

## Chapter 1. Introduction and overview

*Shun no toil to make yourself remarkable by some talent or other; yet do not devote yourself to one branch exclusively. Strive to get clear notions about all. Give up no science entirely; for science is but one.*

*Seneca*

This thesis is concerned with the impact of the eruption of Santorini (Thera) volcano in the Late Bronze Age. Santorini volcano is situated in the Aegean Sea in the Eastern Mediterranean (see figure 1.1 and plate 1-1) and is a caldera type volcano (Friedrich 2000). In the Late Bronze Age it erupted with catastrophic force, and it is regarded as one of the largest eruptions of the last few millennia with a Volcanic Explosivity Index of 6.9 (Newhall and Self 1982; Decker 1990). The Late Bronze Age eruption cycle of Santorini is often called the Minoan eruption after the dominant culture group in the area at the time. The Minoan culture was centred on the island of Crete, approximately 120 km to the south of Santorini. The exact timing of this eruption is a matter of great debate, but is agreed by all recent mainstream scholarship to have occurred within the period 1650 to 1450 BC (Baillie 1995; Buckland et al. 1997; Warren 1998; Manning 1999).

It has been proposed (e.g. by Marinatos 1939; Page 1970; Nixon 1985; Graham 1987, p11; LaMoreaux 1995) that the eruption, through the action of tephra fallout from the eruption column and through the generation of tsunamis, caused major damage to the island of Crete and was a significant factor in the decline of the Minoan culture (see chapter 2 for detailed review). Because of the size of the eruption and the volcanic material in the atmosphere there may also have been a significant global impact. This proposal has a long history and has fallen in and out of favour with the proposed impact perceived as increasing or decreasing in intensity accordingly.

The Santorini caldera is made up of three islands: Thera, Therasia and Aspronisi (figure 1.1). Thera is the largest and most spectacular with sheer cliffs on the inside of the caldera that reveal the stratified deposits from many eruption cycles through the Quaternary. The current topography of these three islands is largely a result of the Minoan eruption. Since that time two further islands have grown up from extruded lava deposits in the middle of the caldera. These are Palaea Kameni and Nea Kameni.

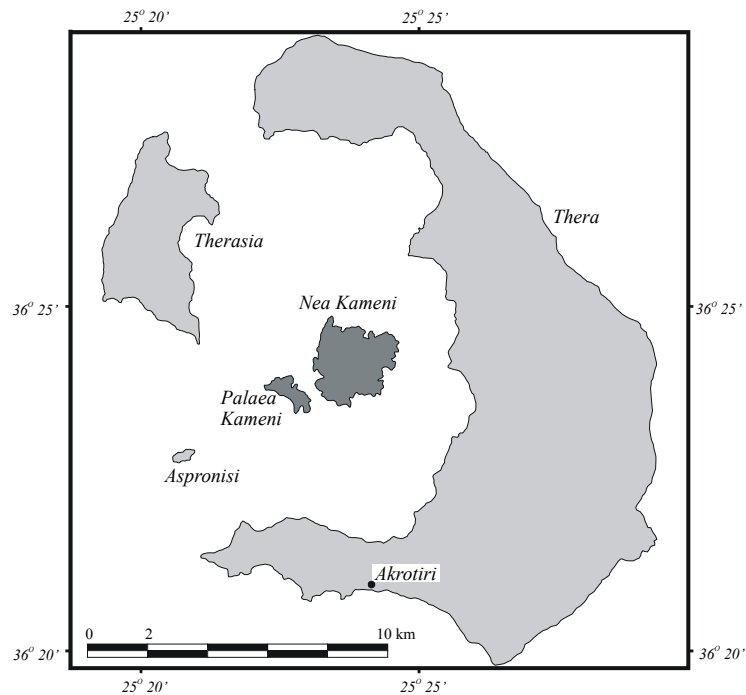


**Plate 1-1 View from Therasia across the caldera waters. Nea Kameni is in the middle distance and then Thera. The thin white line of Minoan pumice can be seen capping the cliffs of the caldera on Thera. Mount Profitis Ilias then rises in the background.**

