us think that these were either remnants of previous storage or that these plant remains fell into the pots after the site was covered with pumice when the roof collapsed on the pots.

The only sample in Xeste 3 which could have been comparable to the storage samples is sample 81(10). It represents the contents of a pot, but it rather seems as if the storage jar was empty and the seeds were intrusions (as in the case of fig and olive), or the pottery had not been cleaned thoroughly and the legumes and barley were left-overs from previous use.

Fill contexts: Xeste 3

Samples 81(1) to 81(8), except for 81(7) (Table5.15) were retrieved from various levels of rooms 7 and 10 but, unfortunately, it has not been decided yet where the first floor ended and the ground floor began. Study of other archaeological data should give us information on this matter. Consequently, our interpretation of these samples can be only limited, and they are treated as fill samples here.

We still do not know anything about the function of Xeste 3 except that it seems to have been some kind of public building (religious and/or administrative), the use of which seems to have been different from that of the West House.

Room 10 is not yet fully excavated but from the point of view of plant remains it seems to have had a functional use as regards subsistence. This conclusion is tentative and will need substantiation from other contextual data. However, what is striking is the high density of seeds compared to other samples (sample 81(7) and 81(12); cf. Table5.2) for quantities of soil processed. The number of seeds per litre soil, compared to the other samples, is very high and include *P.sativum*, *Hordeum*, *Olea europaea*, cf.*L.clymenum*, *Lens culinaris*, and *L.cicera/sativus*. Moreover the quantity of both legume and olive fragments, compared to other wet-sieved samples, is equally high.

Legumes Unlike the West House, there is a *predominance of Pisum sativum* (13.1%). Whereas in the West House, it was represented by only one sample. Cf.*L.clymenum* seems to be less favoured in Xeste 3 in the rooms which were sampled here, and is represented by only 3.6% (Table5.15). Remains of lentil total only 3.3%, and this figure is a further indication that this plant was not very important.

It is interesting to note that the average size of both legumes and cereals is much larger than in the West House, and the possible reasons for this will be discussed in chapter 6.

Cereals As in the West House, barley remains the dominant cereal (23.2%), and the predominance of assymmetric caryopses probably indicates the six-row variety, *H.vulgare*. The near absence of wheat in Xeste 3, except for the presence of one spikelet fork (*T.monococcum*), so far reinforces our previous findings from the West House, even though one might have expected a higher presence of wheat in Xeste 3, as it was probably a public building.

Segetals/ruderals There seems to be several categories of plants under this heading. First, there are small weeds retained by fine sieving, i.e. several species of *Trifolium*, Papaveraceae, as well as ruderal plants e.g. *Urtica dioica*, and *Hyoscyamus niger*. A third group of a garrigue-type vegetation i.e. *Satureja sp.*, *Thymus sp.*, and *Origanum sp.* is also present. Even maquis ecological niches are depicted with the presence of *Thymelaea hirsuta* (Table5.23). Yet, their presence does not imply that these plants existed in the vicinity of the site. These seeds could have travelled long distances on people's cloths, shoes, and even on animals, or perhaps brought back deliberately.

Sewer contexts: West House

Unfortunately, most of the sewer had been excavated by Professor S.Marinatos and no samples had been collected. Only a small fraction of soil was preserved in the clay pipes which were collected (sample 81(11)), as it was believed that very few seeds would be trapped in a perpendicular clay pipe. However, the small quantity of soil (Table5.2) left *in situ* in the sewer pit had some seeds. What is significant in this case is not the species of seeds but their mineralized state of preservation, which is totally different from the seeds collected from floors and storage areas. The second very interesting difference from other samples is the great number of puparia, identified by Dr.D.Webley (pers.comm. 9/3/1983) as belonging to a dipterous fly (gnats?), the larvae of which feed and thrive in wet organic rich muds and so forth. These puparia are also mineralized. Thirdly, there are very tiny and strangely eroded bone fragments which are mineralized as well. Future analysis by specialists might indicate whether these had passed through the gut.

5.1.5 Insect infestation

Very little is known of insect infestation of agricultural produce for prehistoric and even historic periods, as it is a neglected field which needs further investigation. The best evidence for this is from stored grain, which is exactly what the site of Akrotiri offers. As evidence accummulates, it should become a rich source of information on this field. However, so far, we have only a few samples with weevil infestation, and, as yet, these insects have not been identified. What is interesting is the low infestation levels of the crops from Akrotiri (Table5.20, see also Table5.21), which tends to agree with Kislev's belief (1986(b), unpublished) that 'damage to stored cereals and pulses was considerably lower in ancient times than it is today'. Infestations can be as low as 0.8% (sample 17 -lentils) and as high as 9.9% (sample 78 -lentil) but they are mostly around only 2-3%.

5.1.6 Weeds and wild plants

Weeds and wild plants will be noted here, and the implications of their presence will be discussed in the next chapter. Furthermore, no mention will be made of their flowering periods and their soil, and moisture requirements (Table5.24).

Segetal weeds or weeds of cultivation

Sherardia arvensis

This seems to have been the commonest weed in legume crops. Not only is it represented by high numbers (Tables5.4, 5.6-5.9), but it is also represented in 67% of the cf.*L.clymenum* and *Lens culinaris* samples.

Buglossoides arvensis

This is the second most abundant weed both in number in and across the samples (Table5.4, 5.6, 5.8, 5.16). It is also represented in 56% of the cf.*L.clymenum* samples, 33% of the *Lens* and 50% of the *Hordeum* samples. All the other segetal plants represented at Akrotiri are listed in the tables.

It comes as no surprise that the large majority of weeds of the West House, especially those collected from pots, are weeds of cultivation. The odd intrusion of a few plants from other ecological niches is no cause for concern at this stage.

Ruderal weeds or weeds of waste places

They are present in the floor samples from Xeste 3 (Table5.15), which is in tune with what one would expect. They are the following: *Urtica dioica* (which was never observed as a segetal 'even under the lightest ard cultivation'(Hillman 1984:21), *cf.Hyoscyamus niger*, and *Cucubalus baccifer*.

Salt/fresh water plants

There is no indication of water sources in the neighbourhood of the site, except for the presence of some plants prefering wet or marshy environments (Table5.24). The presence of some plants is indicative of such environments: e.g. *Schoenus nigricans*, *Sagittaria cf.sagittifolia*, Salicaceae (Fig.5.3c), *Juncus cf.subulatus*, *J.cf.acutus*, and *Thesium sp.* (Fig.5.4a). A unique presence of another species, *Allium cf.subhirsutum*, might just have been incidental. Moreover, the presence of Salicaceae is indicative of some kind of wet environment.

Garrigue/maquis plants

The West House samples from pots consistently contained *Thymelaea cf. hirsuta* leaves which will be discussed in the next chapter. In some of the water-floated samples from Xeste 3, we also seem to have seeds from the same species (Table5.15). The presence of these plants is fairly constant and could not be taken as incidental. Other garrigue/macquis-type plants that are represented include: *Origanum sp.*, *Satureja sp.*, *Thymus sp.*, *Capparis spinosa*, *Thymelaea cf. hirsuta*, and *Trifolium cf.scabrum L.*.

5.1.7 Preservation by charring

There are four variables that should be taken into account when one examines charred seeds as they affect their preservation and condition of charring. These are temperature, duration of charring, moisture content of the seeds at the time of charring, and whether or not charring occured in reduced oxygen.

Temperature

The temperature of the tephra which reached Akrotiri would have been about 300°C. (Tarling, pers.comm.) but due to local conditions (i.e. humidity in the rooms of the houses, protection of seeds by storage jars, evaporation of heat) seeds would perhaps have been directly exposed to slightly lower temperatures. How much lower is difficult to say, but what should be remembered is the major single event of the burial of the site under a thick layer of hot pumice. We know that seed samples exposed to differential heating regimes might have different dimensional changes (Wilson 1984). Under this mantle of unified temperature, some small variations referred to above would have occurred, unless rooms and/or houses caught fire. So far, no signs of fire are visible in any of the rooms in the West House or Xeste 3.

Therefore, the seeds from these places were carbonized under similar conditions of temperature, duration, and moisture.

Seed lustre could be used as an indication of differential heating conditions. Jenkinson (1976:44) stated that a sample of lentils heated for 10 hours had seeds of a more dull lustre than seeds heated for a shorter period. This might explain why seed samples from floors at Akrotiri have more lustre than those from storage jars. The samples in storage jars would have been exposed to less direct heat and less evaporation as the jar behaves like a small oven.

However, Xeste 3 seeds from floor contexts might have been exposed to slightly different heating conditions because they were not in pots, and therefore, exposure was more immediate. One reason for the difference in size of both cereal and legume seeds from these two buildings, as well as the difference of lustre of the seeds'surfaces, could be attributed to this factor. However, there could be other archaeological explanations which will be discussed in the next chapter.

The major constituents of wood, hemicellulose, cellulose and lignin, are reported to have individual breakdown temperatures, and in the case of cellulose the range reported is between 240 and 350°C (Jenkinson 1976:3). In the experiments conducted by Bowman (1966:14) on grains of *T.aestivum*, he had shown that from 250°C seeds could become charred. Below that temperature, seeds were not charred irrespective of the duration of heating (idem:fig.1). However, at 250°C the difference between charred and uncharred was affected by the duration of exposure to heat. He found that times up to half an hour at 250°C did not char the seeds, but charring occurred after 1 hour. Therefore, on this basis, we could assume that seeds at Akrotiri were exposed to heat of approximately 250°C and slightly less than 300°C. It would be interesting at some stage to submit some of the seeds to Electron Spin Resonance Spectroscopy to determine the thermal history of the Akrotiri seeds (Hillman et al.,1985a). Bowman (1966:37) also claimed that in *Hordeum* grains there was unexpectedly a greater decrease in length at the lower temperature of carbonization

(250°C) rather than at the higher temperature (350°C). As samples from the West House and Xeste 3 come from two basically different contexts, we could presume that perhaps this difference in size was due to this differential exposure to temperature and duration of heating. However, we still could not claim that the only reason for this difference in size was difference of heating regimes. Consequently, seeds from the West House could have greater decrease in length (Bowman 1966:37) than seeds from Xeste 3 due, perhaps due to the lower temperature of charring (closer to 250°C). In general, the smaller size of seeds from the West House compared to seeds from Xeste 3 could be due to the exposure of the latter to higher temperature as they were not protected by storage jars or other pots. However, the evidence is still not conclusive.

Duration of heating

The appearance of seeds argues for a long duration of up to 10 hours for those in storage jars, and a shorter duration for those from other areas. Therefore, it could be argued (Jenkinson 1976:44) that quantitative information on the duration of charring could be provided by the external appearance of the seeds.

Oxygen

Bowman (1966:15) also did some experiments to measure the effect of oxygen supply on carbonization, and he concluded that they gave no evidence that reduced oxygen supply increased or decreased the carbonization of cereal grains. This factor, in that case, would only affect differential preservation between seeds and other by-products. Unfortunately, no similar experiments were conducted on pulses, but we could assume that the effects would not be very different from cereal grains. Therefore, we could conclude that the two most important factors in carbonization for Akrotiri are temperature and the duration of heating.

The results of these experiments, together with Tarling's measurements of the temperature attained at Akrotiri, reinforce each other's thesis that the temperature of the tephra did not exceed 300°C. Consequently our proposed temperature of between 250 and 300°C in the houses, and especially in the West House and Xeste 3 in particular, is not unreasonable. However, even if heat loss was slow, 16 hours of subjection to 250°C would not have been enough to char the fragile parts of the cereals. Indeed it is more likely that the temperature would have fallen in the meantime, unlike an oven where temperature could be kept fairly constant. Therefore, the coexistence of uncharred glume parts with charred seeds could be explained if we take into account the behaviour of plant remains in these experiments, which is, that up to c.250°C glumes do not char, but seeds do.

Moisture

Both Jenkinson (1976:46) and Bowman (1966:15) claim that a high/low moisture and 6-10 hours heating is indistinguishable in dimensional terms, especially when the variance is considered. Therefore, moisture content is not a factor to be considered when comparing measurements of the seeds found at Akrotiri. The uniformity of uncharred glume parts of the barley in the West House is another indication pointing to a temperature of 250°, as the same would occur to *Hordeum vulgare* and *H.distichum*. Therefore, the presence or absence of charring seems to have no connection to the burning process, which, as M.Robinson and V.Straker (unpublished 1986) claim, would have been due to fully oxidizing conditions. Oxidising or unoxidising conditions should not affect the nature of silica to any great extent. Their claim (idem) that 'high temperature oxidising conditions are required to burn out all the carbon and leave only the silica skeletons'seems a different method from Bowman's to reduce plant remains to silica, since the 'glumes and straw of the spikes heated at 350°C. for half an hour were carbonized and the spike remained intact'(idem).

5.1.8 Preservation by silicification

At first, some of the above samples, especially the 'bulgur-type' samples from the West House, seemed to have been submitted to two different and independent processes. All of the glume parts, paleas, lemmas and mainly the awns, and even some barley embryos, seemed somewhat mineralized/silicified, whereas the seed parts were charred. A guess was that, they may have represented some kind of barley beer-making, whereby the glumes would have absorbed part of the fermented liquid and had become mineralized before the charring process. Therefore, a sample (sample 71, 0.55 gms. of glume parts) of the 'bulgur-type' was submitted for X-ray diffraction at the department of Geology at Sheffield University and Professor C.D.Curtis was kind enough to provide some results. These showed that whatever the material, it had an amorphous structure, and was definitely not mineralized, but was rather of an inorganic nature.

