

1 *The archaeology of disasters: past and future trends*

ROBIN TORRENCE AND JOHN GRATAN

WHY STUDY DISASTERS?

In a landmark book which examined the role of volcanic eruptions in human evolution, Sheets and Grayson (1979: 6) could legitimately note that very few archaeologists had paid significant attention to the potential cultural effects of the natural hazards (e.g. volcanic tephra, earthquake-damaged walls, etc.) whose occurrences were apparent from many of their excavations. The current situation is radically different. In recent years studies stressing the impacts of past natural disasters on ancient societies have increased dramatically, although the majority of these are still authored or inspired by natural scientists and astronomers rather than archaeologists (e.g. Ambrose, 1998; Driessen and Macdonald, 1997; Harris, 2000; Isaacson and Zeidler, 1999; McGuire *et al.*, 2000; McCoy and Heiken, 2000; Newhall *et al.*, 2000; Nur and Cline, 2000; Peiser *et al.*, 1998; Siebe *et al.*, 1996; Stiros and Jones, 1996). Volcanic eruptions have led the way as the most commonly invoked environmental forcing mechanism, but droughts, floods and earthquakes are now also regularly proposed as triggering cultural change.

If we look to the modern world as a model for what we might expect to find in the past, we find that severe climatic events that wreak havoc on human communities, destroy homes and livelihoods, and inflict high levels of mortality are surprisingly frequent and widespread. For instance, Tobin and Montz (1997) provide a graphic catalogue of disasters during the single typical year of 1985.

An earthquake in Mexico killed 20,000 people; a tropical cyclone killed 11,000 in Bangladesh, and one in Vietnam killed 670; 300 died from landslides in the Philippines; a volcano erupted in Colombia killing 25,000; a flood in China added 500 to the death toll; a storm in Algeria killed 26; cold waves were responsible for 290 deaths in India and 145 in the United States; a heat wave killed 103 in the United States; and 52 died in Egypt in a fire.

(Tobin and Montz, 1997: 1)

A detailed study by Glickman *et al.* (1992) found that between 1945 and 1986,

2.34 million people lost their lives to disasters and that 30 disasters and 56,000 deaths occurred on average per year. Consequently, the study and management of natural hazards has become an important concern for the modern world, which now makes large financial investments in hazard prevention and relief. The United Nations went so far as to declare the 1990s the International Decade for Natural Disaster Reduction (IDNDR), an action that stimulated and fostered huge programmes for research and for disaster awareness programmes.

Given the importance ascribed to natural disasters in the modern world, it therefore seems reasonable to assume that they were also frequently experienced by past societies. To what extent have severe environmental events had a significant effect on cultural histories? Based on the marked increase in popular and professional archaeological publications on their role in the past (e.g. Keys, 2000; McGuire, 1999; Schoch and Aquinas, 1999), one might assume that disasters have become fairly widely accepted as important agents of cultural change.

We feel it is important to question whether the current popularity of external natural forces in accounting for human evolution and social change in the remote past is simply a product of modern concerns or has identified a genuinely important mechanism for change that has been relatively neglected until recently. The critical issue of correlation (an extreme natural event happened about the same time as the observed cultural change) versus causation (the cultural change was dependent on the environmental event) has rarely been satisfactorily addressed by detailed and systematic research (cf. Sadler and Grattan, 1999; Chapters 6 and 18). Too often archaeologists and earth scientists have simply assumed that the occurrence of extreme natural events means that they were the prime movers in cultural change without demonstrating that the latter was solely or largely dependent on the former.

Consequently, the overall aim of this book is to critically examine the role of extreme environmental events in causing cultural change. The authors have deliberately taken a sceptical point of view and have carefully examined the evidence in order to distinguish between coincidence and dependence. We begin with a programmatic chapter by Shimoyama which proposes an analytical framework and a set of basic concepts that should guide archaeological disaster studies. Examples from Japan are used to illustrate his methodology. This statement about ideal methodology is followed by case studies with broad coverage in both spatial (North and South America, Europe, Asia and the Pacific) and temporal terms (several thousand years ago up to the present day). They also involve a wide sample of different mechanisms (climatic change, volcanoes, tsunamis, floods, earthquakes and a shipwreck) to present detailed assessments of the relationship between specific natural processes and cultural responses. The inclusion of historical and modern studies illustrates that the widest possible research framework is required in order satisfactorily to evaluate the role of human disasters. The modern studies make a particular contribution because they highlight areas of behaviour that archaeologists cannot monitor effectively. For example, Gibbs's account in Chapter 5 of a shipwreck off the west coast of Australia provides

a gripping story of social disintegration following a catastrophe. The detailed reconstruction of the impact of the toxic gases that affected Europe in 1783 (Chapter 6) reminds us that some catastrophic events may not generate certain kinds of data and are therefore 'invisible' in archaeological terms. The recent disasters in Papua New Guinea (Chapter 3), the Philippines (Chapter 4) and Japan (Chapter 18) suggest that attachment to land or place may explain why some people do not abandon their homes even when faced with very dangerous and unpleasant conditions. Case studies like these provide explicit models that can help shape future archaeological work and so they form a very important part of this book.

The results presented in the wide-ranging case studies highlight the importance of critical, analytical research to determine how and in what situations natural factors create disastrous conditions for humans and whether these have significant, long-lasting effects. On the scales over which archaeology generally deals, the papers emphasise the flexibility and adaptability of past societies and the importance of the social context in determining the ultimate outcome, a point which has also only recently been accepted in modern disaster research (e.g. Blaikie *et al.*, 1994; Oliver-Smith, 1996; Tobin and Montz, 1997). The many substantive and theoretical issues raised by the papers also demonstrate that archaeological analyses of past disasters have a very important role to play in planning for the future.

