# Neolithic Thessaly: radiocarbon dated periods and phases

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ABSTRACT – *Thessaly in Central Greece is famous for settlement mounds (magoules) that were already partly formed in the Early Neolithic period. Some of these long-lived sites grew to many metres in height during the subsequent Middle, Late and Final Neolithic periods, and were also inhabited in the Bronze Age. Such magoules served as the backbone for defining relative chronological schemes. However, their absolute dating is still a topic of debate: due to a lack of well-defined sequences, different chronological schemes have been proposed. New radiocarbon dates obtained in the last few years allow a better understanding of the duration not only of the main Neolithic periods, but also of the different phases and sub-phases.*

KEY WORDS – *Thessaly; Neolithic; radiocarbon dates; absolute and relative chronology*

## *Neolitska Tesalija: Radiokarbonsko datirana obdobja in faze*

IZVLEČEK – *Pokrajina Tesalija v osrednji Grčiji ima ohranjene številne naselbinske gomile (magoules), ki so nastale že v obdobju zgodnjega neolitika. Nekatera od teh dolgoživih najdišč so merila tudi več metrov v višino v kasnejših neolitskih obdobjih (v srednjem, poznem in finalnem neolitiku), poseljena pa so bila še tudi v času bronaste dobe. Te naselbine so predstavljale osnovo pri definiranju relativnih kronoloških shem. Zaradi pomanjkanja dobro definiranih stratigrafskih sekvenc pa ostajajo njihove absolutne datacije predmet številnih razprav in različnih kronoloških shem. V preteklih letih smo pridobili številne nove radiokarbonske datume, ki nam nudijo boljši vpogled v trajanje tako neolitskega obdobja v celoti kot tudi vpogled v časovno razdelitev posameznih neolitskih faz in podfaz v Tesaliji.*

KLJUČNE BESEDE – *Tesalija; neolitik; radiokarbonski datumi; absolutna in relativna kronologija*


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## Introduction: early investigations and the first radiocarbon dates

The first scientific investigations of Neolithic sites in Thessaly were conducted in its south-eastern areas, close to the Pagasitic Gulf (the Regional Unit of Magnesia – compare Figure 1). Situated in the hilly areas west of the modern city of Volos and close to the village of Sesklo, the prehistoric eponymous *magoula* was investigated more than a century ago by Christos Tsountas, in 1901–1902 (*Tsountas 1908*). The excavations revealed a lengthy stratigraphic succession covering all periods of the Neolithic, although in today's perception the earlier periods at the site are more prominent. Simultaneously, the nearby site of Dimini became famous for the later and final periods of the Neolithic. These findings gave rise to international as well as Greek interest in Thessalian *magoules* (*e.g., Arvanitopoulos 1910*); British archaeologists (*Wace, Thompson 1912*) recorded and occasionally investigated some Thessalian *magoules*.

With comprehensive publications by French (*Béquignon 1932.89–191*) and German (*Grundmann 1932. 102–123*) researchers in the 1930s, international interest in Neolithic Thessaly intensified. In 1941, excavations based on a extorted permit were carried out in Visviki Magoula by Hans Reinerth and his team from the universities of Berlin and Tübingen (*Alram-Stern, Dousougli-Zachos 2015*). Thanks in part to the intervention of the German Archaeological Institute in Athens, the work permit was not renewed in 1942 (*Hauptmann 2015.2*). More than a decade later, the prolific German-Greek collaboration between Vladimir Milojčić and Dimitrios R. Theocharis led to the systematic investigation of *magoules* situated mainly in eastern and southern Thessaly. The excavation methods applied by Milojčić met the highest standards of their time. The interpretation of the finds and their contexts relied largely on his highly erudite chronological scheme, which was based on a relative chronological approach supported by, and developed from, the method of comparative stratigraphy. According to this method, all relevant stratigraphic sequences from north-eastern Africa, the Near East and Southeast Europe were compared and tied together in a supraregional, not to say intercontinental perspective. The expectations of the Neolithic in Greece were thus not unbiased, since Milojčić's interpretations of both the beginning and end of the period were largely influenced by his view from the North (the Balkans with the Starčevo and Vinča cultures – (*Milojčić 1950/51.54–63*) and from the East (the Near East with the PPN – *Milojčić 1956*).

Milojčić's relative chronological appraisals were challenged in the late 1950s by the new and indeed revolutionary radiocarbon dates. Due to his premature death in 1978, Milojčić did not have the chance to re-appraise his views. In his last critical article on this topic (*Milojčić 1973.3–11*), he points to the contradictions not only between relative and absolute chro-

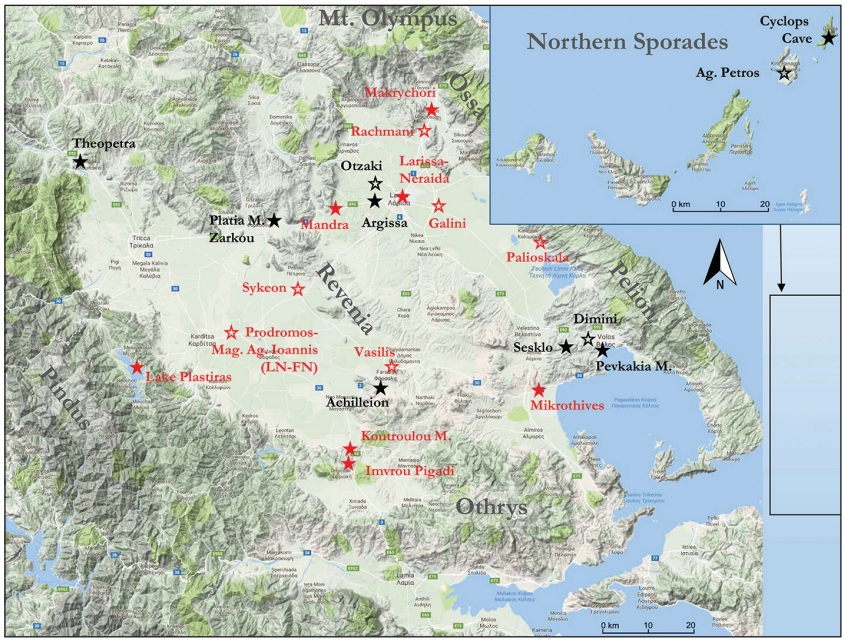


***Fig. 1. Thessaly: the vast plain (approx. 14 000km²) surrounded by steep mountains is divided by the Mid-Thessalian Hills (Revenia) into eastern and western parts; Magnesia with the islands of the Northern Sporades and the zone around the Pagasitic Gulf is also part of Thessaly (included in the study area is the municipality of Domokos in the northern Phthiotis). Only radiocarbon dated sites from the Neolithic are plotted (c. 6500–3300 cal BC): rendered in black are the 10 sites that were radiocarbon dated between the 1960s and 1990s; recently dated 13 sites are in red. Filled-in stars: sequences with four or more dates per site and phase; empty stars: 1–3 dates per site and phase (background for the map from URL: https://www.google.de/maps).***

nology, but also to the discrepancy between astronomical and radiocarbon years. And indeed, the first internationally accepted calibration curve was achieved only in late 1985 (*Stuiver, Becker 1986*). His repeated cautioning of an unduly uncritical acceptance of the radiocarbon method might have derived even from the dates obtained on animal bones he himself had excavated in Argissa Magoula in 1958: Reiner Protsch and Rainer Berger (*1973.235–239*) published three highly doubtful dates on bones that led to the assumption that the Early Neolithic (henceforth, EN) started in Thessaly around 7000 BC (for a critique of these dates, compare *Reingruber 2015; Reingruber, Thissen 2016. www.14sea.org/3_IIc.html#*).

