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Social and biophysical vulnerability of prehistoric societies to Rapid Climate Change

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ABSTRACT – *Previous studies of the impact of Rapid Climate Change (RCC) on prehistoric communities have often been restricted in their explanatory power due to the lack of an appropriate analytical tool capable of combining palaeoclimate data with archaeological culture. In this paper, we seek to remedy this shortfall by introducing theoretical-methodological concepts adapted from modern vulnerability and risk studies. Using this approach, our focus shifts from climate proxies to prehistoric cultures themselves.*

IZVLEČEK – *Prejšnje študije vpliva hitrih klimatskih sprememb (HKS) na prazgodovinske skupnosti so bile pogosto nepopolne zaradi neprimernih analitskih orodij pri povezovanju paleoklimatskih podatkov z arheološkimi kulturami. V članku želimo to pomanjkljivost odpraviti s pomočjo prevzetega teoretsko-metodološkega koncepta v modernih študijah o ranljivosti in tveganju. Pozornost usmerjamo od klimatskih dejavnikov k prazgodovinskim kulturam.*

KEY WORDS – *Rapid Climate Change (RCC); biophysical vulnerability; social vulnerability; coping strategies; Anatolia; Neolithic*

Introduction

An understanding of complex cultural and social behaviour not only requires consideration of a plethora of extrasomatic systems, *e.g.* technology, social relations, symbolism, religion, and language, but also calls for studies which seek to comprehend inherent mechanisms devoted to the long-term maintenance of cultural traditions, which, should the need arise, switch to some entirely new mode of existence, often within an astonishingly brief time span. Such complex and at first apparently stable and continuous cultural development interrupted by an often remarkably rapid system response is what makes the study of all human societies so challenging, and this is nowhere more apparent than when dealing with prehistoric communities. At present, however, we have only minimal empirical data to evaluate the sensitivity of prehistoric communities to natural hazards. Neither do we dispose of any useful (generally applicable) theoretical tools to predict how these communities might have reacted in hazardous situations. In fact, our understanding of societal vulnerability in the prehistoric periods is so limited that – to begin – we must simply state that we have no (generalisable) theory at all (worthy of the name) by which insights can be gained into whether prehistoric communities were sensitive (or not) to natural hazard events. In particular, we understand very little of the societal impact of abrupt climate change. This general lack of theory has its background in the historical development of modern archaeology.

Domestication of Natural Disasters

Traditionally, modern archaeological theory views the evolution of social complexity as an internally generated and linear process that has unfolded progressively through time. This trait can be traced back as far as Childe, who noted that progress has consisted essentially in the improvement and adjustment of the social tradition (*Childe 1936.30*). Indeed, among the most drastic shortcomings of related approaches are their predominantly descriptive character. To begin with, this leads to the failure of contemporary archaeological theory to place serious focus on the societal impact of natural disasters, including the often important role played by climate variability, but also to an underestimation of the role of factors such as chaos, chance and the unexpected (*e.g. Terrell 1988*). Indeed, the influence of adverse climate, as well as other forms of environmental crisis, catastrophe and disaster, has long been eyed with scepticism. As a result, such factors are seldom taken seriously as triggers of cultural change. Often, the societal impacts of volcanic eruptions, earthquakes, tsunamis, or of a repeated series of severe winters or prolonged droughts, even warfare, are simply taken as one-off events, which are consequently assumed to have little lasting societal impact (*i.e.* 'storms in teacups'). The more general view is that the specific societal transformation would have occurred anyway – although perhaps somewhat later. The basic assumption here is that the effects of most natural hazards will be automatically absorbed by societal mechanisms in the course of the prevailing cultural cycle. Consequently, very little thought has been given to the lasting impact of environmental disasters on prehistoric cultures.

Climatic vulnerability of prehistoric societies

In the past few years, major advances in palaeoclimatology have provided a range of new perspectives for archaeologists, both for the Pleistocene and the Holocene. In recent contributions (*Weninger et al. 2006; 2009; Clare et al. 2008; Weninger and Clare 2010; Clare in press*) we have indicated temporal coincidences of some major cultural transitions in the eastern Mediterranean and specific meteorological mechanisms underlying Rapid Climate Change (*sensu Mayewski et al. 2004; Rohling et al. 2002*) which could be causally related. In the present paper, we take these previous studies one step further by introducing a set of theoretical-methodological concepts adapted from contemporary vulnerability and risk studies. In so doing, we move on from the initial task of simply identifying geographic regions and archaeological settlement phases which might have been prone to impacts of RCC to a more detailed analysis of underlying societal vulnerability in these regions. However, before continuing, we briefly review the RCC mechanism, aspects of which will be referred to further below.

