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The effects of the 8.2 ka event on the natural environment of Tell Sabi Abyad, Syria: Implications for ecosystem resilience studies



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ABSTRACT

Research on ecosystem resilience and climate–ecosystem interactions is extremely complex due to the large variety of factors that play a role in ecosystem functioning. This study aims at determining which factors are involved in ecosystem resilience, which methods are needed to investigate this, and how archaeology can contribute to such research. The influence of the 8.2 ka climate event on the natural environment of Tell Sabi Abyad, Syria, serves as a case study for larger-scale ecosystem resilience studies.

This study presents some critical notes to the assumption that the changes which took place in Tell Sabi Abyad at the timing of the 8.2 ka event were a direct result of climate change triggered by the event. Though a number of changes in culture and farming methods date back to the timing of the 8.2 ka event, as yet no evidence has been found for wild flora and fauna shifts which could indicate climate deterioration. Other factors that could have influenced the changes observed in the archaeological record, like anthropogenic influences or cultural development, should not be ruled out as determining factors for the changes that took place at Tell Sabi Abyad at the timing of the 8.2 ka event.

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1. Introduction

Over the past decades climate change has become a topic of global concern. With the rising atmospheric CO₂ levels the debate on the sustainability of the world's ecosystems has intensified. Climate fluctuations are, however, not uncommon in the world's geological history. Past climate fluctuations show large, more or less regular climate shifts: the 10–100 ka scale Glacial–Interglacial cycles (Rose, 2010), millennia scale 1–10 ka Stadial–Interstadial cycles (Dansgaard et al., 1993), century scale oscillations like the Little Ice Age (LIA) (Eddy, 1976) and so-called abrupt climate anomalies, in particular the 8.2 ka event (Alley et al., 1997).

Research on climatic events in the past plays an important role in the efforts to gain insight in future climate developments. Ice core analysis, for example, has shed light on long-term climate variability (Rose, 2010), but also helps to understand the environmental consequences of abrupt or short-term climate fluctuations.

This is done through studies on more recent climate anomalies, like the Younger Dryas, the 8.2 ka event, and the Little Ice Age, (Alley and Ágústadóttir, 2005; Russell, 2010).

The 8.2 ka event in particular has received much attention for this purpose, not only from climatologists, but from archaeologists as well (Akkermans, 2004; Alley and Ágústadóttir, 2005; Wiersma and Renssen, 2006; Russell, 2010). Many archaeological studies focusing on the impacts of the 8.2 ka event have been done at sites in the Near East, including Catalhöyük, Anatolia (Weninger et al., 2006) and Tell Sabi Abyad, Syria (Akkermans, 2004; Akkermans et al., 2010). Many studies focusing on the impacts of the 8.2 ka event have been done in the Near East, because the area offers good opportunities for studying not only past societies, but also the effects of abrupt climate change on society, an important research question of this time (IPCC, 2013). Such studies have been done at, among others, the well documented sites Çatalhöyük, Anatolia (Weninger et al., 2006) and Tell Sabi Abyad, Syria (Akkermans, 2004; Akkermans et al., 2010). It has been argued that the 8.2 ka event had significant consequences for the late Neolithic farmers in the Near East, especially for the communities that were located in marginal areas with relatively low precipitation. As agriculture and

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pastoralism are both highly dependent on water availability, reduced precipitation can have a major impact on farmer societies (Russell, 2010). However, the question remains which role the 8.2 ka event has played in the developments that took place at Tell Sabi Abyad, and to what extent other factors were involved (Akkermans, 2004; Blockley and Pinhasi, 2010; Maher et al., 2011).

The aim of this research is to determine which factors play a role in the resilience of ecosystems, which methods are needed to study this, and how archaeological research can contribute to such studies. The research on the influence of the 8.2 ka event on the natural environment of Tell Sabi Abyad serves as a case study for larger-scale research on ecosystem resilience.

This study was carried out by reviewing the literature on existing geological data, climate models and archaeological data (e.g. van Zeist and Waterbolk-van Rooijen, 1996; Akkermans, 2004; Alley and Ágústsdóttir, 2005; Rohling and Pälike, 2005; Wiersma and Renssen, 2006; Akkermans, 2010; Russell, 2010). This multi-disciplinary approach enables ecosystem resilience to be studied on a local level, while larger scale effects were investigated using global geological and climate data.

