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Climate forcing due to the 8200 cal yr BP event observed at Early Neolithic sites in the eastern Mediterranean

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Abstract

We explore the hypothesis that the abrupt drainage of Laurentide lakes and associated rapid switch of the North Atlantic thermohaline circulation 8200 yr ago had a catastrophic influence on Neolithic civilisation in large parts of southeastern Europe, Anatolia, Cyprus, and the Near East. The event at 8200 cal yr BP is observed in a large number of high-resolution climate proxies in the Northern Hemisphere, and in many cases corresponds to markedly cold and arid conditions. We identify the relevant archaeological levels of major Neolithic settlements in Central Anatolia, Cyprus, Greece and Bulgaria, and examine published stratigraphic, architectural, cultural and geoarchaeological studies for these sites. The specific archaeological events and processes we observe at a number of these sites during the study interval 8400–8000 cal yr BP lead us to refine some previously established Neolithisation models. The introduction of farming to South-East Europe occurs in all study regions (Thrace, Macedonia, Thessaly, Bulgaria) near 8200 cal yr BP. We observe major disruptions of Neolithic cultures in the Levant, North Syria, South-East Anatolia, Central Anatolia and Cyprus, at the same time. We conclude that the 8200 cal yr BP aridity event triggered the spread of early farmers, by different routes, out of West Asia and the Near East into Greece and Bulgaria.

Keywords: 8200 cal yr BP event; Radiocarbon; Neolithisation

Introduction

Greenland ice core records have revealed that 8200 yr ago, temperatures in the North Atlantic region decreased abruptly, and then subsequently recovered, during an interval of about 200 yr. A large number of contemporaneous climate events are documented in terrestrial records in North America (Yu and Eicher, 1999; Spooner et al., 2002), the Caribbean (Hughen et al., 2000), Europe (Von Grafenstein et al., 1999; McDermott et al., 2001; Schmidt and Gruhle, 2003; Tinner and Lotter, 2001; Klitgaard-Kristensen et al., 1998), Africa (Gasse, 2000), and Western Asia (Siani et al., 2001; Arz et al., 2003). In central Greenland the surface air temperature dropped by 3–6°C (from $\delta^{18}O_{ice}$ e.g. Johnsen et al., 2001), and perhaps up to 7.4°C (Leuenberger et al., 1999, from ^{15}N of N_2 measurements in the GRIP ice core). A reduction in air temperature of this magnitude is likely to be linked with drier conditions and stronger winds over the North Atlantic and drier monsoon regions (Alley et al., 1997; Bauer et al., 2004).

According to Barber et al. (1999), the observed cooling was caused by a catastrophic collapse of the last remaining ice dome

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of the Laurentide Ice Sheet covering Hudson Bay. During deglaciation, a remnant ice mass blocked the northward drainage of the large glacial lakes Agassiz and Ojibway, which previously discharged southeastwards over sillways to the St Lawrence river. Around 8200 yr ago, the ice dam collapsed, allowing the lakes to drain swiftly northwards into the Labrador Sea. The release of the estimated 1.6×10^{14} m^3 of freshwater (Teller et al., 2002) previously stored in the proglacial lakes through Hudson Strait may have substantially weakened the deep-water formation in the North Atlantic. Two research groups have performed dedicated numerical climate simulations of the 8200 cal yr BP event, both using coupled atmosphere–ocean–biosphere models (Renssen et al., 2001, 2002; Bauer et al., 2004). The studies by Renssen et al. (2001, 2002) confirm that the amount of freshwater stored in the proglacial Lake Agassiz is sufficient to lower the surface water density in the Nordic Seas below the threshold value for salinity-driven (contrasting wind-driven) deep-water formation (cf. Rahmstorf, 2003). These studies demonstrate that the thermohaline circulation (THC) perturbation could be maintained for many hundreds of years, depending on the amount of freshwater released and the duration of the freshwater pulse. Although not directly predicted by the modelling studies, the 8200 cal yr BP event may also have been accompanied by huge and fast-propagating surface gravity waves, that would lead to massive floods in coastal regions in the North Atlantic. This requires empirical confirmation. The amount of outflowing water corresponds to a global-mean sea level rise of 0.5 m (Bauer et al., 2004).

In contrast to the 4200 cal yr BP climate change event, which has aroused considerable interest in archaeology (Weiss et al., 1993; Staubwasser et al., 2003), no archaeological study has been undertaken to identify the potential effects of the much larger 8200 cal yr BP event. In this paper, we begin the archaeology of the 8200 cal yr BP event by exploring the question: which prehistoric periods, archaeological sites, and cultural processes in the Eastern Mediterranean are the most promising candidates for showing response to the postulated climatic forcing? We place emphasis on the Eastern Mediterranean due to the advanced state and complex character of the prehistoric communities in this area. The archaeological systems in these regions are further promising, for their enhanced sensitivity towards the envisaged droughts. We also considered focusing this study on Central Europe, but concluded *a priori* that – due both to the prevailing temperate Atlantic climate and the limitations of the archaeological data – the possible effects of the 8200 cal yr BP event in the European Mesolithic may be less clearly recognisable.

We began by selecting a number of climate proxies according to the following criteria (1) all likely show the same climate event, (2) as many as possible derive from sites close to our study area, and (3) the records should be dated with the highest presently attainable temporal resolution. The selected proxies are shown in Figure 1. Because our archaeological studies are based on tree-ring calibrated ^{14}C-ages (Reimer et al., 2004), we first synchronised all these proxies – as closely as achievable by visual comparisons – with the tree-ring widths measured for the Central European Oak Chronology (Klitgaard-Kristensen et al., 1998). By this measure, we obtain an age estimate for the 8200 cal yr BP event scaled to the European tree-ring chronology, thus producing the highest achievable absolute dating precision for the 8200 cal yr BP event (Weninger et al., 2006). We note that minor (decadal) adjustments of published age models for the Greenland Ice Cores GRIP, GISP2, and NGRIP, as well as for Cariaco, Ammersee, and Crag Cave are necessary to achieve direct visual comparison of all these proxies. For example, the $\delta^{18}O_{ice}$-GISP2 data shown in Figure 1 are shifted 40 yr younger, in comparison to the age values published by Grootes et al. (1993) (Fig. 1). The age shifts of the other climate proxies under study can be taken from the individually shifted time-scales in Figure 1. This procedure allows us to define a precise reference time interval 8300–8000 cal yr BP for the climate event under study, with overall temporal resolution we judge to be a few decades on the tree-ring age scale. We show this reference time interval for the 8200 cal yr BP event as a differentially greyed band (dark grey = "early 8.2", medium grey = "middle 8.2", light grey = "late 8.2") in all graphs of the calibrated archaeological radiocarbon ages (Figs. 3–5). The chronological results shown in Figure 1 are supported by the recently published Greenland Ice Core Age Model (GICC05) age model (Vinther et al., 2006).

Before proceeding, we would like to bring attention to the studies by Ariztegui et al. (2000) on Italian continental records and Mediterranean marine sediments, and notably to an interruption in the deposition of Sapropel S1 dating ca. 8000 cal yr BP. This points to an abrupt change to colder/dryer conditions in the otherwise warm and humid conditions of the early Holocene, in the entire Mediterranean. Ariztegui et al. (2000) have tentatively related this dry snap to changes in solar irradiance or cosmic ray flux. However, judging by its chronological position, it appears to be entirely coeval with the increasingly dry period ca. 8250–8000 cal yr BP, that clearly interrupts the periods of flash-floods dating from 8400 to 6900 cal yr BP identified in the Soreq Cave stalagmite (Fig. 1, cf. Bar-Matthews et al., 2003). There are, we conclude, sufficient strands of evidence in support of our basic hypothesis, that during the time period ca. 8250–8000 cal yr BP, at least some of our study regions (Levante, Anatolia, Mesopotamia, Greece, Bulgaria) experienced unusually cold/dry climatic conditions.

Radiocarbon database

Our studies are based on a substantial radiocarbon database for the Pre-Pottery and Pottery Neolithic periods in Southeast Europe and the Near East (Total $N = 7360$ ^{14}C-dates). The present studies are concentrated on the large settlements (mostly tell-mounds i.e. multi-phase stratified settlements) encountered in Turkey ($N = 649$), Greece ($N = 253$) and Cyprus ($N = 130$), for which extensive series of stratified ^{14}C-dates are available. This selection of large sites may introduce an unavoidable bias due to the lack of comparative data. Our approach is to identify the stratigraphic position (metric depth), architectural phase and specific cultural association, at each site for which the ^{14}C data

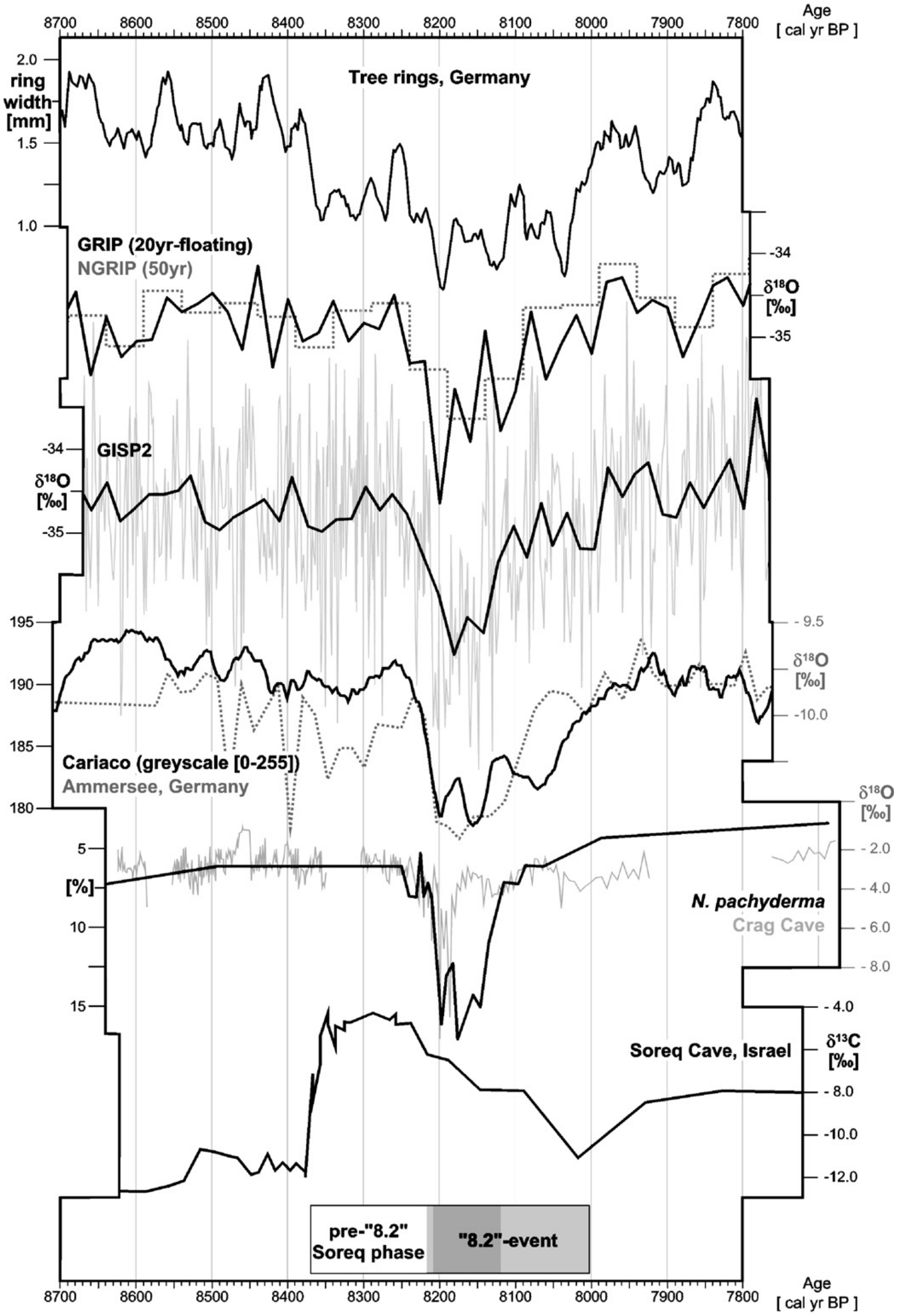

Figure 1. Climate proxies in the time-window 8700–7800 cal yr BP, with minor (decadal) adjustments on age models to achieve a better visual fit with the Central European Tree-Ring Chronology (after Weninger et al., 2006). From top to bottom: Tree-Ring Width (Oak, Germany), Klitgaard-Kristensen et al., 1998. $\delta^{18}O_{ice}$ (GRIP, Greenland, 20 yr averages), Grootes et al. (1993). $\delta^{18}O_{ice}$ (NGRIP, Greenland, 50 yr averages), North Greenland Ice Core Project Members, 2004. $\delta^{18}O_{ice}$ (GISP2, Greenland, ca. 10 yr averages), Grootes et al., 1993. Marine Varve Greyscale (Cariaco Basin, Venezuela), Hughen et al. (2000). $\delta^{18}O_{Ostracodes}$ (Ammersee, South Germany), Von Grafenstein et al. (1999). Percent N. pachyderma (Norwegian Coast), Klitgaard-Kristensen et al., 1998. $\delta^{18}O_{stalagmite}$ (Crag Cave, Ireland), McDermott et al., 2001. $\delta^{13}C_{stalagmite}$ (Soreq Cave, Israel), indicating a period with flash-floods 8500–7000 cal yr BP (only partly shown in this graph), interrupted by an increasingly dry period ca.8250–8000 cal yr BP, Bar-Matthews et al. (2003). The visual subdivision of the 8200 cal yr BP climate event (greyed box on lower time-scale) into a "pre-8.2 Soreq" phase (8370–8220 cal yr BP), followed by three subphases "Early" (8220–8210 cal yr BP), "Middle" (8210–8120 cal yr BP), and "Late" (8120–8000 cal yr BP) subphases, is established for the specific purposes of the present archaeological studies.

show an occupation overlapping the 8200 cal yr BP time interval. Once identified, we then treat these settlement phases as individual case studies. The geographic location of these sites is shown in Figure 2.