The Minoan culture group founded on the island of Crete was one of the first civilisations in Europe (Graham 1987; Dickinson 1994; Prehistoric Archaeology of the Aegean, [http://devlab.cs.dartmouth.edu/history/bronze\\_age/](http://devlab.cs.dartmouth.edu/history/bronze_age/) for basic review of Minoan culture). It had a long history of development from the Early Bronze Age around 3100 BC through to the end of the Post Palatial period around 1100 BC. By the Late Bronze Age the Minoan culture had grown significantly in size, influencing the Cycladic island group and trading widely in the Eastern Mediterranean sphere. It was a complex society with a stratified hierarchy and a redistributive economy that allowed craft specialisation to take place. The eruption is thought to have occurred in the archaeological time period called Late Minoan 1A (LM IA). Currently there are two theories relating to exactly when this was in terms of a calendarical date. The two theories are called the High Chronology and the Low Chronology. Figure 1.2 illustrates the difference in time proposed by the two chronologies and chapter 2 will focus on this issue in depth.

From the beginning of the LM II period the Minoan civilisation had passed its zenith and there was an increased mainland Mycenaean presence if not amalgamation into the Mycenaean hegemony (see figure 1.2 for chronology). The civilisation was largely forgotten since few written details on the culture survived into the historic period. It is only since archaeological work began in the late 19<sup>th</sup> century that the heights that the civilisation

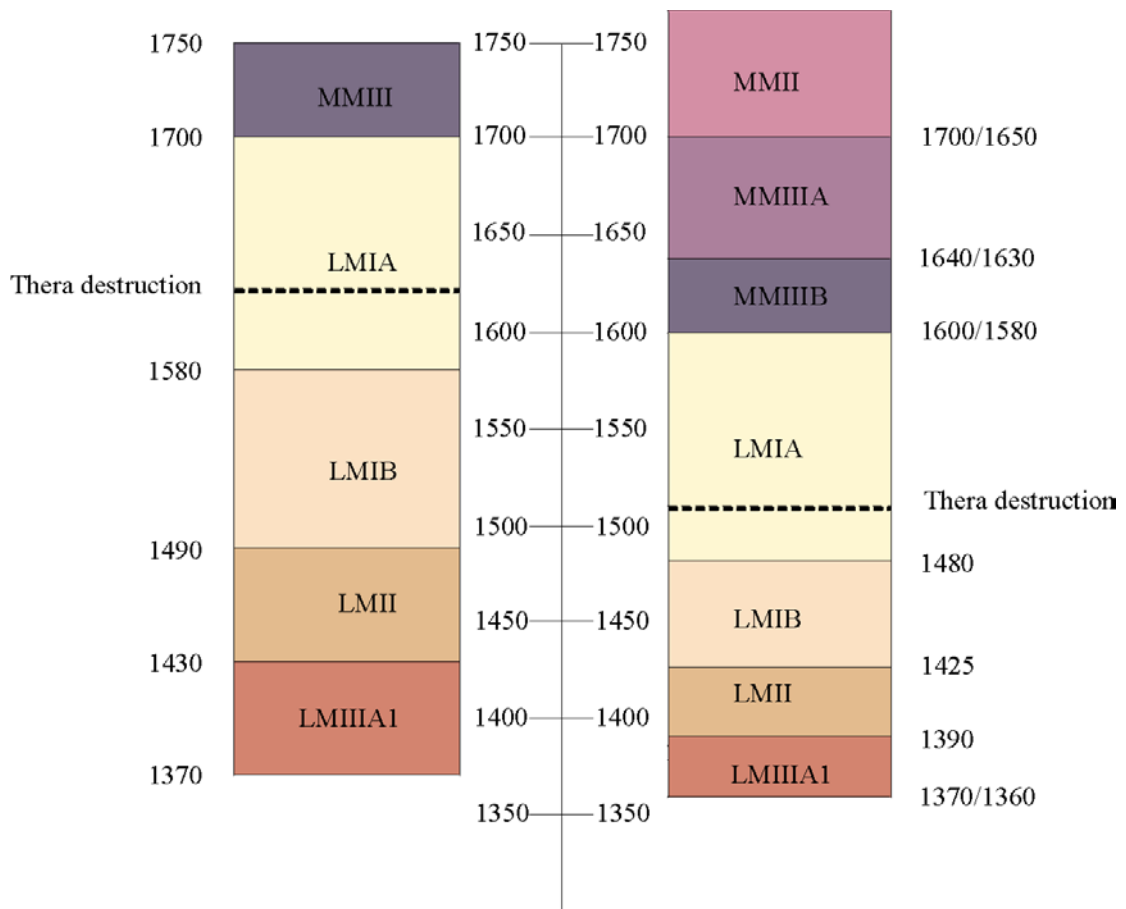
reached have been revealed. The island of Santorini is situated within the area of the Cycladic culture group but by the time of the eruption this was very heavily influenced by the Minoan culture (e.g. Branigan 1981; Hägg and Marinatos 1984; Wiener 1990). The site of Akrotiri on Thera which was largely preserved by the volcanic eruption is a unique site presenting an unprecedented glimpse of a Bronze Age town (Doumas 1983).