It is known that non-silicified cells are rendered invisible with ordinary transmitted light and that silicified ones are seen by the use of phase contrast with polarized light (Parry & Smithson 1964:170). Sure enough, as soon as the cells were examined under the use of phase contrast, it became clear we were dealing with silicified samples.

Silicification 'is a passive non-selective deposition mechanism' (Hayward & Parry 1980:545). Monosilicic acid 'is absorbed into the plant and transported to the aerial parts where it is polymerized to silica gel and opal which form in the lumen of some epidermal cells and as incrustations of cell walls'(Hayward & Parry 1973:579). Examination of barley *H.vulgare* indicated that all detectable silica was in the palea and lemma and none was detectable in the aleurone and endospermic tissue of the caryopses (idem:586), although this is disputed by others (Hodson & Parry 1982:226). Awns were also heavily silicified. Therefore, it could be concluded that culms, floral bracts and awns of barley accumulate more silicon than other parts of the plant. This provides one explanation for the presence of these silicified parts of the plant in our samples, and the extent perhaps was due to several reasons.

In this context it was interesting to see Bowman's (1966:10) claim that 'glumes and straw of *T.dicoccum* spikes heated at 250°C for 16 hours became shrivelled, brown and very fragile but were uncharred, although the grain was carbonized'. This uniformity of uncharred glume parts of the cereals in the West House could be another indication pointing to perhaps 250°C. Another explanation could be that discussed by M. Robinson and V. Straker (1986) who claim that 'high temperature oxidising conditions are required to burn out all the carbon and leave only silica skeletons'. This would have charred the fragments of caryopses, leaving the already heavily silicified parts uncharred. At Akrotiri, it seems that the former possibility is the most likely for the evidence of other finds, e.g. very few pieces of charred wood, demonstrates that high enough temperatures were not reached.

5.1.9 Preservation by mineralization

Only two samples so far from Akrotiri exhibit mineralization, samples 81(11) and 81(13) (Table5.15), and they were retrieved from sewer pits. The mineralized seeds from these samples exhibit a *crystalline or semi-crystalline* appearance, especially seeds of *Ficus carica.* Mineralization occurs as a replacement of the already dead plant material by inorganic substances and in these examples, the inorganic substances would be related to faecal and other material. Unfortunately, no X-ray diffraction was done on these samples in order to reveal the type of mineralization, but generally we would expect phosphate mineralization to have occurred from faecal deposits (Green 1979:283). Calcium could be included as, often, lime was thrown into the cesspits as a sterilizing agent, just as in Greek villages today.

Chapter 6

Akrotiri: Interpretation of palaeoethnobotanical data

6.1 Introduction

After the presentation of the data in the previous chapter, some interpretations of the plant remains will be given in term of crop processing stages, agricultural practices, possible uses of rooms, and storage information.

6.1.1 Background information

West House: The ground floor

In addition to the entrance hall (Fig.4.4-4.7:1&2), the ground floor has 7 rooms, and accessibility from one room to the next was through a door (without corridors). Travel through the ground floor of the house had a clock-wise direction:

hall 1 ----> 3A ----> 3C ----> 4 ----> 5 ----> 7 ----> 6 ----> 1 (?)

and anti-clock-wise motion

hall 1 ----> 6 ----> 7 ----> 5 ----> 4 ----> 3C ----> 3A ----> 1

The use of all of these rooms has not yet been resolved, and the use of room 3B is particularly enigmatic. It seems to have had no access to other rooms except for a window opening on the east wall of room 5. No plant remains have been collected from 3B and 7. The latter room has not yet been excavated down to the ground floor. In 3B not only was there an apparent lack of plant remains but there also was a lack of all material finds. In other words it seems to have been totally empty.

In room 3A, along the west wall there was a milling installation (Pl.2), but no samples were recovered. Most probably, no crops were stored in 3A, for most are easily visible, and, therefore, should not have been missed on excavation. The most probable loss would have only been flour, and chaff.

In room 4 as well, there is no indication of any storage, as the three samples we have collected (samples 24, 62, 72) are all from well 23 (Fig.4.2). 'Wells'are soundings which were excavated in order to place the dexion metal columns for roof supports and they include, very often, pre-L.C.1 material, and are of pre-L.C.1 phase.

The only rooms which seemed to have been used for storage are 3C, 5 and 6, the two latter rooms having most of the relevant evidence (20 samples from 5, 15 from 6 and 7 from 3C). Area 7 was largely occupied by the small staircase leading to the upper floors.

Therefore, in order to store material in rooms 5 and 6, it would have been easier to enter under the staircase (1) into room 6 and subsequently, through area 7 to room 5, thus avoiding rooms 3A, 3C and 4 which could have been mainly reserved as activity rooms (working rooms).

West House: First floor

Unlike the ground floor, one could travel only clock-wise on the first floor from the landing:

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hall 1 ----> 3----> 5 ----> 4 ----> 5 ----> 7 ----> 6
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Room 3 was the largest of the rooms. Its use is still open to interpretation. However, the large number of loom-weights together with the existence of the wide window facing south, probably point to the use of this room as a weaving-cum-sitting area. Unfortunately, the five samples collected from this room held no plant material (Fig.4.4) and, therefore, the usage of this room remains uncertain until the completion of Mrs.A.Michaelidou's study (Ph.D. in progress). Room 3 leads to room 5 which seems to have been probably the most prestigious room of the house, although much smaller than room 3. High status is attributed to this room because of the following factors: wall paintings of the two fishermen, the flotilla and the town fresco, the 'polyparathyron'(multiple windows) overlooking the west and north, and a wealth of good quality, imported, pots. Only one sample of plant remains was collected from this room (sample 21) but this perhaps could have fallen from the roof of this house.

Room 4 ought to have had a more private function due to its limited accessibility to other rooms (no direct access to room 3 and only to room 5), and also due to its proximity to the water-closet room (south-west corner of room 4). Here again, only one sample of plant remains was collected (sample 25) which could also have fallen from the roof.

Area 7 was a multiple-purpose area combining a staircase, small landing, cupboard and also corridor leading to room 6. Six samples were collected from the 'cupboard'for plant remains but only one had macrofossil plant remains (sample 75) (Table5.17) and one had a cf.*L.clymenum* imprint (Fig.4.4). Some other organic remains had been preserved in other pots but they still need to be analysed. Three samples were provided (samples 58, 59, 64) from room 6 for macroscopic analysis for plant remains. Two of these come from pots which were built within a bench, thus reinforcing the view that storage was not confined only to ground floors (cf.Xeste 3, room 10). Access to the storage facilities in rooms 6 and 7 could be from the ground floor by a staircase, thus bypassing the main living areas (rooms 3, 4 and 5) of the first floor.

West House: Second floor

The only architectural detail which indicates the existence of another floor is the fact that the principal staircase continued in wood to the second floor terrace, and the inner walls of room 6 are thick, indicating the existence of a built structure above. A calculation of the volume of stones found on the north and east side of the building reinforces the argument for a second floor only in this part of the house and namely, over room 6. What the use of such a room could have been is still open to debate.

West House: Storage information

Some tentative calculations of the volume of storage have been made for the West House, based on the number of large pots which have been reconstituted. As all pots which could be restored have been reconstituted, our calculations probably approach their initial numbers. Pots of medium and small size have not been taken into account.

As already stated, the visibility of plant remains, especially seeds in a pot buried under a protective layer of ash, is high and so most plant macrofossil remains would have probably been sighted and/or collected. Flour and/or liquid could probably have been missed. However, we have found macrofossils in only a small fraction of pots. The explanation for this is obscure, and an integrated study of all archaeological finds, both organic and inorganic, should be completed before any conclusions can be reached on this point.

West House: Abandonment procedure

As has already been mentioned, the habitation phases of the L.C. West House still need more precise definition but are, broadly speaking, the following:

1. Earthquake
2. First abandonment of site (length of time unknown but rather short)
3. Return for a short length of time by all or a few of the inhabitants
4. Signs of imminent danger and second abandonment
5. Total cover of site with pumice

Several archaeological indicators show that the West House had been reoccupied after the first abandonment, but by whom and for how long is yet to be resolved. A multitude of questions remain at present unanswered. Was it the owners of the house who reoccupied the West House? Was it their 'servants'or other 'troglodytes'? How long was it reoccupied for? As there were substantial repairs in the settlement after the first abandonment, we could assume that the time that elapsed between the reoccupation and the final abandonment could not, perhaps, have been counted in days or weeks, but should rather be calculated in months. The upper limit could have been less than a year for several reasons, one of which is that the wall plaster of the house was being repaired when the second abandonment was forced upon the inhabitants. It seems that the house was cleaned of any rubble which might have amassed after the first earthquake, and the wall paintings on the west and north walls of room 5 (upper floor) had been cleared; for these must have fallen after the first seismic wave (Ch.Televantou, pers.comm.), as this part of the building was structurally not as strong as the rest of the house. This has implications for the interpretation of the plant remains from this house. Are the plant remains we are finding the left-overs of the first or the second abandonment? Or are they partly of the first and of the second abandonment? The vast amount of unused pots could imply that not all, but only some, of the inhabitants of the West House came back. Could the bad quality of the cereals and legumes account for this fact? Could the scarcity of wheat also account for this? Could it mean that in the first abandonment the inhabitants had had time to salvage even grain, and that the re-occupiers had had to content themselves with whatever was available? Discussions of these points will have to remain open until the study of all remains are concluded. Meanwhile, we shall treat all the plant remains as belonging to one period (post-first abandonment).

6.1.2 cf. Lathyrus clymenum (Spanish vetchling)

It was interesting to note that all but one of the seven samples of *cf.L.clymenum* crops came from room 5 on the ground floor, the exception being sample 65 from room 3C. There was also one sample of imprints from area 7. Sample 65 (Table5.4) seems to have been near to the final stage(s) before consumption. This observation is based on the fact that sample 65 has, in weight, more split legumes than whole ones. It also contains the smallest seeds of all the samples and the weight of whole seeds is less than half the weight of legume fragments. The smallest seeds would have been the least likely to have been split/crushed, and, therefore perhaps, escaped the processing stage. A case in point is the fact that sample 65 has the largest number of seeds of *Lathyrus cicera/sativus* which are of the end of the pod (Fig.5.6) which reinforces even more our point.

Crop contaminants and crop rotations

The commonest contaminant in this crop is *Lathyrus cicera/sativus* (high contamination of 16.5% in sample 1, and lowest contamination is 2% in sample 9. See Table5.4), and the second most common is lentil (high 4.2% in sample 1 and low 1.1% in sample 9). Barley occurs in three samples, 2.5% in sample 5/10, 1.8% in sample 9, and 0.8% in sample 14. These contaminants could be interpreted as evidence of a rotation system (Dennell 1978b:92). However, this interpretation could be somewhat dubious as the evidence could also be indicative of crop processing, e.g. crops threshed previously on the threshing floor, or even indicative of the purity of the seed corn (Dennell 1978b:92). It might also represent a sowing preference ('maslin'), or even a remnant of a once cultivated crop. An example of this was noted by G.Jones (1983b:3.1.4.) on Amorgos, where grass pea, *Lathyrus sativus*, crops were often contaminated by bitter vetch, *Vicia ervilia*. Although the latter cultigen was not deliberately grown at the time, it had been cultivated as a separate crop in the past and may have persisted as a relic.

It is of some archaeological significance to note that crops grown on two fairly close islands (Karpathos and Amorgos) with basically the same subsistence agriculture have significantly different cropping systems. On Karpathos, farmers were very careful in keeping different cultigens separate, whereas on Amorgos, crops were often mixtures (G.Jones 1983b:7.2.2.). One can argue that there can be no one single answer to why cultigens are found mixed in crops. On these lines, G.Jones statistically tested two possibilities using the Amorgos ethnographic data. One was to test whether contaminants were affected by the crop grown the previous year on the same field, and/or whether they were affected by the last crop threshed on the same threshing floor as the crop contaminated seed. Her results indicate that the relationship between major crop contaminant and previous crop threshed was not significant for any of the groups of samples. Moreover, the relationship between crop contaminant and previous crop grown was not strong. The most consistently significant relationship was between crop contaminant and crop sown. She goes on to note that cereal crops tended to be most contaminated with other cereal crops and legume crops by other legumes, despite the fact that farmers generally operated a cereal/pulse rotation system, just as at present day Thera. The interpretation of such an observation could be twofold. One is that it is difficult to separate seeds which looked very alike (e.g. barley and wheat/oat; pea/lentil and common vetch) and the second is that this type of impurity was not considered totally undesirable and, therefore, it was not considered worthwhile to clean the grain too thoroughly. However, a very valid question put forward by G.Jones (idem) was whether seed corn itself would have been contaminated if crop rotation were not practised on Amorgos? Therefore, ultimately, the contamination of the seed by a cultigen does not rule out the possibility of its being due to some kind of crop rotation (e.g. wheat/oat; lens/grass pea) but what it cannot say is when and how that crop rotation had occurred.

In the light of what we have said, it is interesting that all the samples of cf.*L.clymenum* have as their major cultigen/contaminant, a pulse crop (i.e. *L.cicera/L.sativus*, *Lens*, *Lupinus cf.albus L.*. The samples, therefore, seem to be consistent with Jones'observations on Amorgos, namely that pulses tend to be contaminated by other pulses, rather than with cereals.