2. Characteristics of the 8.2 ka climate event

2.1. Cause and consequence of the 8.2 ka event

The sudden climate event that took place around 8200 years ago was first observed in oxygen isotope records from Greenland ice cores (e.g. Johnson et al., 1992; Alley et al., 1997; Rasmussen et al., 2006). The event was characterized by a reduction in annual temperature in the northern hemisphere, as well as increased seasonality (Wiersma and Renssen, 2006). This event was most likely the result of a disrupted Thermohaline Circulation of the northern Atlantic (Clarke et al., 2003; Alley and Ágústsdóttir, 2005; Rohling and Pälike, 2005; Wiersma and Renssen, 2006) after a sudden drainage of the Laurentide meltwater lakes (Fig. 1). Increased melting of the Laurentide ice sheets, possibly caused by the rising

temperatures during the Holocene, led to the breakthrough of the ice dam that used to cut off the freshwater lakes from the northern Atlantic (Rohling and Pälike, 2005; Wiersma and Jongma, 2010). The sudden influx of a huge volume of fresh water had a strong effect on the existing thermohaline circulation pattern, hence causing it to collapse. An alternative scenario is the cooling event having been triggered by a sudden sea level jump that was caused by the drainage of the Laurentide lakes (Hijma and Cohen, 2010).

The exact timing of this sudden meltwater outburst is subject to debate. The Greenland icecores show around 3 °C temperature reduction (Kobashi et al., 2007) starting around 8250 calBP with a duration of ca. 160 years (Thomas et al., 2007).

The weakened oceanic conveyor belt was only of a short-lived nature and lasted for about 160 years before the climate turned back to previous conditions (Rasmussen et al., 2006, 2007).

The duration of the process leading to the Laurentide meltwater pulse is unknown. Though the 8.2 ka event is regarded as a sudden, short-term climate anomaly, some researchers suggest that the event could be related to a more long-term climate fluctuation. Rohling and Pälike (2005) argue that the climate anomaly spans 400–600 years, starting 8600 years ago, and that more sudden climate changes ca. 8200 years ago appear superimposed on the longer term cooling.

The effects of the 8.2 ka event were of a global scale, but were strongest in the northern hemisphere (Wiersma, 2008). In general, annual temperatures decreased all over the northern hemisphere, while some places, mainly in Africa and Asia, became drier (Alley and Ágústsdóttir, 2005). Speleothem records from China, Oman and Brazil confirm this global impact of the 8.2 ka event, while also showing a variation in climatic impacts per region (Cheng et al., 2009).

2.2. Uncertainties regarding the effects of the 8.2 ka event

Ever since the 8.2 ka climate anomaly was found in Greenland ice core data, climate fluctuations from all over the world dating

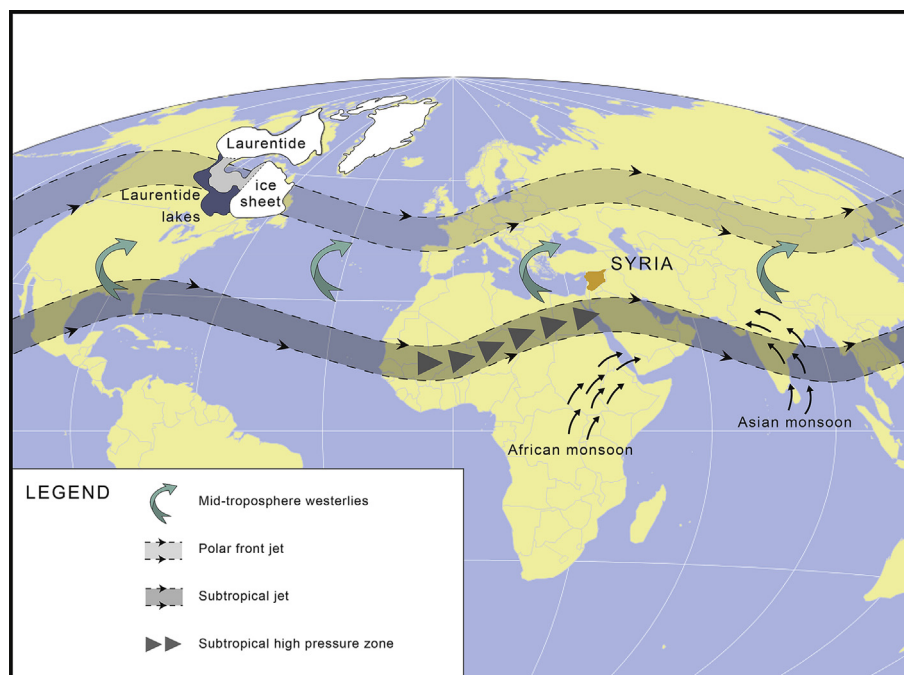


Fig. 1. The Laurentide ice sheet just before the 8.2 ka event, closing off the Laurentide lakes, and climate systems influencing northern Syria (see paragraph 4.1) (Wiersma and Jongma, 2010).