**Figure 1.1** The Santorini caldera archipelago. The islands left by the Minoan eruption are shown in light grey. The more recent lava extrusions are shown in dark grey. The Minoan site of Akrotiri is marked on the south coast of Thera.

This thesis addresses the question of how the eruption of Santorini might have affected the culture groups in the area and how this impact is preserved within the archaeological and geological record. Many previous works have touched upon or addressed parts of this subject (see above and summary sections in chapters 2 and 3). However, there are two main reasons why a doctoral thesis is the correct place to re-examine this area. First, the size and length of the study mean that an integrated approach can be taken rather than focusing on just one issue. A wider remit presents a firmer basis for study and therefore better grounds for valid conclusions to be drawn. Secondly, much of the previous work noted above has not undergone critical review. Part of the aim of this thesis will be to critically examine ideas and data put forward by other researchers and assess the validity of their arguments. Whilst there will probably always be some variation in opinion, because of the inherent time element which has blurred or removed vital data, it is hoped that a

balanced in-depth study will be of great use to both archaeological and volcanological researchers as well as providing a focus for new research directions.

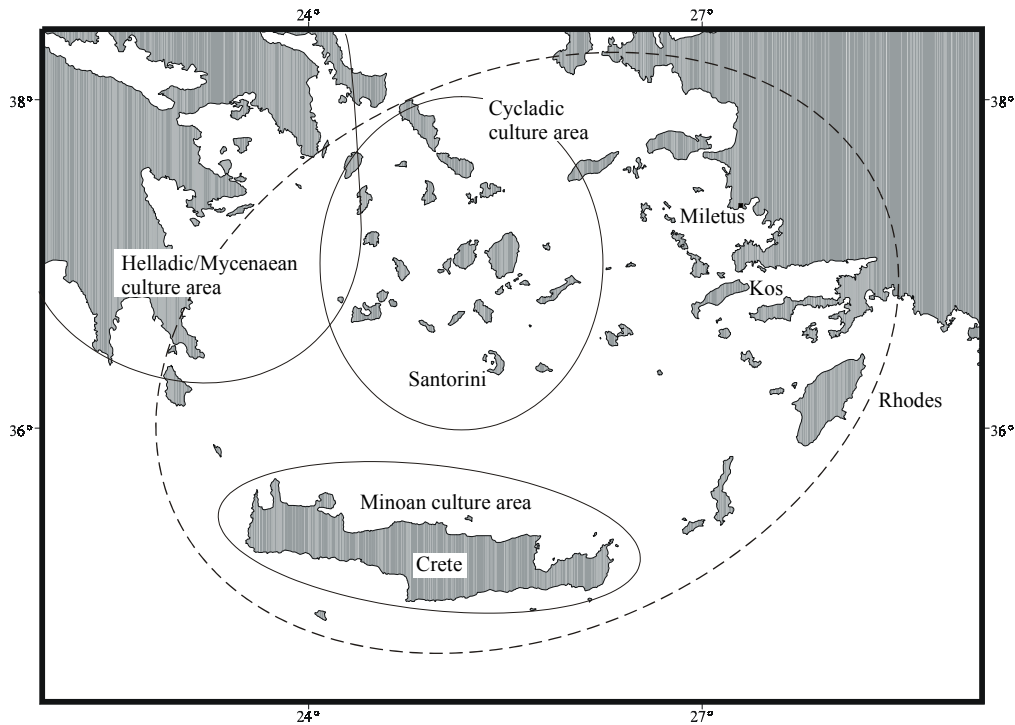


**Figure 1.2** Archaeological time periods with the High Chronology on the left and the Low Chronology on the right. The High Chronology data is taken from Rehak and Younger (1998, table 1, p99) and based on Manning (1995), the Low Chronology data is taken from Driessen and Macdonald (1997, fig2.3, p23) and based on Warren and Hankey (1989, p169).