THEORETICAL IMPORTANCE OF DISASTERS

Apart from the current popularity of the concept that catastrophes were a powerful agent for cultural change, there are a number of compelling reasons why studying natural disasters is important for archaeological theory and practice. Archaeological theory about the pace and character of cultural change has generally assumed that the process is mainly internally generated, unfolds slowly through time, and inevitably leads to greater socio-cultural complexity and so-called levels of progress. Although environmental determinism has also been quite influential, various forms of the Functionalist or Processualist theories, which dominated archaeological and anthropological thought from the 1970s until recently, stressed homeostasis and equilibrium, properties which are in conflict with the notion of rapid change induced by external factors. Processual archaeologists are unlikely to have envisaged one-off events as having had a major effect over the very long time scales that archaeologists generally study. Despite experiencing a major catastrophe, societies are expected to have picked themselves up, dusted themselves off, and continued on their relentless social evolutionary path to complexity. As a result, scholars focused on what they saw as 'normal patterns of behaviour' and 'had little to say about systems whose normal coping mechanisms failed' (cf. Torry, 1979: 518, 521). In contrast, disasters are an important subject for study because, as noted by Oliver-Smith (1996: 303),

they 'signal the failure of a society to adapt successfully to certain features of its natural and socially constructed environment in a sustainable fashion'. Since they demonstrate what were the limits of adaptive processes, a focus on how societies respond to disasters would seem to be an important way to understand the general processes of evolution.

Alternatives to social evolutionary thinking which focus on non-linear change, chaos, punctuated change and catastrophism (e.g. studies in van der Leeuw and McGlade 1997) provide a significant challenge to archaeological theory, but have received very little attention to date, although their role within modern studies of natural hazards has been promoted by Bryant (1991: 5–6). Chance events or what Gould (1989) has called 'historical contingency' are also beginning to be recognised as key factors within the process of cultural evolution (e.g. Terrell, 1988; Zeidler and Isaacson, *in press*). We argue that studying the cultural consequences of natural hazards and the disasters they may have caused in the past may suggest a very productive methodology for breaking out of established patterns of thought. Careful studies of past disasters also provide a useful format for testing alternative approaches to cultural change and may perhaps even lead to new ways for conceptualising non-linear processes.

Finally, archaeological research can make a contribution to helping managers cope with contemporary disaster events. From archaeological research we may establish the principal components of a disaster, reconstruct the physical event itself, assess the physical damage it caused, and identify the response strategies of the exposed culture. More importantly, since archaeology operates over a large enough time scale, it can assess the long-term impacts of a disaster that might be overlooked in a modern study. Studies have already shown that long after the world press has moved on, local catastrophes can have profound long-term effects on the lives of the people involved and these have the potential to permeate and eventually alter the society as a whole (cf. Chapters 3, 5 and 12; Mbunwe-Samba, 1999; Grayson and Sheets, 1979: 628; Oliver-Smith, 1986). Furthermore, disasters can accelerate social processes that were in train beforehand (Blong, 1984: 186; Oliver-Smith, 1996: 313; Chapter 14). It is therefore very important to promote research which specifically evaluates the effects of natural disasters over longer time scales than is usually the case in modern disaster studies. Detailed archaeological case studies can make a significant contribution to this goal.

With very few exceptions, disasters were widely ignored until the seeming exponential increase in mortality and damages in the recent past created a new awareness of their potential impacts. The danger, however, is that some scholars have gone too far and are making a simplistic analogy between modern concerns about disasters and potential effects in the past. This has led to the adoption of a dangerously uncritical approach when hypothesising the importance of past extreme environmental events. Although we argue that the role of disasters may have been overlooked, we also stress that their role in causing cultural change must be very carefully evaluated on a case-by-case basis.

CONCEPTS AND DEFINITIONS

Risk management, which entails the study of natural hazards and their social impacts, has become increasingly popular in the last decade due to the boost of the United Nations IDNDR and economic challenges to the insurance industry posed by natural disasters. Until recently there were two separate fields of research. On the one hand, earth scientists studied the physical properties of the volcanoes, earthquakes, floods, tsunamis, etc., aiming to predict their occurrences and likely impacts (e.g. Bryant, 1991; Blong, 1984). On the other, social scientists focused on the short-term consequences of disasters and stressed cultural aspects of communities in determining their vulnerability to natural processes and their methods for coping with stress (e.g. Torry, 1979). Unfortunately, the two fields are still relatively separate and distinct (e.g. compare McGuire, 1999 or Harris, 2000 with Blaikie *et al.*, 1994), although there are signs of major changes and recognition that both aspects need to be better incorporated into disaster research. Archaeological research can gain a great deal from the current debates taking place within the broad field of disaster management. Although Sheets and Grayson (1979: 4–6) reviewed this research in the introduction to their book, it was written before social scientists were heavily involved in disaster research (cf. Torry, 1979) and this is reflected in the emphasis in their text on the natural science approach. Previous archaeological studies of disasters have also mainly been influenced by earth scientists (e.g. McGuire *et al.*, 2000; McCoy and Heiken, 2000). The papers in this book represent a significant change toward a more integrated methodology in which the environmental and social variables are considered to be equally relevant.

Although they may be initiated by natural factors, ‘disasters are social phenomena’ (Shimoyama, Chapter 2). As emphasised by Blaikie *et al.*,

the ‘natural’ and the ‘human’ are so inextricably bound together in almost all disaster situations, especially when viewed in an enlarged time and space framework, that disasters cannot be understood to be ‘natural’ in any straightforward way.