Field fragmentation

The fragmentation or not of fields at Akrotiri was another question which interested us, as we know that in Greece today, and in Thera in particular, field systems are very small (Chapter 5). The economic implications are manifold. One beneficial effect is that it is easier to own both good and poor fields rather than one or the other, and thus it helps act as an equalizing force in the community. Secondly, it ties better with subsistence agriculture whereby farmers can grow several types of crops, albeit in small amounts, depending on the soil of their fields, instead of planting large areas with a smaller number of cultigens. This system creates a buffer in case a particular crop fails and acts as a type of 'risk minimisation' of the few resources available, whereas larger fields would economize labour and time but indicate a different kind of agricultural 'extensification'not applicable in our context.

Fragmentation could also imply a particular inheritance system, and if fragmentation was like today, it could indicate types of land ownership which could have economic and social repercussions. The extent of field fragmentation in L.B.A. Thera might be investigated by the study of cf.*L.clymenum* crops.

The hypothesis put forward here is that samples found in different pots could represent crops grown in different fields. This could be tested by seeing if the seeds of *Lathyrus* and other cultigens in each sample were of a discrete size, and/or shape, and if each sample had its own characteristic weed seed assemblage. Either or both might indicate that crops were grown under different field conditions, and this might in turn imply that crops were grown in small but distinctive fields.

The West House samples seem ideal for this purpose. First, they belong to one unit, a complete house which most probably belonged to one family (Chapter 4). Secondly, the whole house was destroyed all at once in one event which sealed its contents. Thirdly, the crop was similarly protected in pots, which would, partly, eliminate, differential preservation and, fourthly, and more importantly, exposure to charring would have been largely similar for all samples.

Sixty seeds of cf.*L.clymenum* crop were measured from each of the eight samples and an analysis of variance (Fig.5.5) was plotted for length, breadth and thickness, and the two ratios of L/B and L/T. Although the F factor of significance was high in the three measurements, the ratios were less significant. On the basis of their seed size, the samples could be grouped into three separate entities (Table5.5), the largest being sample 40, the smallest sample 65 and the intermediate sample 20/29. The same pattern seems to emerge from the analysis of variance of the highest contaminant, *L.cicera/L.sativus* for the same group . This is followed closely by *Lens* for the largest sample (40) but the smallest seeds belong to sample 9. In *Hordeum* it is reversed, where sample 5/10 is the largest, and the smallest, contrary to *Lens*, is sample 14. Therefore, on size alone of all these species of plants, perhaps, it is possible to group them under four groups (Table 5.5), i.e. sample 40 belongs to a class of its own, followed by sample 65, the smallest, sample 20/29, and parhaps samples 1 and 5/10. Sample 40 is interesting for three other reasons. Firstly, it belongs to a different period, the M.B.A. as it was found in Sector Delta, room D1a, when soils were better than in the L.B.A. (Davidson 1978a,1978b,1980). Therefore, one interpretation of these M.B.A. seeds is that they portray a period when soils were not yet depleted of their nutrients, but other interpretations should obviously be considered when more M.B.A. samples become available. Secondly, it is a weed-free crop, and also the 'healthiest'crop in that no weevil infestation was detected. Several interpretations could be given, e.g. it could have been reserved for sowing, or could have been thoroughly cleaned for human consumption. Whatever the reason, we can also see that contamination by other cultigens was not considered a negative effect, and was not eliminated.

Alternatively, this sample might reflect an economic and social difference between the inhabitants of the West House and Sector Delta, with the latter owning better fields, and being more careful with food destined for human consumption. However, this seems unlikely as all the archaeological indications point to the West House belonging to a fairly wealthy, 'middle class', family. Although little is known of Sector Delta, as it has not been totally excavated, the archaeological finds (especially wall-paintings) do not point to a higher status than the West House. A further explanation could be that the inhabitants of Sector Delta had dealings with land (farmers?) and therefore, had seed grain, whereas the owners of the West House had a different trade, or even had farmers working for them who would have stored seed grain in their farms, perhaps somewhere in the suburbs. Had the inhabitants of the West House been wealthier than the people living in Sector Delta, we would have also expected them, like their counterparts in Greece today, to own houses in the country, or katikies, as solitary houses near fields and away from villages are called. There, one would assume, they would have kept all the seed for sowing. The largeness of the seeds of sample 40 combined with the inclusion of flax could also indicate some kind of irrigation. Could we be detecting garden agriculture for spanish vetchling versus the dry-farmed vetchlings in the West House? This is a question that should find an explanation once more samples are processed from more contexts of the site, and when more ethnographic work is done on weeds of dry and irrigated farming. However, even flax, which is a water-loving plant, can grow in dry-farming, and it seems safe to assume that most crops would have been grown in a system of *dry-farming similar to that used today.*

However, in order to follow our previous argument for the detection of groups in our cf.*L.clymenum* crop, general features of each sample should also be considered (Table6.3). Samples 20/29 and 16 seem to have some similarities. In sample 20/29, there seems to be a higher presence of legume stems than in other samples, and the legume fragments are also more numerous than elsewhere (c.8.7gms.). Moreover, it is the only sample which contains *Coriandrum sativum* as a contaminant/weed. Yet, Samples 16 and 20/29 are very similar in having the same contaminants/weeds in approximately the same proportions, and the contamination of the whole crop is also similar in weed numbers and percentage of contamination by weeds.

Another group could have been samples 14 and 9, although the association is not as strong as in the previous group. The level of contamination of the crop is almost identical, i.e. 94.7% for sample 9 and 95% for sample 14. What is of note is that weed seeds are more numerous in sample 14 (Table5.4). Moreover, two more factors are to be kept in mind. One is that these two containers are very close together in Room 5 (Fig.4.5) and that the pot containing sample 9 was a cup, whereas the one containing sample 14 was a small storage jar. A possible interpretation for such a phenomenon will be given below.

Yet another group could be samples 1 and 5/10 (Table5.4). However, the weed seeds are more abundant than in most other samples (except for sample 20/29), especially sample 1 which contained 584 weed seeds, an amount which is not even justified by the large sample weight (220.68 grams). As for the weeds, although the percentage of their contamination is comparable (sample 1, 7.4% and sample 5/10, 2.8%), they are of different species but of the same size range. These facts probably indicate a real difference that is not simply the result of sampling. As an additional point, the barley seeds are also fairly large (Table6.3). One possibility that would explain the large seed size is that sample 5/10 might have come from soils which had slightly more soil nitrogen than those of sample 1. Another factor in favour of this hypothesis is the large size of *Sherardia arvensis nutlets in sample 1, a weed* which prefers high nitrogen and basic soils (Table5.24). However, none of our points is conclusive, and more work needs to be done on weed ecology in Greece and on the ethnographic relationships between weeds, field-type, and seed sown before this point could be clarified.

Therefore, the seven samples of cf.*L.clymenum* from the West House, could be grouped into five types which might perhaps portray some kind of field fragmentation (Table6.3). However, our data are clearly not conclusive enough to answer the questions of whether or not fields were fragmented in the L.B.A. of Akrotiri, but it is an area of study which will hopefully be pursued, in the future.

.1.3 Other crops

ens culinaris (lentils)

'wo out of the three samples of lentils are stored in room 5, ground floor (Fig.4.4) nd one is in room 6. Contaminants are what one would expect, mainly pulses, vhereby the highest contaminant in two out of the three samples is cf.*L.clymenum* nd only one has, as highest, *L.cicera/sativus*. Again there is no direct evidence for rop rotation.

The presence of cleavers (*Galium aparine*) in two out of the three samples is inter- esting as it is totally absent from samples of cf.*L.clymenum*, whereas in the lentil samples it is present in comparatively large numbers. In northern Europe, cleavers would be considered (M.Jones 1984:489) an autumn germinating weed (Hillman 1981:146). Yet, the absence of this weed does not automatically imply spring-sowing. However, it is probable that pulses, just like today, were autumn-sown at Thera, due to the low rainfall and to the high temperatures in spring whereby not enough moisture would be available before the ripening period of the plants. Theophrastus (H.P.VIII 1 3-4) though assigns them to spring sowing. (Could it be that his homeland, Lesbos, was wetter?)

Samples 17 and 37/61 come from two different rooms and apart from the similarity of having the same number of contaminant species, namely four species (Table5.8) and having a high presence of *Sherardia arvensis* and *Galium aparine*, their dissimilarity is of note in the range of other weed species. Could we be seeing here crops from two different fields?

Hordeum vulgare and H. distichum (barley)

There are two samples (2 and 71; Table5.11) of barley crops, and also the barley which was present in the 'maslin'sample (78). However, none of the two former samples is pure 2-row or 6-row, but seems to be a mixture of both, with emphasis on 6-row. Sample 71 is probably a by-product of a barley crop. Firstly, most of the grains are very small, like tail-grain. Although barley is small at Akrotiri, samples of barley we find on floors are not as small as these. Moreover, we found rachis segments and internodes, culm nodes, a few culm bases, pedicil tips, and, of course, the ever-present awns as well as some lemmas. The culm bases are important as they could indicate, if present in quantity, that barley was uprooted. Therefore, due to all of these factors, and also to the coarseness of the pot in which this sample was found, as well as to its archaeological context (Room 3C), it seems probable that sample 71 was a by-product (stage 7, Hillman 1984b:4) and could have been preserved for animal feed or as a famine or emergency food.

Triticum *monococcum* s.l. (einkorn)

The scarcity of wheat samples is somewhat unexpected, especially as we know that it was a cereal which had a high status in the Mycenaean period. The presence of *T.monococcum* ('maslin'sample 78) and the scarcity of *T.dicoccum* s.l. is also puzzling especially when we know that the former does not make good bread, whereas emmer's bread is marginally better. Could it be that the inhabitants of Akrotiri did not have a tradition of leavened bread but rather used flat bread? The presence of what appears to be two wheat flour samples, samples (39 & 58), have only *Triticum sp.* awns (Table5.12) preserved which are impossible to speciate and, therefore, we could only claim that, on the basis of macroscopic remains, *T.monococcum* s.l. is the only species which seems to have been deliberately cultivated. Moreover, sample 78 seems to have been a 'maslin' where lentils, wheat (einkorn) and barley (hulled) were recovered in that numerically descending order (Table5.13). The presence of these crops in a single sample is puzzling and could be considered the result of tertiary processing which is the mixing of crops just before consumption. Firstly, had these crops been planted together, they would have presented enormous problems to the cultivators at the time of reaping as these crops ripen at different times. We would expect lentils to ripen first fallowed by barley and last wheat. Secondly, the threshing would have been slowed down if these were threshed together and most probably, just as today, the threshing of crops followed a very precise pattern where some plants were always threshed first (see section 1.7.4) where pulses were always threshed before cereals and barley before wheat. Nevertheless, wheat and barley could have co-existed together on the same fields and could have therefore belonged to one crop but lentils would have, most probably, been planted separately.

Ficus carica (figs)

The presence of figs could not, unfortunately, reinforce the hypothesis that the site was finally destroyed in the summer. This belief is partly based on the fact that stored crops were low in quantity which could have meant that the inhabitants had had no time to replenish their stores with the new produce of the harvest. Yet, the presence of fig cannot be taken as determinant, especially as we know that figs were dried and kept for winter food as well, and would have been a source of relish to a population who would not have had many winter fruits and certainly not very many sweet foods, as we know that the main source of sweetener was honey. They could also have been preserved by making fig vinegar (Darby et al., 1977:615, Papyrus Anastase 3,3,5) which would, presumably, have included most of the seeds.

Vitis vinifera (grapes)

Grapes are also a poor indicator of when the site was destroyed as they could also be dried and kept for year-round consumption. Their uses would have been manifold, i.e. wine, dried grapes, vinegar, and might have been used, as well, in baking.

Olea europaea (olives)

It seems that the olives at Akrotiri were produced locally (Chapter 5). Olive crushing could have been conducted on a household level with crushing on saddle querns prior to pressing (Amouretti 1984:267). The by-products of crushing, which could also have been conducted on specialised premises, e.g. the Therasia site, and would have been transported to Akrotiri for use, perhaps, as fuel. Therefore, whichever was the case, it is an indication for the local cultivation and production of olive oil. Whether local production covered their needs or not, is still an open question. In Syria, olives are placed in a mortar where they are pounded and we are beginning to have some indications that perhaps this was the case for M.B.A. Akrotiri.

Linum usitatissimum (flax)

For more details on the *Linum* seeds found at Akrotiri see Chapter 5. The question of the size of flax seeds is open to various interpretations. One reason for the small size of these seeds could be that the flax was not planted for linseed but for linen, as there is no deliberate selection for large seeds. Another reason could be that the seeds were harvested when cf.*L.clymenum* was ripe and the flax plants had not fully matured. Large seeds could also have been a reflection of some type of irrigation in dry regions. On the other hand, if flax was grown for the dual usage of fibre and linseed, we would expect only some seeds to be fully matured and others not matured and consequently, slightly smaller. What the explanation is for Akrotiri remains, at present, obscure as we have very few seeds and from only one context, where they are present as contaminants.