In the following, our procedure for each site is to briefly review the published archaeological architecture and finds, and then discuss the available ^{14}C-dates. All ^{14}C-ages are tree-ring age-calibrated using the dataset INTCAL04 (Reimer et al., 2004). For graphic representation of calibrated ^{14}C-ages we use the method of multiple-group calibration (Weninger, 2000). The underlying method of probabilistic ^{14}C-calibration is described in Weninger (1986).

We present a broad chronological overview (Fig. 3) of the archaeological ^{14}C-data under discussion for the regions of Cyprus, Turkey, Greece, Greece-Theopetra-Cave and Greece Franchti-Cave, all in comparison to the reference time interval (greyed) for the 8200 cal yr BP event, as defined above. The total available ^{14}C-data for the Neolithic sequence on Cyprus begins in the 11th millenium cal yr BP and ends around 8000 cal yr BP, with a data maximum centered around 8200 cal yr BP. As will be discussed later, this maximum is due to the availability of two large series of ^{14}C-ages for the aceramic sites Khirokitia and Kalavassos Tenta. In Turkey, when again we focus our attention on the time interval around 8200 cal yr BP, we observe the opposite—an extended minimum in the dating series. In Greece the early Holocene ^{14}C-sequence shows only a small number of (Epipalaeolithic and Mesolithic) dates prior to the interval under study, followed by a major step centered on the 8200 cal yr BP study interval. This step marks the beginning of the earliest Neolithic in Greece; we must further specify (due to continuing archaeological discussions) as (1) producing pottery and (2) known from tell-mounds (i.e. excluding cave sites). The large number of ^{14}C-ages available for the Greek Early Neolithic partly corresponds to the special attention given to this period during the past few decades of archaeological research. We will discuss the relevant (^{14}C-dated) sites below. We have enhanced the appearance of this step by subtracting from the database, and showing separately, the ^{14}C-data for Theopetra Cave and Franchthi Cave. These cave sites are most important for our understanding of the Mesolithic/Neolithic transition in Greece. The overall picture is that the Greek Mesolithic is a highly mobile maritime culture, with preference for coastal settings. The majority of known Mesolithic sites are situated in marshes, on beaches and dunes, and along streams, at distances ranging from a few to a few tens of km from the Mesolithic shore (Van Andel, 2005). The clear exception for an inland Mesolithic site is Theopetra Cave, which is situated in the Thessaly basin (Facorellis et al., 2001). Yet even here the earliest pottery-bearing strata have ^{14}C-ages close to (and not older than) 8200 cal yr BP. We conclude that all presently known early pottery finds in Greece are associated with the incoming farming communities, and do not reflect pottery manufacture by Greek Mesolithic groups. However, as can be recognised from Figure 5 (e.g. Argissa Magoula), there do exist some ^{14}C-radiometric indications of a pre-8200 cal yr BP occupation of the tell-mounds in Greece, which appear to have significant temporal extension. Earlier

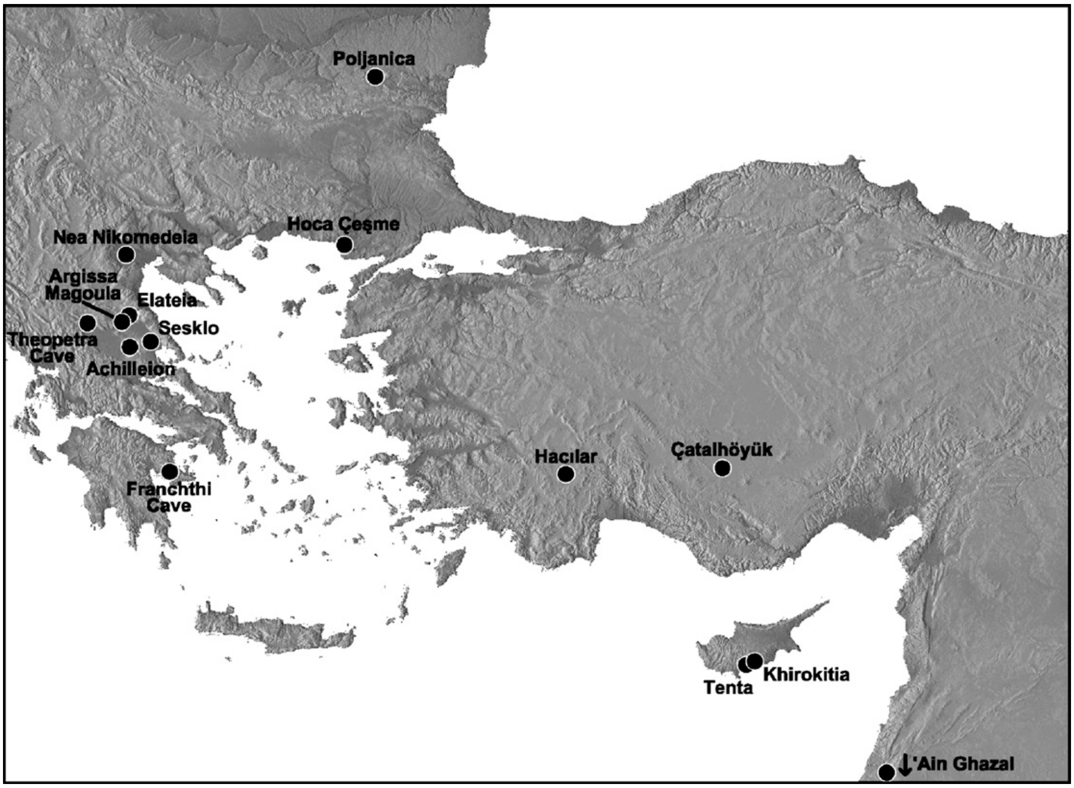

Figure 2. Geographic location of the archaeological sites in the Eastern Mediterranean.

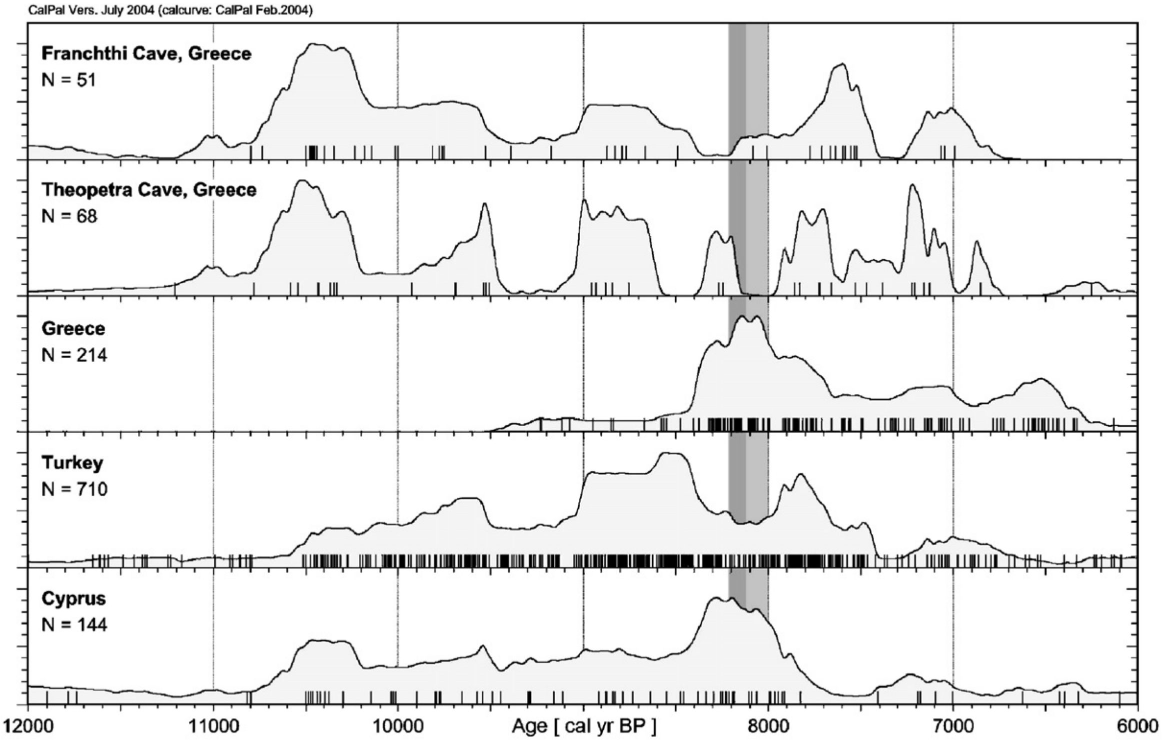

Figure 3. Cumulative calibrated dating probability of radiocarbon data from the Eastern Mediterranean, arranged according to regions Cyprus, Turkey, and Greece, compared to time window on the 8200 cal yr BP event (greyed interval 8250–7950 cal yr BP cf. Fig. 1). For Greece, the ^{14}C data for the Theopetra Cave and the Franchti Cave are plotted separately. Radiocarbon Data: Cologne Near-East Neolithic Radiocarbon Database (www.calpal.de).

researchers have taken these ^{14}C-dates at face value to imply the existence of a pre-pottery (aceramic) period in Greece. Many archaeologists still today predominantly take these dates at face value, and infer they provide evidence for an early start of the pottery Neolithic in Greece. In the discussion below we will show both modes of interpretation to be unfounded.

We now proceed with a more detailed description of the archaeological sites under study, starting with the Late Aceramic Neolithic on Cyprus (at Khirokitia, Kalavasos Tenta), then jumping over to Turkey to have a first look at the 8200 cal yr BP event (as described above: actually the observed ^{14}C-data minimum) as it appears in the Late Neolithic/Early Chalcolithic transition in Central Anatolia (at Çatalhöyük East/West and Hacılar), following which we discuss the Early Neolithic in North-West Anatolia (at Hoca Çeşme). We then move westwards through Macedonia (Nea Nikomedeia) and finally southwards into the plains of Thessaly (Sesklo, Achilleion, Argissa Magoula, Elateia). In Central Anatolia our focus is on the transition from the Late Neolithic to the Early Chalcolithic. In all the other regions (Macedonia, Thessaly, Bulgaria) we are focussing on the Earliest Neolithic, as defined e.g. by the appearance of painted red Monochrome pottery (Schubert, 1999). This journey around the Eastern Mediterranean is completed with a brief glimpse at the Earliest Neolithic in Bulgaria (Ovcarovo-Platoto) prior to the Karanovo I period. Although this approach today has an overall “Out-of-Anatolia” direction, we do not necessarily assume this corresponds to the spread of farming during the Neolithic, which we expect to be more complex. We also do not discuss the archaeological sites of South-East Anatolia contemporary to the 8200 cal yr BP event, for which we have not identified any plausible (i.e. clearly exceptional) climate influences. The situation in the Levant has been examined in a previous paper (Weninger et al., 2006).