back to around this time have been attributed to the 8.2 ka event. However, a great deal of uncertainty exists on the exact level of influence of the 8.2 ka event, and on the extent to which other factors played a role in global climate fluctuations. A critical view on the climate research related to the 8.2 ka event is necessary. First and foremost, there is the question of synchronization. Are all “events” observed in geophysical and prehistoric proxies contemporaneous? This question translates immediately into: how well are the events dated? Furthermore, to what extent do global influences relate to local ecosystem changes? In the recent years it has become clear that global climate impacts do not necessarily correlate with changes locally in the Near East (Blockley and Pinhasi, 2010).

The 8.2 ka event is most significantly dated in Greenland Ice as an “abrupt climate change event” (Alley et al., 1997). A composite analysis of the ice cores Dye3/GISP2/GRIP/NGRIP shows a time range for the event of ca. 8250–8090 calBP (Thomas et al., 2007).

The counting error of the ice layers is about 50 years (Rasmussen et al., 2006). This time range is coeval with the absolutely dated tree-rings from Austria (Nicolussi et al., 2009) and Germany (Spurk et al., 2002), and with a composite record of speleothems dated by U-series isotopes (Cheng et al., 2009). However, this timeframe is offset by about 200 years from the drainage of Lake Agassiz (Barber et al., 1999; Kleiven et al., 2008). Summarizing a workshop on the chronology of the 8.2 ka event, Schmitt and Jansen (2006) state that “significant chronological problems remain”.

In relation to these dating uncertainties, Alley and Ágústadóttir (2005) warn for ‘Anomaly hunting’: the ease with which local environmental changes are sometimes being associated with the 8.2 ka event. This makes it difficult to give an exact overview of the environmental changes related to the 8.2 ka event (Alley and Ágústadóttir, 2005).

An example is the observed periods of increased drought in Africa between 8500 and 7800 calBP, which caused a water level reduction in several lakes in north Africa (Gasse and van Campo, 1994; Gasse, 2000). As cooling events in higher latitudes are known to induce dry periods in tropical areas, it has been suggested that this drought could have been a consequence of the 8.2 ka event (Gasse and van Campo, 1994; Gasse, 2000). However, in a number of other African lakes this water level reduction was not found, which makes the extent of the influence of the 8.2 ka event debatable (Alley and Ágústadóttir, 2005). Furthermore, it was shown that the onset of the dry period, as well as its duration varied between the lakes. It therefore cannot be stated with certainty if this dry period in Africa is a result of the 8.2 ka event, or if multiple factors played a role.

Even if a climate shift can be dated with precision and is found to correspond with the timing of the 8.2 ka event, it cannot be stated with certainty that the two are related. An example is a drying event recorded in speleothem data from Oman. Though a clear shift is seen in an oxygen isotope record dated at the time of the 8.2 ka event, it was also observed that similar shifts took place throughout the Holocene with similar magnitude, without having any relation with global climatic shifts (Alley and Ágústadóttir, 2005).

In addition, there are examples of studies that have revealed no significant climatic influence of the 8.2 ka event in the region at all. Eastwood et al. (2007) record no significant climatic impact from the 8.2 ka event in south-western Turkey and the Taurus mountains, nor in east Turkey. Similar results were found from botanical remains in Lebanon. According to Hajar et al. (2010), no evidence for a climate deterioration around 8200 years ago was found in pollen records from that region. However, it must be stressed that these studies rely respectively on lake sediment records and pollen records, the dates of which are of limited reliability.

For a more extensive description of timing uncertainties related to studies on the impacts of the 8.2 ka event, and of the studies that lack significant evidence for a climate impact, see Alley and Ágústadóttir (2005).

3. Tell Sabi Abyad: the excavations and climate characteristics

3.1. Background

Tell Sabi Abyad (‘Mound of the White Boy’) is located in northern Syria, 30 km from the Turkish border. The site forms part of a cluster of mounds that are located in the Balikh valley, between the Euphrates and Tigris rivers (Fig. 2).