Milojčić's critique of the radiocarbon method had a lasting impact on investigations carried out by German-speaking archaeologists in Southeast Europe. Quite to the contrary, investigations by English-speaking archaeologists (*e.g.*, Marija Gimbutas in Achilleion and Colin Renfrew in Sitagroi: *Gimbutas 1974. 283, Tab. 2; Renfrew 1970.280–311*) used the method in their research, with well-known results. Also, Theocharis recognised the radiocarbon method as a

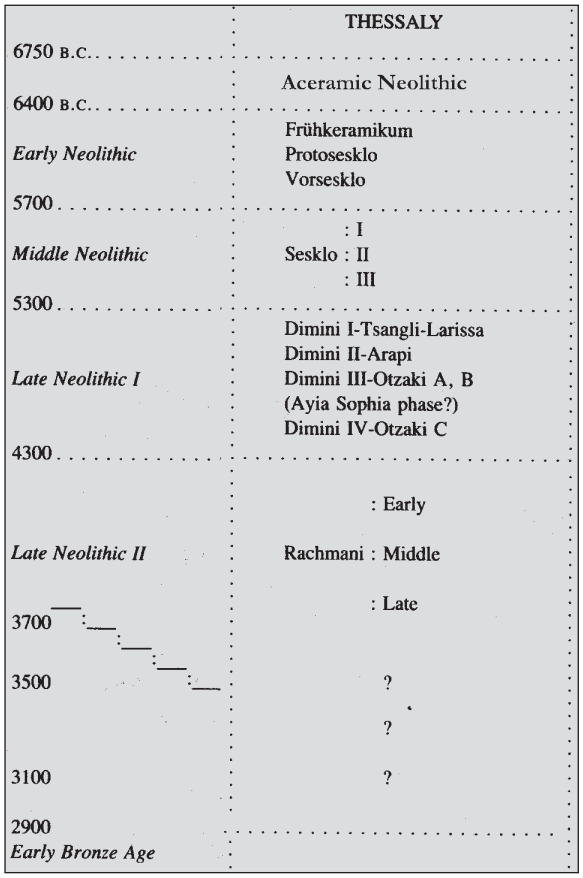


***Fig. 2. Duration of Neolithic periods and their phases as proposed by John Coleman in 1992.***

powerful tool early on, and compiled the available radiocarbon dates not only from Thessaly, but from all over Greece (*Theocharis 1973.119*). He was followed in this approach by younger scholars, *e.g.*, an updated version of his list inclusive of dates from Anatolia was published by Mies H. J. M. N. Wijnen (*1981.130–133*). However, it was not until the end of the 20th century that these dates were analysed in a broader context.

### *First radiocarbon-based appraisals of the duration of Neolithic periods and phases*

The first thorough synthesis based on absolute chronology was developed by John Coleman (*Coleman 1992.206, Fig. 4*). Not only did he bring together both published and hitherto unpublished dates from Greece, he also made them easily comparable by systematically using the calibrated dates, not uncalibrated values. He presented the dates separately for each region and compared the periods and phases obtained by relative chronological assessments accordingly. In this way, the duration of each period and phase became more evident (Fig. 2).

According to the knowledge of that time, the Neolithic period started in Thessaly with a Preceramic (Aceramic) phase comparable to the Pre-Pottery Neolithic in the Near East. Its beginning was almost undisputedly accepted as 7000 BC, being thus coeval with the PPNB in Anatolia. Together with the EN, it should have lasted until 5700 BC. In contrast, the subsequent period of the Middle Neolithic (henceforth, MN) encompassed only a few centuries, from 5700 to 5300 BC. It was followed by the, again, millennium-long phases of the Late Neolithic (henceforth, LN), the LN I ('Dimini': 5300–4300 BC) and LN II ('Rachmani': 4300–3000 BC).

As hardly any dates from Thessaly were available, not even from sites with long stratigraphic sequences, Coleman interpolated the duration of the Thessalian phases by using the results from neighbouring regions, both northern (from Macedonia) and southern (from the Argolid). For example, the dates available for the MN in Serbia started only after 5800 BC (*Coleman 1992.209–210*). The dates from the cave of Franchthi in the Argolid also point to such a late EN–MN transition. Nonetheless, for the earlier periods (EN and MN) the sequence of dates from Achilleion (*Gimbutas 1989.Fig. 3.4* and Fig. 3) could have served as a reliable background. However, Coleman decided in favour of a supra-regional balance between stratigraphic sequences, still very much in the tradition of relative chronological appraisals.

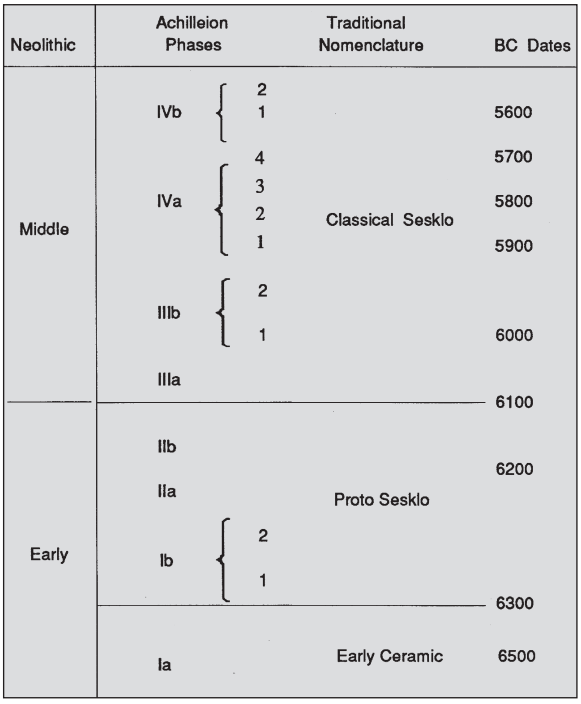


***Fig. 3 Duration of the Early and Middle Neolithic periods and their phases as proposed by Maria Gimbutas in 1989.***

Moreover, he did not verify the quality of these dates (especially not the dates obtained on bones from Argissa Magoula). At that time, it was impossible to determine which dates were more reliable and which were outliers. This is especially the case with the later Neolithic periods, which provided almost no direct evidence, the duration of these phases being more or less guesswork.

Nevertheless, Coleman's scheme became very influential and was often quoted in subsequent studies, in catalogues, handbooks and overviews (*e.g., Papathanasopoulos 1996.28–29, Fig. 3; Alram-Stern 1996.100, Fig. 4; Andreou* et al. *1996.538, Tab. 1*). The duration of the EN and MN periods as well as the transition between the periods around 5800/5700 BC became largely accepted. For the Late Neolithic a competing terminology also came into use: Coleman's LN I there is divided into an LN I and an LN II; Coleman's LN II is labelled as Final Neolithic or Chalcolithic (*Tsirtsoni 2016.19, Tab. 1* and Fig. 4). In order to avoid confusion resulting from the use of the terms 'Late Neolithic II', 'Final Neolithic' or 'Chalcolithic', we follow here the terminology proposed by Hans-Joachim Weißhaar (*1989*) and Zoï Tsirtsoni (*2016*), where 'Final Neolithic' (henceforth, FN) is synonymous with 'Chalcolithic' (henceforth, FN/Ch) and is dated to the second half of the 5th and to the 4th millennium BC. The labels LN I and LN II

| *Date BC* | *Periodization (dominant Aegean terminology)* | *Periodization (alternative Aegean terminology)* | *Thessaly* |
|---|---|---|---|
| **5400** | **Late Neolithic I** | LN Ia | Tsangli-Larissa |
| **5200** | | | Arapi |
| **4800** | **Late Neolithic II** | LN Ib | Otzaki<br>Dimini |
| **4500** | **(Final Neolithic or Chalcolithic)** | LN IIa | Rachmani |
| **4000** | | | |
| **3700** | | LN IIb | Petromagoula<br>Mikrothives |
| **3300** | **Early Bronze Age I** | EBA I | Pefkakia 1-2 |
| **2800** | **Early Bronze Age II** | EBA II | Pefkakia 3 |

***Fig. 4. Duration of the Late and Final Neolithic (Chalcolithic) periods and their phases as proposed by Zoi Tsirtsoni in 2016.***

are used exclusively for the millennium between 5500 and 4500 cal BC.