Rapid Climate Change (RCC)

The existence of rapid fluctuations in Northern Hemispheric Glacial and Holocene atmospheric circulation patterns was first recognised some twelve years ago in a detailed analysis of the GISP2 (Greenland) ice-core glaciochemical record (*Mayewski et al. 1997*). These studies showed that during the Little Ice Age (LIA) in the Northern Hemisphere, and especially during winter months (December/January/February), the Siberian High, the Icelandic Low and the Azores High were all more intense than during the Medieval Warm Period (MWP). In brief, one of the main causes of the LIA, in addition to solar intensity variation, appears to have been a strengthening of the atmospheric pressure gradients between Siberia (High), Iceland (Low) and the Azores (High). Such pressure gradients not only lead to a strengthening of westerlies over the North Atlantic and Europe, but also support the regular influx of cold air masses from Siberia into the eastern Mediterranean (see below).

Subsequent comparisons of the GISP2 glaciochemical record with terrestrial and marine records on a global scale have demonstrated the existence of six distinct time-intervals, each of which showed major cooling anomalies during the Holocene (*Mayewski et al. 2004*). The ages attributed to these (wider) Rapid Climate Change (RCC) intervals are: 9000–8000, 6000–5000, 4200–3800, 3500–2500, 1200–1000, and 600–150 calBP. The most recent of these RCC-intervals corresponds to the LIA. The extent of global cooling that occurred during these periods is evident in widespread glacier advances in both hemispheres and in a strengthening of westerlies over the North Atlantic and Europe. Our idea, therefore, was to provide a more detailed analysis of archaeological sites in the eastern Mediterranean which were potentially affected by RCC-conditions (*Weninger et al. 2009*).

In the eastern Mediterranean, for all the periods mentioned above, the RCC conditions under study are characterised by one and the same, and indeed a quite significant, meteorological mechanism that is well-known from modern observations. This mechanism is not only evident in the palaeoclimate record of the eastern Mediterranean, but is also well-dated by the high-resolution Greenland ice-core record. This is of immediate interest for archaeological RCC-studies, since many prehistoric sites have been dated by the radiocarbon method, and calibrated ^{14}C-ages (despite all their shortcomings) can be placed in direct context with the respective climate records. As first recognised by Rohling *et al.* (*2002*), there is a strong correlation between Greenland GISP2 terrestrial potassium [K^+] peak values and sea-surface temperature (SST) fluctuations, as consistently observed at many core locations in the eastern Aegean. These apparently quite regularly (and abruptly) occurring SST-fluctuations were first measured in core LC21, located east of Crete. As previously noted, modern meteorological observations show that a strengthening of the atmospheric pressure gradients between Siberia (High), Iceland (Low) and the Azores (High) supports an influx of cold air from Siberia into the eastern Mediterranean. The rapid sea surface cooling, as initially observed in LC21, and recently confirmed in further cores (*e.g.* SL21 and MNB3) can therefore be plausibly related to this cold air influx with its source (ultimately) in Siberia. Today, these winds are known as the Mistral, Bora and Vardar, depending upon where they enter the Mediterranean basin (Fig. 1).

The remarkable intensity of the cold north-easterly winds is attested by their capacity to induce surface water cooling in the eastern Aegean. The surface water cooling is all the more remarkable, since the underlying cold air influx typically occurs only for a brief time each year, *i.e.* some few days or weeks during winter and early spring. In support of this interpretation, and due to the specific interest in this mechanism in large parts of the palaeoclimate community, a steadily increasing number of palaeoclimate records are now available from the eastern Mediterranean, the Balkans and north-western Anatolia. Although differing in many details (depending on the specific climate proxy under study), in combination all these records give an indication of the quite regular occurrence of some extreme cooling events in the course of the entire Holocene. An up-to-date selection of published records (June 2010), with an emphasis on records with the highest dating resolution, is shown in Figure 2. In summary, it appears that during RCC-periods, and well-dated by Greenland ice-cores, the eastern Mediterranean was regularly bathed in some of the coldest air masses to be found anywhere on the globe.

Time intervals for RCC

In continuation of previous studies on the societal impact of RCC we have identified a set of shortened (delimited) time-intervals for which we may expect the strongest impact of RCC-conditions. These intervals are as follows: 10.2–10 ka calBP, 8.6–8.0 ka calBP, 6.0–5.2 ka calBP, and (more accurately definable) 3.05–2.90 ka calBP (*Weninger et al. 2009*).