Archaeological sites

Khirokitia/Cyprus

Khirokitia was discovered in 1934 by P. Dikaios (Dikaios, 1953) who conducted first excavations in six campaigns from 1936 to 1946. Further excavations by the French mission (Le Brun, 1998, 2001) are continued today. The site location (34.78 °N, 33.34 °E) is about 6 km from the southern coast of Cyprus on a rocky promontory protruding into the Maroni river valley, which also drains the Troodos Mountain range (cf. Kalavasos-Tenta, below). The settlement is well protected, on one side by steep rocks and on the other by a large perimeter wall. This wall was earlier initially viewed as a main road (Dikaios, 1953: 186–195), if only because it is remarkably wide and runs uphill through the middle of the settlement. A second, equally impressive stone fortification (structure 284), identified later, built when the settlement spread, clearly shows the fortificatory character of these walls (Le Brun, 2001). The settlement contains a large number of circular stone structures with mud-plastered floors with exterior diameter ranging from 2.3 m to 9.8 m. As shown in Figure 4, the summed probability distribution of the calibrated ^{14}C-ages has a central reading at ca. 8300 cal yr BP. To account for the “old-wood” effect, this

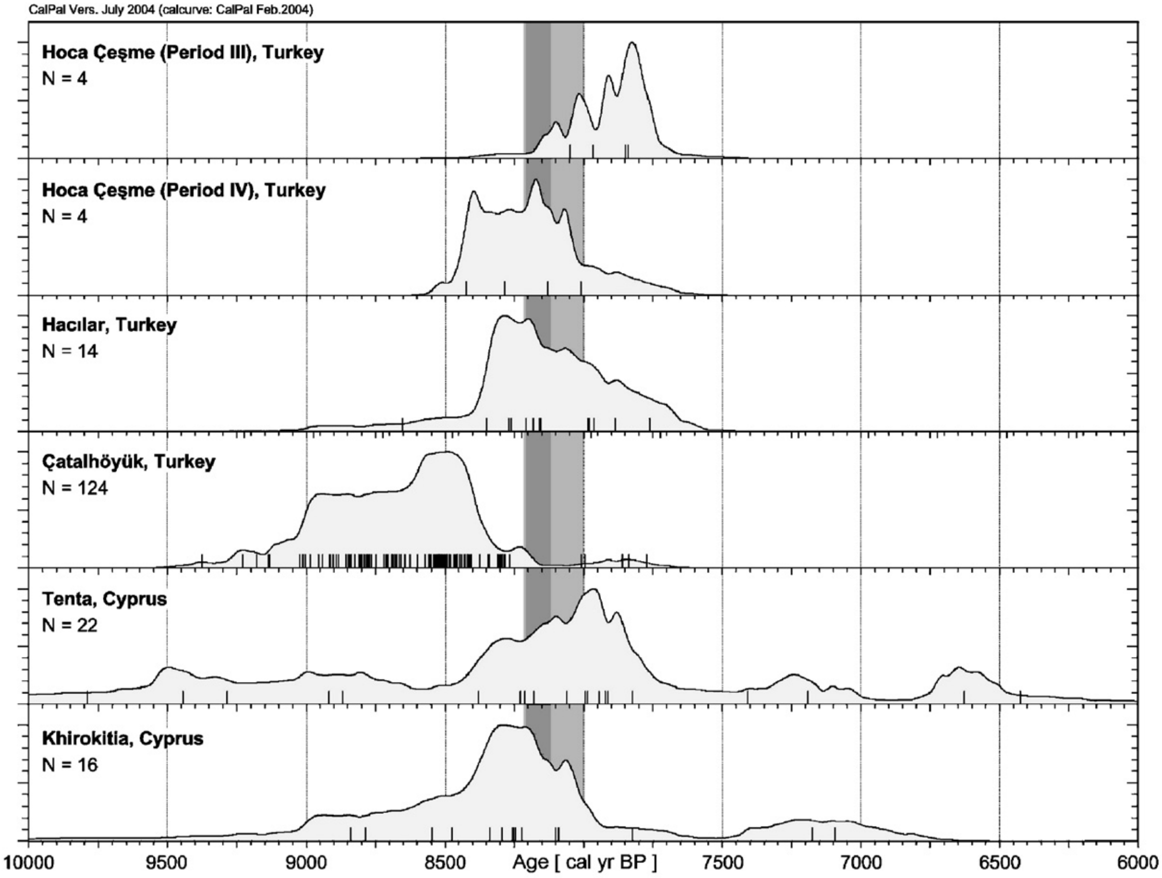

Figure 4. Cumulative calibrated dating probability of radiocarbon data from archaeological sites on Cyprus (Khirokitia/Table 1, Tenta/Table 2), and Turkey (Çatalhöyük East/Table 3, Hacılar/Table 5, Hoca Çeşme IV/Table 6, Hoca Çeşme III/Table 6), compared to time window on the 8200 cal yr BP event (greyed interval 8250–7950 cal yr BP cf. Fig. 1).

supplies us with a ca. 100 yr younger date for the main (excavated) occupation of the site. The site was deserted at some time during or towards the end of the time-span covering the 8200 cal yr BP event (Table 1).

Kalavasos tenta/Cyprus

Following a brief excavation by P. Dikaios in 1947, during which the presence of some substantial stone architecture of the aceramic Neolithic period was revealed, between 1967 and 1984, I. Todd undertook five seasons of excavations at the settlement of Kalavasos Tenta (Todd, 1987). The site location (34.75 °N, 33.29 °E) is on a terrace of the Vasilikos Valley, about 20 m above the valley floor, with a direct view to the neighbouring site of Khirokitia situated a few km to the east. The architecture comprises numerous circular stone structures, many of which contain single or double internal piers, which probably served to support an upper storey. In an early phase the settlement was surrounded by a wide stone wall, with an outside ditch on the southern side of the site. During a later phase, the settlement expanded beyond this wall. A total of 14 human burials were found, either interred in pits below the floors of buildings or in the open areas between the houses and covered by rubbish deposits (Table 2).

Detailed geomorphological studies by Todd (1987) demonstrate that the availability of water in the Vasilikos Valley catchment of the Troodos Mountain range is entirely dependent upon ephemeral precipitation, which commences in late October and continues into May. The mean annual precipitation in the valley is about 600 mm, with virtually no rain falling during the six summer months. The heaviest rainfalls are in December and January, during which time the river flow causes regular flooding of the patchy farming areas in the direct vicinity of the site. In most years rainfall is sufficient for dry-farming of cereals (>240 mm/yr), but crop records kept by a local family for the years 1800–1897 show that famine occurred about every 8 yr. Todd (1987) concludes that farmers can expect difficulties in the Vasilikos Valley for a total of about 28 yr every century.

The aceramic settlement is situated at short walking distances (max ca. 500 m) to the areas available for cultivation, which are located on small terraces at the edge of the river. The fields have a typical size of 100 m × 200 m. The lower fields are regularly inundated by spring floods. With this position, and notably its location on a low terrace directly above a regularly flooding river, the site of Kalavasos-Tenta has an ideal character for the flood-plain model of Van Andel and Runnels (1995).

The available ^{14}C-data (Fig. 4, Table 2) have an overall spread of more than 3000 yr. There is a local cluster of three

Table 1
Khirokitia (Cyprus)

Lab code	^{14}C age (BP)	Material	Site Locus	Site Period	General Period	Cal age (cal BP)	Reference
P-2549	5630±260	n.d.	–	Period 5/4	Cypro-PPNB	6440±300	Todd, 1987
P-2780	5830±60	n.d.	B 7 C: 2.4	–	Cypro-PN	6640±80	Todd, 1982
P-2781	6300±80	n.d.	G 11 C: 9.2	Period 4, late/3	Cypro-PPNB	7210±110	Todd, 1982
P-2977	6580±290	n.d.	G 10 A: 4.1	Period 2	Cypro-PPNB	7430±290	Todd, 1982
P-2975	6970±310	n.d.	F 11 C, E Blk.: 2.5	Period >=3	Cypro-PPNB	7840±280	Todd, 1982
P-2553	7110±90	n.d.	–	Period 3	Cypro-PPNB	7930±90	Todd, 1987
P-2779	7120±90	n.d.	G 12 D: 4.2	Period 4	Cypro-PPNB	7940±90	Todd, 1982
P-2783	7130±410	n.d.	G 11 C: 5.5	Period 4	Cypro-PPNB	8000±380	Todd, 1982
P-2551	7140±90	n.d.	–	Period>=3	Cypro-PPNB	7970±90	Todd, 1987
P-2550	7180±90	n.d.	–	Period>=3	Cypro-PPNB	8020±100	Todd, 1987
P-2552	7250±100	n.d.	–	Period 3	Cypro-PPNB	8080±90	Todd, 1987
P-2784	7380±100	n.d.	G 12 A: 5.8	Period 4, late/3	Cypro-PPNB	8200±120	Todd, 1982
P-2978	7400±260	n.d.	H 12 A: 2.4	Period 4	Cypro-PPNB	8230±250	Todd, 1982
P-2555	7430±90	n.d.	–	Period 4	Cypro-PPNB	8250±90	Todd, 1987
P-2782	7600±100	n.d.	G 11 C: 5.9	Period 4, late/3	Cypro-PPNB	8410±100	Todd, 1982
P-2973	8010±360	n.d.	G 10 A/C: 7.2/7.3	Period 2, Top of Site	Cypro-LPPNB	8930±410	Todd, 1982
P-2974	8020±90	n.d.	G9 D: 3.6	Period 2, Top of Site	Cypro-LPPNB	8870±140	Todd, 1982
P-2548	8350±200	n.d.	–	Period >=3	Cypro-PPNB	9290±220	Todd, 1987
P-2554	8480±110	n.d.	–	Period 2, Top of Site	Cypro-LPPNB	9450±110	–
P-2785	8720±400	n.d.	G 12 D: 5.1	Period 5/4	Cypro-MPPNB	9800±500	Todd, 1982
P-2976	8870±500	n.d.	F 11 C: 3.6	Period >=3	Cypro-PPNB	10030±640	Todd, 1982
P-2972	9240±130	n.d.	G 11 C: 13.2/16.1	Period 5	Cypro-EPPNB	10450±150	Todd, 1982

Database references: Reingruber and Thissen, 2004; Böhner, 2006.

dates centered on 8200 cal yr BP, and some additional seven dates around 7950 cal yr BP. On the basis of these data we could speculate that Aceramic Kalavasos-Tenta was first occupied when Khirokitia was deserted (ca. 8200 cal yr BP) and was itself deserted some 350 yr later (ca. 7850 cal yr BP). In this case the site would have been occupied during the 8200 cal yr BP event, and deserted at the end of the event. The earliest date for the following reoccupation of the site is represented by the measurement P-2780: 5830±60 ^{14}C yr BP. Later attention showed that this sample was archaeologically not *in situ* and contained many roots (Todd, 1987). The ^{14}C-measurements are altogether not very convincing, due to their wide variance, but do convey the impression that Kalavasos-Tenta is another major 8200 cal yr BP candidate.

According to the excavation report (Todd, 1987), the postulated lengthy break of the occupation of Cyprus (>1000 yr) following the 8200 cal yr BP event gains credence at Kalavasos-Tenta, due to the lack of evidence for continuity between the Aceramic and Ceramic Neolithic phases. Despite numerous surveys during the last few decades, no evidence has yet been found on Cyprus to locate sites which could represent the direct successors of Kalavasos-Tenta and Khirokitia. If these exist, they are likely only to be found under the forested areas of the island, for which the visibility of archaeological surveys is limited (E. Peltenburg, personal communication 2004).

Together, the series of aceramic ^{14}C-dates from the sites of Kalavasos-Tenta (Table 2) and Khirokitia (Table 1) and confirm our suspicion that the Pre-Pottery Neolithic period on Cyprus

Table 2
Kalavasos Tenta (Cyprus)

Lab code	^{14}C age (BP)	Material	Site Locus	Site Level	General Period	Cal age (cal BP)	Reference
Ly-4309	6230±160	n.d.	secteur est, carré 34/26–27, Sondage 507	niveau G	Cypro-PPN	7110±190	Le Brun, 1998
Ly-4306	6310±170	n.d.	secteur est, carré 34/26–27, Sondage 507	niveau F	Cypro-PPN	7190±190	Le Brun, 1998
Ly-3716	7000±150	n.d.	secteur est, carré 35/27, S. 117, sol 492	niveau C	Cypro-PPN	7830±130	Le Brun, 1998
BM-852	7294±78	n.d.	tholos XLVI (effondrement de la toiture)	–	Cypro-PPN	8110±80	Todd, 1987
BM-855	7308±74	n.d.	sous tholos XLVI	–	Cypro-PPN	8130±80	Todd, 1987
BM-854	7442±61	n.d.	tholos XLVI (occupation ancienne)	–	Cypro-PPN	8270±70	Todd, 1987
St-416	7445±160	n.d.	below tholos XVII	–	Cypro-PPN	8240±150	Todd, 1987
BM-853	7451±81	n.d.	tholos XLVI (occupation récente)	–	Cypro-PPN	8270±80	Todd, 1987
Ly-4308	7470±140	n.d.	secteur est, carré 34/26–27, Sondage 507	niveau F	Cypro-PPN	8260±130	Le Brun, 1998
St-414	7515±125	n.d.	tholos IA couche inférieure du corridor)	–	Cypro-PPN	8320±120	Todd, 1987
Ly-3719	7540±180	n.d.	secteur ouest, carré 29/24	niveau III	Cypro-PPN	8350±180	Le Brun, 1998
St-415	7655±160	n.d.	tholos IA couche inférieure du corridor)	–	Cypro-PPN	8490±170	Todd, 1987
Ly-3717	7700±150	n.d.	secteur ouest, carré 34/23	niveau III	Cypro-PPN	8560±170	Le Brun, 1998
Ly-3718	7930±320	n.d.	secteur est, carré 35/27 S. 117, sol 492	niveau C	Cypro-PPN	8850±380	Le Brun, 1998
Ly-4307	7930±130	n.d.	secteur est, carré 34/26–27, sondage 507	niveau F	Cypro-PPN	8800±170	Le Brun, 1998

Database references: Reingruber and Thissen, 2004; Böhner, 2006.