(Blaikie *et al.*, 1994: 6)

Most scholars agree that the critical ingredient of a *disaster* is the victims (cf. Chapter 2). Beyond this crucial point the details vary slightly. For example, Tobin and Montz (1997: 6) use 25 deaths as an arbitrary threshold for a disaster. Others require more extensive damage so that ‘all major public and private facilities no longer provide essential social and economic services without extensive replacement or repair’ (Torry, 1979: 518) or that ‘the essential functions of the society are interrupted or destroyed’ (Oliver-Smith, 1996: 305). In other definitions the key factor is the response. For example, a disaster is defined as a situation where ‘recovery is unlikely without external aid’ (Blaikie *et al.*, 1994) or when there is ‘a total breakdown in day-to-day functioning’ and ‘the damage may be so great and so extensive that survivors have nowhere to turn for help’ (Tobin and Montz, 1997: 31). For our purposes the most simple definition – the existence of damage

to individuals or their property – is all that is essential to the definition of a disaster. In this conception disasters can be placed along a continuum ranging from those with minimal consequences to others with economic and social losses. For archaeology the most critical point is not whether a disaster took place but whether it caused cultural change.

Unlike most scholars, who consider natural hazards to comprise mainly environmental events, we make a distinction between forcing mechanisms and hazards. The *forcing mechanism* is defined as the process that initiates the damages. In our scheme the second component of a disaster, the *natural hazard*, comprises the ‘potential interaction between humans and extreme natural events’ (Tobin and Montz, 1997: 5). In other words, a physical process is not a hazard unless it could potentially impact on a social group. In assessing whether natural processes led to past disasters, the existence and nature of the hazard need to be assessed independently from the occurrence of severe environmental events that have been recorded in the geological record.

The potential initiations or forcing mechanisms for disasters can be natural, social (e.g. warfare), or technological (e.g. oil spills, chemical explosions, etc.). In this book we focus on natural forcing mechanisms, which are important environmental events. It is useful to characterise these in terms of their frequency, intensity, duration, areal extent and speed of onset (cf. Bryant, 1991: 9; Tobin and Montz, 1997: 232). Although the importance of frequency and duration are recognised by natural scientists as being important, the cultural impacts of these are rarely studied in much detail because most social science research operates on very short time scales. Archaeology has an important role to play here. Most of the papers deal with processes, which occur suddenly: e.g. volcanoes, earthquakes, tsunamis, floods. Provoking factors with a slow onset, as for example climatic change, have always played an important role in archaeological explanations of cultural change, although the popularity of climate change as a prime mover appears to be on the rise (e.g. Moseley, 1997; Fagan, 1999; Cullen *et al.*, 2000; Weiss and Bradley, 2001; Giller, 2001). It is considered here by Menotti (Chapter 13), and Kornbacher’s discussion of the effects of El Niño (Chapter 12) could be classified in this way, but the problems faced by the prehistoric communities she studied (floods and landslides) mostly arise fairly rapidly. We feel that the issues raised by studying climatic change as a cause of disasters can be quite different from events, which occur suddenly.

Following on from the identification of natural hazards, researchers try to assess the *risk* that a disaster will occur as a consequence of the hazard. This depends on the likelihood of the forcing mechanism occurring as well as the probability that it will happen at a time and place that will affect a community.

More important for archaeology is assessing the *impact* of the disaster once it has taken place. For many anthropologists and social scientists the key variable in a disaster is not the natural event itself but the *vulnerability* of the society which experiences it (e.g. Oliver-Smith, 1996: 314; Tobin and Montz, 1997: 32, 331). As defined by Blaikie *et al.* (1994: 9), vulnerability comprises ‘the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and

recover from the impact of a natural hazard'. It is clear that the more vulnerable the group, the greater the disaster and, by implication, the larger the potential for cultural change. Within most archaeological writing on disasters, the emphasis has been placed on the environmental forcing mechanism and to a lesser extent on the hazard. Very little attention has been paid to the vulnerability of the population affected. Notable exceptions are papers by Sheets *et al.* (1991) and Torrence *et al.* (2000), which compare the effects of volcanic disasters on societies with simple as opposed to complex social organisations. As discussed further below, one of the major outcomes of this book is a refocus on the social component of disasters, particularly with respect to assessing hazards and vulnerability as key elements in cultural change.

COINCIDENCE VS CAUSATION

One of the most serious problems dogging archaeological studies of disasters is the lack of critical assessment of whether the relationships between the natural events and the cultural behaviour identified by the researchers were merely a coincidence or whether the latter was actually caused by the former. Generally there is no doubt that a serious environmental event occurred. The question is whether (1) it was contemporaneous with the cultural change observed and/or (2) the cultural change was a necessary consequence of the forcing mechanism.

The opportunities offered to, and the problems faced by, archaeologists engaged in assessing the influence of natural disasters can be illustrated by volcanic activity. Volcanic eruptions may influence distant archaeological sites through the generation of climate change, the emission of toxic gases and the deposition of tephra. Archaeological sites close to the source may be influenced by tephra fall, toxic and super-heated gas and lava flow. It is tempting and convenient to use the temporal coincidence of a volcanic eruption or the physical evidence of volcanic ejecta to account for change in the archaeological record, but how may these coincidences be established as cause and effect? There is a real danger that coincidence is taken to imply a causal relationship. In such cases the proposed forcing mechanism is assumed to have been powerful enough to have brought about the change observed in the archaeological record. This is especially dangerous when the volcanological data suggest the eruption to have been of moderate magnitude.

This same difficulty is experienced by natural scientists who wish to explain evidence for climate change in terms of the occurrences of major volcanic eruptions (cf. Sadler and Grattan, 1999). In fact the research in this field should sound a word of caution to archaeologists since climatic change generated by any known volcanic eruption during the Holocene has been shown to have been minimal and has never exceeded the variability that occurs normally in response to naturally occurring climatic forcing.