Tell Sabi Abyad dates back to the 7th and 6th millennium BC, covering the Pottery Neolithic to Halaf periods (Nieuwenhuysen et al., 2010). The location of the site at the basin of the Balikh River offered the inhabitants profitable conditions for agriculture and livestock farming, due to relatively high moisture availability in comparison with the rest of the Balikh (Mulders, 1969).

In the past decades, substantial research has been done on the archaeological remains of Tell Sabi Abyad (Cavallo, 1996; Van Zeist and Waterbolk-van Rooijen, 1996; Russell, 2010). Based on these findings it has been argued that the 8.2 ka event led to a change in subsistence opportunities in the region, which was a cause for changes in agriculture, livestock farming, and even cultural characteristics (Akkermans, 2010; Balter, 2010; Russell, 2010).

3.2. Climate and geographic characteristics of Tell Sabi Abyad

Tell Sabi Abyad is located at a river basin of an elevated region, the Jazirah Plain (Russell, 2010). Because of its altitude, this area is generally more arid than its lower surroundings. The Jazirah Plain is characterized by a north-south precipitation gradient, with relatively high precipitation levels in the north and low precipitation levels in the south. As Tell Sabi Abyad is located in the northern part of the area, the site does not show extremely arid characteristics, and can therefore be considered semi-arid (Mulders, 1969). Because the northern part of the valley is more humid than the southern part, the north Balikh is a more attractive place for human occupation.

Currently the climate at Tell Sabi Abyad is characterized by a Mediterranean seasonality: summers are generally dry and warm, and most of the precipitation falls in winter, which is wet and mild (Wigley and Farmer, 1982). It is assumed that during most of the Holocene, the aridity around Tell Sabi Abyad has been similar to or higher than it is now (Russell, 2010).

The site is influenced by three large climate systems (Wigley and Farmer, 1982) (Fig. 1):

- The mid-troposphere westerlies: a westerly flow that is created by the temperature difference between high and low latitudes, and by the rotation of the earth. This circulation pattern creates the mid-tropospheric trough, which reaches from Novaya Zemlya in the north of Europe to the central Mediterranean. It has been observed that this trough is connected to winter rainfall patterns in the eastern Mediterranean.

Related to these westerlies are the so-called jet streams: high windspeed zones in the upper troposphere. There are two of these jet streams: the mid-latitude polar front jet (PFJ), extending from the north and south pole, and the subtropical jet (STJ), which is located at lower latitudes. The position of the PFJ is highly variable, as well as the direction of its wind streams, which usually run from east to west, but can change direction towards a north-south direction.

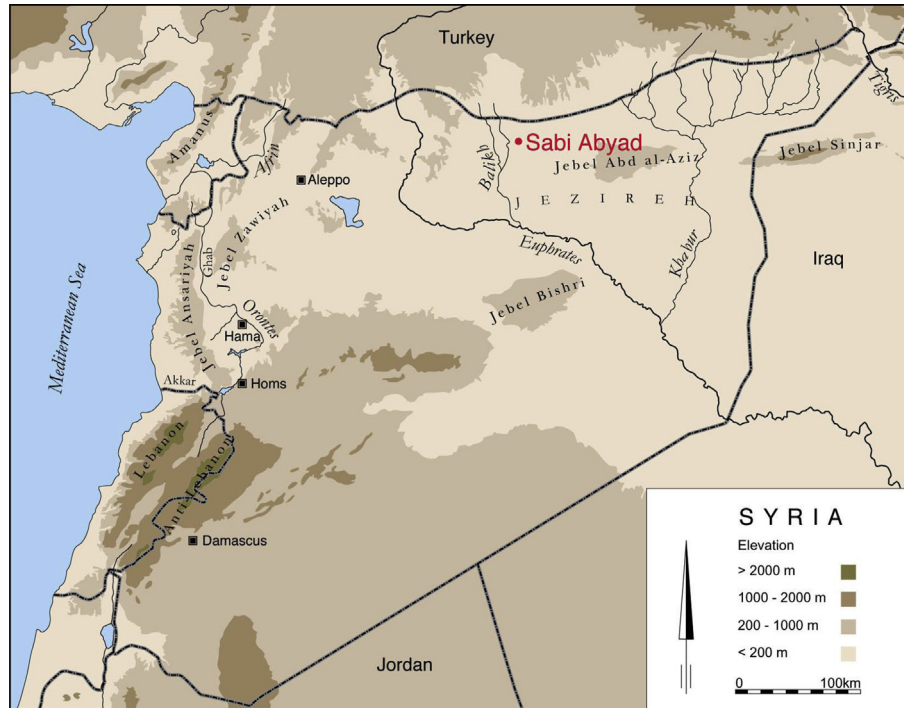


Fig. 2. The location of Tell Sabi Abyad in Syria.