Geographic corridor for RCC

Additionally, based on modern meteorological analogues, we have undertaken efforts to specify the geographic regions in the eastern Mediterranean for which the strongest RCC-impact may be expected. These regions are situated along what we call the 'RCC-corridor', which runs from the Ukraine, through south-eastern Europe, into the Aegean. The RCC-corridor covers large parts of Anatolia and the Levant, as well as the islands of Cyprus and Crete. With the definition of RCC-time windows and the geographic RCC-corridor, we know (approximately) where and when we are most likely to encounter maximal potential societal RCC-impact. These studies are still in their infancy, and although we undoubtedly require a much more detailed geographical framework, as can only be defined by more precise (micro-regional) bio-climatic studies, we nevertheless expect to best identify the societal impact of RCC in semi-arid and/or high altitude (mountain) regions (*e.g.* in the highlands of the southern Levant, and in the Konya plain, Central Anatolia) in contrast to the generally milder coastal areas. However, whether these expectations actually correspond to the archaeological reality is

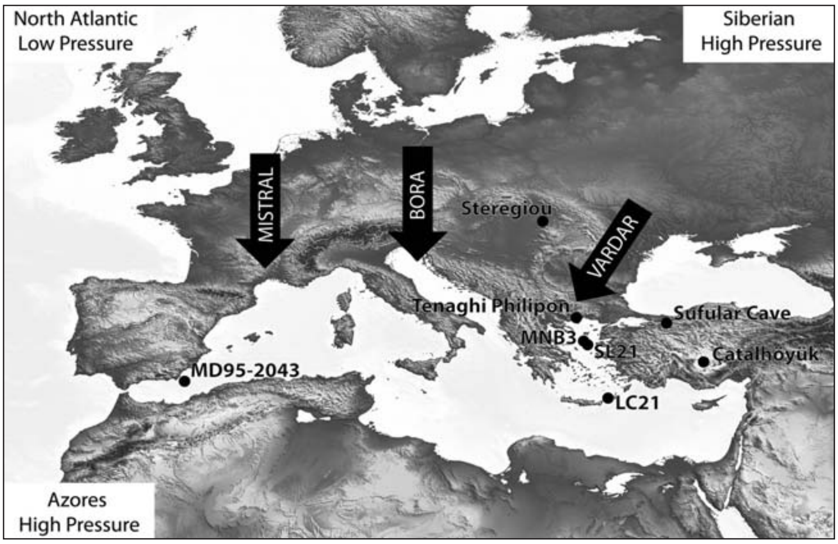

***Fig. 1. Sites mentioned in this text and important RCC winds. SRTM Global Batymetry Data: courtesy of* Becker et al. 2009.**