Table 3
Çatalhöyük East (Turkey)

Lab code	^{14}C age (BP)	Material	Species	Site Locus	Cal age (cal BP)	Reference
AA-27983	7015±55	charcoal	–	–	7850±70	Göktürk et al., 2002
PL-9800526B	7180±80	charcoal	–	–	8030±90	Göktürk et al., 2002
OxA-10092	7185±65	seeds	Triticum	–	8030±70	Cressford, 2001
OxA-11176	7465±75	seeds	Cerealae	building 1, phase 2B	8280±70	Thissen et al., 2004
P-1361	7499±93	charcoal	juniper	level V	8300±90	Stuckenrath and Lawn, 1969
P-769	7505±93	seeds	grain	level VI A	8310±90	Stuckenrath and Ralph, 1965
OxA-11078	7515±60	seeds	Cerealae	building 1, phase 2C	8310±70	Thissen et al., 2004
P-796	7521±77	seeds	grain, (2 types)	level II	8320±80	Stuckenrath and Ralph, 1965
P-781	7524±90	charcoal	oak	level VI B	8320±90	Stuckenrath and Ralph, 1965
P-774	7531±94	charcoal	timber(?)	level III	8320±90	Mellaart, 1975
OxA-11182	7535±45	bone	Capra, wild, horn	building 1, phase 3	8350±40	Thissen et al., 2004
P-778	7538±89	seeds	grain	level VI A	8330±90	Stuckenrath and Ralph, 1965
OxA-11077	7540±60	seeds	Lens	building 1, phase 3	8330±70	Thissen et al., 2004
P-772	7572±91	charcoal	oak	level VI A	8370±100	Stuckenrath and Ralph, 1965
P-827	7579±86	human	charred brain	level VI A	8380±90	Stuckenrath and Ralph, 1965
OxA-11079	7590±60	seeds	Cerealae	building 1, phase 2B	8400±50	Thissen et al., 2004
PL-980515A	7620±100	seeds	Cerealae	–	8440±90	Göktürk et al., 2002
OxA-11045	7620±45	seeds	Lens	building 1, phase E	8430±40	Thissen et al., 2004
AA-19344	7620±50	charcoal	juniper	level IV	8440±50	Newton and Kuniholm, 1999
AA-19345	7626±52	charcoal	juniper	level IV	8440±50	Newton and Kuniholm, 1999
P-797	7629±90	charcoal	juniper	level VI B	8450±80	Stuckenrath and Ralph, 1965
OxA-11007	7630±45	bone	Ovis/Capra	building 1, phase 5B	8440±40	Thissen et al., 2004
OxA-11040	7640±45	seeds	Cerealae	building 1, phase 2B	8450±50	Thissen et al., 2004
PL-9800562A	7640±90	seeds	Cerealae	building 1, phase 2	8460±80	Göktürk et al., 2002
P-776	7640±91	charcoal	juniper	level V	8460±80	Stuckenrath and Ralph, 1965.
OxA-11041	7655±45	seeds	Hordeum vulgare	building 1, phase 3	8460±50	Thissen et al., 2004
P-1375	7661±99	charcoal	elm	level VI A	8480±80	Stuckenrath and Lawn, 1969
OxA-11545	7670±40	seeds	pulses	building 1, phase 4	8470±50	Thissen et al., 2004
AA-19346	7670±50	charcoal	juniper	level IV	8470±50	Newton and Kuniholm, 1999
OxA-11031	7675±50	seeds	Cerealae	building 1, phase 4	8480±50	Thissen et al., 2004
OxA-11043	7680±50	seeds	Triticum dicoccum	building 1, phase 1B	8480±50	Thissen et al., 2004
OxA-11044	7680±50	seeds	Lens	building 1, phase E	8480±50	Thissen et al., 2004
P-1366	7684±90	charcoal	–	level VIII	8490±80	Stuckenrath and Lawn, 1969
OxA-11030	7685±40	seeds	Triticum dicoccum	building 1, phase 4	8480±50	Thissen et al., 2004
AA-27979	7700±60	seeds	Cerealae	building 1, phase 2	8490±60	Göktürk et al., 2002
P-777	7704±91	charcoal	juniper	level VI B	8510±80	Stuckenrath and Ralph, 1965
OxA-11712	7705±55	seeds	Lens	building 1, phase 3	8500±60	Thissen et al., 2004
PL-972139A	7710±70	seeds	Cerealae	building 1, phase 3	8500±60	Göktürk et al., 2002
AA-27978	7710±70	seeds	Cerealae	building 1, phase 3	8500±60	Göktürk et al., 2002
OxA-11155	7710±50	seeds	Cerealae	building 1, phase 2C	8500±50	Thissen et al., 2004
AA-18105	7710±100	charcoal	juniper	level IV	8520±90	Newton and Kuniholm, 1999
OxA-11075	7725±75	bone	Bos, skull	building 1, phase 3	8510±70	Thissen et al., 2004
P-1365	7729±80	charcoal	juniper	level VI A	8520±70	Stuckenrath and Lawn, 1969
PL-980559A	7730±80	charcoal	–	–	8520±70	Göktürk et al., 2002
OxA-11046	7730±50	seeds	Triticum dicoccum	building 5, phase B	8510±60	Thissen et al., 2004
OxA-11029	7730±45	seeds	Lens	building 1, phase 3	8510±50	Thissen et al., 2004
AA-19351	7747±65	charcoal	juniper	level IV	8520±70	Newton and Kuniholm, 1999
OxA-11183	7750±45	seeds	Cerealae	building 1, phase 4	8520±50	Thissen et al., 2004; Newton and Kuniholm, 1999
OxA-11713	7755±55	seeds	Lens	building 1, phase 3	8530±60	Thissen et al., 2004
P-1374	7757±92	charcoal	elm	level XII	8560±100	Stuckenrath and Lawn, 1969
PL-9800563A	7760±90	seeds	Cerealae	level VII	8560±100	Göktürk et al., 2002
PL-980519A	7760±80	seeds	Cerealae	level VII	8550±80	Göktürk et al., 2002
OxA-11049	7760±50	human	bone, juvenile	building 1, phase 2C	8530±60	Thissen et al., 2004
OxA-11032	7765±40	seeds	Cerealae	building 1, phase 2C	8540±50	Thissen et al., 2004
OxA-11050	7775±50	human	bone, juvenile	building 1, phase 2C	8540±60	Thissen et al., 2004
OxA-9945	7775±50	seeds	Scirpus	–	8540±60	Cressford, 2001
AA-27976	7780±55	charcoal	–	–	8550±60	Thissen et al., 2004
PL-980520A	7780±80	seeds	Cerealae	level VII	8580±100	Göktürk et al., 2002
OxA-11028	7780±40	seeds	Cerealae	building 1, phase 2B	8550±50	Thissen et al., 2004
OxA-11042	7785±45	seeds	Triticum/ Hordeum	Building 1, phase 1B	8560±50	Thissen et al., 2004
OxA-11047	7790±50	human	bone, old man	building 1, phase 4	8560±60	Thissen et al., 2004
AA-27980	7790±60	seeds	Cerealae	level VIII–VII	8560±70	Göktürk et al., 2002
PL-9800570A	7800±90	seeds	Cerealae	level VII	8630±130	Göktürk et al., 2002

Table 3 *(continued)*

Lab code	^{14}C age (BP)	Material	Species	Site Locus	Cal age (cal BP)	Reference
OxA-11048	7800±50	human	bone, adult man	building 1, phase 4	8580±60	Thissen et al., 2004
PL-980511A	7800±100	seeds	Cerealae	level IX–VIII	8640±150	Göktürk et al., 2002
PL-980514A	7810±100	seeds	Cerealae	–	8660±160	Göktürk et al., 2002
PL-972431A	7810±80	seeds	Cerealae	level VIII–VII	8630±120	Göktürk et al., 2002
PL-980410A,B	7815±60	charcoal	–	level IX–VIII	8620±80	Göktürk et al., 2002
PL-9800521A	7820±90	seeds	Cerealae	building 1, phase 3	8670±150	Göktürk et al., 2002
PL-9800566A	7820±90	seeds	Cerealae	level VIII	8670±150	Göktürk et al., 2002
PL-9800522A	7830±90	seeds	Cerealae	–	8690±150	Göktürk et al., 2002
PL-972126A	7830±80	seeds	Cerealae	building 1, phase 2A	8680±130	Göktürk et al., 2002
PL-980518A	7840±80	seeds	Cerealae	level VII	8700±140	Göktürk et al., 2002
P-1371	7844±102	charcoal	–	level X	8710±170	Stuckenrath and Lawn, 1969
PL-980513A	7850±100	seeds	Cerealae	level VIII	8720±170	Göktürk et al., 2002
PL-980561A	7850±80	seeds	Cerealae	level VII	8720±140	Göktürk et al., 2002
PL-9800507B	7850±90	seeds	Cerealae	level VII	8720±160	Göktürk et al., 2002
P-1367	7853±97	charcoal	elm/oak	level VIII	8730±160	Stuckenrath and Lawn, 1969
OxA-11051	7855±45	human	bone, old woman	building 1, phase 2B	8670±70	Göktürk et al., 2002
PL-980512A	7860±100	seeds	Cerealae	level IX–VIII	8730±160	Göktürk et al., 2002
OxA-11052	7860±45	human	bone, old man	building 1, phase 1B	8680±70	Thissen et al., 2004
PL-9800568A	7880±90	seeds	Cerealae	level IX–VIII	8760±150	Göktürk et al., 2002
P-1362	7904±111	charcoal	elm	level VI B	8780±160	Stuckenrath and Lawn, 1969
PL-980558A	7910±80	charcoal	–	Building 1, phase 1B	8790±140	Göktürk et al., 2002
PL-980560A	7910±80	seeds	Cerealae	level VIII	8790±140	Göktürk et al., 2002
OxA-9943	7910±55	seeds	Triticum	–	8790±130	Cressford, 2001, 723
P-1363	7911±103	charcoal	timber(?)	level VII	8780±150	Stuckenrath and Lawn, 1969
P-770	7912±94	charcoal	juniper/ oak	level VI B	8780±150	Stuckenrath and Ralph, 1965
P-1372	7915±85	charcoal	elm or bone ?	level X	8790±140	Stuckenrath and Lawn, 1969
AA-19350	7918±54	charcoal	juniper	level IV	8790±130	Newton and Kuniholm, 1999
OxA-9774	7935±50	seeds	Scirpus	level XI	8810±120	Cressford, 2001
P-1364	7936±98	charcoal	elm	level VI B	8800±150	Stuckenrath and Lawn, 1969
P-1369	7937±109	charcoal	–	level X	8800±150	Stuckenrath and Lawn, 1969
PL-972424A	7940±80	seeds	Cerealae	Building 1, phase 1B	8810±140	Göktürk et al., 2002
AA-19349	7944±65	charcoal	juniper	level IV	8810±130	Göktürk et al., 2002
OxA-9980	7955±75	seeds	Triticum	–	8820±130	Cressford, 2001, 723
OxA-9771	7965±55	seeds	Triticum	–	8830±120	Cressford, 2001, 723
OxA-9944	7975±50	seeds	Cerealae	–	8850±110	Cressford, 2001, 723
OxA-9946	7980±55	seeds	Scirpus	level XI	8850±110	Cressford, 2001, 719
AA-19348	7982±52	charcoal	juniper	level IV	8850±110	Newton and Kuniholm, 1999
OxA-9947	7985±50	seeds	Triticum/ Hordeum/ Scirpus	level XII	8850±100	Cressford, 2001, 719
OxA-9776	7985±55	seeds	Scirpus	level pre XII.B	8850±110	Cressford, 2001, 719
AA-19347	7998±54	charcoal	juniper	level IV	8860±100	Newton and Kuniholm, 1999
OxA-9772	8025±55	seeds	Triticum	–	8890±100	Cressford, 2001, 723
OxA-9950	8030±50	seeds	Triticum/ Pisum	level pre XII.B	8900±100	Cressford, 2001, 719
P-1370	8036±104	charcoal	ashes; charcoal-elm	level X	8910±170	Stuckenrath and Lawn, 1969
P-775	8037±96	charcoal	juniper	level IV	8900±160	Stuckenrath and Ralph, 1965
PL-9800565A	8050±70	seeds	Cerealae	level VII	8920±120	Göktürk et al., 2002
OxA-9949	8050±50	seeds	Pisum	level pre XII.A	8920±100	Cressford, 2001
–	8060±80	charcoal	–	building 1, phase 2	8940±140	–
AA-18104	8065±50	charcoal	juniper	level IV	8940±110	Newton and Kuniholm, 1999
PL-972425A	8070±80	charcoal	–	building 1, phase 2B	8950±150	Göktürk et al., 2002
AA-47057	8085±66	bone	Bos, phalanx	–	8980±130	Göktürk et al., 2002
OxA-9775	8090±55	seeds	Triticum/ Hordeum	level XII	9000±100	Cressford, 2001
OxA-9948	8090±50	seeds	Triticum/Hordeum	level XII	9020±70	Cressford, 2001
P-782	8092±98	charcoal	–	level X	9000±180	Stuckenrath and Ralph, 1965
OxA-9892	8150±50	seeds	Lens	level pre XII.C	9120±80	Cressford, 2001
OxA-9893	8155±50	seeds	Triticum/ Scirpus/ Cerealae	level pre XII.D	9120±80	Cressford, 2001
OxA-9777	8160±50	seeds	Lens	level pre XII.C	9130±80	Cressford, 2001
P-779	8190±99	charcoal	–	level IX	9180±130	Stuckenrath and Ralph, 1965
AA-27982	8195±80	charcoal	–	Pre XII.D?	9180±110	Göktürk et al., 2002
OxA-9778	8240±55	seeds	Triticum/ Pisum	level pre XII.D	9220±100	Cressford, 2001
PL-980525A	8390±90	charcoal	–	Pre XII.D?	9380±100	Göktürk et al., 2002