At the beginning of our century, it became even more evident that the scarcity of dates left serious doubts as to how exactly to define the length of a certain period. Catherine Perlès questioned the long duration of the EN, but in her general appraisal she reverted to the scheme as proposed by Coleman (*Perlès 2001. 92, 99*). Especially in a circum-Aegean perspective, a re-evaluation of the old dates has led to other possible interpretations (*Reingruber, Thissen 2005; 2009; Reingruber 2008*). New dates support these adjustments and substantiate new appraisals.

### *New evidence and new appraisals*

With every decade, more dates become available, and especially in the last few years, sound sets of dates allow for some rectifications. Certainly, these

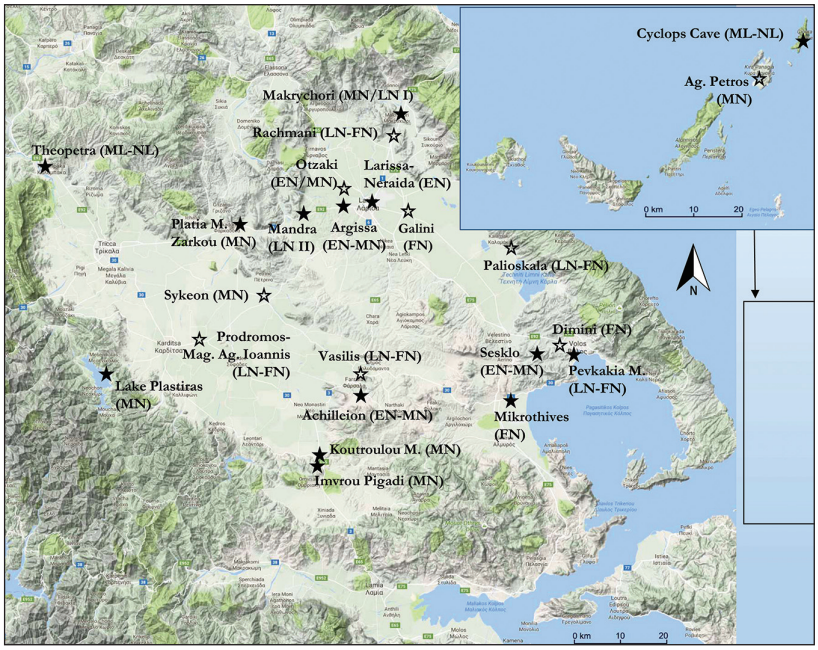


***Fig. 5. Sites with radiocarbon dates for the different periods and phases of the Neolithic Age (c. 6500–3300 cal BC). Filled-in stars: sequences with four or more dates per site and phase; empty stars: 1–3 dates per site and phase (background for the map from URL: https://www.google.de/maps).***

new appraisals must also be considered as provisional: each new sequence will provide new insights. However, future adjustments will probably not be necessary so much in terms of centuries, but rather in terms of decades.

This evaluation relies on the dates from two caves with sequences from both the Mesolithic (henceforth, ML) and the Neolithic (Theopetra Cave and Cyclops Cave) and from 21 open-air Neolithic settlements. Of these, 13 sites have only recently been dated (since 2014 – compare Fig. 1). Many of the new dates derive from early MN sites, especially from sites located in western Thessaly, as well as from sites of the LN and FN/Ch located in particular in eastern Thessaly (Fig. 5).

## The end of the Mesolithic and beginning of the Neolithic in Thessaly (*c.* 6600/6500 cal BC)

The Mesolithic is underrepresented in Thessaly. As is the case in other regions as well, it is very difficult to trace the ephemeral remains of highly mobile groups of people, except in caves where they have been protected from both erosion and alluvial or colluvial coverage. That Mesolithic populations indeed used the terrestrial and marine resources in the region of Thessaly is demonstrated by the two caves situated in its far west (Theopetra: compare *Kyparissi-Apostolika 2000a; 2000b; Facorellis* et al. *2001*) and far east (Cyclops Cave on the island of Youra: compare *Sampson* et al. *2003; Facorellis* et al. *1998*).

In the cave near the modern village of Theopetra, a body of 20 radiocarbon dates shows that the Mesolithic ended there around 6680 cal BC (Tab. 1). Two further dates on charcoal fit into the sequence of the EN, although the first phase is probably not represented. The final publication of the site will certainly allow more detailed interpretations (*Kyparissi-Apostolika* et al. *forthcoming*).

The complicated stratigraphy of the Cyclops Cave is also reflected in the radiocarbon dates, with either many outliers or with samples taken from mixed contexts. The many dates run on shells that needed MRE-corrections (compare Table 2) present another impediment.

Judging by the dates from the two caves, the ML–EN transition must have occurred anywhere between 6680 and 6400 cal BC. In the late 1950s, the transition between the Mesolithic (Epipalaeolithic in Near Eastern terminology) and the Pottery Neolithic was

| Theopetra Cave | | |
|---|---|---|
| **Periods and Phases** | **cal BC 1σ** | **Material** |
| Lower Mesolithic | 8780–7530 | charcoal |
| Upper Mesolithic | 7450–6680 | charcoal and human bones |
| Early Neolithic | 6400–6230 | charcoal |
| Middle Neolithic | 5990–5470 | charcoal |
| Late Neolithic I | 5490–5070 | charcoal |
| Late Neolithic II | 4970–4850 | charcoal |
| Final Neolithic/ Chalcolithic | 4460–4230 | charcoal |

***Tab. 1. Theopetra Cave: three dates with huge standard deviations (>125 years BP) are not included in this table (compare* Reingruber, Thissen 2016*). All dates have been calibrated along the IntCal13 calibration curve (*Reimer *et al.* 2013*), using the OxCal v4.2.4 program throughout this contribution (*Bronk Ramsey 2009*).***

| Cyclops Cave | | |
|---|---|---|
| **Periods and Phases** | **cal BC 1σ** | **Material** |
| Lower Mesolithic | 8600–8350 | charcoal |
| Upper Mesolithic | 8300–6420 | shells (MRE-corrected) and charcoal |
| Early Neolithic | 6450–6030 | shells (MRE-corrected) and charcoal |
| Middle Neolithic | 6070–5670 | bone and charcoal |
| Late Neolithic I | 5300–5000 | shells (MRE-corrected) |
| Neolithic? | 4230–4050 | charcoal |
| Final Neolithic/ Chalcolithic | 3650–3530 | charcoal |

***Tab. 2. Cyclops Cave: the dates on shells are corrected by the Marine Reservoir Effect (MRE), using the ΔR = 167 ± 116 $^{14}$C yr in conjunction with the Marine13 calibration curve (compare* Facorellis, Vardala-Theodorou 2015*; Facorellis et al.* 1998*).***

described as a distinguishable period in human prehistory and labelled the 'Pre-Pottery Neolithic' (PPN) or 'Preceramic Period' (*Milojčić 1956; Theocharis 1973*). Radiocarbon dates from the 1960s seemingly confirmed this interpretation, since *c*. 7000 BC for the 'Preceramic Period' in the Aegean overlaps with the final phase of the PPNB in Anatolia. As has been shown elsewhere (*Reingruber, Thissen 2009*), these early dates are highly dubious. For example, the dates obtained on bones from Argissa Magoula have to be excluded from all future evaluations: they were run on bones before the introduction of the AMS-method; they were published in such a way that the date and the bone sample from which it derived cannot be matched (*Protsch, Berger 1973*) and, in the worst case, they might have been faked (*Reingruber, Thissen 2016: www.14sea.org/3_IIc.html#*). Chronological appraisals relying on the bone samples from Argissa Magoula must therefore be rejected. Moreover, the levels presented as 'Preceramic' contained considerable amounts of sherds that were interpreted by their excavators as intrusions from above (*Reingruber 2008*).