To assess the nature of the association between extreme environmental events and a putative cultural response is not a simple matter and requires a critical approach backed up with careful and systematic analyses, as evidenced by the

papers in this book. They demonstrate that the most productive procedure is to conduct independent analyses of the natural and cultural data, rather than to explain one in terms of the other, which has often been the case. Simply obtaining precise enough dating for the hazard and the cultural change can be extremely difficult, as well illustrated by the case of the Santorini eruption (Chapters 14 and 15). Independent dating of the environmental event is likely to continue to be a difficult problem because radiocarbon determinations are frequently taken from archaeological contexts. This can be dangerous because the site could have already been abandoned prior to the damage created by the forcing mechanisms. Furthermore, the standard deviations of most dates do not always allow a straightforward assessment of contemporaneity.

The archaeological record contains abundant evidence that cultural groups experienced extreme natural events in the past. Numerous sites have been buried by volcanic tephra, walls collapsed due to earthquakes, dwellings destroyed by tsunamis and landslides. Despite our cautions that care be taken to establish causation in each particular case, disasters were certainly not an uncommon event in the past. It is, however, important to note that not all of the case studies conclude that the disaster which was detected had a noticeable impact on social process. Resilience and persistence are commonly stressed (e.g. Chapters 4, 6, 8, 9–11, 15 and 18). This result makes this book very different from many archaeological accounts of disaster, which we believe have over-emphasised the natural forces over the cultural responses.

Modern disaster managers measure the impacts of disasters in terms of deaths and economic costs. Archaeologists, however, are more interested in the implications of these losses for causing cultural change. Their work raises the extremely knotty question about whether a particular disaster had a *significant* effect on the social group(s) that sustained it or interacted with it either locally or on a larger regional scale (cf. Chapters 6, 11 and 16).

Judging from this set of papers, archaeology lacks an agreed definition of 'significant' change and lacks a fully satisfying account of what constitutes causation in relation to a disaster. Does the change need to involve the introduction of new behaviour traits or material culture, a total replacement of a culture, a societal collapse, or simply the abandonment of a farmstead? Although most authors here have looked for fairly drastic change as evidence for significant effects, those studying the more recent periods (e.g. Chapters 3 and 4) are impressed by what archaeologists might consider rather small-scale changes in settlement structure and pattern, and a number of authors have dealt with the issue of mythology and oral history as demonstrating important effects (see below; cf. Blong, 1982).

Second, does the disaster need to have direct effects or can it be a catalyst for change (cf. Blong, 1984: 180–4)? Furthermore, does the change need to follow immediately or can one also posit long-term, follow-on effects that might last several hundred years? For example, Manning and Sewell (Chapter 15) are only satisfied if the cultural change can be linked in a 'direct, immediate or quantifiable way'. Most of the rest of the authors are willing to consider a rather longer period of time and a range of effects. For example, Allison's (Chapter 7) paper demon-

strates that some disasters can continue to have an effect many hundreds of years after the event. Longer-term effects have also been proposed by Kornbacher (Chapter 12), who argues that cultural evolutionary processes can result from natural disasters. Crittenden and Rodolfo (Chapter 4) point out that in some cases the worst effects are not experienced until long after the forcing event. In their case lahars (mudflows) from the Pinatubo eruption in the Philippines created serious damage five years later and at the time of writing, nearly 10 years after the initial event, they were still a significant threat to life and property. Driessen (Chapter 14) argues that indirect, follow-on effects of a disaster can accelerate a process that is already in motion (cf. Blong, 1984: 186; Oliver-Smith, 1996: 313).

Temporal and spatial scales

Whether cultural change has been defined as ‘significant’ depends very much on the temporal and spatial scale of the research. In the short term, many of the disasters studied in this book would have been termed ‘catastrophic’ by modern students of natural hazards because they led to large losses of life and/or property, sometimes over very large regions. In many cases a site or region was abandoned following the event. One controversy that arises and has not been handled satisfactorily is establishing whether abandonment of a site or region is a form of cultural change and if so, what length of time is required to label this ‘significant’ cultural change. For example, Torrence (Chapter 16) detected a period of abandonment up to 1,000 years long in Papua New Guinea following a volcanic eruption, but when the region was recolonised, there was virtually no difference in the material culture assemblage. Clearly the local group had been seriously affected by the disaster since it ceased to exist, but the larger regional population which recolonised it many years later had not experienced serious impacts: the basic stone toolkit had remained unchanged. What appears to have been an immediate and catastrophic cultural disaster in the immediate short term appears as nothing of the sort when considered over a longer time scale as the landscape is recolonised and utilised afresh. What we cannot even begin to guess at, however, is whether the *lack* of change is actually due to the effects of the volcanic eruption and drastic reduction in population. Perhaps the eruption caused a cessation in changes that were previously in motion: i.e. it retarded rather than promoted change. Perhaps the only way to resolve the issue of significance in situations like these is to work on multiple time scales, rather than to impose an arbitrary overall measure of what constitutes ‘significant’ cultural change.

There are clear differences between the way volcanic eruptions and other hazards are perceived by those exposed to them during their daily lives, the descendants of those who experienced them, those who report them at a temporal or physical distance, and the excavators and interpreters of the physical debris of past events. The effects of disasters often live on far beyond the time when they occurred. One of the issues we were interested in investigating was the role of oral history and mythology about past disasters in guiding later responses to similar events. Certainly stories about disasters have been passed down in many communities (cf. Blong, 1982), but do they have a more pragmatic effect, as for

example in regulating social behaviour? None of the authors who addressed this topic found clear evidence supporting this hypothesis. For example, the myths in Vanuatu (Chapter 9) depicted disasters as purely social rather than natural events. Johnson (Chapter 11) argues that Aleuts have a folklore concerned with natural hazards, but this is almost entirely dominated by storms at sea – an immediate and ever-present danger to people who rely upon the sea for so much of their livelihood. Earthquakes and volcanic eruptions are mentioned but only impinge on peoples' lives indirectly. A far more important and immediate threat was the activities of other Aleut groups with whom they may have been in competition. In contrast, Davies (Chapter 3) highlights one of the problems with modern studies of oral history among communities where the social fabric has broken down and traditional stories are no long passed on.