Coriandrum sativum (coriander)

In sample 20/29, the 46 seeds of this plant should be considered as contaminant intrusions and perhaps not deliberate cultivation. Whether there was deliberate cultivation of this crop plant at Akrotiri is still to be proved. From linear B sources (Ventris & Chadwick 1956), we know that coriander was used in food for flavouring, perhaps added to drinks as well, and also in perfumery (Shelmerdine 1985). As it can grow in dry waste places, fallow land and calcareous arable land (Hanf 1983:457), it is not indicative of any special husbandry techniques.

Use of other wild plants: *Capparis spinosa*, *Origanum sp.*

Satureja sp., *Thymus sp.* There is no indication so far that these plants were either deliberately cultivated or collected at Akrotiri (Table5.15). Their absence though from crop samples is rather indicative of contamination not related to crop processing but perhaps indicative of plant collection and usage for condiment. This is based on the fact that capers are large and would have a similar size to the seed and the other Labiatae are in heads and would have also been in the same size range as the crop, especially the legume crop, and could have been present with the crop after coarse sieving. However, they are not weeds of cultivation but of cliffs the former and garrigue the latter, and their rare presence in crops is expected. Their presence though in fill contexts could be interpreted in more than one way. They could just be incidental intrusions in the settlement by way of people's shoes and clothing, or could have been deliberately collected for their intrinsic food value. This will remain an open question until more samples are studied.

6.1.4 Crop husbandry

Even as late as 1925, Jardé (1925:77,note 2) mentioned that a 'maslin' crop, and in this particular case, a mixture of wheat and barley was grown at Thera, and he goes on to say that in Greece in 1921, 'maslin' crops occupied 21% of cultivated land (cf.Wagstaff & Augustson 1982:131, who mention that in 1916 'maslin', in Greek 'mighadi', took up 10.6% of the cultivated area of the Cyclades). Presently in Greece, crops are sometimes grown together in the same field as a mixed crop. G.Jones saw that more often than separately, barley and wheat were grown together on southern Amorgos as a mixed crop (Jones 1983b:3.1.4.) and was used mixed for human food, or the wheat and barley grains were partially separated using sieves, the former used for human consumption and the latter for animal feed. Also common vetch (*Vicia sativa*), and grass pea (*Lathyrus sativus*), were sometimes grown as mixed crops for animal fodder (Jones 1983b). Somewhere in the Cycladic islands (unfortunately no reference was made as to where) J. Renfrew (1973:26) saw in the summer of 1965 a field of wheat, barley, and oats mixed with peas and beans. Therefore, surprisingly enough, the mixture of crops can be of different types, either cereals together, pulses together, or even cereal and pulses as in the last example. This 'multi-cropping'needs to be investigated more thoroughly, especially in examples of very mixed crops such as pulses and cereals, for one would have thought that different ripening times would slow reaping down.

This form of cropping is characteristic of subsistence agriculture and ensures, in case of climatic or other hazards, that some form of return is obtained from the land. In the 19th century, both 'mighadi', which is referred to as an equal mixture of wheat and barley, and 'yenima', which is a mixture in which barley exceeds wheat, was also common in the Aegean Archipelago (Wagstaff & Augustson 1982:131). Therefore, archaeological samples are sometimes difficult to classify and what might be seen as a contaminant could be part of a 'mighadi'crop. One sample at Akrotiri which implies this existence is sample 78 of the West House, (Table. 5.13) where crops in order of ascendance are *Lens culinaris*, *Triticum monococcum*, and *Hordeum sp.*. This could imply that cereals were being planted with pulses, perhaps on the same fields but the probabilities are slim. It is more likely that for sample 78, perhaps wheat and barley were grown together, and lentil was grown apart. Therefore, it is believed that this sample would have been mixed in the tertiary processing stage.

6.1.5 Crops and/or contaminants

At L.B.A. Akrotiri, our information based on the samples collected from the West House and Xeste 3 points to the existence of the following crops being deliberately planted: *cf.Lathyrus clymenum*, *Lens esculenta*, *Pisum sativum*, *Hordeum vulgare*, *H.distichum*, *Triticum monococcum*, *Vitis vinifera*, probably *Ficus carica*, and *Olea europaea*. There are also indications that, perhaps, the spectra of crops was even larger, i.e. *Lathyrus sativus/cicera*, *Vicia ervilia*, *Lupinus cf.albus L.*, *Triticum dicoccum*, *Avena sp.*(?), *Linum usitatissimum*, and *Coriandrum sativum*. However, at this stage, we could not be sure of the planned cultivation of this last group. The spectrum could, most probably, increase as soon as more of the site is studied.

Nevertheless, not only is the presence of species interesting but also the relative abundance and/or scarcity of these species. At present, our understanding is restricted due to the study of only the West House and very little else, but the samples from both Xeste 3 and Sector Delta give us glimpses of different crops (e.g. *Lupinus cf.albus L.* and *Linum* in Sector Delta) and also different emphasis of cultivation or, at least, storage. That is to say, in the West House there seems to have been a partiality to the cultivation and/or use of cf.*L.clymenum* on a wide scale, whereas in Xeste 3, cf.*L.clymenum* is not abundantly represented but the emphasis seems to be towards *Pisum sativum*.

Irrigation cannot be attested at Akrotiri but one sample (78) possibly suggests irrigation, or fields which had been near a water area (well?) or even near water-channels, and includes *Sagittaria cf. sagittifolia* (cf.seeds of *Alisma* in 'fine sievings'from non-irrigated fields at Asvan) (Hillman 1984b:21).

6.1.6 Weeds

Only recently have weeds been evaluated as indicators not only of edaphic (pH, moisture, soil nitrogen) and climatic (temperature, light, continentality) factors, but also as 'agricultural indicators'(Holzner 1982:187). Various detailed studies have been written on the ecology of agricultural weeds in western Europe, Britain, Germany, France, Holland (e.g. Brenchley 1911; 1920; 1940; Brenchley & Warington 1933; 1945; Braun-Blanquet 1932; Ellenberg 1950; 1974; Tuxen 1958; Oberdorfer 1954), but, unfortunately, the results can be used only with great reservation when one comes to interpret the weeds of Greece. The reason is that weeds are very adaptable, and therefore their value as indicators varies from area to area. For example, weed species which originate in warm areas prefer calcareous soils in cooler regions while indifferent in their optimal climate to soil pH, and those that indicate soil humidity in dry climates have no indicator value in areas with humid climate (Holzner, idem). Moreover, a further difficulty of ascribing a niche to weed species is that competition between plants may influence their distribution and abundance. This leads to situations when weeds can be different from area to area, and even from plant community to plant community within the same broad ecological conditions of soil, climate and agriculture.

In archaeology, however, we are not concerned with the interaction of weed species with one another, but their interaction with the environment and, in particular, the man-made one. As it is widely agreed that groups of species are more reliable indicators than single species, we should keep this factor in mind when we come to interpret archaeological weed groups. Experiments held at Rothampstead and Woburn (Brenchley & Warington 1945) have shown that crop type and method of cultivation have a greater effect on weed floras than the nature of the soil and its treatment.

G.Jones (1983b:7.2.3.4) found that she could discriminate, with some degree of confidence, between cereal and pulse crops by their associated weeds. This method should of course, be applicable to archaeological samples.

Another successful experiment (idem:7.2.4) was to discriminate between soil types, and her results indicated that 'crop type has a greater effect on weed seeds accompanying crops than does the soil type on which they grow'. She goes on to claim that it is possible 'to distinguish between samples from crops grown on different soils on the basis of the weed seeds found in crop samples (idem:7.2.4.6). What is also interesting is that samples from pulse crop grown on different soils could be distinguished more readily than samples from cereals (idem:7.3.3); however this needs to be proved for other areas and might not be applicable everywhere.

Moreover, Jones (idem:7.2.5) wanted to discriminate between samples from crops grown on terraces and on flat fields and the result proved that 'differences between field types can also be detected from the weed seeds in crop samples', although the effect of that factor was not considered as strong as the previous ones. However, there is some indication that some species prefer flat fields and others terraces.

Weeds at Akrotiri

As very little is known of weeds' soil preferences as well as of their more general ecology in Greece, it is difficult to ascribe edaphic and other characteristics to the few types found at Akrotiri. More intensive and extensive fieldwork on weeds need to be done in Greece before we can use the information and apply it to archaeological samples.

Distinguishing between cereals and pulses

G.Jones'hypothesis of being able to distinguish between these two major types of crops on the basis of weeds seems to be validated at Akrotiri. If we compare Tables5.4 and 5.8 we see that all four types of pulse samples have the same contaminants (cf.*L.clymenum*, *Lens culinaris*, and *Pisum sativum*), and weeds (i.e.*Sherardia arvensis*, and *Buglossoides arvensis*). Only in the lentil crop do we see the appearance of a different weed, *Galium aparine* which does not occur in the other pulses for some inexplicable reason, but at Amorgos was consistently associated with pulses (idem:7.2.8.1). Could it refer to a different sowing time?

On the other hand, consistent with Jones's (1983b) findings at Amorgos barley crops are only slightly contaminated by pulse contaminants and weeds (Table5.11 barley crop), and the presence of other Gramineae and Cerealia is much higher than in pulse samples. We also encounter the presence of *Lolium temulentum* and *Papaver cf.hybridum* in cereal crops which are common weeds of cereal cultivation.

Distinguishing between soil types

When it comes to distinguishing ecological preferences for cereals and pulses, Jones (idem:7.3.4.3) found in the course of her ethnographic work at Amorgos that, for pulses, pH was the most important factor for discriminating soil types and, for cereals, it was moisture content. Therefore, for schist-based soils, acid tolerating species were associated with pulses, and it was the wet-loving species which were associated with cereals, because of the moisture retention of these soils (compared to limestone-based ones).

What the soils of L.B.A. Thera were is a question that still remains partly unanswered; however, they could not have been very different from those of today (Davidson 1978:726). The farmers would have had to contend with soil moisture deficits (although it is debatable), a soil low in organic matter and clay, resulting in poor water and nutrient storage and highly susceptible to erosion (Davidson 1978a:736).

In general terms, we could suggest that most of the pulses at Akrotiri would have been grown on limestone-based soils due to the basic preference of their weeds (Tables5.24). Only one sample (16) of cf.*L.clymenum* (Table5.4) indicates the presence of an acid-loving species, *Chrysanthemum segetum*. Could this just be incidental, or is it an indication of a crop grown on schist-based soil? The question remains unanswered for the present. However, basic-loving species such as *Sherardia arvensis*, *Buglossoides arvensis*, *Calendula arvensis*, and *Papaver cf. rhoeas* are more prevalent. On the other hand, it is impossible at this stage to make generalizations about cereals as we have very few samples but, there is some indication of wet-loving species i.e. *cf.Sinapis arvensis*, *Sagittaria cf. sagittifolia*, *Juncus sp.*, and *Schoenus nigricans*. This could mean one of two things. Firstly, cereals could have been planted in schist-based soils which were more water-retentive or secondly, they could have been planted on limestone soils but in areas with a higher water-table or near some kind of winter-stream.

From the indirect evidence of the soil types used at Akrotiri, and from the little information the weeds provide, it seems that the L.B.A. farmers used mainly light, and sandy, rather than heavy soils. The presence of a few culm bases in the barley samples cannot be taken as an indication of uprooting. On light, sandy soils barley is likely to get involuntarily uprooted, and this might be indicated by a few culm bases in one sample (71) of barley. From the evidence we have of palaeosols, the inhabitants of Thera used such soils because they were the only ones available, rather than ones deliberately chosen.

Distinguishing between flat fields and terraces

G.Jones (see above) claims that it would probably not be possible to distinguish between these two types of locations, as the distinction was not very clear and rather small. However, as terraced soils seem to be generally more fertile than plains, it would be logical that terraces would exhibit different soil fertility in their weed populations. I also believe that with our limited knowledge of weeds at Akrotiri, it would be dangerous to make such a claim. Ethnographic work, among other lines of research, will need to be done on Thera itself for it to be applicable to our samples.

Manuring and irrigation

Theoretically, it should be possible to identify manuring and irrigation from the weed seeds present in the samples. However, from the samples we have studied, it seems that there is a balance between weeds needing a high nitrogen level in soils and those needing a low one (Table5.24), which could mean that there was some kind of equilibrium as regards soil nitrogenous content. This could have been achieved by various agricultural practices, such as by folding goats and sheep in fields, rotation and/or fallowing and so forth. Only sample 40 could indicate, perhaps, the use of manure as *Linum usitatissimum* was present and although it is a plant that can grow in dry-farming, it is best suited for fertile and deep loams. The possibility of the manuring of fields, however, remains as suggestive, and the process of manuring will be a question which will be tackled eventually when more archaeological data become available from Akrotiri and when more weed ecology is studied in Greece in relation to this particular problem. What was somewhat expected in the water-floated samples from Xeste 3 was the high presence of weeds of waste places and roadside (Table5.15). Obviously, as they are mostly from floor samples, these seeds could have been carried back to the settlement on people's shoes, clothes and so forth.

The other sample (78) (Table5.13) has *Sagittaria cf. sagittifolia*, a water-loving plant, and although its presence does not necessarily imply irrigation, the fields must have been near a source of water, perhaps a well or a water channel. This could imply directly or indirectly that some sort of irrigation could have been used.