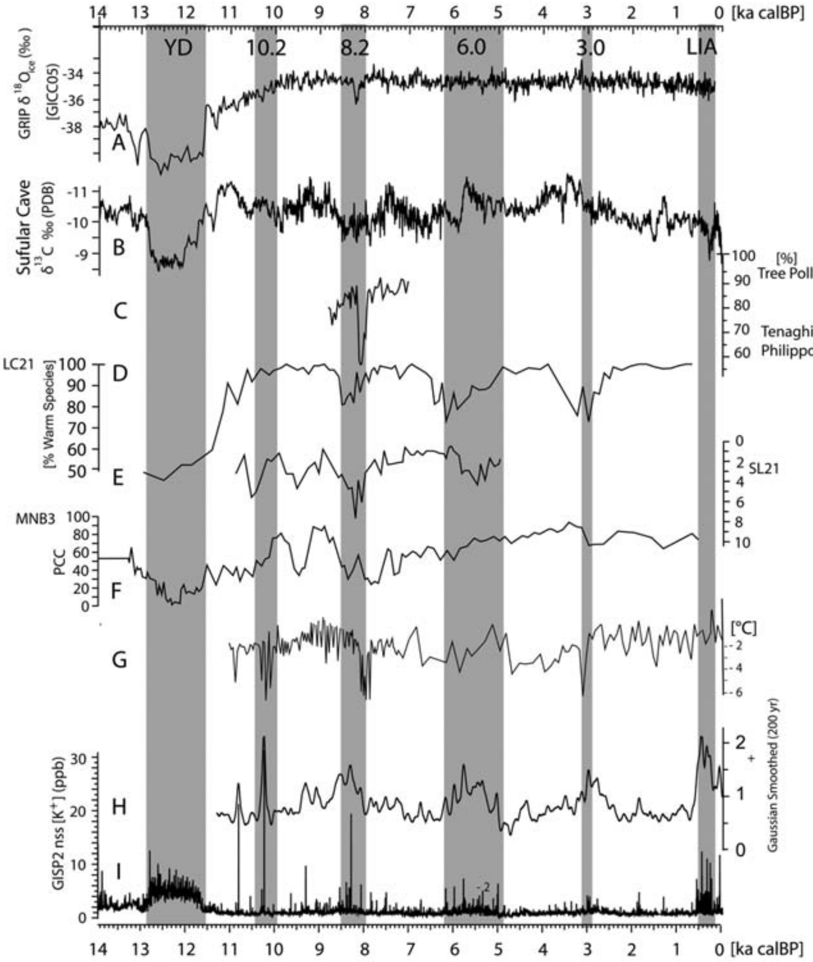

Fig. 2. Selected Palaeoclimate Records showing Holocene Rapid Climate Change (RCC) (for locations **cf.** ***Fig. 1), (A) GRIP ice-core δ18O as proxy for air-temperature over Greenland (*****Grootes et al. 1993*****); (B) Sufular Cave δ13C as proxy for tree/steppe vegetation (*****Fleitmann et al. 2009*****); (C) Tenaghi Philippon Tree Pollen as proxy for tree/non-tree vegetation (*****Pross et al. 2009*****); (D) eastern Mediterranean core LC21, marine fauna as proxy for SST-variations (seasonal: winter/spring)*** **Rohling et al. 2002*****; (E) Eastern Aegean core LS21, marine fauna as proxy for SST-variations (seasonal: winter/spring)*** **Marino et al. 2009*****; (F) Northern Aegean Core MNB3, PCC = Planktonic Climate Curve as proxy for SST-variations (*****Geraga et al. 2010*****); (G) Steregoiu (Romania), peat vegetation pollen relations as proxy for Mean Annual Temperature of the Coldest Month (MTC, °C) (*****Feurdean et al. 2008*****); (H) Gaussian smoothed (200 yr) GISP2 nss [K+] as proxy for the Siberian High (*****Mayewski et al. 1997; Meeker and Mayewski 2002*****), (I) High-Resolution GISP2 nss [K+] as proxy for the Siberian High (*****Mayewski et al. 1997; Meeker and Mayewski 2002*****).***

still to be tested. Therefore, although we now have a sound understanding of the archaeology contemporaneous with Holocene RCC intervals, we are still lacking both a clearer perspective of the sensitivity of the different landscapes within the aforementioned RCC-corridor and data relating to the biophysical and societal vulnerability of afflicted prehistoric societies.

Climatic vulnerability of prehistoric communities: general considerations

To begin, we should not assume a priori that RCC-contemporary prehistoric communities were particularly sensitive to the effects of RCC. This remains to be established. Our initial judgement is, however, as already indicated above, that the apparent lack of corresponding archaeological data may simply be caused by prevailing theoretical perspectives, *i.e.* perhaps the data is already available, but its true background has yet to be recognised. Notwithstanding, in this paper, in pursuit of such questions, let us now take loan of concepts that are central to modern vulnerability theory.

Climatic vulnerability: modern perspectives

The concept of vulnerability has in recent years found a reception in various spheres of risk and disaster research, as well as in poverty, food insecurity, famine, and climate studies (*e.g. Blaikie et al. 1994; Cutter 1996; Adger and Kelly 1999; Kelly and Adger 2000; Alwang et al. 2001; Prowes 2003; Adger 2006*). Current interpretations of the concept of vulnerability are dominated by two paradigms: biophysical vulnerability and social vulnerability. As will be shown below, although they were specifically developed for modern applications, it is possible to adapt certain components of these two concepts to the field of archaeology.

Perhaps the most widely accepted insight from modern vulnerability studies is that the societal impact of catastrophic events is not solely a product of the physical event itself. It is equally attributable to the prevailing properties of the afflicted community. As such, it is the presence and actions of individual humans (*i.e.* the prevailing social and economic system itself) that may turn an otherwise only weakly acting natural event into a major human catastrophe. Depending on the complex interaction between natural events and properties of the afflicted community, natural catastrophes may – or may not – induce some significant disturbance in the stability of the social system affected (*Dikau and Weichselgartner 2005; Dikau 2008*).