The conclusions reached by this study will hopefully be of use not only to those interested in the specific study of the Santorini eruption but will also be of use to those studying extreme events within the archaeological record.

Because the aim of the thesis is quite broad in scope it will also deal with a number of ancillary issues. The exact date of the eruption is still not known, and it is hoped that this thesis will aid in the clarification of the debate between a high or a low date for the eruption. The identification of past tsunami deposits within stratigraphic records will help in assessing areas at risk from future inundations. Modelling of tephra fallout patterns will help in assessing potential damage from future eruptions of the Santorini volcano. By clarifying the type and quality of data that can be gathered from past extreme geological

events and the impact they had on a society it is hoped to improve the assessment of the impact of future events.



**Figure 1.3** The geography of the main culture groups in the Aegean area in the Late Bronze Age. There was contact, overlap and dissemination between these groups. The dashed ellipse represents the sphere of Minoan influence for the period under study.

## 1.1 Methodology

The question of the impact of the Santorini eruption on Minoan civilisation has a long history. The proposal of a causal association was first put forward by Marinatos in 1939<sup>1</sup>, and was subsequently developed by writers such as Luce (1969) and Page (1970). The island and its last major eruption were studied in depth during three conferences on the subject (Kaloyeropoulou 1971; Dumas 1978; Dumas 1980; Hardy et al. 1990a; Hardy et al. 1990b; Hardy and Renfrew 1990) and there have been many studies which have clarified individual aspects of the eruption or of the archaeological data. Recently, a major work by Driessen and Macdonald (1997) was published at the beginning of this thesis project which attempted to look at the archaeological evidence for the eruption on Crete, and a further work by Manning (1999) addressed the issue of the absolute date of the eruption. However, despite the vast literature that has built up, the issue is still not clear.

<sup>1</sup> J Schoo (1937) had made a causal link two years earlier but this had largely been ignored, see Driessen and Macdonald (1997, p107) for details.

One of the main reasons for this is that within the scope of an article or conference paper it is not possible to examine in depth all of the issues. Assumptions that are discredited within one speciality can be accepted by experts from another. The result is a paper that can confuse as much as clarify. This work will assess the question with up-to-date material and look at all aspects.

There are two main strands to the study of the impact of Santorini: the archaeological and the volcanological/geological. These strands have developed concurrently, beginning approximately at the same time with Fouqué's volcanological study of Santorini beginning in 1867 whilst the excavation of the Alaphouzouos quarry by Nomicos and Alaphouzouos on Therasia had begun the previous year . Fouqué's work on Santorini was published in 1879 whilst Minos Kalokairinos' excavations at the Minoan site of Knossos on Crete began in 1878<sup>2</sup> (MacGillivray 2000, p92). Initially therefore, I shall be reviewing the work of the archaeological and volcanological material. However there needs to be a methodology to grasp the holistic view of the end product whilst breaking the subject down into smaller conceptual elements. As an inspiration for this I have chosen Plate 1-2 which shows a cliff section on the south coast of Thera. The plate embraces the formation processes of the eruption as well as the impact of time, which has blurred and obscured the data.

The section sums up the four elements of fire, earth, air and water. The fire aspect is the original eruption process itself and the transmogrification of magma into pyroclastic products. The earth element is the preserved sequence that is visible to us today. Although it preserves the stages of the eruption its structure has changed since that time, solidifying and settling. The earth element also represents the archaeological material buried and entombed at Akrotiri within the pyroclastic products. The element of air is represented by the carved hollows within the section. The eruption was hugely powerful and yet as that force was spent it was the air and winds that directed the light pyroclastic products and dictated the fallout pattern of the debris. The water element appears at the bottom of the section and is eroding and blurring the details of the eruption products. The eruption could have generated large tsunamis that may have transmitted the strength of the eruption through the water affecting the shores of the Aegean and beyond. The complexity of studying this volcanic eruption is that it is the interaction of these four groups betwixt and

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<sup>2</sup> Kalokairinos' excavations were short lived, Evans began excavation at the site in 1900.

between each other that is important. Often they have been looked at in isolation. This thesis will attempt to examine them in turn and then look at them holistically.



**Plate 1-2** Section of cliff on south coast of Thera showing the eroded deposits from the Minoan eruption of Santorini.