The radiocarbon dates for the EN I levels at the *magoules* of Argissa and Sesklo fit well with the gaps

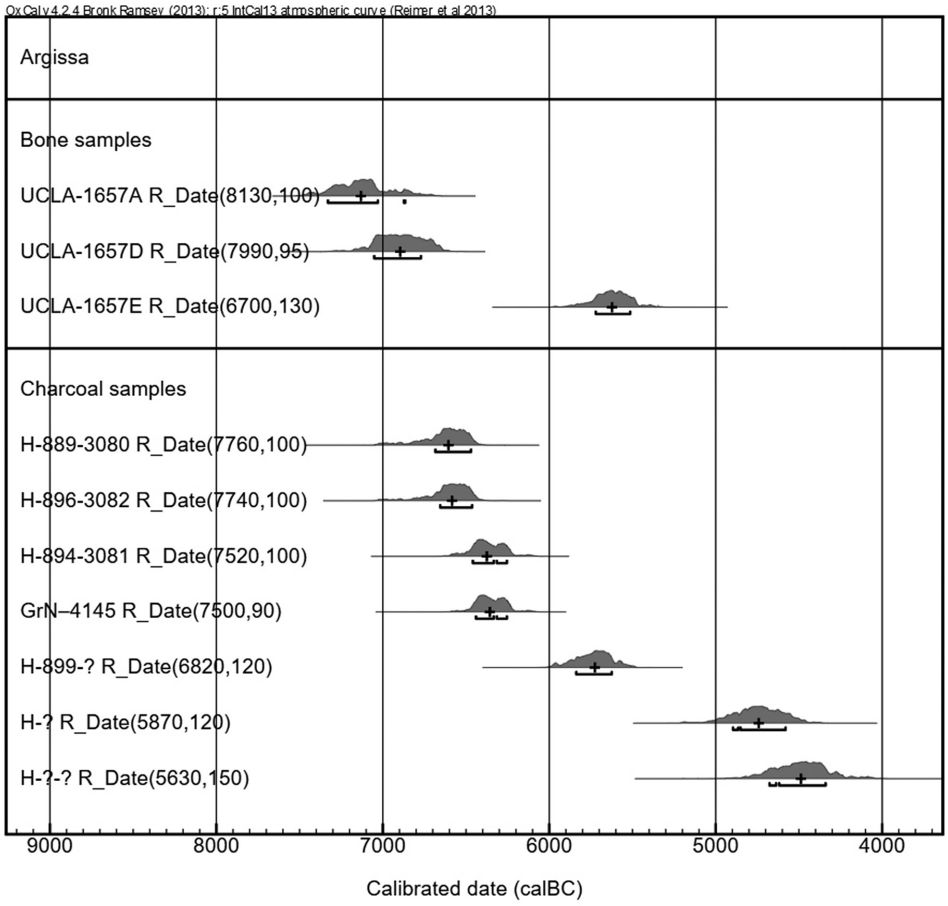


***Fig. 6. Argissa Magoula: note that the bone samples published in 1973 are erroneous and that the reliable sequence starts with the charcoal samples, for which 6600 cal BC serves as a terminus post quem (*Reingruber 2008.157*).***

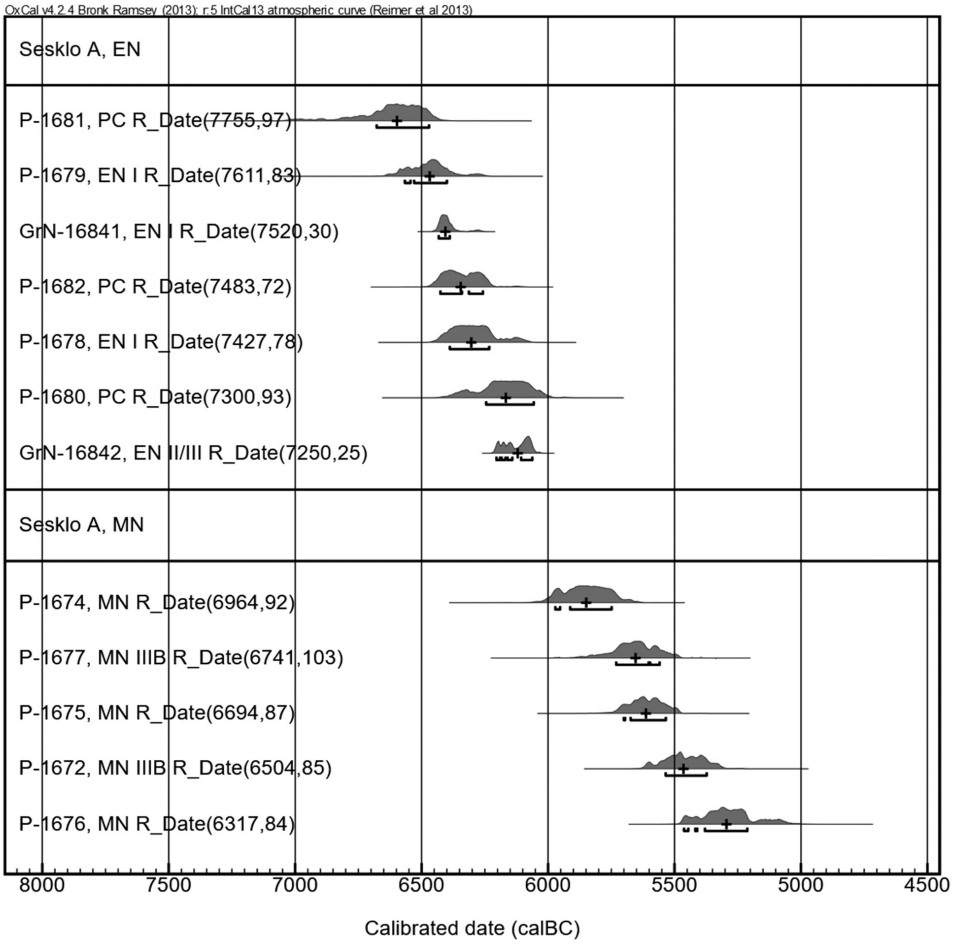


***Fig. 7. Sesklo Magoula (or Sesklo A): all dates are on charcoal (*Lawn 1975*).***

in the sequences of the caves mentioned above (Figs. 6 and 7). In a circum-Aegean perspective, this interpretation coincides well with the newly obtained dates from Ulucak, Çukuriçi Höyük, Franchthi and Paliambela-Kolindros (dates and references are compiled in *Reingruber, Thissen 2016*). Some of the earliest sites dated to around 6650 cal BC may have at their base a thin 'Aceramic' level, but they are exceptions rather than the rule. It could be further argued that the Thessalian dates are some decades younger: If it is accepted that the four oldest charcoal samples from Argissa Magoula (three from so-called pits and one from level 28b above them) do indeed belong to the same phase of the EN I (compare *Reingruber 2008.Tab. 3.1*), then their combined result post-dates 6500 cal BC (Fig. 8). Even this result must be regarded as a *terminus post quem* (TPQ), since the charcoal derived from unknown wood species: the old-wood effect can thus not be excluded (compare *Reingruber, Thissen 2009; 2016*). Therefore, a re-evaluation of the old dates from Argissa and Sesklo shows that the beginning of the EN in Thessaly can be dated