- A south-western influence through mid-latitude subtropical high pressure systems, which reach the Middle East from the Sahara and have their strongest influences in the southern regions of the Middle East.
- The South-Asian and East-African monsoon climate, which also mostly influence the southern regions of the Middle East.

The climatic spatial heterogeneity around Tell Sabi Abyad is not only caused by the different climate systems that are present in the region and the strong precipitation gradient, but also by the geographical characteristics of the area. In particular the Taurus and Kurdistan mountains are an important regional climatic factor (Van Zeist and Bottema, 1999). Also, the distance from the sea and continental influences from the east and the north are decisive for climate characteristics (Van Zeist and Bottema, 1999).

3.3. Ecosystem pressure factors in Tell Sabi Abyad

Due to the aridity of the region, precipitation is the most important limiting factor for agriculture in Tell Sabi Abyad. Temperature fluctuations are considered to have little influence on the environment, as slight temperature variations remain within acceptable limits for most of the species present in the region.

Wind circulation patterns play an important role in precipitation variability. The upper westerlies (which include the mid-troposphere westerlies) are thought to be responsible for the onset of the rainy season in winter. In addition, the polar front jet is characterized by a highly variable southern border which overlaps with the northern border of the subtropical jet. According to Wigley and Farmer (1982), this point of overlap could have implications for the environment in the region where this overlap occurs and its surroundings. Considering the variability of the southern border of the PFJ, the influence of this wind-speed zone could vary over time, and might have affected the environment of northern Syria in the past as well.

Also changes in the Indian monsoon system could have effects on precipitation in the Middle East. Under normal circumstances

the monsoon leads to increased precipitation in the north of the Middle East and increased aridity in the southern parts (Wigley and Farmer, 1982). A reduction in the monsoon strength is associated with increased aridity, while a strong monsoon is associated with increased precipitation. The effects of the Asian monsoon are stronger in the south-eastern part of the Arabian peninsula, and seem to have a lower impact on the northern regions (Wigley and Farmer, 1982).

Apart from external climate factors, internal factors play an important role in ecosystems as well. Tell Sabi Abyad is located in a region with an unstable climate, which has put plant and animal species into a vulnerable position. According to Tchernov (1982) only a slight change in environmental conditions would be enough for existing ecosystems to collapse. It is not certain how vulnerable the ecosystems were during the 8.2 ka event, but it should be noted that the natural environment of Sabi Abyad might have been more heavily affected by a climate anomaly than some other regions in the world.

Another important factor of influence is human activity (Clason and Clutton-Brock, 1982; Bottema, 1989). Though the northern Balikh allows tree growth, in the past decades the vegetation has deteriorated due to over-grazing of livestock, and has been showing more and more signs of a steppe landscape (Bottema, 1989). Clason and Clutton-Brock (1982) have argued that not only present-day agriculture affects ecosystems, but also past human interactions with nature had visible effects on the natural flora and fauna. For one, overgrazing resulting from the domestication of especially goats and, to some extent, sheep could have led to a deterioration of the existing environment (Clason and Clutton-Brock, 1982). Russell (2010), however, argues that no clear evidence has been found to support or dismiss this theory.

4. Changes observed in archeological records

The 8.2 ka event has been connected with changes in cultural and farming characteristics, and relocation of communities in the

Near East. These developments were most prominent in the Levant and Mesopotamia (Russell, 2010). In those regions, many sites were abandoned between 8300 and 8200 years ago, presumably as a result of impaired agricultural production due to decreased precipitation. In the Balikh valley at least ten settlements were abandoned (Akkermans, 2004; Weninger et al., 2006). This massive migration throughout the Middle East has been suggested as an important factor in the neolithisation of south-eastern Europe (Berger and Guilaine, 2009).

Tell Sabi Abyad is one of the few sites that appear to have had continued occupation throughout this time (Van der Plicht et al., 2011), although the population did diminish (Akkermans, 2010). Akkermans (2004) has argued that many of the surrounding sites that were deserted were re-occupied a number of decades after they had been abandoned. The new inhabitants built their settlements next to the old deserted settlements, and introduced new subsistence strategies (Akkermans, 2004).