Database references: Gérard, 2001; Thissen et al., 2004; Böhner, 2006.

ends abruptly and simultaneously at all other known (and ^{14}C-dated) sites around 8200 cal yr BP, or sufficiently close to this date to make the desertion of the island a very good candidate for climate forcing due to extended aridity.

Çatalhöyük/Central anatolia

Çatalhöyük is one of the largest and best-studied archaeological sites in the Near East. The site is situated at 31.83 °N, 35.90 °E in the Konya Plain of Central Anatolia (Fig. 2). This location is well inside one of the major natural distribution zones for (at least) four of the most important major early Neolithic domesticates (cattle, sheep, goat, and pigs) (Uerpmann, 1987) and is a core area also for the natural distribution of wild cereals.

According to geomorphological and hydrological studies (Kuzucuoğlu, 2002) the Konya plain is basically karstic, with seasonal inundation during winter and early spring months. The plains are largely covered by impermeable and nutrient poor lacustrine marls that become salty at times of heavy evaporation. The grass-covered steppe-like rangelands are well-suited to animal husbandry, and the forest-rich areas of the Konya plain and bordering high-lands can be expected to support wild game in large numbers. As Kuzucuoğlu (2002) notes, the settlement and activity patterns of this altogether semi-arid region will rely strongly on access to freshwater. The Konya area has a continental, semi-arid climate with cold winters and warm-dry summers. The low annual precipitation (<350 mm/yr) is concentrated on the winter and spring months. Kuzucuoğlu (2002) further observes that the alluvial fan of Çatalhöyük will only be useful for agricultural purposes when water is available for flooding. On the basis of the available data we therefore conclude that the situation at Çatalhöyük for rainfall-based agriculture must have been tenious. The low average rainfall would have made Çatalhöyük quite vulnerable to any sustained drought condition.

The site covers two large and independent tell settlements (East mound: 600 × 350 m; West mound 200 × 200 m) that were discovered by J. Mellaart in 1961 and extensively excavated in the following years (Mellaart, 1965, 1975). Excavations are continuing on both sites under the direction of I. Hodder. The two settlements are situated in close vicinity to each other (distance: 200 m), but separated by the Carşamba river, which has constructed an expansive alluvial fan in the Konya plain. The larger mound of Çatalhöyük-East has 12 major architectural phases, labelled Level XII (oldest) to Level I (youngest). Without exception, even following the major fire at the end of Level VIA, we cannot observe an interruption in the sequence of buildings and courts (Düring, 2001, 2002). The densely-closed distribution of calibrated radiocarbon data (Fig. 4, Table 3) confirms the hypothesis that the occupation of Çatalhöyük-East was continuous for more than 1000 yr. This long ^{14}C-sequence ends abruptly around 8250 cal yr BP (Fig. 4). Taking into consideration that the majority of dates are on potentially long-lived wood charcoal (notably Juniperus, Ulmus and Quercus), and that the youngest Phase I is not represented in the data, we conclude that the site became uninhabited some 100–200 yr later. This simple dating is entirely in concordance with the architectural radiocarbon wiggle-matching results of Newton and Kuniholm (1999). These are based on detailed tree-ring derived estimates for the occupation length of selected architectural units, under the assumption that the wall plasters may represent annual applications (Newton and Kuniholm, 1999). The two dates available for the base levels of the adjacent Chalcolithic settlement at the Çatalhöyük-West are both younger by a few hundred years (Table 4). A corresponding shift in occupation from the old site to the new one is generally acknowledged, but the reasons remain to be clarified. We also note that the shift from Çatalhöyük-East to Çatalhöyük-West, which immediately follows the 8200 cal yr BP event, is accompanied by the introduction – for the first time in substantial amounts – of high-quality pottery. We conclude that, following ca. 1000 yr of continuous settlement, the site of Çatalhöyük-East was abruptly deserted at some time within the 8200 cal yr BP event, and speculate that this was due to a combination of crop-failures as well as dried-out wells.

Hacilar/central anatolia

The low tell settlement of Hacılar (38.40 °N, 34.18 °E) is situated in the South-West Anatolian lake district, in the direct vicinity of a water source. Excavations were performed 1957–1969 by J. Mellaart, who identified 7 architectural phases that are labeled I to VII, old to young (Mellaart, 1970). Hacılar is a small, but heavily fortified village, built as the result of some purposeful and systematic plan. The site contains a dozen rectangular houses, systematically arranged around a central walled court. This court and additional houses, external to the central area, are encompassed by a massive and free-standing fortification wall. Many researchers conclude that settlement at Hacılar began during a very early phase of the PPN (Pre-Pottery Neolithic) and continued for a long time, but this notion is supported by only a single radiocarbon measurement, which may be an outlier (Table 5, BM-127: 8700 ± 180 ^{14}C yr BP). If we suspend three further early BM-dates from analysis, the remaining 12 ^{14}C-dates consistently cluster around 8200 cal yr BP (Fig. 4). This is quite in accordance with the architectural plan, and we conclude that Hacılar was occupied for a limited

Table 4
Çatalhöyük West (Turkey)

Lab code	^{14}C age (BP)	Material	General Period	Site Locus	Cal age (cal BP)	Reference
PL-980524A	6940 ± 80	charcoal	Early Chalcolithic	Core CH96W, base of mound	7790 ± 80	Göktürk et al., 2002
AA-27981	7040 ± 40	charcoal	Early Chalcolithic	Core CH96W, base of mound	7890 ± 50	Göktürk et al., 2002

Database references: Gérard, 2001; Thissen et al., 2004; Böhner, 2006.

Table 5
Hacılar (Turkey)

Lab code	^{14}C age (BP)	Material	Species	Site Level	Site Locus	Cal age (cal BP)	Reference
P-315	6926±95	charcoal	(poutre)	level IA	Room 5, Roof Beam	7780±90	Ralph and Stuckenrath, 1962
P-315A	7047±221	charcoal	–	level IA	Room 5, Rood Beam	7900±210	Ralph and Stuckenrath, 1962
P-313	7150±98	charcoal	–	level VI	Area E, ash from fireplace	7990±110	Ralph and Stuckenrath, 1962
P-326A	7169±131	n.d	–	–	–	8000±140	Bienert, 2000
P-316	7170±134	charcoal	–	level IIA	Area N, Room 4, Roof Beam	8000±140	Ralph and Stuckenrath, 1962
P-316A	7172±127	charcoal	–	level IIA	Area N, Room 4, Roof Beam	8010±130	Ralph and Stuckenrath, 1962
P-314	7340±94	charcoal	–	level IX	Area E, ash from fireplace	8170±110	Ralph and Stuckenrath, 1962
P-313A	7350±85	charcoal	–	level VI	Area E, ash from fireplace	8180±110	Ralph and Stuckenrath, 1962
P-326	7386±131	charcoal	–	–	–	8200±130	Bienert, 2000
AA-41604	7398±63	charcoal	juniper	level VI	Area P, Burnt Post, id BM-48	8230±80	Thissen et al., 2004
AA-41603	7452±51	charcoal	juniper	level VI	Area P, Burnt Post, id BM-48	8280±60	Thissen et al., 2004
AA-41602	7468±51	charcoal	juniper	level VI	Area P, Burnt Post, id BM-48	8290±60	Thissen et al., 2004
BM-48	7550±180	charcoal	–	level VI	Area P, Burnt Post	8360±180	Barker and Makkey, 1960
BM-125	7770±180	charcoal	–	level VII	Area P, Corner Beam from Room	8660±230	Barker and Makkey, 1963
BM-127	8700±180	charcoal	–	level V (aceramic)	Area Q, ash from fireplace	9810±240	Barker and Makkey, 1963

Database references: Gérard, 2001; Thissen et al., 2004; Böhner, 2006.

time-span, in the range of one to two centuries, centered on the 8200 cal yr BP event.

Hoca Çeşme/northwest Anatolia

The mound of Hoca Çeşme is situated in the Northeastern Aegean (40.70 °N, 26.11 °E), on a terrace overlooking the Marica river. This site for the first time allows us to trace the development and possible spread of the Neolithic painted pottery from Anatolia into Southeastern Europe (Parzinger and Özdoğan, 1996; Özdoğan, 1998). Most important for the present studies is the earliest Phase IV, which shows a number of circular structures with wooden posts sunk into the bedrock. One building has a floor paved with pebbles, that was plastered and painted. The site has an enclosure wall, preserved to a height of 1 m, with smoothed and polished inner face. This wall is most likely a fortification (Özdoğan, 1999). Despite the relatively wide distribution of the four available ^{14}C-dates on charcoals, dating between 8400 and 8000 cal yr BP, it is clear that the occupation of Hoca Çeşme IV runs parallel with the 8200 cal yr BP event, with a slight tendency towards “8.2 ka-Early” (Fig. 4). The following Phase III dates more to the end of the 8200 cal yr BP event, with essentially unchanged architecture (Table 6).

Both phases demonstrate the use of the exquisitely made thin-walled red-slipped and burnished Monochrome pottery with ’S” profiles, which has a wide distribution in Anatolia (Özdoğan, 1999), as well as in the Balkans, Macedonia, and Thessaly (Todorova, 1998).

The detailed comparative studies undertaken by Schubert (1999) confirm that the occurrence of Monochrome red pottery appears to mark the earliest Neolithic in all these regions. However, the problem remains that the Monochrome pottery can at present hardly be separated from the early painted wares (Vitelli, 1993) and impresso pottery (Budja, 2001) which also mark the beginning of the Neolithic in these regions. As far as radiocarbon dates are available, everywhere the calibrated dates have readings on or close to the 8200 cal yr BP event (Fig. 5). Typical examples are Poljanica Platoto/Bulgaria (Table 11), Elateia/Thessaly (Table 10) and Sesklo/Thessaly (Table 12). In

Table 6
Hoca Çeşme (Turkey)

Lab code	^{14}C age (BP)	Material	Site Phase	General Period	Cal age (cal BP)	Reference
GrN-19356	6520±110	charcoal	Phase II	E-CH	7430±100	Özdoğan, 1997
GrN-19310	6890±280	charcoal	Phase II	E-CH	7760±250	Özdoğan, 1997
GrN-19782	6890±60	charcoal	Phase II	E-CH	7740±60	Özdoğan, 1997
GrN-19781	6900±110	charcoal	Phase II	E-CH	7760±110	Özdoğan, 1997
GrN-19780	6920±90	charcoal	Phase II	E-CH	7770±90	Özdoğan, 1997
GrN-19311	6960±65	charcoal	Phase II	E-CH	7800±80	Özdoğan, 1997
Hd-16726/17084	7005±33	n.d.	Phase III	PN	7860±50	Karul, 2000
Hd-16727/17038	7028±50	n.d.	Phase III	PN	7870±60	Karul, 2000
GrN-19357	7135±270	charcoal	Phase III	PN	7980±260	Özdoğan, 1997
GrN-19355	7200±180	charcoal	Phase IV	PN	8030±180	Özdoğan, 1997
Hd-16724/17186	7239±29	n.d.	Phase III	PN	8070±60	Özdoğan, 1997
GrN-19779	7360±35	charcoal	Phase IV	PN	8180±80	Karul, 2000
Hd-16725/119145	7496±69	n.d.	Phase IV	PN	8300±70	Karul, 2000
Bln-4609	7637±43	n.d.	Phase IV	PN	8450±50	Karul, 2000
HD-14217/13822	7349±38	charcoal	Shrine Phase	PN	8150±70	Özdoğan, 1997

Database references: Gérard, 2001; Thissen et al., 2004; Böhner, 2006.