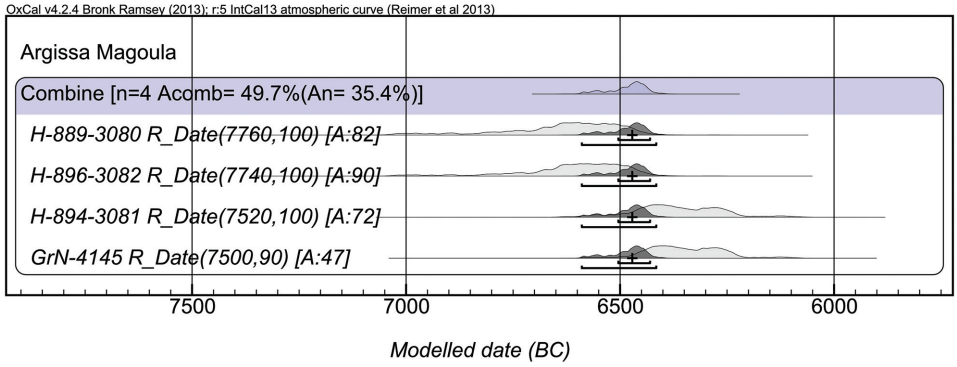


***Fig. 8. Argissa Magoula and the beginning of the Neolithic as resulting from combining the charcoal dates.***

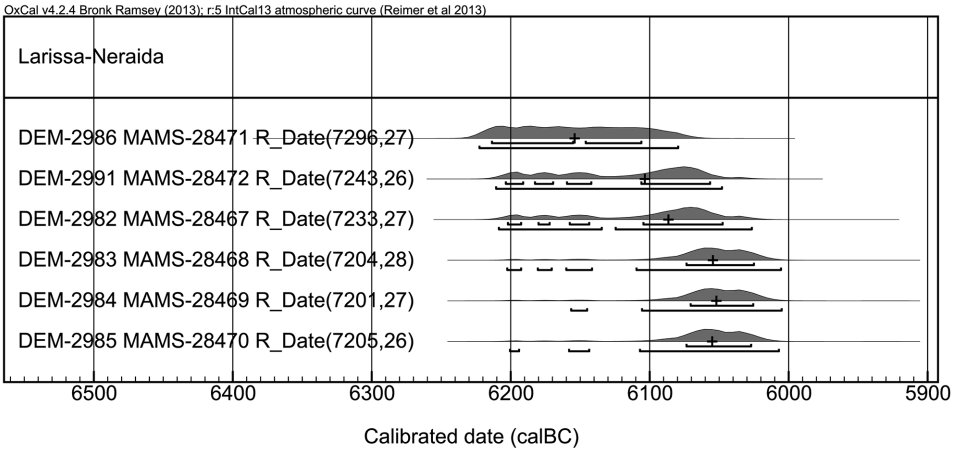


***Fig. 9. Dates for the Early Neolithic II from Larissa-Neraida.***

to only after 6500 cal BC. In addition, new dates from Sesklo run on old samples support this view: the oldest of them (DEM-2440) resulted in 6450 cal BC (*Maniatis, Kotsakis 2016*).

Although Thessaly is especially famous for the EN period, unexpectedly, despite the many efforts of the last decades, evidence for the beginning of the Neolithic Age is difficult to obtain. However, pottery of the 'Protoseskl o'-type was discovered (*Anetakis 2012*) during rescue excavations in the low *magoula* of Neraida in the city of Larissa. Six $^{14}$C dates date this phase of the EN (EN II or 'Protoseskl o') between *c.* 6200 and 6000 cal BC (Fig. 9) – but note the long interval covered by three of the dates. Such intervals are the result of flat portions (plateaus) in the calibration curve (see below). The median values, even of date DEM-2986 with 6150 cal BC, especially of all other dates at 6100/6080 cal BC, are compatible with the end of the EN II.

The most comprehensive sequence is still the one from Achilleion, including 40 dates from well-defined excavation units. Two more dates with huge standard deviations derive from a test-pit and have not been included in the statistical model proposed in Fig. 10. The model confirms the beginning of Phase I in Achilleion shortly after 6300 cal BC, and the transition from the EN to the MN during Phase IIIb around 6000 cal BC (note that no dates are available for Phase IIIa). The stratigraphic sequence ends in Phase IVa, with layers 2–10 dating to the 60th century cal BC. Additional samples assigned to Phase IVa derive from pits and ditches dug into layers 10–21. They suggest that the occupation lasted until 5800 cal BC. The single, much later, date for Phase IVb also derives from a pit that attests a brief re-occupation around 5540 cal BC. This youngest date corresponds well with the end of the MN at 5500 cal BC.

Achilleion Phase Ia starts according to this model at 6280 cal BC and thus does not date to the beginning of the EN in Thessaly, but is coeval with the EN II phase. This view is also supported by the pottery with painted motifs of the 'Protoseskl o' variant appearing from Phase I onwards. Furthermore, 6280 cal BC can be considered a useful *terminus ante quem* (TAQ) for the EN I ending around 6300 cal BC. Finally, if Coleman had given more weight to this sequence of dates, an alternative view regarding the transition EN/MN could have been considered: there is no direct evidence from Thessaly that the EN lasted there until 5800 cal BC (compare Tab. 3).

| Abs. dates cal BC 1σ | Archaeological phases | Sites |
|---|---|---|
| *c.* 6600 | EN I ('Initial Neolithic') | Beginning of the EN in predominantly coastal and/or hilly areas of the circum-Aegean |
| *c.* 6500–6300 | EN I ('Early Ceramic') | Argissa, Sesklo |
| 6280–6070 | EN II ('Protoseskl o') | Achilleion I–II, Sesklo, Larissa-Neraida |
| 6070–5980 | EN III/MN I ('Preseskl o') | Achilleion IIIb, Otzaki |
| 5980–5800 | MN I ('Sesklo I') | Achilleion IVa, Cyclops Cave, Theopetra |
| *c.* 5750–5600 | MN II ('Sesklo II') | Argissa, Sesklo, Agios Petros, Theopetra |
| *c.* 5540 | MN III ('Sesklo III') | Achilleion IVb, Sesklo |

***Tab. 3. The Early and Middle Neolithic sequences in Thessaly with the two terminological proposals at the transition EN-MN (in red). In brackets, the terms used and/or established by Milojčić and Theocharis.***

## The EN-MN transition (6000/5900 cal BC)

In the terminology of Milojčić, the final phase of the EN received the label 'Vorsesklo' ('Presesklo') and is relative-chronologically situated between 'Protosesklo' (EN II) and 'Sesklo' (MN). Expanding on this phase, Johanna Milojčić-von Zumbusch labelled it 'Magulitsa culture' and on the basis of pottery styles from Otzaki Magoula advocated two sub-phases (*Milojčić–v.Zumbusch 1971.146–148*): the older phase of the middle strata with so-called 'Barbotine' pottery with finger pinches and nail impressions, and the