Archaeological finds from Tell Sabi Abyad indicate that significant changes occurred during and after the timing of the 8.2 ka climate event. These include:

- **Changes in architecture.** After the return of the migrated societies, two new types of buildings are introduced, the so-called 'warehouses': large, rectangular buildings with many small rooms, suggesting an increased importance of food storage and thus uncertain food production (Verhoeven, 1999); and 'tholoi': small, round buildings which were periodically replaced and most likely used as residential houses (Akkermans, 1996). Tholoi were already found in Tell Sabi Abyad between 8500 and 8200 years ago, but only after 8200 years ago they start to appear in large numbers (Akkermans, 2010).
- **The appearance of seals and sealings.** The appearance of sealings after the 8.2 ka event implies that food storage and distinguishing personal possessions seem to have gained importance (Duistermaat, 1996). This indicates an increase in social stratification. According to Verhoeven (1999), the seals were used predominantly by nomadic people. Thus, these seals might be a sign of increased mobility.
- **Social stratification.** The appearance of sealings with which personal possessions were distinguished indicates that social stratification increased. Another development that suggests this is the increased mobility starting around 6200 BC (e.g. Bar-Yosef and Khazanov 1992). An increase in mobility improves possibilities for interaction between communities and cultures. It is assumed that this change is accompanied by an increase in social stratification, since an advance in trading practices allowed for the development of a surplus of products (Bar-Yosef and Khazanov 1992).
- **Changes in burial practices.** At the timing of the 8.2 ka event, a number of remarkable changes take place in grave goods and funerary practices, among which a sharp decline in secondary human remains as grave goods, a decline in animal remains as grave goods and a near complete disappearance in intramural and group burials (Plug, 2014; Plug et al., 2014). Further research on funerary practices at Tell Sabi Abyad is necessary to discover if and in what way these changes relate to the climate impact of the 8.2 ka event (Plug, 2014).
- **Changes in livestock composition.** Between 8300 and 8200 years ago a temporary reduction in cattle has been observed in Tell Sabi Abyad (Russell, 2010). In the same period, pigs disappear from the archaeological record, and the share of domestic goat and sheep increases (Russell, 2010). This development suggests reduced moisture availability, as the species that require little water become more common (Russell, 2010). In addition, an increased mobility is observed in animal husbandry

from around the time of the 8.2 ka event, with an increased amount of shepherds leading a nomad life (Bar-Yosef and Khazanov, 1992; Verhoeven, 1999). This could indicate that nutritious grasslands became scarcer.

- **Increased dependence on secondary products.** From the same time it was seen that people became more efficient with the use of their livestock: the first proof for milk consumption dates back to around 8200 years ago, as well as wool production and the use of animal traction (Balter, 2010; Russell, 2010). Furthermore, the number of spindles, used for making textiles out of animal fibres, increased around the time of the 8.2 ka event (Balter, 2010; Russel, 2010).
- **Changes in agriculture.** A shift takes place from an emphasis on wheat to an emphasis on barley, the latter being better suited for dryer climates (Cappers, 2014).

5. Palaeoclimatic setting: comparison of climate models with local vegetation changes

5.1. Global climate models correlate with Mediterranean effects

Climate models on global impacts of the 8.2 ka event show that the Mediterranean Sea was influenced by the fresh water perturbation from the Laurentide lakes (Wiersma et al., 2011). This led in the Eastern Mediterranean to a temperature reduction of about 1 °C (Wiersma and Renssen, 2006; Renssen et al., 2007; Wiersma et al., 2011).

Besides a decrease in temperature, a reduction in precipitation was observed (LeGrande et al., 2006; Wiersma and Renssen, 2006). Wiersma and Renssen (2006) suggest that the Middle East and north Africa were more characterised by increased dryness in summer months than in winter months, while south-eastern Europe shows a slightly stronger dry impact during winter, in comparison to summer precipitation changes. This is related to a northward shift of the westerlies and a weakening of the westerlies in the south of the continent (Wiersma and Renssen, 2006). As the influence from south-eastern Europe plays the most important role in winter precipitation, it could be expected that a reduction in precipitation in south-eastern Europe leads to reduced winter precipitation in northern Syria. The additional reduced precipitation seen in North Africa implies an overall weakened monsoon system, negatively affecting summer precipitation in the Near East (Berger and Guilaine, 2009).