The memories and effects of disasters do not always just fade away. Past disasters can be resurrected and used within modern contexts. For example, Bryne (1997; 1999a) has discussed how the physical remains of disasters continue to play a very active part in political struggles long after they have occurred. Memories can be extremely powerful. He has argued that governments in the Philippines and in Bali have taken active measures to obliterate and hide the physical remains of, in this case social, disasters. He has also demonstrated that memories about ancestors can be awakened and preserved through a focus on places where disasters took place (Bryne, 1999b). Allison (Chapter 7) discusses how the events of AD 79, the destruction of Pompeii and Herculaneum, and their burial under many metres of volcanic debris, has coloured modern impressions of the nature of volcanic disasters. Given the predominance of this event in modern scholarship and popular imagination, it is surprising to find out that the wider region affected by this eruption, the *Palma Campania*, was not abandoned, the culture did not change, and the buffering offered by the Roman empire was considerable. We should keep in mind, however, that the events of AD 79 were not the first such catastrophe to have an impact on this region and its cultures.

The problems of temporal scale are especially important for slow-onset events, such as climatic change, which require a different modelling procedure. For example, in Switzerland, Menotti (Chapter 13) shows that climate change appears to have caused a rise in lake levels leading to significant cultural change that occurred over the space of two generations. While the inundation of previous lake shores and consequent destruction of settlements may have been relatively rapid, the cultural response was not immediate. In the face of such events, communities have time to consider a number of strategies before the final response is adopted. A somewhat comparable situation may have arisen with rapid-onset events. The response need not have been immediate if the damage was not devastating. In some instances groups could take their time over considering whether, when and how to resettle.

Focus on variability

In our view there has been too much emphasis on trying to decide how much impact is enough to be considered as important. This has skewed the research

such that only the most devastating events are accepted as valid (cf. Chapter 16). The best way forward is to adopt the procedure used by Shimoyama (Chapter 18). He acknowledges that a wide range of effects from disasters can be expected and should be monitored. In this approach all events are considered as 'significant' despite a substantial range in the nature and degree of cultural change. In fact, arguments over the 'significance' of a disaster in terms of the scale of its impacts on social life detract from the more important task of assessing the nature and degree of the interrelationships among the forcing event, the hazard, vulnerability of communities, and outcome. For understanding why some extreme natural events have a different and perhaps larger impact than others, it would be useful to conduct detailed and systematic analyses which present the cultural outcomes of the extreme environmental event over a number of temporal and spatial scales.

CRITICAL VARIABLES

At this preliminary stage of archaeological research on disasters, it would be worthwhile to move on from the controversy about whether disasters as a general phenomenon are culturally significant or not and focus attention on the very wide range of responses that have been observed. A productive approach would be to examine a range of variables characterising the natural forcing mechanisms and the cultural responses to see if any general patterns can be detected. Historical and modern studies, such as those presented in Chapters 3–7, would play a particularly important role in this exercise. It is hoped that this book will stimulate someone to take on this task as a major piece of research. At this early stage, however, one can already detect some intriguing patterns resulting from the case studies presented in this volume and these could serve as hypotheses for future research.

Magnitude

It is quite clear that the magnitude of a natural hazard is not the sole or even a straightforward predictor of its cultural impact. It requires a conscious act of discipline on the part of the modern archaeologist or geographer studying the impact of a historical or prehistoric natural hazard to analyse the data carefully. A part of one's judgement is naturally coloured by the magnitude of the event, as it is uncovered through a research project. The geographical extent of a tephra fall and its thickness, buildings which show signs of damage, tsunami deposits, narrow tree rings and ice-core acidity all tempt us to assume significant environmental forcing and disaster. However, the studies presented in this volume suggest that while the influence of natural hazards is a factor that may be considered in many regions of the world, few severe environmental events have been responsible for major cultural change.

Perhaps one of the best examples of the absence of a simple correlation between scale and outcome is presented by Grattan *et al.* (Chapter 6). In this case the effects of air pollution on a vast continental scale, which was caused by a volcanic eruption, is revealed. All the material which illuminates this event points

to a major disaster: crops were destroyed in the field from Scandinavia to southern Europe; plants were defoliated; people fell sick and even died. Contemporary writers described profound social unease and even panic and it is not exaggerating to suggest that people feared Armageddon and the end of the world. In the historical record the severe air pollution event was shortly followed by the French Revolution and the Napoleonic Wars. Were we considering this material from a distance of 2,000 rather than just over 200 years, we might be comfortable to associate all these events. Reality is rather different. Severe as they were, the events of 1783 did not enter folklore, European agricultural production easily compensated for the destroyed crops and agricultural prices were stable. Even occasional episodes of high mortality do not appear to have unduly troubled the late eighteenth-century communities affected – perhaps because episodes of this kind were seen as the natural order of things. All things considered, although the magnitude of the event was high, the geographical extent of the hazard was continental and the environmental impact was severe, the concentrated sulphuric acid aerosol, which blanketed the continent of Europe in 1783, did not lead to cultural change. European culture and environment were not sufficiently vulnerable to a hazard of this nature and were adequately buffered against its impact.

This historical case provides several very important lessons for prehistoric archaeologists, who can rarely detect events on a yearly basis. First, only a very detailed dating programme would show that a major cultural event that followed not long afterwards (warfare) was not caused by the severe environmental event. Second, the magnitude of the event was not the key variable. Third, it emphasises the importance of vulnerability in determining the ultimate outcome of a disaster.