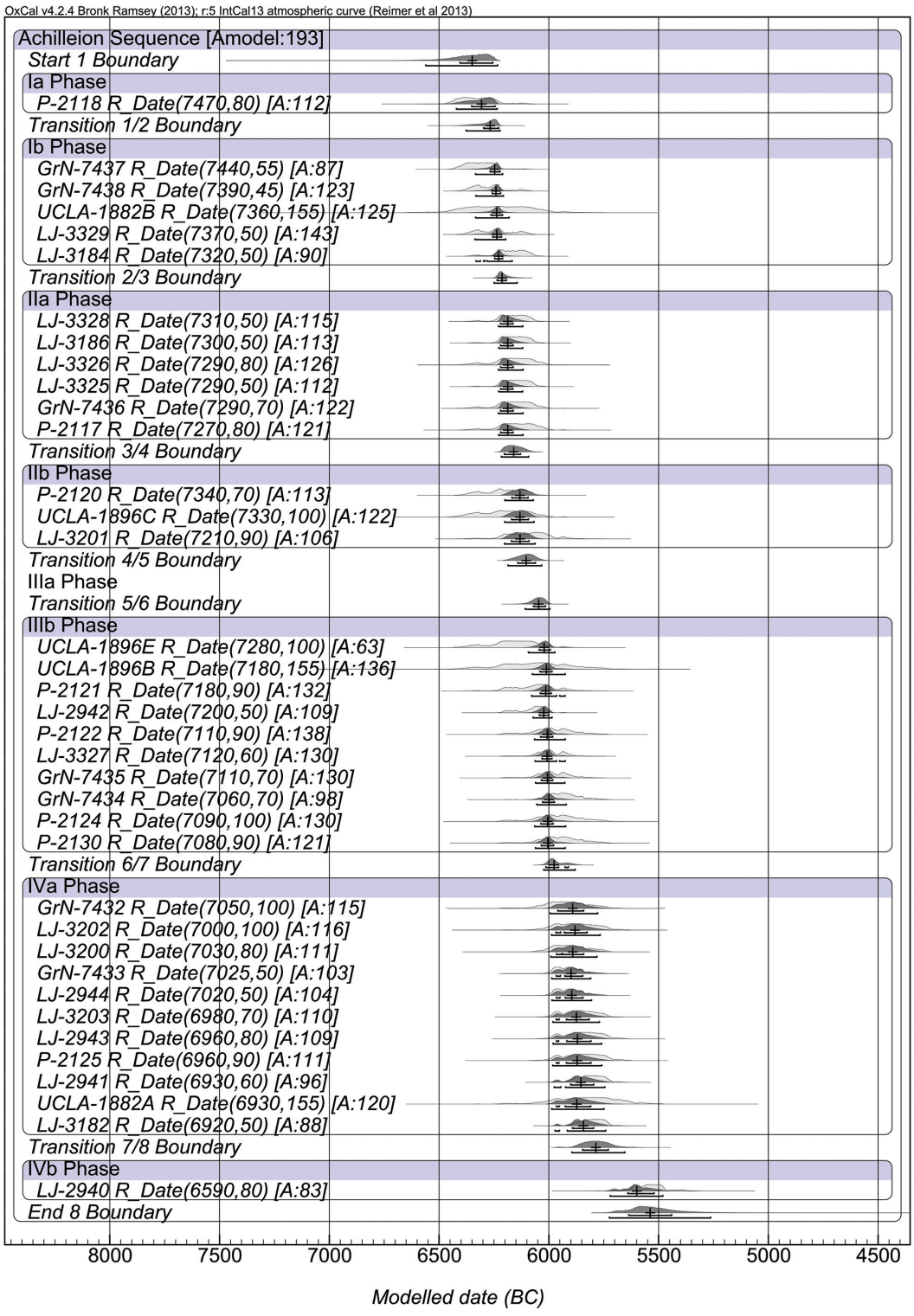


***Fig. 10. Achilleion: dates modelled statistically according to the seven phases Achilleion Ia to IVb (excluding two dates with huge standard deviations from a test pit) (all dates from* Gimbutas 1989*).***

somewhat younger phase of the upper strata, with so-called 'Cardium' pottery, with impressions made with an instrument. These interpretations are not grounded on sufficient stratigraphic observations (note that, precisely at the transition from the EN to the MN, 60–70cm are missing from the stratigraphic sequence in Otzaki: *Milojčić 1971.13,15; Pl. V*). Moreover, the division into two sub-phases relies on only few inventories, mainly on material deriving from sites in north-eastern and western Thessaly. It is especially in these parts of Thessaly that the defining pottery style for the EN III, Impresso pottery, occurs. Farther south (in Achilleion and Sesklo) this kind of pottery appears infrequently, and fades out completely south of the Spercheios valley. This may be the reason why Gimbutas proposed an alternative separation: she not only rejected the division of the EN into three stages and suggested an early start to the MN at 6100 cal BC instead (*Gimbutas 1989. Fig. 3.4* and Fig. 3). She even arrived at completely different conclusions concerning impressed pottery styles: based on less than 20 sherds, she suggested that first the punctuated/stabbed Impresso pottery appeared in phase Achilleion IIIb and stopped with Phase IVa, when fingernail impressions were applied to pots (*Gimbutas* et al. *1989.92* and Tab. 5.5).

Irrespective of styles, the radiocarbon dates for the levels with Impresso pottery both in Achilleion (phase IIIb) and in Otzaki (Area III, upper level) are of the same period, between 6060/6030 and 5880/5830 cal BC (Figs. 10 and 11).

Therefore, the transition between the two periods of the EN and the MN can be dated in Thessaly to around 6000 cal BC, but the correspondence between relative and absolute chronology is currently not satisfactorily solved. Only new and sound stratigraphic evaluations will contribute to a better definition of this transition. For the time being, a division into three EN-phases can be advocated.

That the MN started at the latest in 5900 cal BC is corroborated by dates known since the 1990s from the Cyclops Cave, Theopetra and Platia Magoula Zarkou; this view is further supported by dates obtained from Sykeon (Figs. 12 and 13). Also, new dates from the western fringes of the Pindus Mountains