## **1.2 Structure**

Chapter 2 (Earth) looks at the archaeological setting for the eruption. It assesses the period of time in which the eruption took place and the problems, which are related to its absolute chronology. It places the pre-eruption island, and in particular the site of Akrotiri, within its Late Bronze Age setting and how the island related to other sites and cultures. A problem with an examination of the archaeological material is that there is a tendency to extrapolate data from one site across a cultural group because of the lack of, and the great variability in, recorded and published data from sites. The use of type-sites for pottery sequences is the quintessence of this practice. To work around this problem I have created a theoretical model of a Bronze Age site and divided it into three zones. Each zone will not only have been affected in different ways by the eruption, but they also have different methods of preservation and investigation.

Chapter 3 (Fire) examines the geological setting of the volcano and how studies have refined the eruption sequence that took place. This is of vital importance since the estimates of material erupted and the shape of the pre-eruption island have changed fundamentally over the years. A major difference between the archaeological and the volcanological data is the way that the material is examined. The examination of an

archaeological site is by its nature destructive as material is removed from its context, in effect it is only possible to have one detailed examination of a site. The geological data which uses mapping and recording of sections to substantiate theories is largely non-destructive and this means that a number of researchers can examine the same prima-facie evidence and come to different conclusions based on new theories and ideas.

Chapter 4 (Earth) looks at the cores and samples that have been collected over a period of time that relate to the Santorini eruption. Because of the nature of the Santorini caldera there are two pieces of evidence that are needed to formulate ideas of the size of the eruption and its impact. There is the evidence on the island itself which was dealt with in chapter 3 and there is evidence from elsewhere. The stratigraphy on Santorini is relatively straightforward since it is still well preserved. The other material largely consists of tephra and cores and samples that have been collected by many different researchers over time. The original work in this area for the Santorini eruption was conducted by Ninkovich and Heezen (1965) who identified Minoan tephra in deep-sea cores from the Mediterranean. On the basis of presence and absence within cores they drew a distribution map of where the tephra fell. The degree of interpolation and extrapolation within and from this original distribution is large. Since then there have been more samples found at sea and on land, from geological sections and archaeological sites. This chapter gathers all of that material and looks in detail at the validity of the source data and their use for determining tephra fallout patterns.

Chapter 5 (Water) focuses on the least studied and most poorly understood of the main topics, the propagation and inundation of the coastal regions by tsunamis. The potential destructive force of this source is great, however the generation of tsunamis from volcanoes has not only been poorly observed but their preservation within the geological record is largely dependent upon certain specific geological features such as back-water areas. This chapter looks at how tsunamis could have been generated by the eruption and what sorts of evidence we could expect to find. It then examines evidence that has been put forward for the eruption and critically examines the conclusions drawn from that evidence.

Chapter 6 (Earth) looks at evidence collected during two field trips to the Aegean area. There are two main types of evidence, geological and archaeological. The geological data

were collected by auger or from samples taken from roadside sections. The archaeological evidence is quite different since permission to excavate could not be sought across many sites. The evidence therefore takes the form of sections and material photographed mainly concentrating on the coastal zone outlined in chapter 2. This is the most poorly understood of the archaeological areas and because of the rapid expansion of the tourist industry along the coastal margins is also the most under threat of destruction. Because of the rapidly changing topographic conditions due to the development of this zone the use of a photographic record is of great use in preserving some of these data. This was illustrated to the author by the speed with which some critical areas of evidence were being destroyed as observed within the time span of one year.

Chapter 7 (Air) presents the results of computer models for the distribution of tephra from the eruption. Parameters from the eruption such as the column height or the mass of material ejected have been linked with modern wind data for the area to power a tephra distribution model. There is a basic assumption that the average wind character has remained largely stable since the Bronze Age period. Using wind direction vector data collected for the whole height of the eruption column the model maps where the material would be blown. The use of this is twofold:

- (i) To ascertain variable patterns of distribution throughout the year. By comparing this distribution to material on the ground, times of the year when the eruption could not have taken place can be inferred.
- (ii) It will indicate the amounts of material that might have fallen over specific areas and therefore the level of damage that those areas might have suffered from tephra fallout. By inference it may also indicate those areas which would not have been directly affected by tephra fallout.

Chapter 8 summarises the above chapters and draws together conclusions incorporating the various ideas. Most importantly it looks at the areas that need future research to help further elucidate the issues raised in this work. That there needs to be a focus for further research is indicated by the speed with which the landscape is being developed. Answers for important research questions are preserved with the geological and archaeological records but these are non-renewable resources and are disappearing at an alarming rate.