Crop rotation, fallow and weeding

The fairly low proportion of perennials in the crop samples at Akrotiri, (Table5.23), indicates that either the land was cropped continuously, with only a summer fallow (as today), or some kind of intensive weeding (hoeing or fallow and ploughing) was being done on the fields at Akrotiri. The presence of *Thesium sp.* (Fig.5.4A) could denote arable land after fallow (Turrill 1929:226) (samples 1 and 5/10), but the number is small and could only be suggestive. Some type of crop rotation is likely to have been performed with pulses and cereals, especially as there is some inconclusive indication of uprooting. If cereals were uprooted, there would be less stubble for animals to feed on, and this in turn means that they would provide less manure to the land, and so the field would be depleted in soil nutrients. The uprooting of pulses, which is also performed today, is evident from the Akrotiri samples as some weeds are very short i.e. *Sherardia arvensis* (*Table5.23*), (*although* Jones, pers. comm. has mentioned that it was a common weed at Amorgos, where they reaped with sickles). One would also expect the weeds to have been on the short end of their height potential under dry-farming. As argued above, some form of crop rotation must have been used at Akrotiri but the sequence of plants used is not, yet, known. Today a three-crop rotation system is often applied instead of leaving fields fallow. This makes good sense because the soils of Thera are very light and, if left fallow, much of the soil would have been eroded. Therefore, in the Theran context, fallow fields are no solution for replenishing depleted fields.

6.1.7 Crop processing

For Akrotiri, our intention was to investigate the three main stages of crop processing, the first being performed on the fields or near them, whilst the other two are mainly performed in the house or open areas of the settlement. The second stage deals with the cleaning of the plant species for food, and the third, deals with the preparation of the cleaned seeds for cooking. Therefore, these three stages can be classed as primary, secondary and tertiary processing stages.

Primary processing: Reaping

There are various methods of reaping but basically they could be grouped under two subheadings of either a) reaping with reaping implements or b) reaping by hand. In present day Santorini legumes are reaped by hand whilst cereals are reaped with sickles although they were also reaped by hand in the past. Our concern here is how reaping was conducted in L.B.A. Thera.

Metal implements were rarely found at Akrotiri for reasons already discussed. Only six bronze sickles (A.Michaelidou, pers.comm.) (Pl. 3) have so far been found, and none of those is from the West House. Similar sickles are still used in Iran (Lerche 1968:37), one large smooth-edged one (Fig.4.8) being used only for wheat harvesting, and another small and serrated, very similar to the shape of the Akrotiri ones, and used in harvesting barley and other green crops.

Moreover, flint sickle tools are also extremely rare (A. Agraphioti, pers.comm.), What this scarcity implies is somewhat dubious. On the one hand, it could imply that reaping tools were scarce thus indicating the reaping of legumes and/or cereals by hand. Alternatively, it could indicate a rigid division between the rural and urban population, whereby the urban population would not have performed agricultural jobs, but would have relied on the rural countryside to provide them with subsistence goods. A third hypothesis is that the inhabitants had 'country houses'near their fields where agricultural implements would have been kept. It is probable that sickles were not used a great deal at Akrotiri. In the first place, the presence of short weeds (Table5.23), such as, *Sherardia arvensis*, *Emex spinosa*, *Ornithopus cf.compressus* and others, in legume samples implies that crops of *L.clymenum* and lentil were uprooted, as these weeds would probably have been missed had sickles been used. Although culm bases have been sighted (Table5.11, sample 71) and could suggest uprooting in cereals as well, if found in considerable numbers, their small numbers could imply either of two things. Therans either uprooted the cereals as well and cleaned them thoroughly of culm bases. Secondly, cereals could also have been uprooted. The small number of culm bases in sample 71 could imply that barley was uprooted, and the culm bases later removed as these can be cut just before threshing. Sample 24, M.B.A. phase, (well 23, room 4) has a chaff sample which is of note due to the presence of culm bases and is another point in favour of opting for uprooting. An alternative explanation, of course, is that crops were reaped with sickles, and a few plants accidently uprooted. At present, the evidence either way is inconclusive.

Primary processing: Threshing

Today threshing is done by animals on round threshing floors which are dispersed all over the island. What was practised at L.B.A. Thera is difficult to say, but it is most probable that threshing floors did exist.

It is usual to draw a distinction between farming in wet and dry areas when threshing and storing practices are discussed, because in wet areas threshing is generally performed under cover, either by lashing or by using flails, whereas in dry areas, threshing is done out of doors, by trampling with animals, as on Santorini today, or by sledges which have flint blades, or even by sticks, flails and cudgels (Hillman 1981). More importantly, it is done in dry climates on a large scale after the har-

, and usually around May or June depending on the time of ripening of the crop. tly May and early June is the time of threshing at Thera today. This clearcut otomy of farming practises in wet and dry areas was probably put forward for reasons:

. present day agricultural practises in Greece, whereby crops are threshed all at once and not piecemeal as in north Europe, are widely practised, and

:. different threshing methods cannot be distinguished beyond these two major categories of wet and dry zone adaptations.

s probable though, that originally this dichotomy was not as clearcut, and in-nediate solutions may have existed which have since become extinct due to the line of traditional farming systems. In Greece, for example, which has a fairly dry ime, and contrary to known models, Jones has evidence that crops were stored their spikelets at Assiros Toumba (Jones 1979) and Iolkos (Jones 1982). Crops uld have been preserved better in their spikelets as the climate was slightly wetter these two sites.

ı the lee side of threshing floors, branches of various bushes growing in the vicinity : often placed, e.g. *Sarcopoterium spinosum* or other, in order to trap the by-oducts of winnowing (chaff, straw). Furthermore, the threshing floor is sometimes ept between one crop and another to reduce mixing, and branches are again used : this sweeping operation. At Amorgos (Jones 1983b:3.2.4) branches of juniper re put on the straw and chaff pile in order to prevent it from blowing away when nnowing was complete. The effect of this operation was visible in the actual ding of juniper berries in the winnowing by-products. However, in our samples : seem to find evidence of this practice in the cleaned crop itself, as four of the *L.clymenum* and two of the barley samples (samples 2 and 71) have *Thymelaea* aves. These could only have been included in the winnowing stage, where it is likely at bushes would have been used for brushing or 'raking'. At Amorgos (Jones 1983 b:3.2.6.) fragments of straw were sometimes raked off the top of the crop pile in the final stages of winnowing using a thyme bush as a hand rake which, there, introduced thyme flowers into the samples. Hillman (1981:fig.6, stage 4) however, observed this after threshing and just before winnowing, which could perhaps have been the time it was introduced at Akrotiri. If it was done before winnowing, it would have been done to rake off roots and the green parts of the plant before trampling the remaining of the plants (i.e. second threshing; Jones 1984b:44), in order to facilitate winnowing. However, it is likely that a rake was used. It would be interesting though to do more ethnographic work on these crop processing stages, especially on Thera itself, and, particularly, in relation to *L.clymenum* crops.

Primary processing: Hummeling

This is considered necessary today to extract barley awns from the crop product. For barley, it could take place after threshing but before winnowing (Fig.3.2) (just before step 5) and more precisely after the first threshing, because a second threshing is performed exactly for the reason of extracting the remaining awns (Jones 1984b:45). Presumably, the first threshing would break the top of the awns and the second would break their base. At this point, we should refer to sample 78 which has evidence of the base of barley awns amongst other fragments which belong nearer the tip of the awns. Here, it seems as if hummeling had not been performed and this might imply that it was used as animal feed. On the other hand, the presence of other crop plants in the sample (*T.monococcum* and *Lens esculenta*), as well as the absence of evidence for stables and animal stalling within the settlement, argue for it being intended for human consumption. However, if barley was harvested before it was fully ripe and hummeling was done by hand and in small quantities at home in a piecemeal fashion, one would expect to find awns in houses, or at least the finer fragments as well which are towards the tip of the awn. At Akrotiri, tips of awns seem to be fairly common, but are, unfortunately, unquantifiable. Therefore, one of two possibilities may be considered. Either hummeling was not done at all and the second threshing and winnowing (Fig.3.2) was not performed, even though hummeling is considered important today when barley is used as human food. Perhaps the same concept did not prevail in the past, just as at Amorgos today (Jones 1984b). This possibility is reinforced by the finds of awns in the flour samples, which perhaps were sieved out just before it was consumed and after it had been milled, as on Amorgos today (G.Jones,pers. comm.). However, what is striking from the Akrotiri samples is the unexpectedly high number of awns, particularly of barley. Quantification could be neither numerical nor based on weight but only relative to other types of chaff fragments within the sample. This high frequency could indicate that the hummeling process was conducted within the settlement, or it could be due to the excessive survival of awns. We have already seen that a great number of plant parts were preserved not through charring but through silicification, and awns are especially prone to be preserved through this process as they have very high levels of silica depositions.

Primary processing: Coarse sieving

It seems that all of the crops including cf.*L.clymenum* and *Lens esculenta* were brought to the West House after they had been coarse-sieved (product of stage 6, Hillman 1984b) (Fig.3.2). In other words, the by-product of the crops, i.e. legume pods, and very large weed seeds which would have been retained by the sieve, are not present in the samples which were studied. This is why we do not find pods or other parts of the pulse plant except for minor fragments of those parts. Even the cereal samples have no by-products of the first coarse sieving, and very few straw fragments, e.g. culm fragments rachises and spikelet forks have been preserved. Unfortunately, the only sample which represents the by-product of coarse sieving is sample 24 (Table5.12) and it belongs, as we have said, to the M.B.A. phase (well 23, Room 4), a previous phase of the West House. It is regarded as a by-product of coarse sieving as the plant remains include the predicted by-products i.e. rachis internodes, culm fragments and heavier fragments such as culm bases, and pedicils.

This first sieving was probably done, just as today, on the threshing floors, since no such by-products have so far been found in the West House. There are two possibilities to explain the existence of rachis fragments and culm bases in sample 24:

1. It could be a by-product of coarse sieving ('cavings');
2. Or threshing could have been done at home in a piecemeal fashion with flails.

Both possibilities would indicate that during the M.B.A. animals were kept in the settlement, which does not seem to be the case in the L.B.A. However, this last point needs to be investigated when more of the previous phase of the settlement is excavated. The find of what is believed to be the by-product of coarse sieving in the M.B.A. without an equivalent by-product in the L.B.A. could be fortuitous in the West House, but it is more likely that it reflects a real absence of this stage in the L.B.A. settlement. If so, it could reflect a change in the economic structure of the settlement from a semi-urban/subsistence status to an urban/consumer structure, whereas in the M.B.A., the by-products would have been used within the settlement, if, as suggested, animals were still stalled within the confines of the site, and not elsewhere, as in the L.B.A. This may also indicate a difference between a primary producer site and a consumer one (Hillman 1981:142). In a consumer site, the by-products of the first sieving should not be present as the product is traded in bulk after it has been cleaned (Hillman 1984b:4,fig.2). It would be interesting to see if this suggestion is confirmed when more samples are recovered from other areas of Akrotiri.

However, Xeste 3 has the same pattern of crops brought to the building after having been coarse sieved. In all the Xeste 3 samples, there is only one spikelet fork. Spikelet forks can be indicative of a by-product of fine sieving (Hillman 1984b:22), but the presence of only one spikelet could be totally fortuitous, and thus not indicative of this crop processing stage. Unfortunately, we have no samples from well-defined floor contexts from Xeste 3. Those that we have should be treated as coming from fill deposits until the stratigraphy of the rooms is clarified. Therefore, the presence of weeds of arable land such as *Silene sp.*, *Rumex sp.*, and *Trifolium sp.* need not have resulted from sieving. Seeds of other plants such as *Urtica dioica*, and *Hyoscyamus niger* could be treated as incidental to the site, as a result of travelling on people's shoes, clothes, animals, and possibly even growing between the houses.

Secondary processing: Sieving in the house

The interpretation of samples 16 and 20/29 is difficult, but a hypothesis will be put forward which may, or may not, be validated in the future by other samples. We can hypothesize that sample 16 represents a clean crop but sample 20/29 could be the tail grain or residue of the same crop. The argument for regarding both as the same crop rests on the similarity of weed types in both samples (see Table5.7; 6.3) except for the presence of *Coriandrum sativum* in sample 20/29, which will be explained later.

As noted earlier, sample 20/29 has seeds of cf.*L.clymenum* which are shorter, narrower and thinner than those from sample 16, and there is very little overlap in the breadth measurements. *Coriandrum sativum* fruits are all broken in half (none are whole fruits) and the diameters of half the fruits are in the range of c.2 mm. These would have passed through a sieve which might have separated samples 16 and 20/29, the former containing large seeds, and the latter smaller ones (tail grains), as well as cleaning residues. The mesh size, inferred from measurements of the seeds themselves, would have been in the range of 2.5-3.0 mm., if we assume that legumes behave like cereal crops in the way they get sifted through a sieve, i.e., endways (Dennell 1978b:87; Hillman 1984:23). Therefore, we might be seeing here the prime grain sample (sample 16) and the tail grain sieving residue (sample 20/29). This fine sieving would probably have taken place piecemeal throughout the year, and would have been associated with food preparation. Jones (1983b:3.2.8) claims that at Amorgos, where the sieve size was c.2-2.5 mm., pulses were finely sieved just before cooking. However, what is puzzling is the elaborately decorated pot in which sample 20/29 was stored, for why would Therans put tail grain in such an elaborate pot, unless they used what was available and empty, irrespective of pot type?