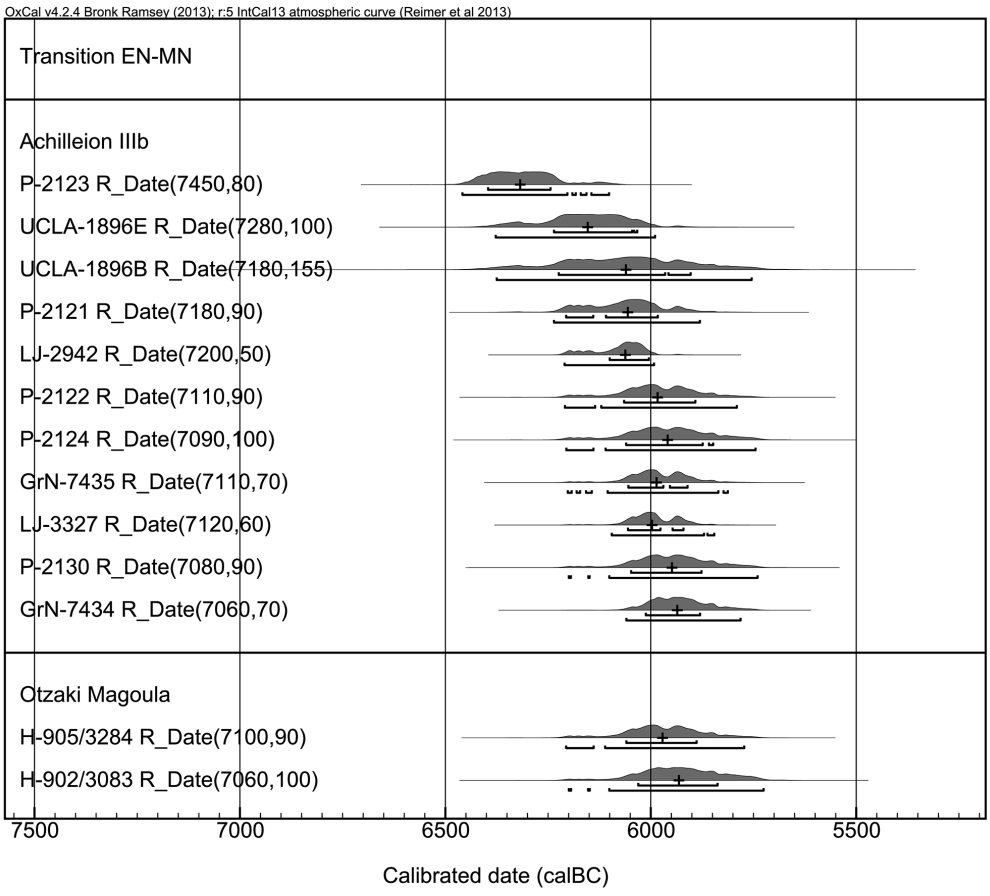


***Fig. 11. Dates for the transition EN–MN (the modelled dates of phase Achilleion IIIb in Fig. 10 resulted between 6070–5980 cal BC, corresponding well with the two dates from Otzaki Magoula; see* Reingruber 2008.270*).***

and from the southernmost tip of the Thessalian Plain in northern Phthiotis (now included in the municipality of Domokos) confirm this view: four dates from Lake Plastiras fall into the first quarter of the 6th millennium BC, as is the case also with two charcoal dates obtained from Imvrou Pigadi (Fig. 14). From the latter site, another four dates obtained by thermoluminescence dating do not contradict this view (*Kyparissi-Apostolika* et al. *2016.38*), despite the huge error margins of 500 years inherent to the method (Tab. 4). The reliable sequence consisting of six dates from Koutroulou Magoula confirms that the beginning of the MN occurred early in the 6th millennium BC (*Hamilakis* et al. *in print*).

Therefore, a first phase of the MN can be securely dated to between 6000/5900–5750 cal BC. For the ensuing centuries, fewer dates are available, but those from Achilleion and Theopetra can be followed up until 5500 cal BC. The 500-year duration of this pe-

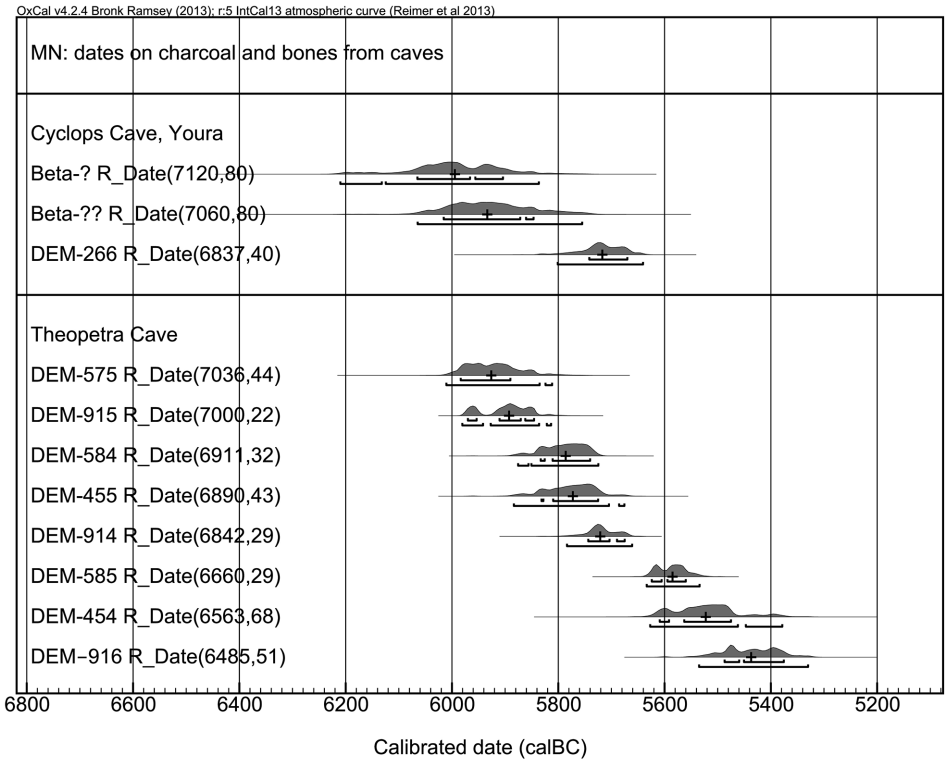


***Fig. 12. Charcoal and bone samples from the MN levels in the Cyclops Cave on Youra (compare* Facorellis *et al.* 1998.Tab. 1; Trantalidou 2003.157*) and from Theopetra Cave (*Facorellis *et al.* 2001*).***

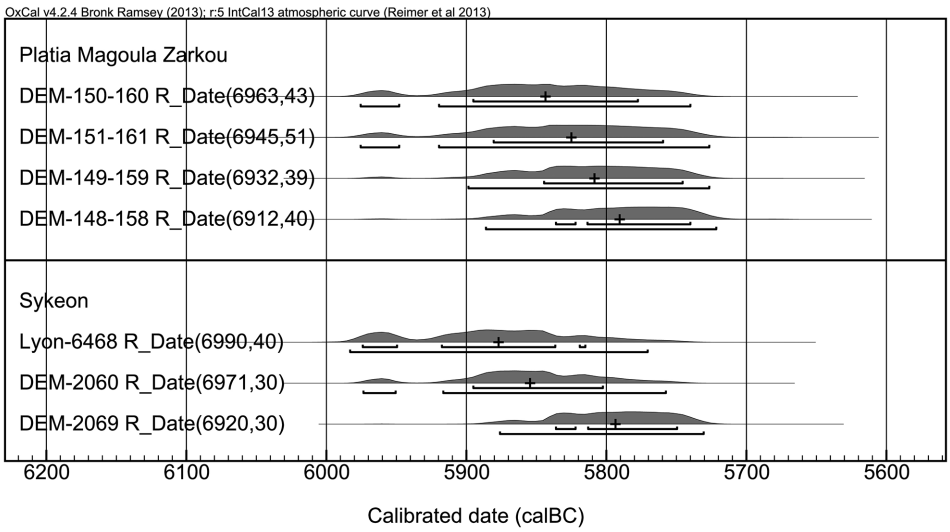


***Fig. 13. Platia Magoula Zarkou and Sykeon: dates from the MN levels (*Gallis 1990.214, Tab. 1; Maniatis *et al.* 2016.63–64, Tab. 1*).***