Duration and frequency

The duration and frequency of the forcing events are likely to be key factors in determining the scale of cultural response. Familiarity with the risks involved should ensure that the environmental and physical risks are continually weighed and socially controlled. People appear to be willing to take quite high risks in the case of rare events in order to reap short-term benefits. Maintaining settlement in locations which are subject to infrequent hazards such as earthquakes and tsunamis is a good example. In Chapters 3, 4 and 9–11 groups are shown to have chosen to ignore natural hazards. In these cases the long-term benefit of locating a settlement in a particular location or the lack of suitable alternatives appear to override any concern relating to rare, if catastrophic, environmental events.

In contrast, disasters which occur frequently or over a relatively long period of time can intensify evolutionary development and engender rapid change. For example, Kornbacher (Chapter 12) considers the response of the Moche culture in Peru to a significant range of natural hazards due to the effects of El Niño, including massive flooding and erosion, dune incursion and mass wasting. It is apparent that in response to the influence of a series of environmental catastrophes, these people adapted their subsistence strategies, moved settlements to different locations and developed different, more efficient, building techniques. In essence,

however, they retained many of the preceding cultural traits. Furthermore, the influence of the natural hazards in this case appears to have been to stimulate rather than devastate the culture. This 'positive' response is one that is rarely considered in studies of disasters and should be studied more widely in parts of the world that are subjected to frequent hazards over a relatively long time period.

Perception

Is it safe to assume that exposed communities view a hazard as a threat? Modern studies have shown that the perception of hazards is critically important to how a community reacts to a forcing mechanism (e.g. Bryant, 1991: 259–60). Mbunwe-Samba (1999) has presented a very graphic study of how the community affected by the catastrophic Lake Nyos gas explosion has failed to come to terms with the event because the survivors have not found an acceptable explanation for the sudden deaths. In this case the absence of a clear perception has markedly delayed recovery from the disaster.

On balance, the case studies presented here show that people at risk are more overtly concerned with the social rather than the natural world. For example, Johnson's (Chapter 11) study of 87 Aleut Eskimo tales and narratives found that only eight mentioned natural hazards, a result that is confirmed by Saltonstall and Carver's (Chapter 10) review of folklore from the neighbouring Kodiak Archipelago. The perception that earthquakes are not a severe threat in this region is borne out by the archaeological data, which fail to show any correlation between earthquake incidence and cultural change. Lowe *et al.* (Chapter 8) also found very little oral history among the Maori in New Zealand concerning volcanic hazards. In Chapter 9 Galipaud argues that in Vanuatu natural disasters are perceived as social rather than natural events. Furthermore, since extreme environmental events are seen as caused by humans rather than as natural occurrences, they are not feared. In modern-day Papua New Guinea, people also believe that the disastrous tsunami which they experienced was humanly generated and they were clearly uncomfortable with the explanation provided by the earth scientists (cf. Chapter 3). In other cases the forcing event was ascribed to the actions of supernatural beings or deities (e.g. Chapters 2, 8 and 10).

Survivor mentality may also be a critical factor in how people recover from a disaster. Gibbs (Chapter 5) describes the experiences of the survivors of a shipwreck. From these experiences it is evident that in certain survival situations the preceding social order may be subsumed by the activities of a single group and the long-term welfare of the greater community compromised to satisfy the short-term goals of a single segment of the society. Conflict between sections of the survivor community may then occur, with an unpredictable outcome. Driessen (Chapter 14) and Satoru (Chapter 2) also argue that the community's perceptions of a disaster can be instrumental in how the population reacts. They also point out that different perceptions of the disaster on the part of the victims and the authorities in charge of disaster relief can lead to conflicts and/or may prolong the suffering (cf. Chapters 3 and 4).

Vulnerability

Social scientists emphasise vulnerability as the most important factor in understanding the variability in how societies react to disasters (e.g. Torry, 1979; Blaikie *et al.*, 1994; Oliver-Smith, 1996) and their findings are echoed in most of the studies presented here. Recent works especially focus on how particular social settings create vulnerable communities by reducing their ability to recover (e.g. by creating poverty) or by placing them in hazardous settings, which would not normally be settled (e.g. floodplains, hillsides prone to landslides, etc.). Although attachment to place is identified as a factor in making Bacolor and neighbouring towns highly vulnerable to the mudflows from continuing Pinatubo, Crittenden and Rodolfo (Chapter 4) also note that the people had virtually nowhere else to go. This type of socially induced vulnerability is probably most relevant for highly complex societies in the modern world, but a very broad notion of vulnerability – in terms of the ability of a community to return to its previous state – is clearly most important in explaining the wide range of responses illustrated by the papers in this book.

Are simple societies less able to respond to the pressure generated by the occurrence of natural hazards? While this may be the view of some natural scientists considering modern hazards (e.g. Chester, 1993; Blong, 1984: 186, 387), anthropologists have proposed the opposite view (cf. Torry, 1979: 523; Oliver-Smith, 1996), and the archaeological record suggests that ancient cultures were in fact highly resilient.

These issues are discussed in detail in Chapter 16, where cases from prehistoric Costa Rica and Papua New Guinea are considered. In terms of the former, 10 volcanic eruptions occurred within a space of 4,000 years, yet archaeologists detected relative cultural stability (Sheets *et al.*, 1991). One might argue, however, that the Costa Rican eruptions were relatively moderate in terms of severity and it is therefore not surprising that little cultural response has been observed. In contrast, during the past 6,000 years prehistoric groups in West New Britain province of Papua New Guinea have been exposed to a series of exceptionally large volcanic eruptions, which probably devastated the vegetation across vast areas of this island. Yet even here severity of the hazard event itself is not the sole factor determining cultural response. Clearly, in addition to the severity and scale of the natural hazard, social variables are critical to the way groups recover from and may change in response to disasters.