Samples 9 and 14 are the closest in all three measurements (Table5.5), and the proportion of the crop to contaminant/weeds is comparable in the two samples. However, contaminants are more abundant in sample 9 than weeds in sample 14 (Table5.7). The sieve mesh detected would have been in the range of 2.5-3.0 mm., and it seems that just as at Amorgos, this stage was done piecemeal throughout the year as need arose. At this point in the research, we still cannot be totally sure whether or not fine sieving was followed by hand-sorting; for most probably, it would be difficult to separate these two stages, i.e. fine sieving and hand-sorting (see Hillman 1984b, table 1:10). We need to process many more samples before we could even hope to be conclusive on this point. However, sample 40, which stands out in the analysis of variance, has no weed seeds. Whether this represents a further stage is unclear yet. This might be the case for we cannot accept that fields of that period, (or any other for that matter) were weed-free. It is, however, strange that hand-sorting is detected in Sector Delta 1a but not in the West House. There could be several equally plausible explanations for this. One could be that the seed destined for sowing have been the largest and 'healthiest'of the crop, and it is interesting that no weevil infestation was detected at all in sample 40.

Sample 2 has seeds which seem very deformed, and there was no possibility of telling whether the barley grain was symmetric or assymmetric, and, therefore, no way of knowing what proportions of *H.vulgare* and *H.distichum* were represented. As we mentioned above, the presence of the latter is attested by rachis internodes. However, in addition to this deformity, there could be several reasons for their small size. It is possible that the grains were a failed crop, a tail grain, or just not fully ripe. The last is what one can name the 'milk-crop'(Hillman 1984b:4) (Fig.3.2) (cf.also green cereals can be uprooted prematurely for fodder) (Hillman 1984a:117).

This 'milk-crop', or 'green-corn', was sometimes made of glume and free-threshing wheats (Hillman 1984b:141). For example in the Bible, three stages in the ripening of grain is referred to (Avitsur 1972-75:228). The first is when the corn is green, and this was not stored but eaten immediately. The second is an intermediate stage when the kernels are not quite ripe and short of their full weight. The third is the fully ripe stage. In Schwalia (Bavaria), *T.spelta* was harvested unripe, dried and dehusked with a loosely-set rotary quern. After the grain was milled, the traditional Grukernsuppe was made. In Turkey, 'firig'is made from scorched, milk-ripe grain and in Syria/Palestine 'frikke'is made from scorched, cured dough-ripe grain (idem). Pliny (Nat.Hist.XVIII,298) describes as well the harvesting of unripe grain.

In sample 71 (Table5.11), there were few culm bases. Although their number was small, they perhaps indicate uprooting of barley. They could also indicate plants accidentally uprooted while reaping, by cutting the straw, as it happens occasionally with crops on light soils as experienced on the island of Karpathos (pers.comm. G.Jones). Since we know that soils on Thera were light, we could be seeing further indication of this phenomenon. However, what is interesting in sample 71, and perhaps argues for the point that this sample is a by-product of a 'milk-crop', is the presence of pedicils (culm/spikelet intersection). The harvest of a 'milk-crop'could be done by ear plucking or stripping the spikelets by hand but the former is not a good method for free-threshing cereals, and would have left the spikelet bases (including the pedicils) behind on the standing plant. By contrast, ear stripping seems more likely to remove the entire ear and, in many cases, the top of the culms (Hillman 1985b:7) (also cf. sample 24; Table5.12). Therefore, the product might have been stripped and taken to the house, in this case, the West House, and cleaned there. Could we be seeing this practice at Akrotiri, where barley was collected (stripped) (sample 24) (Table5.12) while green?

The pot, a large spouted jar, containing sample 2 suggests that some kind of beverage (e.g. soup, drink) must have been either prepared or stored in it. Had we found the barley without the abundance of fish bones, which were included in the sample, we could have presumed that some kind of barley beer-making was in process. However, the inclusion of fish is, to say the least, puzzling. Perhaps, it might have been some kind of fish broth.

The water-floated samples of Xeste 3 (Tables5.15), samples 81(1) to 81(8), were retrieved from various levels of room 7 (Fig.4.2) but, unfortunately, it has not been decided yet where the first floor ended and the ground floor began. The combination of other archaeological data, once studied, should give us information on this matter. Therefore, at present, due to the small number of samples and due to the gap in our knowledge of the stratigraphy of rooms 7 and 10 of Xeste 3, our interpretation of these samples can be but limited. We still do not know much about the function of this building, except that it seems to have been some kind of public building (religious and/or administrative), and appears somewhat different from the West House.

What is of note is that the plant material does not represent by-products of a medium to coarse sieve, for none of the contaminant/weeds were coarser than the crops (legumes and/or cereals). Only in two samples (81(1) and 81(6)) larger stones were found (*Olea europaea*) as well as *Vitis vinifera* in four samples. However, it is more likely that these were intrusive from other activities, e.g. eating, and/or wine making and olive pressing that were not necessarily conducted in these two rooms. The unique *T.monococcum* spikelet fork could have been the by-product with all the other small weed seeds of a fine sieving (Hillman 1984b:22), but the interpretation of a single specimen is riddled with dangers. Therefore, in tune with other findings from the West House, the first sieving would, probably, have been performed after winnowing near the threshing floors or somewhere else in the settlement, but the product was probably not brought back to Xeste 3.

In the unique sample of *P.sativum* of the West House, which is though in a very poor state of preservation, there is some indication that fine-sieving was practised, i.e. there were contaminants the size of the seeds but hardly any small weed seeds. The evidence from the charring of the seeds themselves, together with information from the excavation diary, and the fact that the sample was found in a pot lying on top of an ash layer confined between stones perhaps representing a hearth, encourage us to believe the last stage of processing, namely, the act of cooking might be represented.

In conclusion about the water-floated samples we can say that because they represent 'fill'of the rooms, we cannot attribute to them a particular stage of crop processing, but we can exclude the stages they do *not* represent. What we can say is that they probably represent a mixture of crop-processing stages and other incidental inclusions. We could claim that the plant remains represent stages starting from coarse sieving onwards and whatever came before, was performed in other rooms of the house or, most probably, away from it, on the threshing floors.

Secondary processing: De-husking of hulled barley

This is practised by using mallets and mortars and the grain does not need to be boiled or dried beforehand (although some informants in Turkey stressed that the grain had to be properly ripened and dried and also sprinkled with water prior to pounding) (Hillman 1985b:20).

It is quite clear that de-husking of barley was practised at Akrotiri as the top of the lemma and top sections of the awns are rarely found on the seed. However, the presence of awns in some samples, (and even the 'bulgur'ones) (Table5.17) may indicate that the grains were cleaned by sieving just before use as otherwise the awns can cause irritation to the throat when eaten. On Karpathos (G.Jones 1983b:3.2.9) the stubs of barley awns were broken off one by one by hand, a type of hummeling, so that they did not contaminate the flour and so forth, and the inhabitants did not even use barley chaff as fodder, whereas on Amorgos (Jones 1983b:3.2.5), the barley awns were not considered a problem for animals.

After the winnowing of barley to separate the straw from the seeds, hummeling/ dehusking would have taken place to extract as much of the husks as possible, and to break and extract the awns. The hummeling stage could be done in various ways, for example by hand, (as mentioned for Karpathos), by trampling and rubbing the grain, warm from the kiln perhaps, or with the feet in a straw basket as in Orkney (Fenton 1978:373). Another way of hummeling dried grain was by spreading it on the threshing floor and beating it with a flail (idem). One possibility is that part of the hummelling at Akrotiri was done on the roof of the West House, since awns, which might have fallen from above, were found in samples from rooms 4 and 5 (first floor).

Secondary processing: Hand sorting seeds for sowing

Whether hand-sorting was applied on Akrotiri or not is impossible to tell at this stage. It would probably have been applied after storage and just before cooking. Although the chances of the sample's survival in that state are meagre, Akrotiri surely still holds many surprises. Ethnographic evidence from Amorgos (Jones 1983 b:3.2.9) indicates that hand-sorting was done very thoroughly 'leaving virtually no contaminants with the grain'. On Akrotiri, on the other hand, even samples which seem to have been carefully cleaned (e.g. sample 40) have contaminants which could indicate that either the sample had not been hand-sorted or, most probably, and just as in ethnographic studies, contaminants were not always treated as harmful.

Tertiary processing: Cracking of grain kernels

At Asvan, c.88 kilos of wheat per family (5-6 persons) are ground and made into bulgur to be used for year-round consumption, and the only crop used is wheat (cf. 50-75 Kg. for each member of a family among the Arabs of Israel, Avitsur 1972:231). Of the free-threshing wheats, only the macaroni wheat *T.durum* is regularly used to produce bulgur, and bread wheat *T.aestivum* is considered unsuitable (Hillman 1985b:15). There were, as well, foods prepared from crushed or ground grain harvested in its milk-state (Hillman 1985b:16). The threshed wheat is passed through a gut sieve to remove some of the weed seeds and husks, and then the wheat is cooked with water in a large cauldron. This cooked wheat is then dried in the sun for 2-3 days, after which it is sieved again and hand sorted to remove the weed seeds. The clean wheat is then cracked. The bulgur is then put through fine sieve (of linen, or some other material in the prehistoric period; Hillman 1985b:18) to remove the dust (Weinstein 1973:275). From barley grains, various foods are made in Turkey (Hillman 1985b:21), such as roasted barley, barley porridge, the Greek 'maza', barley dumplings, and barley bread, and there is no reason why some, if not all, were prepared at Akrotiri. These 'grits'were the basic cereal diet of Palestinian Arabs, especially as travellers saw them in the late 19th and early 20th century. Bread was eaten only on festive occasions (Avitsur 1972:231).

As already noted, there are eight samples from the West House, some of which have coarser and others finer particles of barley (Table5.12). For reasons already discussed, we can be certain that these samples do not belong to barley samples accidentally broken.

The preparation of the barley crop could have followed the procedure described above for wheat, at least for the samples with few weeds. However, not all bulgur samples from Akrotiri are weed-free and some have rather a large number of weed seeds, contrary to what one would have expected, had barley passed the type of stringent processing described by Hillman (1985b). An additional factor is that all the samples contain barley awns, which probably, indicates that cleaning was not done very thoroughly. Finding that a crop at such an advanced stage of processing could have such a number of undesirable by-product elements is surprising. The care given to cleaning legume comes as a striking contrast as they seem, comparatively, clean (cf.sample 40). However, the final cleaning of 'bulgur'could also have been reserved to the very final stage, just before cooking, and seems to agree with our data from the flour samples. It is particularly interesting and also pertinent to Akrotiri, that the models of breadmaking found at Thebes (Egypt) (19th century B.C.) demonstrate that grains were crushed and pounded using wooden pestles and stone mortars and then ground in a saddle-quern (Avitsur 1972:233). Cleaning was not too pernickety, and a fine sieve was not used until just before cooking.

Tertiary processing: Flour

There are ten samples which could be classified as flour, both of cereals and legumes. Although the number is small, these samples probably reflect a fairly accurate picture of their original numbers, especially as flour would not have been stored for any length of time due to the poor preservation of normal flour. The flour would generally have spoilt within two to three months, although flour from parched grains can last considerably longer (Avitsur 1972-75:230).

Flour could have been prepared in similar ways to those used in Thebes noted above (Egypt, 19th B.C.; Avitsur 1972-75:233). This brings us back to the interpretation of the bulgur-type samples mentioned above. They could either have been consumed as 'grits' (e.g. gruel), or they represent a stage before the making of flour. It would be interesting to see whether 'bulgur'can be preserved for longer periods than flour. If so, this could have implications on storage patterns, as storage would be in the form of 'bulgur' rather than flour. In addition to the querns found on Akrotiri, four whole structures, named 'mills'were excavated, one of which is in the West House. These (Pl. 2) took the form of stone blocks creating a hollow depression, a kind of rectangular rubbing area. The grain must have been ground in them by means of stone rubbers, flat on the underside and convex on the upper side, and probably, held with two hands by the operator. It must have been a painstaking process, scarcely suitable for the mass-production of flour/meal, as evidenced by its presence in a moderate sized building as the West House.

There is evidence of wheat and barley flour (Table5.12), as well as samples of finely ground legumes, as samples 23/28, 54 and 55 seem to have more finely ground legumes than the rest of the samples. This induces us to believe that it might have been, perhaps, some type of legume flour. Pliny (Nat.Hist.XVIII, 68-69 and 102-4) claims that amongst several methods used for leavening, flour of bitter vetch *Vicia ervilia* or chick-pea (cicerculae) *Cicer arietinum* was used to leaven barley bread. The fact that flour made from these two pulses was used in Roman times does not exclude, perhaps, the possibility of other pulses from providing leavening. Moreover, yeast, could have been obtained as a by-product of brewing, or from 'souring'ground grain in water, (O Donachair 1981:64), but some ethnographic work needs to be conducted in this field.