Biophysical vulnerability

As introduced above, a differentiation is made in modern studies between biophysical and societal vulnerability. Biophysical vulnerability (*Burton et al. 1993; Hilhorst and Bankoff 2004; Macchi et al. 2008*) is typically defined as the exposure of human systems to natural extreme events and, as a consequence, to hazard. Hazard is described as a disruption in the equilibrium of the natural event's system (*e.g.* climate) (*Burton et al. 1993.31–34, Fig. 2.1*). When examining the severity of natural extreme events, a number of factors must be considered. Burton *et al.* (*1993.35*) refer to the seven dimensions of hazardous events: magnitude, frequency, duration, speed of onset, geographical extent, spatial dispersion, and temporal spacing. Evidently, different types of natural extreme event result in varying types of hazard, which can take different tolls and place quite different challenges upon afflicted societies (*e.g. Gaillard 2007*). For example, whereas in the case of an earthquake or a tsunami, a society must react spontaneously, the effects of intermittent droughts and epidemics are more gradual and demand quite different decisions made over longer time spans. Disruption to the prevailing equilibrium of natural events (climate) can compromise and, in severe cases, even lead to the destruction of human use systems. Thus, biophysical vulnerability focuses not only on the nature, frequency and magnitude of the natural extreme event itself, but also on its impacts upon a society's resources. Resource impacts are dictated by such factors as location of residence, availability of natural resources, building technology, as well as land use and land cover.

Location of residence dictates the relative profusion of available resources. It follows that groups living in physically isolated and already harsh environments are those most likely to be exposed to hazard. Particularly vulnerable landscapes include, for example, semi-arid regions and high altitude (mountain) areas. Significantly, a group's location of residence will be rooted in past or present political, economic and social processes (*Hilhorst and Bankoff 2004.4*); here lies the interface between biophysical and social vulnerability (see below).

Availability of natural resources has obvious priority for the well-being of human systems. Following Macchi *et al.* (*2008.20–21*), for traditional societies the most important resources (other than food and water) are wood for timber and fuel, fibre for clothing, medicinal plants for health care and religious purposes, as well as materials for income generating activities. Both extreme natural events and human impact can lead to the loss of natural resources culminating in an increased level of biophysical vulnerability.

Building technology (housing quality) and land use (land cover) patterns are, of course, closely related to the previously mentioned factors. In prehistoric periods, the erection of architectural structures relied strongly on the availability of local resources (timber, adobe, stone, fibre *etc.*). Housing quality will become of immediate concern for a community should natural events lead to the disappearance of construction materials, or structures no longer provide adequate shelter for inhabitants under changed circumstances. Since architectural structures in prehistoric periods are so strongly dependant on local building materials, we may expect building quality to vary with land cover.

Social vulnerability

In contrast to biophysical vulnerability, the term social vulnerability is used in modern risk and disaster studies to emphasise the human dimension to hazard: "*The crucial point about understanding why disasters occur is that it is not only natural events that cause them. They are also the product of the social, political, and economic environment (as distinct from the natural environment) because of the way it structures the lives of different groups of people.*" (*Blaikie et al. 1994.3*).

Clearly, social vulnerability can only be fully understood through familiarity with the afflicted communities, not only in terms of their socio-economic circumstances, but also the extent to which different groups of society are integrated within the mainstream system; particular groups may be excluded from this system and therefore disadvantaged. Ultimately, social vulnerability studies must consider the societal perception of the causes of natural extreme events and environmental change. Indeed, this perception (and corresponding memory of past events) will itself have a strong impact on a group's (future) vulnerability. Such factors complicate all vulnerability studies, especially when contemplating prehistoric communities. There are, however, vulnerability models which are more easily adapted to prehistoric data than others, and to exemplify this adaptation, we focus here on the so-called 'pressure and release model' after Blaikie *et al.* (*1994*).

'Pressure and release'

The pressure and release model (*Blaikie et al. 1994*) is based on the assumption that: The risk faced by people must be considered as a complex combination of vulnerability and hazard. Disasters are a result of the interaction of both; there is no risk if there are hazards but vulnerability is nil, or if there is vulnerability but no hazard event. A disaster occurs when a significant number of vulnerable people experience a hazard and suffer severe damage and/or disruption of their livelihood system (*Blaikie et al. 1994.21*). In this model, the (wide range) of socioeconomic factors constituting social vulnerability are grouped according to three different levels, each of which differs in its proximity – or remoteness – to the potential catastrophe (Fig. 3).