A number of papers have discussed why the disasters that they studied had very little impact on long-term cultural behaviour. For example, Saltonstall and Carver (Chapter 10) argue that the Alutiiq were not severely affected by the relatively frequent earthquakes in the region. Since they were highly mobile and maintained long-distance contacts, relocation could be undertaken relatively easily. Adaptation of cultures to hazards is also illustrated in Chapter 8. As far as can be established, it appears that Maori culture in New Zealand was not unduly perturbed by volcanic activity. Areas under the most direct threat – i.e. proximal to the volcano – were apparently utilised for transient activities, settlement only

occurring as a last resort during times of political crisis. Indeed, the designation of zones of known or perceived risk as sacred areas placed out of bounds may be a codification of a practical necessity.

In Chapter 18 we can see that in many cases Japanese communities simply adapted to the occurrence of hazards and accommodated their routine to it. Even in Japan, with its many active volcanoes whose eruptions must have caused extreme hardship, as detailed by Machida and Sugiyama (Chapter 17), Shimoyama (Chapter 18) argues that cases where outright abandonment occurs following a volcanic event may have been relatively rare. The problem here is to find out whether the differences in ceramic styles between the archaeological contexts above the volcanic tephra and those buried beneath it were a direct result of the volcanic disaster or were due to normal cultural change.

LOOKING AHEAD

The incidence of disasters is said to be increasing in the modern world (e.g. Tobin and Montz, 1997: 2), and consequently the amount of resources invested in the study and mitigation of natural hazards has increased dramatically. It is perhaps not surprising, then, that archaeological speculation about the impact of disasters in the ancient world has also become very popular. Although we argue that the study of past disasters can make a very useful contribution to archaeological method and theory, because it provides an alternative to a previous focus on adaptation and stability, the case studies presented here do not present unmitigated support for the role of disasters in causing cultural change. Many human communities have occupied very risky and hazardous environments and have therefore experienced disasters relatively frequently. The impact of these events on the individuals who survived them must have been overwhelming, judging from our recent case studies. People experienced huge losses in terms of deaths of kin and friends and destruction of property. Despite the enormous damage sustained in the short term, most of the disasters studied by the authors in this volume had very little if any effect on cultural change, when viewed over more than a few generations. Of the exceptions, the Santorini eruption may have only been a catalyst in a process that was already under way (although even this is controversial), settlement change in Switzerland was slow to react, and the nature of cultural replacements in Papua New Guinea and Japan are as yet difficult to interpret. Only Kornbacher (Chapter 12) has provided evidence for a concatenation of disasters caused by El Niño to have led to significant cultural change over the very long term. Her paper raises the important issue that most archaeologists have been expecting disasters to cause cultural collapse or breakdown rather than evolution. Previous work may have focused too narrowly on individual events rather than view the risky environment itself as something which could shape cultural change. Adopting this more positive approach might lead to productive reanalyses of cultural processes among communities living in risk-prone environments.

The key variable identified in these studies has been what is loosely called in modern disaster research the 'vulnerability' of the societies in question. Mobile subsistence and settlement patterns and/or extended social networks appear to have been particularly important because they have enabled groups to resist change by moving temporarily to other areas. Alternatively, some groups made huge efforts to resist change or put themselves at risk because they had a strong attachment to place (or nowhere else to go). Why do some groups emigrate and others stay? More detailed research is needed to understand the myriad range of ways that societies have coped with the disasters that they have faced. We also have a very poor understanding of how groups assess risk and how they respond to it. Most of the studies suggest that even when they are recognised, long-term risks are ignored in favour of short-term economic gains (cf. Grayson and Sheets, 1979: 626). If this is the case, do communities take account of the risks by maintaining memory of how to adapt through story-telling or other behaviour patterns that are only rarely called into use? Or are certain behaviours which enable flexible responses, such as mobility and exchange networks, actually long-term outcomes of living with disasters? Much more research is necessary to address these questions using events with suitably long time spans.

A more flexible approach to the question of what constitutes a 'significant' response to disasters would also provide productive research. To date past disasters have either been totally ignored by archaeologists or used in a very uncritical way to account for cultural change. This 'all or nothing' approach glosses over what must have been a wide range of responses to disasters of varying magnitudes and frequencies by groups with different social and economic structures. Some of that range is illustrated in this volume, which demonstrates the value of looking at recent cases as well as those represented in the archaeological record, but many more detailed and critical studies are required before we have enough data to adequately assess the role of disasters in human history. It is hoped that these studies demonstrate the importance of disasters in raising questions about human adaptation and change and will pave the way to further research.

REFERENCES

- Ambrose, S. (1998) Late Pleistocene human population bottlenecks, volcanic winter, and differentiation of modern humans. *Journal of Human Evolution* 34: 623–51.
- Blaikie, P., Cannon, T., Davis, I. and Wisner, B. (1994) *At Risk: Natural Hazards, People's Vulnerability, and Disasters*. London: Routledge.
- Blong, R. (1982) *The Time of Darkness: Local Legends and Volcanic Reality in Papua New Guinea*. Seattle: University of Washington Press.
- Blong, R. (1984) *Volcanic Hazards: A Sourcebook on the Effects of Eruptions*. Sydney: Academic Press.
- Bryant, E. (1991) *Natural Hazards*. Cambridge: Cambridge University Press.
- Byrne, D. (1997) The archaeology of disaster. *Public History Review* 6: 17–29.
- Byrne, D. (1999a) Human disasters and heritage lies. Paper presented at the Fourth World Archaeological Congress, Capetown, South Africa.