The use of bread at Akrotiri poses several questions. Firstly, ovens similar in dimension to the present day ones used in Greek villages are unknown at L.B.A. Akrotiri. Were there specialized bakeries outside the excavated area? Or was there bread of a kind that did not need ovens? Or, even, was there unbaked bread (Hillman 1985b:17)? At present, we are in no position to answer these questions. However, the milling installations within the houses argue against central bakeries and point to it being a household occupation. Secondly, the cereal species cultivated (i.e. barley, einkorn) at Akrotiri are not appropriate for leavened bread. Could they have made the Near Eastern type of bread, the 'khubz' (flat bread; Lerche 1981:190)? If so these could have been made in two ways. It was either baked in a 'tannur'type oven which, in shape, is like the so-called bee-hive of Akrotiri, or a tabun (Avitsur 1972-75:239) which is ideal to overcome shortage of wood fuel as it can burn any kind of fuel, including the most low-grade burnable materials, and is fired on the outside (laid in a layer of embers and ashes), or even baked on a frying pan on an open fire (this method was used in Ireland to bake oatcakes) (O Donachair 1981:63).

Tertiary processing: Splitting legumes

At Akrotiri, this must have been done using a saddle-quern or a mortar. We have evidence of this stage from eight samples (Table5.16), as well as, perhaps, from sample 65 (cf.*L.clymenum*).

The 'legume meal'does not seem to have been reserved for one species of legume crop, as all the legume species at Akrotiri seem to have been split at times. In sample 7, there seems to have been a predominance of cf.*L.clymenum* (50%), whereas in sample 55, there were both cf.*L.clymenum* and *Vicia ervilia* (12%). *Lens* seem to predominate in sample 35, with 35% presence. The splitting up of legumes seems to be very popular even today in Greece where 'fava'type dishes (split legume gruel) exist and are made from various species of legume. Another evidence of split legumes in the MIIIII-LIII (transition) is a sample studied by Jones (forthcoming) from Thebes (Greece).

6.1.8 Storage

The use of rooms is also closely connected to the understanding of storage patterns, which in turn may give us some insight into the function of the individual units/rooms. We cannot claim that palaeoethnobotany can solve this economic/social question on its own, but it may add a further dimension to this end. We shall try here to examine the distribution of plant material within the West House in particular, not through time, as the West House is a one-period building (at least for the last phase we are dealing with) but across space. Sample 24, which represents the previous phase, will be omitted as we know nothing of its context within the previous building period.

Our axiom is based on the fact that archaeobotanical samples offer a different type of information concerning the utilization of plants and the processing of these in space. These, in turn, inform us of the spatial usage of built and open spaces. From Akrotiri, and especially the West House, we have evidence for plant utilization which falls into five basic types. First, there are samples of cleaned crop products (primary storage). Although their economic importance cannot be assessed in quantitative terms, we can be reasonably sure that all the stored legume crops have been collected when found in storage jars as they are more visible than other processed stages, i.e. 'bulgur-type'samples, flour and so forth.

Secondly, samples with smaller visibility were found (secondary, and tertiary processing) e.g. flour, bulgur-type split cereal/legumes and by-products, which could have been partially missed. Sometimes 'missed'samples were recorded but not collected, as when a sample was seen in room 5 of the West House and was recorded as not collected because the excavators could not separate the 'organic substance'from the soil. However, the economic importance of these samples cannot be fully assessed as it is not known whether they date from before or after the first abandonment of the site. Although we could not be sure about either periods, it is felt that the archaeological evidence gathered so far point to the second of these possibilities, i.e. after the first abandonment phase. However, what is important is that we can treat them as a whole *and belonging to one period in time.*

These samples provide us with evidence as to where plant foods were stored and perhaps processed just before consumption. As regards the legume fragments, they ought to represent fairly accurately their numerical presence as their visibility is higher than the second, 'bulgur'type (barley meal) which, in some instances, could have been missed by the excavators, especially in the pre-1976 period excavations.

Thirdly, the by-products of crop processing should give us an insight into fine sieving and related crop processing stages, which were performed in the settlement/house. Fortunately, some of the by-products in the West House were stored in pots, for example the chaff samples and sample 71 (Table5.11). Otherwise, we would have missed altogether the evidence for that stage, as we have no samples from the floor levels of the West House. Those from Xeste 3, which is a different type of building, reinforce what we already know from the samples of the West House as regards crop processing. Even though they come from fill rather than floor contexts, they act as negative evidence by telling us what can be excluded. Therefore, we can be fairly certain that stages prior to coarse sieving can be excluded when we deal with the evidence for the L.B.A. West House.

Fourthly, a closer stage to food consumption (tertiary processing) is indicated by what appears to be flour and cooked plant remains (Table5.12). Finally, there is a range of cultigens and wild plants which occur as contaminants in some samples, although some at least could have been cultivated deliberately in other cases.

West House: Ground floor

Stored crops were kept, mainly, in three ground floor rooms, i.e. 5, 6 and 3C.

Most of the pulses were kept in Room 5 (Fig.4.4) except for the lentil crop which was kept in Room 6 (sample 37/61) and both the spanish vetchling and pea crops which were kept in Room 3C (samples 65&31). The former (37/61) was perhaps a secondary storage product nearer to consumption. The latter room (3C) had sample 65 which has very small seeds of *cf.L.clymenum* and seems to have been a partially processed crop. Regarding the other sample (31), the charring of the seeds themselves, as well as the *information from the excavation diary, and the fact that* the sample was found in Room 3C in a pot lying on top of an ash layer, indicate that it represents the last stage of processing, the act of cooking itself. At Akrotiri, legume crops, in particular, were stored after they had been coarse sieved. When it comes to discussing the storage of cereals, we are slightly more at a loss as the samples are not numerous. Basically, there are four cereal samples (samples 2, 24, 71, 78), one of which is M.B.A. (sample 24) and should be discussed separately. Samples 2 and 78 are a stage further from primary storage, and probably in secondary storage just before food preparation. (Here, primary storage denotes the stage immediately after coarse sieving and/or secondary processing, whereas secondary storage denotes the product of the tertiary processing stage). There are various reasons for such a claim. Firstly, sample 2 has few weed seeds, and no contaminants coarser than grain and rachis fragments. Also quite a few bulgur-type fragments, contaminants, and fish bones were present and as regards context, the sample was contained in a spouted storage jar, probably used for storing liquids such as gruel or soup.

Sample 71 could have been the by-product of stage 7 (Fig.3.2) (i.e. second sieving with 'wheat sieve') and it incorporates tail grains, weed seeds, rachis internodes, and awns. It is perhaps a case in point for arguing that this activity took place piecemeal in the house. Pending further samples of this stage, it should be only taken as indicative but not conclusive of this activity. Sample 78 is a 'maslin'mixture of lentils, wheat and barley (Table5.13). This mixture argues against the crop being planted together as a 'maslin'crop, for there is little possibility of threshing them together; i.e. lentils and barley follow the free-threshing sequence and einkorn, the glume wheat sequence. Therefore, the two former crops (lentils and barley) could have been products of stage 6 and 7 (Fig.3.2), whereas einkorn would have been the product of stage 12 (product of third sieving), and consequently, the two stages would not have coincided. Therefore, their coexistence in the sample is likely to have occurred after primary storage and perhaps in secondary storage, prior to cooking.

Out of the samples collected from Room 5, eight represent pulses, five were 'bulgur-type'samples, one legume fragments, and three 'chaff'samples.

Towards the west of the West House, the buildings continued and left only a very narrow passage between the West House and the other building(s), as yet unexcavated. This would have limited the natural light available, especially when the window of room 5 (Fig.4.2) was facing west, and the lack of light would have impeded any type of crop processing. On the other hand, the West House owners had immediate accessibility to the upstairs quarters through area 7 which had a narrow staircase leading upstairs, and also immediate access to room 6. A feature of Minoan architecture, mentioned by Begg (1975:26) and which we see in the West House, is that backrooms seem to have storage pithoi. In the West House they occurred mainly along western external walls, (room 5).

When we turn to room 6, what strikes us is that we get the impression that this room was mainly reserved for the second stage of stored crops (tertiary processing) (Fig.4.4). From an architectural point of view, this might make sense. Room 6 has good accessibility to light from the two northern windows and probably had a door leading to the outside and to room 3A under the staircase (main staircase 1 & 2), which could have produced a draught, helpful when sieving or hand winnowing. It is also interesting to note that most of the 'bulgur'-type samples and the pulses are in Room 5, whereas most of the legume fragment samples (5 samples) are in Room 6. The reason for this is at present obscure. Could it be that Room 5 stored items needed to be re-processed before consumption? In other words was the 'bulgur'which was present in Room 5 ready to be made into flour when necessary? It would be interesting, once Tania Devetzi has studied the stone tools and their distribution in the West House, to see if their pattern matches that of the plant remains.

Rooms 3A, and especially, 3B and 4 are of obscure function. Room 3A had a milling installation on the west wall, and a hearth, not far from the door leading to 3C, but what other jobs were performed there is impossible to say, although the presence of a hearth could imply some cooking. However, the size of the room implies that other housework chores were performed in this area, but no botanical data were recovered. Unfortunately, no samples were collected from the milling installation but the absence of samples in storage pots probably reflects an actual absence of plant storage. Only fully processed organic remains, like flour, are likely to have been missed, as well as material found on the milling installation (debris). Moreover, material from the hearth and the floor would certainly have been overlooked. This room was most probably used as a working room for food preparation, perhaps cooking, and other activities.

Room 3C could have been an auxiliary to room 3A, and could have been used for part of the processing and perhaps cooking as -a possible hearth was found under sample 31. Furthermore, samples 33 and 38 could be classed as flour samples, and 34 is a bulgur-type sample. As for sample 71, it could be treated as a by-product of coarse sieving. Therefore, all of the plant samples recovered from 3C seem to have undergone some kind of secondary and even tertiary processing, as none are related to primary storage. There seems to have been a hearth as well in the room, perhaps, reserved for functions other than cooking. The 3 samples (samples 24, 62, 72) in room 4 came from a previous phase of the house and, therefore, cannot be treated as being connected to the L.B.A. structure. It is odd that we did not find any stored product in this room although the fact that it is damp and at a lower level than room 5 and 3C might have been a reason for not using it for storage. Could it have been the quarters of the domestic staff? Here again, the study of the contextual evidence should give us clues to the use of this room, especially as no plant remains have been retrieved from the floor levels.

Room 3B is a total enigma as it has no door but just a window leading to room 5. It does not seem to have been a cistern as no lining was detected on the walls and floor, and as far as one could tell from the excavation diaries it was found empty of pottery and other finds.

West House: First floor

Room 3, the largest in the house has produced no botanical remains although five samples were collected for this purpose. Therefore, the use of this room is as obscure as room 5 where one sample (21) was collected but yielded only some awns. However, the size of room 3, its position in the house, and the width of the window overlooking the south (the triangular square) lead us to think that it must have been some kind of living-cum-working room (the find of many loom-weights, perhaps, connects this room to weaving amongst other things). For several reasons, Room 5 should also be considered as a living room. Among others, it commands a position important to the function of the house for it leads to room 3 and to the more private quarters of room 4. Room 5 also commands the two sets of polyparathyra (set of windows) on the northwest and west sides and more important it is decorated with wall paintings. It should, therefore, be treated as an entertaining-cum-religious area.

Room 4 might have been associated with more private activities, such as sleeping. The lack of botanical remains, the find of wall-paintings, its inaccessibility to the outside of the house (no door leading to room 3), and the closeness to the sanitary installation (southwest corner) lead us to believe this room was not used for food production and consumption.

Three samples (samples 58, 59, 64) were collected from room 6 but only two produced botanical remains, and both seem to have been flour. The fact that the storage jars (samples 58, 59) were built in a bench, the accessibility of the room from the ground floor of the West House storage areas and the 'cupboard'in area 7, induce us to believe that this room was designed for storage and perhaps it acted as an intermediary between the lower storage/cooking areas and the living areas upstairs, a sort of larder. Although many pots of the type used for liquids were found in room 6, it is still impossible, at this stage, to say whether they belong to the ground floor or the first floor of this room.

Area 7 upstairs is the linking point between the ground floor and the first floor. Of the six samples collected (samples 79, 80, 81, 82, 75, and 76) only two produced botanical remains, samples 75 and 76. The former is a bulgur-type sample while the latter represents impressions of cf.*L.clymenum* seeds, imprinted in fine ash in a pot. It is impossible to be sure whether the latter represents a stored crop or cooked food, and experimental work needs to be done for a quantitative and qualitative study of cooked foods before this question is answered but one would be more inclined to say that it represents cooked food within some form of liquid. This view is based on the fact that had it been a stored crop, the plant material would have charred, whereas, in this case, the plant material decayed after deposition of the very fine ash and just left imprints behind.

West House: Second floor

Because of the continuation of the major staircase (1 & 2) beyond the first floor and above to the second floor, and the indication that there was a second floor on the West House, at least on the east side, we could presume that many of the household jobs could have been conducted on the roofs. A model of a clay house from Archanes gave support to this suggestion.

Implications of storage

At Assiros (Jones et al., 1986) it was found that at least three rooms in the settlement were used for communal storage and, possibly, some type of redistribution took place. However, no such evidence is forthcoming from Akrotiri, and it seems that each structure was an economic entity independent of any 'central place'. The evidence from the West House and other buildings conveys this impression, although we should keep an open mind. With the combinations of factors we have at hand, we could say that the West House had most of its storage facilities on the ground floor (Rooms 5 and 6; working areas 3A and 3C) with some storage extension to the first floor (rooms 6 and area 7). The lack of storage in a room should also be taken as an indicator of a different use of social space, and, in combination with other contextual evidence as well as an understanding of architectural grammar, should give us a glimpse of the use of space by the L.B.A. inhabitants. This would in turn provide social and economic indicators. Even within the rooms allocated for food storage and production, there seems to have been some kind of organization and segregation of space reserved for some particular functions. Based on our botanical data, we could say that on the ground floor, rooms 5 and 6 were reserved for storage *per se.* However, even within storage areas, items were stored separately. Room 5 was reserved for legume storage (Fig.4.4) and especially for all primary storage, whereas the botanical data from room 6 could refer to secondary storage (Fig.4.5). Room 6 (first floor) is also a type of storage room, but perhaps for products which are in a more 'ready to eat'form, and could be a kind of intermediate kitchen -a larder- between downstairs and the first floor. Furthermore, the absence of other botanical remains could be an indication of its other uses, such as, perhaps, a storage room for liquids. Unfortunately, no pottery has, so far, been submitted to gas chromatography to detect and analyze food residues, but the study of other contextual data should provide some more specific clues towards the understanding of their uses.