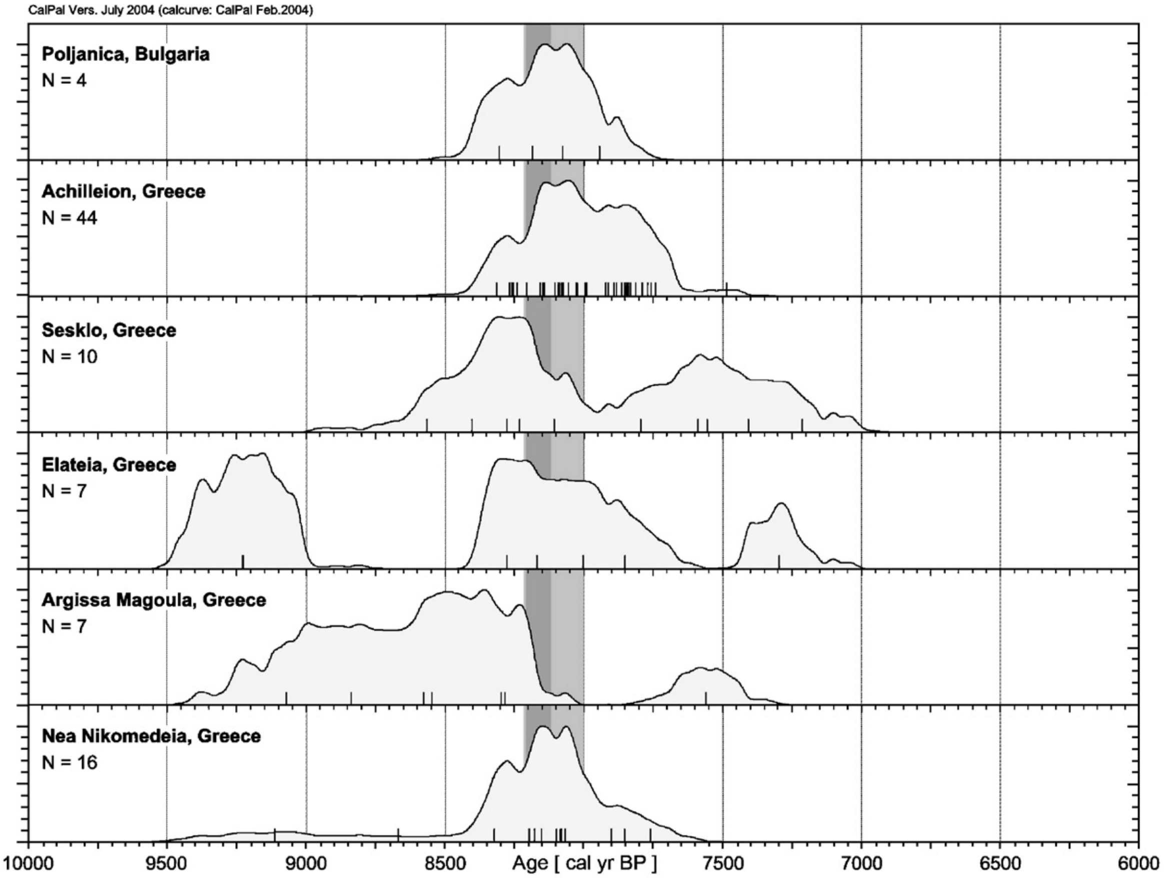

Figure 5. Cumulative calibrated dating probability of radiocarbon data from archaeological sites in Greece (Nea Nikomedeia/Table 7, Argissa Magoula/Table 8, Elateia/Table 10, Sesklo/Table 12, Achilleion/Table 9) and Bulgaria (Poljanica/Table 11). Compared to time window on the 8200 cal yr BP event (greyed interval 8250–7950 cal yr BP cf. Fig. 1).

the following we will complete our discussion by discussing the stratigraphic situation for the earliest Neolithic at the sites of Nea Nikomedeia, Argissa Magoula and Achilleion.

Nea Nikomedeia/north Greece

Nea Nikomedeia is a low settlement mound situated (40.59 °N, 22.29 °E) to the west of Thessaloniki in northern Greece in the alluvial plain formed by the rivers Haliakmon and Axiosin. Today, the site is located in a marshy salt-plain, and earlier it may have been in closer proximity to the coast. Such a site would have been both ideal for cattle grazing (Rodden and Wardle, 1996) and for utilising marine sources (Shackleton, 1970), but Bintliff (1976) rejects this interpretation and proposes that Nea Nikomedeia was an inland site surrounded by well-drained old lacustrine silts. He supposes this location would have allowed the cultivation of winter and spring crops. As shown by the extensive excavations in the years 1961–1963, the mound contained six large rectangular buildings (ca. 7.60 m length) built of mud-walling in timber-stud framework. The largest house had a square shape (12 × 12 m) and was subdivided by three parallel rows of posts and internal buttresses. This central structure may have had ritual function. Initially, the site was considered to represent only one major architectural phase (Rodden, 1962), but further analysis allowed the identification of two building phases. These were separated by a humus layer, suggesting possible abandonment (Rodden and Wardle, 1996). In the first phase it appears that four of the six houses were grouped around the large central structure. In this phase the site was fortified by earthen walls. In the second phase the fortification was reinforced by a ditch, which may have been water-filled (Table 7).

A total of 16 ^{14}C-dates has been published (Table 7) and a large majority of them are highly consistent AMS-dates (Pyke and Yiouni, 1996) measured on a (post-excavation) selection of short-lived cereals and animal bones. The summed probability distribution (Fig. 5) shows a remarkably small spread of the calibrated ^{14}C-ages, with central value indicating an earliest occupation at the onset of the 8200 cal yr BP event. A few samples have slightly younger readings, which would agree with the possibility that the Early Neolithic at Nea Nikomedeia has two phases separated by a hiatus. But this interpretation goes one step beyond the precision achievable with the given measurement errors. There are a few samples (e.g. GX-679 and Q-655) with significantly older readings, but these ^{14}C-measurements derive from earlier studies and are not convincing. In our opinion Nea Nikomedeia is likely to have been only briefly occupied, at the most a few decades. We would finally like to emphasise that the site is rather small, which may be the consequence of restricted resources of any kind.

Table 7
Nea Nikomedeia (Greece)

Lab code	^{14}C age (BP)	Material	Species	Site Locus	General Period	Cal age (cal BP)	Reference
OxA-4280	6920±120	seed	Triticum dicoccum	C1 Spit 2A	Early Neolithic	7770±110	Pyke and Yiouni, 1996
OxA-1603	7050±80	seed	Triticum dicoccum	C1 Spit 2A	Early Neolithic	7870±80	Pyke and Yiouni, 1996
OxA-4281	7100±90	seed	Triticum dicoccum	C1 Spit 3A	Early Neolithic	7920±90	Pyke and Yiouni, 1996
OxA-4283	7260±90	seed	Lens culinaris	K6/1FG	Early Neolithic	8090±90	Pyke and Yiouni, 1996
OxA-3875	7280±90	bone	Sus	NN F6/1 FC PD, 0470	Early Neolithic	8110±90	Pyke and Yiouni, 1996
P-1203	7281±74	charcoal	charcoal	EN 2, B4/1, ash pit	Early Neolithic	8100±70	Stuckenrath, 1967
OxA-3873	7300±80	bone	Ovis	NN D8/2,J358	Early Neolithic	8120±80	Pyke and Yiouni, 1996
OxA-1604	7340±90	seed	Triticum dicoccum	C1 Spit 3A	Early Neolithic	8170±110	Pyke and Yiouni, 1996
OxA-3874	7370±80	bone	Capra	NN B5/1,L644	Early Neolithic	8190±110	Pyke and Yiouni, 1996
OxA-3876	7370±90	bone	Bos	NN C9/1, L644	Early Neolithic	8190±110	Pyke and Yiouni, 1996
OxA-1605	7400±90	seed	Hordeum vulgare	H6/1a+H7/A	Early Neolithic	8210±110	Pyke and Yiouni, 1996
OxA-1606	7400±100	seed	Lens culinaris	K6/1FG	Early Neolithic	8210±110	Pyke and Yiouni, 1996
OxA-4282	7400±90	seed	Hordeum vulgare	H6/1a+H7/A	Early Neolithic	8210±110	Pyke and Yiouni, 1996
P-1202	7557±91	charcoal	charcoal	A4/3 feature A	Early Neolithic	8350±100	Stuckenrath, 1967
GX-679	7780±270	n.d	–	phase I	Early Neolithic	8680±310	Pyke and Yiouni, 1996
Q-655	8180±150	charcoal	charcoal	EN	Early Neolithic	9120±220	Godwin and Willis, 1962

Database references: Reingruber and Thissen, 2004; Böhner, 2006.

Argissa Magoula/central Greece

The tell mound of Argissa Magoula is situated in the plains of Thessaly (39.66°N, 22.33°E) on the edge of a terrace, which is partly cut away by the river Peneios, with regular annual floodings. Excavations in this major Early Neolithic site were performed in 1958 by V. Milojčić (1962), who defined the lowest layers as *pre-pottery*, partly due to the microlithic character of the obsidian tools, and partly due to the (supposed) absence of pottery in the final 30 cm of a small cut. However, although Milojčić (1962) himself emphasises that sherds were found in all levels, he invests considerable effort in demonstrating that the pottery finds from the lowest levels must have been reworked, i.e., derive from higher levels. In addition, many of the ^{14}C-ages (Fig. 5, Table 8) appear to be "old". By modern reasoning, the data have such high scatter – in relation to the sample stratigraphy – that the entire series would appear meaningless, *perhaps* with one or the other exception e.g. the sample GrN-4145: 7500±90 ^{14}C yr BP which was processed on a burnt post. This post may correspond to a tree cut at some time during the 8200 cal yr BP event. But, we must emphasise, all ^{14}C-ages given in Table 8 derive from the same few square meters of a thoroughly disturbed excavation area (e.g. Milojčić, 1962: Plan IV). Nevertheless, even today, many authors believe that this (wide) distribution of (highly questionable) ^{14}C-measurements (Table 8) may be used to date a *pre-pottery* phase of the Neolithic in Greece. This hypothesis has been thoroughly dismanteled, independent of the ^{14}C-ages, by a re-analysis of the site stratigraphy (Reingruber, 2002, 2004).

Achilleion/Thessaly

Due to its long stratigraphy and extensive ^{14}C-sequence, Achilleion is one of the most important tell settlements for prehistoric research in Greece. The site is situated at 39,26 °N and 22,42 °E in the flood-plains of Northeastern Thessaly. First excavations were carried out by D. Theocharis in 1962 and continued 1973–1974 in joint research with M.Gimbutas (Gimbutas et al., 1989). One of the explicit aims of these excavations was to test the existence of a pre-pottery phase of the Neolithic in Greece, as had been postulated by V. Milojčić on the basis of excavations at Argissa Magoula. An exceptionally large number of ^{14}C-dates are available, which cover the entire stratigraphy in a highly consistent manner (Fig. 5, Table 9).

At Achilleion we have an unusually complete sequence of stratified settlements with four major architectural phases I–IV (identified by large letters e.g. I, II) and a variety of subphases

Table 8
Argissa Magoula (Greece)

Lab code	^{14}C age (BP)	Material	Site Locus	General Period	Comments	Cal age (cal BP)	Reference
UCLA-1657E	6700±130	bone	spit 28b	Early Neolithic I	"Early Ceramic"	7580±100	Milojčic, 1973
H-889	6820±120	charcoal	Δ8/9, Pit Alpha (?), Posthole in Pit	Middle Neolithic	"Preceramic"	7690±110	Milojčic, 1965
GrN-4145	7500±90	charcoal	Γ8, 28b, Burnt Post	Early Neolithic I	"Early Ceramic"	8300±80	Vogel and Waterbolk, 1972
H-894-3081	7520±100	n.d.	Γ9, Pit β	Early Neolithic I	"Preceramic"?	8320±90	Coleman, 1992
H-896-3082	7740±100	n.d.	E11, pit γ	Early Neolithic I	"Preceramic"?	8550±100	Coleman, 1992
H-889-3080	7760±100	n.d.	Δ8/9, Pit Alpha (?)	Early Neolithic I or II	"Preceramic"?	8580±120	Coleman, 1992
UCLA-1657D	7990±95	bone	n.d.	Early Neolithic I	"Preceramic"?	8840±140	Milojčic, 1973
UCLA-1657A	8130±100	bone	n.d.	Early Neolithic I	"Preceramic"?	9070±170	Milojčic, 1973

Database references: Reingruber and Thissen, 2004; Böhner, 2006.