These three levels are termed (1) root causes, (2) dynamic pressures, and (3) unsafe conditions. Root causes are underlying ideological processes. They are described as a set of well-established, widespread notions within a society, which can be observed in economic, demographic, and political domains. These notions express themselves, for example, in prevailing forms of social hierarchy and ideologies. As such, root causes strongly affect the allocation and distribution of resources between different (more or less privileged) groups of people within a society. Such factors are particularly significant for the capacity of a group to respond, cope, and adapt in times of stress. Dynamic pressures translate the effects of root causes, and a culmination of both these factors leads to the emergence of unsafe conditions and (particular) group susceptibility. In the modern world, typical dynamic pressures can include such factors as a lack of local investments and markets, rapid population growth, deforestation and urbanisation, as well as failing infrastructures and public institutions. Unsafe conditions are expressed in a variety of factors, ranging from the coerced settlement of unsafe locations to the practise of dangerous livelihoods, low income levels, malnutrition, and endemic disease. Of significance for our studies is the observation that (modern) social units already experiencing poverty, inequality, and marginalisation appear to be more vulnerable to the physical impacts of natural extreme events than those in which this is not – or is less – the case. To conclude, according to Blaikie *et al.* (*1994*), it would be the joint effects of root causes, dynamic pressures and unsafe conditions that – assuming the community indeed encounters a natural hazard event – ultimately leads to a catastrophic scenario.

Coping strategies

Coping strategies applied by a community vary, depending on the type of hazard involved; reactions to abrupt natural hazard events are distinct from responses to other dangers which develop at a more gradual pace. Among the many dangers associated with RCC, frequently recurring phases of intense aridity, the effects of severe winters and frosts, as well as the occurrence of severe downpours would have led to some drastic impacts on contemporary systems. Depending on the underlying social fabric, *i.e.* the capacity of a given system to counter this threat, severe food shortages would have ensued (either generally or among certain unprivileged groups within society).

Turning briefly to potential coping strategies, these can be either preventive, *i.e.* enforced in anticipation of a threatening event, or they can be applied during the event itself or in its aftermath (*Dikau and Weichselgartner 2005*). In the archaeological record, some of the most easily observable adaptation processes must be those to have been applied in the short-term following an abrupt and unexpected hazard event. On the other hand, socio-economic adaptations to long-term (prolonged) natural hazard events will probably prove especially difficult to detect in the cultural (archaeological) record. Coping strategies are numerous and can include, for example, an increase in levels of spatial mobility, resource diversification, and risk dispersion. In cases where assets and resources essential for coping (*e.g.* water, land, tools, labour, social networks, specialised knowledge and skills) cannot be 'commanded' by a population or part thereof, *i.e.* where coping ability is low, people may be forced to resort to such measures as theft, violence and warfare (*Clare et al. 2008*); indeed, in this respect, violence (in the form of raiding and pillaging) can – and should be – considered a

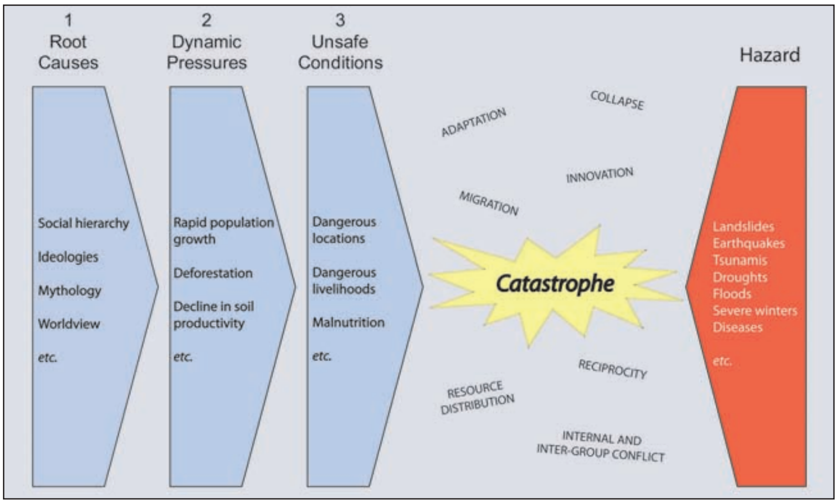

Fig. 3. Schematic representation of social vulnerability, adapted from Blaikie* et al. *(*1994*).

coping strategy in its own right (*Clare in press*). "*The means by which human beings secure their food supply in the face of [...] uncertainty are thus as central to society as the consequences of shortage are drastic and they have far-reaching ramifications throughout cultural behaviour and social life*." (*Halstead and O'Shea 1989.1*).