As already stated, crops were stored in the West House after coarse sieving (free threshing). This implies that crops were processed *in toto*, perhaps, near the fields or by the farmers who produced and transported them to the settlement in bulk after this primary crop processing stage. Alternatively, crops were bartered or exchanged from producers, in which case, Akrotiri should be viewed more as a 'consumer'site. The botanical data for the initial processing stages of reaping, threshing and coarse-sieving are absent (as in most archaeological sites) but the preservation at Akrotiri is such that the by-products of these activities would have been preserved had they been present. Only the M.B.A. sample (24) could be the by-product of coarse sieving, which is in itself a rare find. The implication of this find could be twofold. Either the inhabitants of Akrotiri stalled animals in the settlement in the M.B.A. and not in the L.B.A. or else the status of the site changed from being a producer in the M.B.A. to that of a consumer site in the L.B.A.. However, at this stage this argument is not based on enough data (and the evidence is largely negative, namely the lack of evidence for by-products of the pre-coarse sieving stages). It is, however, a point which needs further consideration when more botanical remains are recovered from Akrotiri.

Use of pots and storage information

Pending the study of pottery and its completion by M.Marthari, it will be impossible to speak of real numbers of all pots for the West House. However, had numbers been calculated, we still would not have been totally sure how much of the pottery would have been in store and how much in active use during the life of the West House. Therefore, we used only large and medium pithoi, not smaller than 65 cm. high for the calculations of storage capacity of the West House. This gave us a minimum volumetric estimate of c.3300 litres for the amount of food material stored in the West House.

So far we have been unsuccessful in assigning definite uses to the types of pottery at Thera. It seems that each pottery type had multiple functions (Table6.2) and, interestingly, some pots, whose shape imply some form of liquid content, i.e. ewers, amphoras, and kraters, were used for storing dry plant materials as well. Even the jars with tubular spouts which one can claim to have been used only for olive oil, wine or other liquids, contained cf.*L.clymenum* and *Hordeum*. Barley however needs to be further investigated as it might have been used to make beer and the same could have been the case with cf.*L.clymenum* (legume wine) (Athenaeus X.432):

> "Hegesander records also that in the Theran islands the people drink wine with pulse instead of barley meal sprinkled on it, and it is said that this drink is better than that made from barley"

An attempt was made to tabulate decorated, undecorated and unknown pottery for the most important crops (Fig.6.1) in order to see use of pottery and whether any status was ascribed to some crops rather than to others. Our premise was that crops of higher status would be kept in decorated pottery. However, the interpretation of the pattern that emerged is not clear, and there was no clear correlation between decorated and undecorated pottery and their contents. This non-correlation was evident when we tabulated the 'chaff' samples and saw that the proportion kept in decorated and undecorated pots was not very different from what was happening to other types of plant products.

Chapter 7

Conclusions

The significance of the archaeobotanical remains from Thera must be reviewed in their wider Aegean context. As the 'Pompeii' of the Aegean, the site of Akrotiri offers unique potential:

- for clarifying certain taphonomic issues in archaeobotany;
- for the use of archaeobotanical data to gain understanding of the use of space, and use of objects;
- for the use of archaeobotanical data to gain insights into Bronze Age society, economy and agriculture.

7.1 Taphonomic issues

Although some earlier remains have been found, the potential of Akrotiri is most apparent in the L.B.A. destruction horizon with the complete burial of the site at one point in time. The immediately underlying deposits are, therefore, contemporary. In addition, the surviving plant remains display three important characteristics: preservation by charring is unusually widespread; local environmental conditions favour preservation by silicification; and sewer contexts permit preservation by mineralisation. Moreover, the value of these various types of material is greatly enhanced by the unusually fine contextual definition afforded by the architectural complexity and unusual preservation of the site. The wide range of preservation types represented extends the range of plant products and by products recovered. In addition to the charred remains found on most Aegean sites, the silicified material encompasses such rarely preserved processing by-products as light chaff and awns, while mineralised material from sewers provides actual evidence of diet. In effect, this potentially covers the complete spectrum of the preparation and use of plants as food. For had silicification not taken place, it is doubtful whether these by-products would have survived, and therefore, crop processing could have been incompletely understood. However, at present, by knowing that all these types of preservation are represented at Akrotiri, we feel happy that differential preservation due to differential exposure to temperature is minimised on the site of Akrotiri, which has great implications for the understanding and interpretation of macrofossil plant assemblages. In other words, the chance of survival of certain types of plant material in a great part or most of the site -at least if the indications which we have at present still persist in the uncovered section of the site- is equally represented. For example, the presence of glumes in certain areas only could portray their presence *only* in those parts of the site, and their absence elsewhere would not *per se* be attributed to differential preservation. That is, of course, when we compare same contexts, and when other factors, not taken into account for those samples studied, are not present, for example, conflagrations, exposure to flame (hearths). These equal factors (e.g. protection of seeds by pottery walls, enveloping of objects by ash of similar temperature, same moisture content of stored seeds, etc.) make results comparable in quality within the site, and thus create a cumulative bank of knowledge of plant processing and use at Akrotiri, Hypotheses which could be generated from a set of samples can be tested against other sets of macrofossil remains on the same site and period time. However, the contribution of Akrotiri helps to extend to our increasing ır understanding of macrofossil plant material from other sites as well. Although chaeobotanical investigations at Akrotiri have so far been conducted only on a nall scale, they already demonstrated the potential of the site as a testing ground ır studies elsewhere where preservation is less complete. For example, silicified reservation of chaff etc. underlines the absence of such plant components at sites here preservation is by charring alone. Likewise, the recovery of mineralised material *from sewers* at Akrotiri provides a possible explanation for similar finds *out f context* at other sites.

urthermore, a potential source of information which has not yet been fully investiated on Akrotiri, but which is an ideal ground for such work, is the study of cooked oods, namely plant food. As it has already been mentioned in this text, there are ndications that certain samples found in the West House seem to have undergone ome form of cooking. Unfortunately though, this is just a qualitative description ased on previous knowledge of how charred seeds should look like, when not previously immersed into water or other liquid medium. Experiments need to be made and results studied before we can give accurate descriptions of how cooked seeds could be distinguished from other, just badly damaged, seeds. Therefore, a different line of investigation needs to be conducted at Akrotiri, aiming at a qualitative and quantitative understanding of how seeds are deformed when cooked (e.g.soups), and how cooked food can be detected chemically. There is also a need to analyse charred/cooked, foods in order to detect substances, especially vegetable substances, used in cooking, e.g. oil, spices.

7.2 Use of space - use of objects

The contemporaneity of objects, architecture and organic/inorganic remains gives us a new dimension of understanding at Akrotiri which is the *vertical dimension.*

Being able to understand the function of whole houses horizontally as well as vertically is not common in the Aegean, nor elsewhere for that matter. At Akrotiri, the fact that plant material can be collected from the upper floors contributes to our understanding of the function of these rooms. This extra dimension of being able to understand the interaction of ground floors with upper floors is unique. Therefore, Akrotiri could be used as an archaeological laboratory, where macrofossil plant remains found out of context on other sites, could be, partly, understood in the light of our finds at Thera.

Not only can we differentiate between the different uses of space at Akrotiri, e.g. working areas, living areas, but storage areas themselves can also be differentiated, suggesting that these were fairly specialized. Some storage areas were, probably, reserved for crops which seemed to need further processing, e.g. crops stored after coarse sieving and crops needing tertiary processing (e.g. Room 5, West House), and other areas were reserved for crops having undergone further processing, probably in the house, and ready for consumption (e.g. Room 6, Area 7, West House). What this differentiation means in social/economic terms still needs to be investigated. The seimiotics of storage need to be further investigated before this point is fully understood. Could it reflect some form of division of labour?

Not only do we have a close understanding of space in L.B.A. Akrotiri, but this could be further extended to objects, in particular, pottery. The use of pottery could not be studied in more detail in Greece than at Akrotiri. All pots left by the inhabitants were preserved *in situ* with all they contained. Therefore, potentially, not only can we attribute particular uses to pottery and other objects, but the status attributed to some plants/foods can be deduced from the type of pottery they were stored in, e.g. plants found in imported and fine pottery would denote high status of the crops they contained.

7.3 Bronze age society, economy and agriculture

Turning to the implications of this study for society and economy in the L.B.A. Aegean, a basic distinction may be made between patterns of crop processing and consumption, on the one hand, and crop husbandry, on the other.

7.3.1 Crop processing and consumption

At one level, finds of crops in the last stages of processing demonstrate which species were consumed and in what form. At Akrotiri, the type of preservation allows for such interpretation. For example the finds of whole samples of 'bulgur', and split legumes within pots could be taken as indicative of deliberately cracked cereal and split legumes, in contrast to accidentally cracked and split ones. The reason is that these samples were not water floated and thus not tempered with in such a way which could, in certain circumstances, reduce whole seeds to broken and split seeds respectively. Moreover, all were protected by the pots. Therefore we would expect similar destruction of testa, for split legumes between as well as within samples, as the testa together with the embryos, are partly responsible, for preserving the two cotyledons together.

Supplementary evidence of food consumption also comes from the sewage. Once information of this type is available from a much larger excavated area, the spatial distribution of different types of food and food preparation may contribute to the identification of social and economic differentiation within the community. Similarly, the distribution of processing residues may indicate whether the provision of food was organised on a community scale or on a domestic scale as has tentatively been suggested for bulgur, flour and olive oil. On most sites, the combination of a paucity of archaeobotanical material and of poor contextual information conspire to prevent analysis of this type on a sufficiently large scale. However, it is felt that a great deal of ethnographic work needs to be conducted in this direction, namely in the following aspects of food consumption and production:

1. production of split pulses, bulgur and flour;
2. ethnographic parallels in the making of these tertiary processed food forms, especially in the area concerned which would be the southern Aegean;
3. tools used, and investigating the possibility of usage also of tools which would have had a low visibility, e.g.wood;
4. microscopic study of the breakage patterns of the plant macrofossils after experimentation with various tools, motion patterns, and processing of plant material prior to tertiary processing. These experiments need to be qualitative and quantitative.

7.3.2 Crop husbandry

In addition to its archaeological wealth, Thera exemplifies the problem of aridity, widespread in Aegean agriculture. To cope with this problem, modern farmers on Thera use a variety of cultivation practices, such as intercropping cereals and pulses with vines. In the future, the existence or non-existence of such practices in the Bronze Age may be determined by the study of weed seeds found with ancient crops. However, this will require a far larger assemblage of ancient material as well as local studies of modern weed ecology.

The existing evidence for the crops themselves does offer two possible insights into Late Bronze Age methods for combating aridity. First, a range of pulse species was cultivated: certainly cf.*Lathyrus clymenum*, *Lens culinaris* and *Pisum sativum*, and possibly *Lathyrus cicera/sativus*, *Vicia ervilia* and *Lupinus cf.albus*. Such diversity reduces the risk of total crop failure. Secondly, the two crops most commonly represented, spanish vetchling (cf.*L.clymenum*) and barley (*Hordeum spp.*), are particularly well adapted to the difficult local conditions. Barley is widespread today in the arid south-east of Greece where concentration on this species from prehistoric times has been suggested previously (Renfrew 1968a). Spanish vetchling, by contrast, is a very rare crop today - except on Thera and a few other Aegean islands. Since the vegetation of Thera must have been completely destroyed by the L.B.A. eruption, the cultivation of this most unusual pulse both now and then underlines the influence of Theran soils and climate upon local agricultural practice.

This last observation points to the need not only for further archaeobotanical work at Akrotiri, but also for further ethnoarchaeological study of traditional farming on Thera to facilitate the interpretation of this unique archaeological resource.

Beyond mere storage, Akrotiri potentially offers insight into field fragmentation in the L.B.A. settlement. Our assumption is that samples of the same crop plant, stored in different storage jars, could give us some indication of field fragmentation. Samples which have the same weeds and proportion of weeds, although they might be derived from different fields, at this stage, cannot give us any positive information, for the *same weeds* could occur in *different* as well as the *same* fields. The nature of this difference depends on many other factors at play, such as soil, moisture and so forth. However, samples of the same crop which display a whole set of *different* weeds, proportions of weeds, size of crop seed, size of weed seed, if not connected to crop processing, should be tied down to depicting crops from different fields. A great deal of ethnographic work needs to be conducted on the decision-making governing the act of threshing crops on the same threshing floor, whether crops from different fields are stored apart prior to threshing, and the decision-making in storing crops of different fields. If consistent patterns of fragmentation do occur, this will have enormous implications for our understanding of L.B.A. society.

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