Table 9
Achilleion (Greece)

Lab code	^{14}C age (BP)	Material	Site Phase	Site Locus	Cal age (cal BP)	Reference
GrN-7435	7110±70	charcoal	III b	A-1-16	7930±70	Gimbutas et al., 1989
GrN-7434	7060±70	charcoal	III b	A-2-14	7880±70	Gimbutas et al., 1989
GrN-7432	7050±100	charcoal	IV a	D-4-2	7870±100	Gimbutas et al., 1989
GrN-7433	7025±50	charcoal	IV a	B-4-18, Pit	7870±60	Linick, 1977
LJ-2940	6590±80	charcoal	–	B-4-1 0, Firepit	7500±60	Linick, 1977
LJ-3182	6920±50	charcoal	IV a	C-1-21, Graben, locus 24/190-200	7760±60	Linick, 1977
LJ-2941	6930±60	charcoal	IV a	B-4-15, 17, 18, Abfallgrube, four n°1, sq. c/15 i	7770±70	Linick, 1977
UCLA-1882A	6930±155	charcoal	IV a	D-4-2, Post hole , IIIl	7780±140	Gimbutas et al., 1989
LJ-2943	6960±80	charcoal	IV a	A-1-10, Herdstelle	7800±90	Linick, 1977
P-2125	6960±90	charcoal	IV a	B-4-13, Pit	7800±90	Lawn, 1975
LJ-3203	6990±70	charcoal	IV a	D-4-19, Graben	7830±80	Linick, 1977
LJ-2944	7020±50	charcoal	IV a	B-4-18, Grube	7860±60	Linick, 1977
LJ-3202	7020±100	charcoal	IV a	C-4-9, carre K-9, Floor of circular construction	7840±100	Linick, 1977
LJ-3200	7030±80	charcoal	IV a	D-2-11, Firepit	7850±80	Linick, 1977
P-2130	7080±100	charcoal	III b	D-2-17, roof beam	7900±100	Lawn, 1975
P-2124	7090±90	charcoal	III b	A-2-14, Oven	7910±90	Lawn, 1975
P-2122	7110±90	charcoal	III b	B-2-17	7930±90	Lawn, 1975
LJ-3327	7120±60	charcoal	III b	A-4-21, Fireplace	7940±60	Linick, 1977
P-2121	7180±90	charcoal	III b	B-2-1 6, remplissage de la pièce 441	8020±100	Lawn, 1975
UCLA-1896B	7180±155	n.d.	III b	A-1-13	8010±160	Gimbutas et al., 1989
LJ-2942	7200±50	charcoal	III b	A-2/3-15, 16	8040±60	Linick, 1977
LJ-3201	7210±90	charcoal	II b	D-2-19 ˋcarbonised lensˋ , 2F-12.2045	8050±90	Linick, 1977
LJ-3181	7240±50	charcoal	II b	D-2-22, context id LJ-3180, fosse à gypse n°3	8070±70	Linick, 1977
UCLA-1882B	7260±155	n.d.	Ib	B-1-31, III	8100±150	Gimbutas et al., 1989
P-2117	7270±80	charcoal	II a	A-1-26	8090±80	Lawn, 1975
P-2128	7270±80	charcoal	–	Combination two different samples tsq.A,D2-4,lev.8 und D3 lev.8H-11.2121 (Korb)	8090±80	Lawn, 1975
LJ-3325	7280±50	charcoal	II a	B-5-20, 21	8100±60	Linick, 1977
UCLA-1896E	7280±100	n.d.	III b	A-3-14	8110±100	Gimbutas et al., 1989
LJ-3186	7290±50	charcoal	II a	B-5-24, locus 22/120-130	8100±60	Linick, 1977
LJ-3326	7290±80	charcoal	II a	A-2-22	8110±80	Linick, 1977
GrN-7436	7295±70	?	II a	A-1-21	8110±70	Gimbutas et al., 1989
LJ-3328	7300±50	charcoal	II a	A-1-16	8110±60	Lawn, 1975
LJ-3184	7320±50	charcoal	I b	A-2-14	8120±60	Linick, 1977
UCLA-1896C	7330±100	n.d.	II b	D-4-2	8160±120	Gimbutas et al., 1989
P-2120	7340±70	charcoal	II b	B-4-18, Pit	8170±100	Lawn, 1975
LJ-3329	7360±50	charcoal	I b	B-4-1 0, Firepit	8180±90	Linick, 1977
GrN-7438	7390±45	?	I b	C-1-21, Graben, locus 24/190–200	8240±60	Linick, 1977
P-2123	7450±80	charcoal	III b	B-4-15, 17, 18, Abfallgrube, four n°1, sq. c/15 i	8270±80	Lawn, 1975
P-2123?	7454±78	n.d.	–	D-4-2, Post hole, IIIl	8280±80	Lawn, 1975
UCLA-1896A	7460±175	n.d.	I a	A-1-10, Fireplace	8260±170	Gimbutas et al., 1989
P-2118	7470±80	charcoal	I a	B-4-13, Pit	8280±80	Lawn, 1975
LJ-4449	7490±150	charcoal	I a	D-4-19, Graben	8290±140	Gimbutas et al., 1989
LJ-3180	7550±60	charcoal	II b	B-4-18, Pit	8350±60	Linick, 1977

Database references: Reingruber and Thissen, 2004; Böhner, 2006.

(identified by small letters a, b, c, etc.). The phases and subphases are defined by pits, pit-houses, houses with stone basements, courtyards, open fireplaces, closed ovens, and working areas. According to the pottery finds, the settlement covers the entire Early Neolithic (Phase Ia—Frühkeramikum; Phases Ib–IIb—Proto-Sesklo) as well as the classical (middle Neolithic) Sesklo-Period (phases IIIa–IVb).

Pottery is already established in the earliest layers, at bedrock. The dense sequence of ^{14}C-ages begins ca. 8250 cal yr BP, and this date would either correspond to phase Ia (Gimbutas et al., 1989) or to phase Ib (Perlès, 2001). Allowing for the dating of old wood, in both cases we have strong radiocarbon evidence for a begin of the settlement sometime during the 8200 cal yr BP event (Fig. 5). This absolute date on the pottery sequence of Achilleion is of major importance for all studies of the Neolithisation of Greece and South-East Europe. According to Gimbutas et al. (1989), the earliest phase of Achilleion (Ia) contains fine, red polished ceramics, and no painted pottery, so that an initial *pure* monochrome phase may be comprehensible.

Red monochrome pottery

The existence of this early ceramic phase of the early Neolithic has been established for other sites in Thessaly (Gediki, Soufli, Argissa, Sesklo), as well as for Elateia (Table 10) in Central Greece, and may well represent the very earliest phase of the Neolithic to be found on the open sites (tell-mounds) of Central Greece (Wijnen, 1981; Alram-Stern,

Table 10
Elateia (Greece)

Lab code	^{14}C age (BP)	Material	Site Locus	General Period	Pottery	Cal age (cal BP)	Reference
GrN-2454	6370±80	humic fraction of GrN-3502	Trench 1, Floor at 2.30 m	Middle Neolithic	Earliest painted Pottery (MN)	7300±90	Vogel and Waterbolk, 1963
GrN-3502	7040±130	charcoal	Trench 1, Floor at 2.30 m	Middle Neolithic	Earliest painted Pottery (MN)	7860±120	Vogel and Waterbolk, 1963
GrN-3041	7190±100	charcoal	Trench 2, Floor at 2.55 m	Early Neolithic	Monochrome	8030±100	Vogel and Waterbolk, 1963
GrN-3037	7360±90	charcoal	Trench 3, Bothros at 2.55 m	Early Neolithic	Monochrome	8180±110	Vogel and Waterbolk, 1963
GrN-2973	7480±70	charcoal	Trench 1, 3.10 m	Early Neolithic	Monochrome	8290±70	Vogel and Waterbolk, 1963
GrN-2933	8240±75	charcoal	Trench 1, 1.55 m	Late Neolithic	LN Pottery	9230±120	Vogel and Waterbolk, 1963
GrN-3039	8240±110	charcoal	Trench 1, Floor at 2.0 m	Middle Neolithic	Earliest painted Pottery (MN)	9230±150	Vogel and Waterbolk, 1963

Database references: Reingruber and Thissen, 2004; Böhner, 2006.

2004). What complicates the issue, however, is that red monochrome pottery not only appears at the begin of the Neolithic, but also in later phases, and the different fabrics are often difficult to distinguish (Schubert, 1999). Such classification problems apply to the red monochrome fabrics not only in Thessaly and Central Greece, but also in the neighbouring regions of Macedonia and Bulgaria (personal communication J. Aslanis and J. Bojadziev, 2004). A further complication is that, at a large number of early Neolithic sites, the red monochrome fabrics appear from the beginning together with early red-on-white painted pottery (Thessaly) or else associated with white-on-red painted wares (Macedonia). This makes the stratigraphic sequence at Achilleion all the more important, since here we have the unique situation that phase Ia represents one of the earliest Neolithic settlements in Greece, and radiocarbon dates are at least available for the following phase Ib with early pattern-painted ceramics (Alram-Stern, 1996).

Finally, let us take a glimpse at the Neolithic in Bulgaria, where the earliest farming communities are also known to have produced red monochrome pottery. This has become one major focus of recent archaeological research. The Neolithic chronology in Bulgaria is based on a comparatively large and well-documented ^{14}C-database for the Neolithic (Görsdorf and Bojadžiev, 1996). Up to now, the earliest phase of the Neolithic is radiocarbon dated at only one site, that is Poljanica-Platoto (Todorova, 1989). As shown in Figure 5, the four available dates consistently fall into the time interval expected for the 8200 cal yr BP event. This is no trivial result, since all four dates from Poljanica-Platoto (Table 11) were processed on the bulk organic temper of potsherds (red monochrome), and may therefore be expected to be prone to contamination by admixtures of old carbon. We accept the validity of these dates, for the time being, until more is known about the temporal and geographic distribution of the red monochrome pottery. A number of recent and therefore still partly unpublished excavations in Bulgaria show that the (early) red monochrome wares have an unexpectedly wide distribution, ranging from NE Bulgaria (Koprivec/Biala, a 3-phased site, excavations by I. Vajsov and V. Popov (Todorova, 2003), through NW Bulgaria (Ochoden/Vraza, excavations 2003–2004, directed by G. Ganecovski), as well as in the Strymon valley (Krajnici/Kjustendil, excavations by S. Tschochadjiev). Excavations at Kovačevo/Blagoevgrad (Demoule and Lichardus-Itten, 1994, 1998) also demonstrate the introduction of red monochrome pottery in the earliest phase of the Neolithic of the Strymon valley. These sites all date significantly earlier (ca. 300 yr) than Karanovo I (Thrace) and are likely, together with Hoca Çeşme, Achilleon Ia, and Sesklo Ia, to represent the earliest farming communities in Europe (Table 12).

Future research

This is not the place to address, in detail, the wide spectrum of archaeological questions that arise when we study the possibility that the introduction of early farming into South-East Europe may have been at least partly climate-induced, if not altogether climate triggered. But we would like to add a few comments on possible directions for future research.

Table 11
Poljanica Platoto (Bulgaria)

Lab code	^{14}C age (BP)	Material	Site Phase	Site Locus	Cal age (cal BP)	Reference
Bln-1521	7140±60	sherds bulk organic content	Monochrome Neolithic	Horizon I, Qu. 153, 0,4 m	7950±60	Görsdorf and Bojadžiev, 1996
Bln-1613A	7275±60	sherds bulk organic content	Monochrome Neolithic	Horizon I, Qu. 153, 0,4 m	8090±60	Görsdorf and Bojadžiev, 1996
Bln-1613	7380±60	sherds bulk organic content	Monochrome Neolithic	Horizon I, Qu. 153, 0,4 m	8190±70	Görsdorf and Bojadžiev, 1996
Bln-1571	7535±60	sherds bulk organic content	Monochrome Neolithic	Horizon I, Qu. 49, 0,40 m	8340±50	Görsdorf and Bojadžiev, 1996

Database references: Reingruber and Thissen, 2004; Böhner, 2006.