A case study on the vulnerability of prehistoric communities: Neolithic Çatalhöyük

According to Asouti (*2009*), there is no evidence for the impact of RCC in Neolithic Central Anatolia. In particular, she doubts whether the abrupt abandonment of the East Mound at Çatalhöyük around 8.2 ka calBP has a natural causal background in RCC (contra *Weninger et al. 2006*). We again show the relevant ^{14}C-data in Figure 4. Further, in citing Boyer et al. (*2006*), she makes reference to geomorphological evidence for repeated flooding in the vicinity of Çatalhöyük. Remarkably, Asouti (*2009*) questions the existence of any relationship between flooding regime and settlement distribution, and she does not see any environmental evidence for RCC impact in the Konya plain. In her view, the observed changes in settlement patterns are most likely to have cultural and/or socio-economic causes. We agree with Asouti (*2009*) that climate variability alone does not provide a sufficient explanation for site history. Nevertheless, we would surely be ill-advised to isolate the cultural developments at Çatalhöyük in this manner from the climatic, environmental and vegetation history of the region.

The existence of significant interrelations between the biophysical, climatic and societal developments in this region are well-illustrated by the following historical report by E. Neumann, an engineer who travelled the Konya region in 1890 on behalf of the Istanbul-Baghdad railway project. His report gives evidence as to the severity and societal implications of one of the worst (documented) human catastrophes in this region which occurred during the most recent RCC-interval (*i.e.* the Little Ice Age).

"*One of the worst famines in the modern history of this region occurred from winter 1873 to spring 1875. It most strongly affected the Vilayets (provinces) Kastamuni [*Kastamonu*], Angara [*Ankara*] and Kaiseri [*Kayseri*]. The great drought of 1873 had produced a crop failure, and in November and December there occurred a series of torrential rains, followed in January and February 1874 by some quite extraordinary snowfall. The snowed-in villages had soon exhausted their small amounts of food reserves, and – since the extreme winter had disrupted all communication routes – widespread death and suffering soon followed. It is reported that altogether some 150 000 souls and 100 000 cattle died in a very brief time. The loss of sheep and goats is estimated at 40%.*" (*Naumann 1893*; translated from the German by the authors).

What is perhaps most remarkable about this historical account is that it is not simply the occurrence of one specific catastrophe (*i.e.* the initial drought in 1873) but rather the combination of a number of consecutive natural hazard events (drought in 1873, torrential rainfall in the same year, followed by unusual snowfall in the subsequent winter) that ultimately leads to the disaster. But such an incidental combination of natural hazards is exactly what we expect, not only for the recent LIA, but also for the Neolithic RCC-period. Based on given climate proxies (Fig. 1) we expect the most dramatic natural hazards in the eastern Mediterranean to have occurred during the later subinterval 8.2–8.0 ka calBP of this RCC. At this time, the prevailing RCC-mechanism (8.6–8.0 ka calBP) was amplified by the outflow of the Hudson Bay, leading to a massive disturbance of the North Atlantic Ocean circulation. The climatically anomalous RCC-conditions and the Hudson Bay