- Byrne, D. (1999b) *In Sad but Loving Memory: Aboriginal Burials and Cemeteries of the Last 2000 Years in NSW*. Sydney: NSW National Parks and Wildlife.
- Chester (1993) *Volcanoes and Society*. London: Arnold.
- Cullen, H., de Menocal, P., Hemming, S., Hemming, G., Brown, F., Guilderson, T. and Sirocko, F. (2000) Climate change and the collapse of the Akkadian empire: evidence from the deep sea. *Geology* 28: 379–82.
- Driessen, J. and Macdonald, C.F. (1997) *The Troubled Island. Minoan Crete Before and After the Santorini Eruption* (Aegaeum 17). Liège and Austin: Université de Liège.
- Fagan, B. (1999) *Floods, Famines, and Emperors: El Niño and the Fate of Civilizations*. New York: Basic Books.
- Giller, R. (2001) *The Great Maya Drought*. Albuquerque: University of New Mexico Press.
- Glickman, T., Golding, D. and Silverman, E. (1992) *Acts of God and Acts of Man: Recent Trends in Natural Disasters and Major Industrial Accidents*. Center for Risk Management, Discussion Paper 92-02. Washington, DC: Resources for the Future.
- Gould, S. (1989) *Wonderful life. The Burgess Shale and the Nature of History*. New York: W.W. Norton.
- Grayson, D. and Sheets, P. (1979) Volcanic disasters and the archaeological record. In P. Sheets and D. Grayson (eds) *Volcanic Activity and Human Ecology*, 587–622. New York: Academic Press.
- Harris, S. (2000) Archaeology and volcanism. In H. Sigurdsson (ed.) *Encyclopedia of Volcanoes*, 1301–14. San Diego: Academic Press.
- Isaacson, J. and Zeidler, J. (1999) Accidental history: volcanic activity and the end of the formative in northwestern Ecuador. In P. Mothes (ed.) *Actividad Volcanica y Pueblos Precolombinos en el Ecuador*, 41–72. Quito: Ediciones Abya-Yala.
- Keys, D. (2000) *Catastrophe: A Quest for the Origins of the Modern World*. New York: Ballantine.
- Mbunwe-Samba, P. (1999) The Lake Nyos catastrophe. Was it man-made or a natural disaster? What do non-scientists say? Paper presented at the Fourth World Archaeological Congress, Capetown, South Africa.
- McCoy, R. and Heiken, G. (2000) *Volcanic Hazards and Disasters in Human Antiquity*. Geological Society of America Special Paper 345.
- McGuire, B. (1999) *Apocalypse. A Natural History of Global Disasters*. London: Cassell.
- McGuire, W., Griffiths, D., Hancock, P. and Stewart, I. (eds) (2000) *The Archaeology of Geological Catastrophes*. London: Geological Society Special Publication 171.
- Moseley, M. (1997) Climate, culture, and punctuated change: new data, new challenges. *The Review of Archaeology* 18: 19–27.
- Newhall, C. and 17 others (2000) 10,000 years of explosive eruptions of Merapi volcano, Central Java: archaeological and modern implications. *Journal of Volcanology and Geothermal Research* 100: 9–50.
- Nur, A. and Cline, E. (2000) Poseidon's horses: plate tectonics and earthquake storms in the late bronze age Aegean and eastern Mediterranean. *Journal of Archaeological Science* 27: 43–63.
- Oliver-Smith, A. (1986) *The Martyred City: Death and Rebirth in the Andes*. Albuquerque: University of New Mexico Press.
- Oliver-Smith, A. (1996) Anthropological research on hazards and disasters. *Annual Review of Anthropology* 25: 303–28.
- Peiser, B., Palmer, T. and Bailey, M. (eds) (1998) *Natural Catastrophes During Bronze Age Civilizations: Archaeological, Geological, Astronomical and Cultural Perspectives*. British Archaeological Reports International Series 728. Oxford: Archaeopress.
- Sadler, J. and Grattan, J. (1999) Volcanoes as agents of past environmental change. *Global and Planetary Change* 21: 181–96.
- Schoch, R. and Aquinas, R. (1999) *Voices of the Rocks: A Scientific Look at Catastrophes and Ancient Civilizations*. New York: McNally.

- Sheets, P. and Grayson, D. (1979) Introduction. In P. Sheets and D. Grayson (eds) *Volcanic Activity and Human Ecology*, 1–8. New York: Academic Press.
- Sheets, P., Hoopes, J., Melson, W., McKee, B., Sever, T., Mueller, M., Cheanult, M. and Bradley, J. (1991) Prehistory and volcanism in the Arenal area, Costa Rica. *Journal of Field Archaeology* 18: 445–65.
- Siebe, C., Abrams, M., Macias, J. and Obenholzner, J. (1996) Repeated volcanic disasters in prehispanic time at Popocatepetl, central Mexico: past key to the future? *Geology* 24: 399–402.
- Stiros, S. and Jones, R. (eds) (1996) *Archaeoseismology*. Fitch Laboratory Occasional Paper 7. Athens: British School of Athens.
- Terrell, J. (1988) History as a family tree, history as an entangled bank: considering images and interpretations of prehistory in the South Pacific. *Antiquity* 62: 642–57.
- Tobin, G. and Montz, B. (1997) *Natural Hazards: Explanation and Integration*. London: The Guilford Press.
- Torrence, R., Pavlides, C., Jackson, P. and Webb, J. (2000) Volcanic disasters and cultural discontinuities in the Holocene of West New Britain, Papua New Guinea. In B. McGuire, D. Griffiths and I. Stewart (eds) *The Archaeology of Geological Catastrophes*, 225–44. London: Geological Society Special Publication 171.
- Torry, W. (1979) Anthropological studies in hazardous environments: past trends and new horizons. *Current Anthropology* 20: 517–41.
- Van der Leeuw, S. and McGlade, J. (eds) (1997) *Time, Process, and Structured Transformation in Archaeology*. London: Routledge.
- Weiss, H. and Bradley, R. (2001) What drives societal collapse? *Science* 291: 609–12.
- Zeidler, J. and Isaacson, J. (in press) Settlement process and historical contingency in the Western Ecuadorian Formative. In J. Raymond and R. Burger (eds) *Dumbarton Oaks Conference on the Archaeology of Formative Ecuador*. Washington, DC: Dumbarton Oaks Research Library and Collection.