Table 12
Sesklo

Lab code	^{14}C age (BP)	Material	Site Locus	General Period	Cal age (cal BP)	Reference
P-1676	6317±84	organic	sol 568–126	MN	7240±100	Lawn, 1973
P-1672	6504±85	organic	sol 68–79	MN IIIB	7410±80	Lawn, 1973
P-1675	6694±87	charcoal	sol 68–156	MN	7570±70	Lawn, 1973
P-1677	6741±103	charcoal	–	MN IIIB	7600±90	Lawn, 1973
P-1674	6964±92	charcoal	sol 68–132	MN	7810±90	Lawn, 1973
P-1680	7300±93	charcoal	sq.B1,depth 4.10/4.20 m “first sherds”	Initial Neolithic	8130±100	Lawn, 1973
P-1678	7427±78	charcoal	trench 63,W,68.98	EN I	8250±80	Lawn, 1973
P-1768	7427±78	charcoal	sol 68–98 63W	Neo.	8250±80	Lawn, 1973
P-1682	7483±72	charcoal	sq.B depth 4.32 m, “end of preceramic”	Initial Neolithic	8290±70	Lawn, 1973
P-1679	7611±83	charcoal	Depth 3.88 m, 63.122	EN I	8430±80	Lawn, 1973
GrN-16845	7560±25	charcoal	basal EN I	EN I	8380±20	Reingruber and Thissen, 2004
GrN-16844	7530±60	charcoal	deep sounding	EN I	8320±70	Reingruber and Thissen, 2004
GrN-16841	7520±30	charcoal	floor	EN I	8360±30	Reingruber and Thissen, 2004
GrN-16846	7400±50	charcoal	trench 2	EN I	8250±60	Reingruber and Thissen, 2004
GrN-16842	7250±25	charcoal	roof beam	EN II/III	8080±60	Reingruber and Thissen, 2004
GrN-16843	7110±70	charcoal	burnt deposit	EN III	7930±70	Reingruber and Thissen, 2004
P-1681	7755±97	charcoal	63.124B,sq.1 to XXX, “end of preceramic”	Initial Neolithic	8570±110	Lawn, 1973

Database references: Reingruber and Thissen, 2004; Böhner, 2006.

One key question, it appears to us, is how to draw meaningful and conclusive parallels between modern and prehistoric communities. Particularly relevant to our considerations of the consequences of the 8200 cal yr BP event upon Neolithic communities living in the semi-arid areas of the Near East are the observations made by the German ethnologist Gerd Spittler, set out in two major studies (Spittler, 1989a,b). Here we are offered a precise documentation of the reactions of the semi-nomadic Kel Ewey-Tuareg of Aïr in Niger to recurring periods of drought and famine in the 20th century (Spittler, 1989a,b). While it is difficult to draw any direct comparisons between the actual reactions of the Kel Ewey and the potential experiences of Neolithic communities, what we can surely deduce from the works of Spittler is the wide existing range of possible reactions to drought, including e.g. transhumance, enhanced mobility, and many different modes of risk dispersion.

The second major key to any future research is to identify one or more archaeological sites on which it is possible to study the reactions of the prehistoric communities *in situ*, i.e. sites that were not deserted (which would leave us with correspondingly biased (one-sided) data), but instead continuously occupied throughout the time of the 8200 cal yr BP event. We know of two good candidates for such studies, that is Mersin-Yumuktepe (SE-Turkey) and Tell Sabi Abyad (N Syria).

At the site of Mersin-Yumuktepe (36.78 °N, 34.60 °E), on the Cilician coast of southern Turkey, recent archaeological excavations have yielded evidence for a possibly (brief) hiatus in settlement activity between the archaeological layers XXVI and XXV (after Garstang, 1953) dating to around 8200 cal yr BP. To judge by the spread of radiocarbon dates for these layers (Table 13), we have the impression that this hiatus – if it is real – must have been quite brief (i.e. within ^{14}C-dating limits),

Table 13
Mersin-Yumuktepe

Lab code	^{14}C age (BP)	Material	General Period	Site Phase	Cal age (cal BP)	Reference
Rome-958	5030±60	wheat	Latest Chalcolithic	XIIB	5780±90	Caneva, 1999
Rome-805	5360±80	charcoal	Latest Chalcolithic	XIIB	6140±110	Caneva, 1999
Rome-602	5940±70	charcoal	Middle Chalcolithic	XVI	6780±90	Caneva, 1999
Rome-1010	6675±70	charcoal	Late Neolithic	XXV	7550±60	Caneva, 1999
Rome-809	6980±80	charcoal	Late Neolithic	XXV	7820±90	Caneva, 1999
R-1345	7010±75	charcoal	Late Neolithic	XXV	7840±80	Caneva, 1999
Rome-806	7030±90	charcoal	Late Neolithic	XXV	7850±90	Caneva, 1999
Rome-956	7090±70	charcoal	Middle Neolithic	XXVI	7910±70	Caneva, 1999
Rome-957	7100±70	charcoal	Middle Neolithic	XXVI	7920±70	Caneva, 1999
Rome-807	7160±80	charcoal	Middle Neolithic	XXVI	8000±90	Caneva, 1999
R-1226	7280±70	charcoal	Middle Neolithic	XXVI	8100±70	Caneva, personal communication
Rome-808	7380±80	charcoal	Middle Neolithic	XXVI	8200±110	Caneva, 1999
Rome-1011	7545±75	charcoal	Early Neolithic	XXX	8330±80	Caneva, 1999
R-1343	7640±80	charcoal	Early Neolithic	XXX	8460±70	Caneva, personal communication
R-1344	7750±80	charcoal	Early Neolithic	XXX	8540±80	Caneva, personal communication
Rome-734	7790±80	charcoal	Early Neolithic	XXX	8600±110	Caneva, 1999
Rome-467	7920±90	charcoal	Early Neolithic	XXXIII	8790±140	Caneva, 1999
W-617	7950±250	charcoal	–	XXXIII, Base	8860±310	Rubin and Alexander, 1960

Database references: Thissen et al., 2004; Böhner, 2006.

perhaps 100 yr. Interestingly, it corresponds to the transition from the Middle to Late Neolithic phases of Caneva's amended Neolithic chronology of the site (Caneva, 1999). Presently, it remains inconclusive as to whether this hiatus (a thick series of fine horizontal ashy layers) represents a break in all settlement activities, or whether we are in fact witnessing processes connected with an internal reorganisation of the site. It is at any rate remarkable that following the possible hiatus, the Late Neolithic phase of the excavated area is characterised by a clear change in its function, with the focus now moving from the domestic sphere to more agricultural activities, including storage. This development becomes increasingly evident in the following layer XXIV with its numerous silo constructions. Remarkably, parallels are also attested at the site of Tell Sabi Abyad (36.40 °N, 38.99 °E) in the Balikh Valley of northern Syria. Here too, evidence from recent excavations has shown that at around 8200 cal yr BP there was a shift in settlement activity from the western to the eastern side of the site. Furthermore, in the period following the 8200 cal yr BP event, during the so called Transitional phase prior to the onset of Early Halaf, there appears to have been an increased emphasis on storage, as evidenced by the extensive multi-roomed storehouses found in the Transitional levels of Operation I, and in the introduction of seals and sealings (Akkermans et al., 2006).

Altogether, as most archaeologists involved in Neolithic studies would likely agree, we may conclude that a major key to any successful research would be the reproducible classification and description, accurate and complete mapping, as well as precise radiocarbon dating of the Neolithic pottery in all given study regions e.g. the early red monochrome wares of South-East Europe and the Halaf pottery for the Near East. As far as we can judge from the presently best-dated site of Achilleion/Thessaly, in South-East Europe the development from red monochrome to pattern painting can hardly have taken more than one or two generations i.e. <50 yr.

Conclusions

We have provided a compilation of selected major ^{14}C-dated archaeological sites in Anatolia, Cyprus, Greece and Bulgaria that are good candidates for showing the 8200 cal yr BP cold event. The influence of the 8200 cal yr BP event is best recognised in Central Anatolia. The large and long-flourishing settlement at Catalhöyük-East was deserted quite abruptly around 8200 cal yr BP, and we speculate that this was most likely due to irregularities in the water supply of this large settlement. Following 8200 cal yr BP, the site was re-occupied, but with a shift of the settlement by ca. 200 m to a new position (Çatalhöyük-West). This settlement shift marks the beginning of the Early Chalcolithic *(sensu strictu)* in Central Anatolia.

It is further intriguing that many other major archaeological sites in the Eastern Mediterranean are either first occupied at ca. 8200 cal yr BP (in North-West Anatolia: Hoca Çeşme IV; in Greece: Nea Nikomedeia, Achilleion, Sesklo; in Bulgaria: Ovcarovo-Platoto) or else deserted (in Cyprus: Khirokitia and likely Kalavassos-Tenta). Conversely, in the regions under study we have not been able to identify any sites with clear stratigraphic evidence for a continuous settlement extending through the 8200 cal yr BP event. It is also remarkable that – following the (more or less) simultaneous desertion of Khirokitia and Kalavassos-Tenta around 8200 cal yr BP – the island of Cyprus was apparently deserted and remained uninhabited for more than 1500 yr.

To explain these observations we propose that the 8200 cal yr BP aridity triggered the spread of early farmers out of Anatolia, into Greek Macedonia as well as into the fertile floodplains of Thessaly, and simultaneously into Bulgaria (and likely also other regions, which have not yet been analysed in detail). The background to the observed temporal and cultural trajectories is essentially in accordance with the "spring floodwater farming" model of Van Andel and Runnels (1995), but the rapidity of dispersion requires some additional assumptions. Following 1000 yr of continuous occupation, which had apparently not led to any significant increase in population, the well-established settlement at Çatalhöyük was abruptly deserted. Quite the same process happened at contemporary settlements on Cyprus.

For Central Anatolia, Özdoğan (2002) describes these processes as follows:

> "...what I see is that there must have been an endemic movement which started randomly probably towards the end of the PPNB [Pre-Pottery Neolithic B]. There must have been some kind of beginning stage of this westward movement. There is clearly a kind of a momentum to migrate in masses before the end of the thing. I think this is coming with the latest Pre-Pottery horizon. All of a sudden you see that people are moving."

These observations highlight the major weakness of previous Neolithisation models, all of which lack any plausible mechanism to explain the unexpectedly rapid population movements in Central Anatolia around 8200 cal yr BP (i.e. the transition from the Late Neolithic to the Early Chalcolithic). With the notable exception of the clearly more flexible approach of Özdoğan (1993), whereby the Neolithisation spread from within a "large cultural formation zone," none of the other diffusion models correctly describe the speed with which the earliest farmers moved into southeast Europe. For example, if we assume that the migration may be described by frequent relocation of the settlements over short distances, which is the basis of the calculations put forward by Ammerman and Cavalli-Sforza (1984), then the Neolithic "wave-of-advance" can only proceed at average speeds less than 1 km/yr. The major limiting factors are food production and birth rate. However, on the basis of the site chronologies and geographic distances described above, we conclude that the dispersion speeds are more on the order of 10–50 km per 1–2 yr. As such, the population is expanding more than ten times more rapidly (depending on the assumed settlement area) than can be explained by traditional diffusion models. Such expansion rates are well above all limits based on realistic human growth rate calculations (Zilhão, 1998). Indeed, all such calculations lose their meaning *vis-a-vis* the causal mechanisms for migration indicated by the 8200 cal yr BP aridity scenario. The farmers would be forced to migrate, essentially immediately and with few alternatives, if they wished to survive yet another year of crop failures and encroaching famine.

Evidence for sudden population relocation is not unusual in the Eastern Mediterranean. It was witnessed long before the 8200 cal yr BP event in the southern Levant at the end of the Middle Pre-Pottery Neolithic B (MPPNB), when all of Palestine and the Jordan Valley were suddenly abandoned ca. 9450 cal yr BP, with the populations moving up onto the Jordanian plateau (Rollefson, 1987). Due to the major drop in the availability of archaeological charcoals dating to the interval 9450 and 8950 cal yr BP in Turkey (Fig. 3), our extended compilation of ^{14}C-data now indicates that similar processes may indeed have acted simultaneously in Turkey. However, we have argued previously that such migration processes could well be caused by over-population and over-stress on local ecological habitats. Despite this caution – and indeed largely motivated by the quite exceptional magnitude of the 8200 cal yr BP climate event – in the present paper we nevertheless consider it necessary to place some enhanced emphasis on the likelihood of a primary climatic background to many of the observed socio-cultural processes.

We therefore propose the extension of previous Neolithisation models, whereby the rapid spread of early farming to South-East Europe can be most plausibly understood as a direct and immediate reaction to abrupt climate forcing. The spread of early farming to South East Europe was extremely rapid and entirely synchronous with the catastrophic collapse of the ice dome above Hudson Bay at 8200 cal yr BP, many thousands of miles away. We conclude that the abrupt climate switch 8200 cal yr BP caused some very significant, irreversible, and unexpectedly rapid changes to the contemporary social, economic and religious lifestyle in large parts of Western Asia and South-East Europe.

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