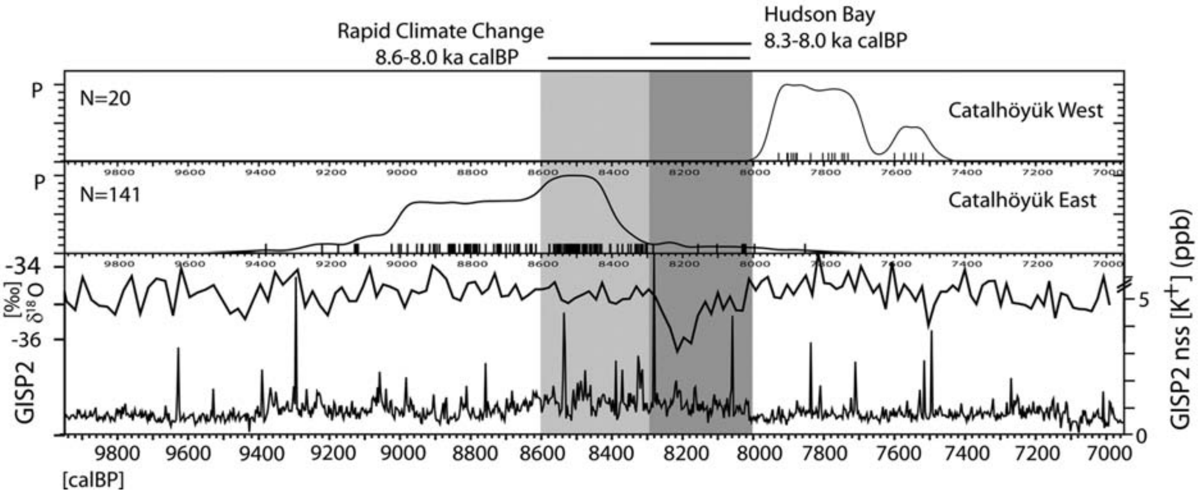

Fig. 4. Radiocarbon Dates from Neolithic Çatalhöyük (central Anatolia) in comparison to selected records for Rapid Climate Change (RCC). Top: ^{14}C-data from Çatalhöyük West (N = 20) and Çatalhöyük East (N = 141). Bottom: Greenland GISP2 ice-core $\delta^{18}O$ (*Grootes et al. 1993*); GISP2 potassium (terrestrial [K^+]) ion proxy for the Siberian High (*Mayewski et al. 1997; Meeker and Mayewski 2002*). According to the RCC-hypothesis (*Weninger et al. 2009*), we expect that the sequence comprising the abandonment of Çatalhöyük East at around 8.2 ka calBP, a ~200 yr (temporary) desertion of the site, and subsequent re-location to the West Mound in the early ninth millennium calBP is causally related to RCC. In the present paper, we addre–ss the associated biophysical and societal processes (see text).

event both came to an end around –8.0 ka calBP. Hence, both the desertion of Çatalhöyük East and the re-occupation of the West Mound correlate with the onset of most extreme RCC conditions and the end of RCC respectively. Considering the expected (strong) causal relationship between given RCC-climate data and socio-economic mechanisms in the Konya Plain, there is every chance that such hazardous local conditions, as described by E. Neumann for the LIA, would also have occurred during the Neolithic RCC.

Consequently, we now take the RCC-hypothesis one step further and analyse societal conditions at Çatalhöyük prior to the (potentially) RCC-related collapse of the Neolithic socio-economic system. As far as presently known, before the attested switch of settlement relocation to the West Mound, Çatalhöyük East had been continuously settled for some 1200 years. This continuity is itself amazing, given the existing hazards of this site location. During this long period, the inhabitants of this settlement must have repeatedly experienced (and successfully survived) some quite adverse environmental conditions (RCC certainly has no monopoly over such hazards). As such, settlement continuity at Çatalhöyük attests to the existence and successful implementation of some efficient buffering and coping strategies – but which appear to have reached their limits during the later stage of the RCC.

We would like to complete these studies by formulating a number of questions to be addressed in future research. First, what are the methods, techniques and strategies (whether conscious or not) by which the inhabitants of Çatalhöyük were able to cope with the – regular or irregular – occurrence of natural hazards (*i.e.* drought, flooding, snowfall)? Second, what happened to the community – assuming our hypothesis is correct – when these mechanisms failed to function under RCC-conditions? Finally, the third and perhaps most important question: how were coping strategies anchored in the Neolithic worldview?

Conclusions: Rapid Climate Change – an emerging Archaeological Research Program

In order to combine such concepts of modern vulnerability theory with archaeological data, what we need – ideally – is an archaeological laboratory dedicated to vulnerability research in prehistoric periods. Such a laboratory would provide an experimental framework within which we may (1) collect empirical data, (2) develop, test and refine corresponding theoretical models (aimed at reproducing compacted data, *i.e.* reliable forecasting of societal responses to natural hazards), and furthermore this laboratory should (3) allow us to study the impact of natural catastrophes on prehistoric communities for the widest possible field of alternative societal modes.

Although in many of its details clearly unachievable, we judge that such a laboratory is already now available with the given RCC-mechanism. First, we have at our disposal a set of delimited RCC-time intervals for which the strongest societal impact of climate variability can be expected, as well as the corresponding geographic regions. Second, due to the recurring character of RCC, its societal impact can be studied for a quite wide range of cultural transitions in the eastern Mediterranean, from the Neolithic (with RCC window 8.6–8.0 ka calBP), through the Chalcolithic (RCC window 5.0–3.2 ka calBP) to the Bronze Age (RCC window 3.05–2.5 ka calBP). RCC-time windows also provide a good indication of the intervening cultural periods, during which the occurrence of the most extreme natural hazards (*i.e.* hazard combinations), at least in terms of climate variability, may be expected to be significantly less probable.

In particular, in view of its still quite hazardous environment, as well as its long settlement history, and not least the advanced state of archaeological research, Çatalhöyük has many of the properties that would allow the site to become a model for future and more detailed theoretical-methodological studies focussing on climate vulnerability in prehistoric societies.

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