The currently available climate models are not detailed enough to give specific information on a small region like northern Syria. Therefore it is not possible to ascertain with high certainty if the effects of the 8.2 ka event were strong enough to influence subsistence strategies or cause vegetation shifts at Tell Sabi Abyad. However, reduced precipitation could have been the cause of vegetation changes observed in certain parts of the Mediterranean. In the Mediterranean region, the 8.2 ka event took place within a period of enhanced precipitation and an increased accumulation of organic material (e.g. Bar-Matthews et al., 1999), known as the youngest sapropel 1 (S1). Within the thick S1 sedimentation layer, a short-lived break in organic depositions has been observed that corresponds with the timing of the 8.2 ka event. This deposition break was presumably caused by cool and dry conditions that could be a result of the 8.2 ka event (Wiersma, 2008).

5.2. Ecosystem resilience

Ecosystem resilience relates to the adaptive capacity of ecosystems to unpredictable shocks (Holling, 2001; Folke et al., 2002). Ecosystems are able to cope with fluctuations to a certain extent,

but the accumulative effects of random effects determines the structural integrity of an ecosystem. A single event, not destructive in itself, could theoretically determine the collapse of an ecosystem if it comes as the final one in a row of subsequent events, and can result in an ecosystem reaching its limit of coping with change (Holling, 1973).

Two types of ecosystem transition occur. A sudden transition from one ecosystem to another, which could for example be triggered by a sudden climate shift or a natural disaster, or could be a result of accumulating effects of minor events. Another type is a gradual shift from one ecosystem to another, which is called 'succession'. Such shifts generally take place in newly developing areas where fast spreading pioneer species are gradually replaced with more tolerant species with a higher resilience.

If the 8.2 ka event had led to an ecosystem shift at Tell Sabi Abyad, it would have likely been a sudden shift or collapse, considering the short term and abrupt character of the climate event. Such a collapse should then at least be observed in the archaeological records of wild plant and animal species. Changes in records of domesticated species could be an indirect indicator, but one should keep in mind that anthropogenic influences can have multiple causes that not necessarily relate to climate influences. A study of Pross et al. (2009) shows that around the timing of the 8.2 ka event the vegetation of the Eastern Mediterranean shifted to a prevalence of more steppe species for about 200 years at the most, after which the vegetation returned to its original state. This correlates with the reduced precipitation shown in climate models. The presence of temperate tree species increased slowly after this temporary dryer period, which implies that the existing ecosystem resumed its original state. However, these changes have not been observed everywhere in the Near East, as has been indicated by studies from Turkey and Lebanon (Eastwood et al., 2007; Hajar et al., 2010). Also in Tell Sabi Abyad no strong evidence has as yet been found for a shift in the natural ecosystems in that area (Cappers, 2014).

6. Discussion

Though faunal data and observed cultural changes at Tell Sabi Abyad seem to indicate a changing environment, their relation to

the 8.2 ka event remains uncertain. The changes found in the archaeological record all involve human induced changes which might have been triggered by a different cause than climate change. As for domesticated plant species, a shift is noticed towards a preference for barley over wheat (Cappers, 2014), barley being a better suited crop for dryer areas. A similar shift in the composition of wild vegetation could not be observed, as sufficient and good quality remains of wild plant species have thus far been lacking in the archaeological record of Tell Sabi Abyad (Akkermans et al., 2006). Furthermore, the changes in livestock composition took place between 6300 and 6200 BC, which is slightly earlier than the estimated onset of effects of the 8.2 ka event found in polar, terrestrial and cave records (see Fig. 3).

The 8.2 ka event may have been one of the key forcing factors behind the changes observed at Tell Sabi Abyad. However, the site does not show "collapse of culture"; prehistoric man could adapt here (Akkermans, 2004). The changes in culture and practices in the communities living in the Balikh region may eventually have been a consequence of human development instead of a result of climate change. For instance, over-grazing by domesticated and sheep could have been a forcing factor (Clason and Clutton-Brock, 1982), though more research is required to gain clarity about this.

In the light of on-going developments during the Neolithic, the 8.2 ka is often seen as a key factor in the Neolithisation in Europe. However, Lemmen and Wirtz (2014) argue that this process, or at least a similar development, would probably also have taken place without the occurrence of a short-term climatic shift. Indeed, they argue that climate events possibly even had a negative effect on the spread of agriculture. Their models indicate that climate events delayed Neolithisation on several occasions with 50 to a 100 years. According to Lemmen and Wirtz (2014), endogenous effects, for instance social stratification (Balter, 2010), supposedly were more influential in the spread of agriculture from the Near East to Europe.

Similar to the uncertainties concerning studies on the 8.2 ka event, interpretations of archaeological data are often clouded in uncertainties and assumptions. In archaeology, the main dating tool is Radiocarbon. The best dated Neolithic site in the Near East is Tell Sabi Abyad, based on a robust series of 145 ¹⁴C dates of the well described prehistoric sequence applying Bayesian analysis. Indeed

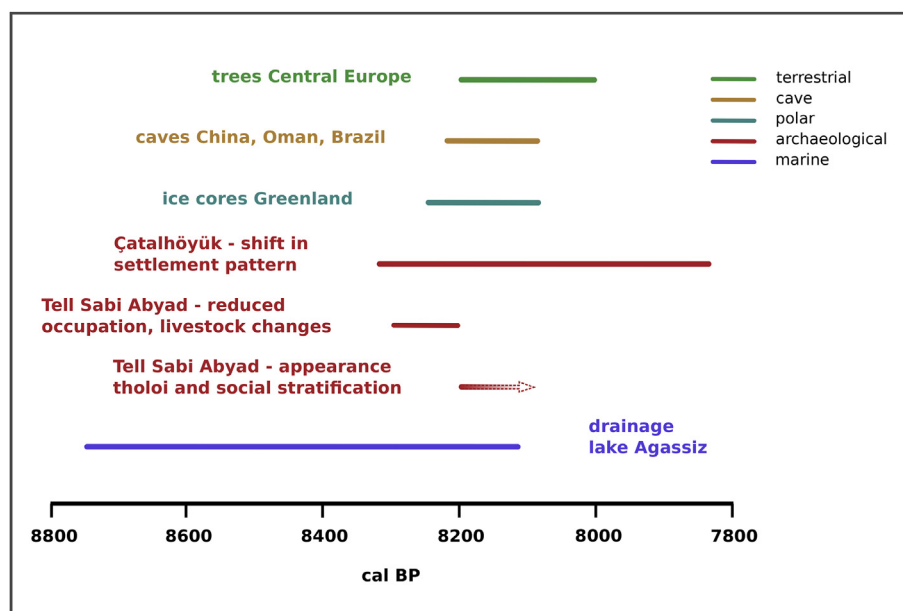


Fig. 3. Archaeological results from Tell Sabi Abyad compared with ice core and marine data, and data from other regions correlating with the 8.2 ka event (Barber et al., 1999; Rohling and Pälike, 2005; Weninger et al., 2006; Thomas et al., 2007; Cheng et al., 2009).

the cultural transition is found to be coeval with the 8.2 ka event as dated by ice, speleothems and tree-rings (Van der Plicht et al., 2011). Unfortunately, there is no climate proxy record available for the site, so one cannot prove that the cooling event 8200 year ago caused the cultural changes at Tell Sabi Abyad. Synchronicity does not imply causality.

Another interesting observation is that before the 8.2 ka climate anomaly became well known (which was approximately since the year 2000), no significant environmental deterioration was mentioned from studies on palaeozoological and palaeobotanical material from the Middle East dating back to the time of the climate event (e.g. Van Zeist and Bottema, 1982; De Moulines, 1997). Only after the 8.2 ka anomaly was detected in several oxygen isotope records, corresponding results were recorded from archaeology (Akkermans, 2004; Russell, 2010; Rietkerk et al., 2011).

To be able to state with more certainty if and to what extent the 8.2 ka event led to environmental changes in the area, further research is needed on the archaeological records of especially wild flora and fauna. Currently, archaeological research is mostly focused on domesticated animal and plant species. Data collection on wild species is still marginal. Though data on domesticated species can give information on indirect effects of climate change, research on direct climate influences on ecosystems requires data on wild species. Long term datasets are required to separate short term environmental anomalies from long term changes, including ecosystem shifts.

7. Conclusion

Thus far no shifts in wild flora and fauna have been observed at Tell Sabi Abyad dating back to the timing of the 8.2 ka event. Though the timing of changes in domesticated species and cultural changes correlates with the timing of the 8.2 ka event, these cannot be with certainty linked to the climate event as long as supporting data from wild species and long term data are lacking. The changes that have thus far been observed in the archaeological record of Tell Sabi Abyad are all human-related and might very well be a result of non-climate forcing factors, like anthropogenic influences or cultural development.

This study stresses the added value of archaeology for research on ecosystem resilience. Comparing archaeological datasets with ice core data and climate models can give a more complete picture of the way in which external factors affect ecosystems and the differences between ecosystem tipping points throughout different regions in the world.

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