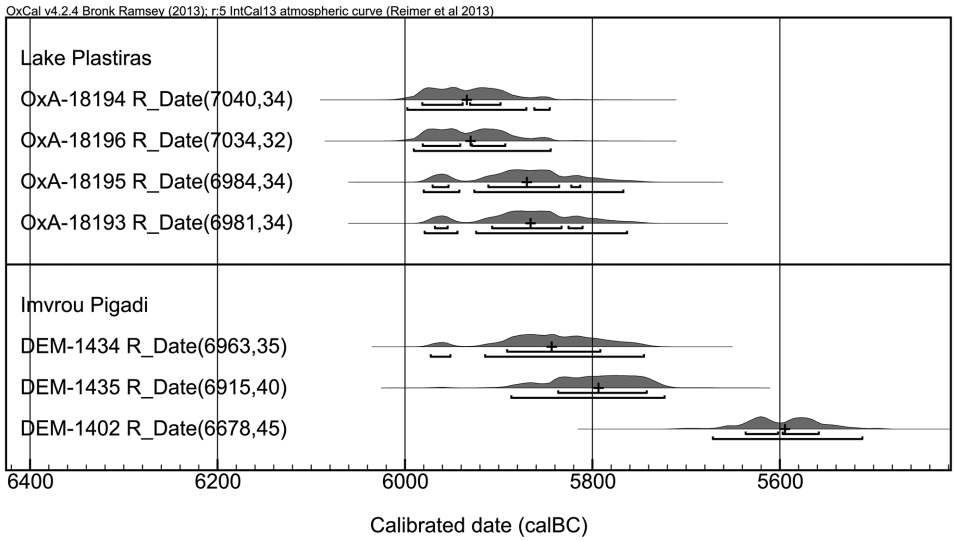


***Fig. 14. New dates for the MN from western Thessaly and the northern Phthiotis (*Kyparissi-Apostolika *et al.* 2009; Kyparissi-Apostolika 2012.436*).***

riod must therefore be shifted by 200 years from 5800–5300 cal BC to 6000/5900–5500 cal BC. Additionally, the single and free-floating dates from Argissa Magoula and Agios Petros (*Efstratiou 1985.167*) do corroborate a dating of the MN to the first half of the 6th millennium BC.

## The MN–LN transition and the LN I (5500–5000 cal BC)

The hitherto known sequences from MN sites suggest that this period ended around or even shortly before 5500 cal BC. There is only one date from Sesklo Magoula (P-1676: 6317±84 BP – compare Fig. 7) that, due to its big standard deviation and due to a plateau in the calibration curve, covers almost 300 years at 1σ (5470–5210 cal BC) and at 2σ more than 400 years (5480–5060 cal BC). It is certainly not suitable for defining the end of the MN at 5300 cal BC.

On the other hand, the oldest dates for the LN I obtained in Theopetra, Prodromos-Magoula Agios Ioannis, and Makrychori (Fig. 15) fit exactly into the centuries 5500–5300 cal BC, supporting the conclusion that the LN had already started at 5500 cal BC. Nevertheless, in the whole of Southeastern Europe, dates for the centuries between 5500 and 5300 cal BC are generally only few in number. In relative chronological terms, this is the time of the Tsangli-Larissa culture (*Gallis 1987*), with major transformations in many parts of the Balkans and Central Europe (beginning of Karanovo III, Vinča A and LBK). In addition, in terms of radiocarbon dates, the final two centuries of the 6th millennium in Thessaly are only poorly represented. No conclusive absolute dates are available yet for the (pottery) culture of Arapi.

| Lab. no. | Date BP | Age BC | ± years | ED (Gy) | U (ppm) | Th (ppm) | K (%) | DR (Gy/ka) |
|---|---|---|---|---|---|---|---|---|
| MI5 | 7177 | 5164 | 515 | 28.86 (2.09) | 5.43 (0.14) | 6.18 (0.18) | 1.81 (0.02) | 4.021 |
| MI6 | 7284 | 5271 | 533 | 30.51 (2.26) | 6.62 (0.15) | 7.46 (0.15) | 1.29 (0.02) | 4.188 |
| MI7 | 7269 | 5256 | 521 | 31.27 (2.32) | 6.02 (0.15) | 7.58 (0.18) | 1.71 (0.02) | 4.301 |
| MI12 | 6808 | 4795 | 499 | 31.69 (2.51) | 7.43 (0.11) | 7.68 (0.14) | 1.47 (0.02) | 4.655 |

***Tab. 4. Thermoluminiscence (TL) dates from Imvrou Pigadi (*Kyparissi-Apostolika *et al.* 2016.38*).***

## The LN I–LN II transition and the LN II (5000–4500 cal BC)

The beginning of the LN II in the first century of the 5th millennium is poorly attested by radiocarbon dates. From Otzaki Magoula, after which all the phases of the LN II have been labelled (*Hauptmann 1981; Hauptmann, Milojčić 1969*), no organic material has been sampled from these levels. Therefore, little can be said about the transition from the LN I to LN II. Moreover, the pottery sequences Otzaki A, B and C cannot be verified with the help of radiocarbon sequences. Most importantly, a first glimpse into the absolute dating of these phases has been made possible thanks to a sequence of eight dates from the sites of Mandra (Fig. 16). Judg-

ing by the median values, the site may have been inhabited between 4900 and 4700 cal BC, during the earlier part of the LN II (*Toufexis* et al. *2009.113; Karagiannopoulos 2016.388; Maniatis* et al. *2016.Tab. 1*). From the later part of the LN II, new $^{14}$C dates were obtained recently from rescue excavations at the famous site of Rachmani, confirming its date to the LN II and the FN/Ch (Fig. 17). Also, the new dates from Prodromos-Magoula Agios Ioannis and from Vasilis fall according to their medians between *c.* 4700 and 4600 cal BC. The pottery from the latter site is mainly of the 'Otzaki' and 'local Dimini' styles.

That the LN II indeed ended around or shortly after 4600 or rather around 4500 cal BC is corroborated by the sequence from Pevkakia Magoula in Magnesia

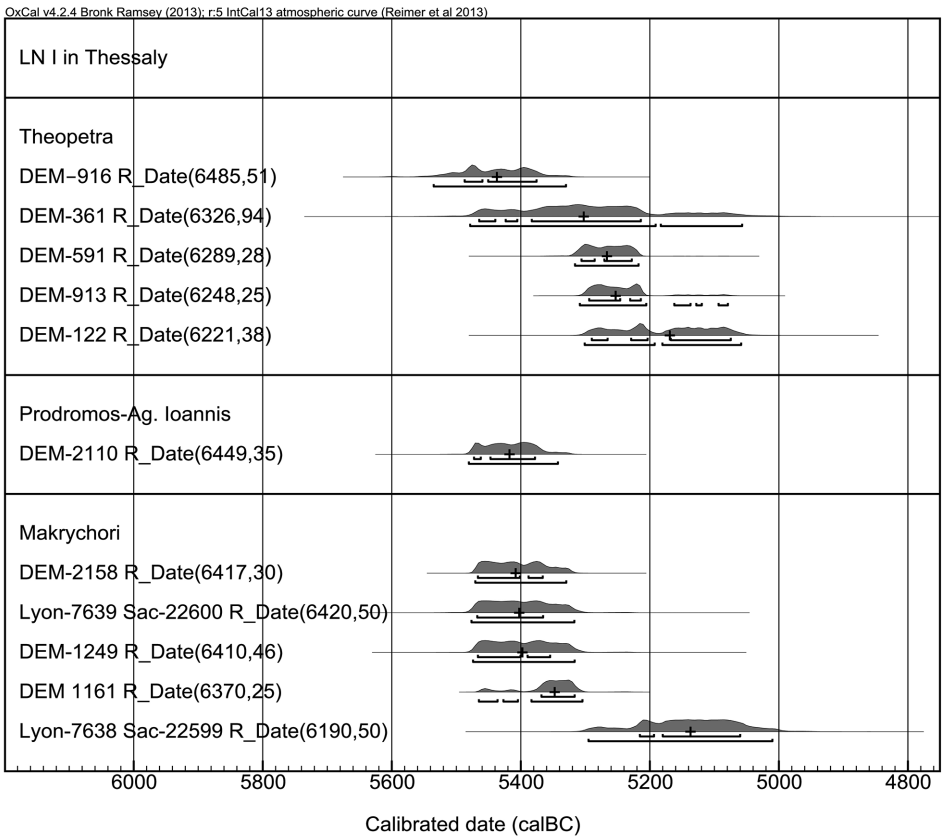


***Fig. 15. Thessalian sites with dates from the LN I (*Maniatis *et al.* 2016.Tab. 1; Reingruber, Thissen 2016*).***

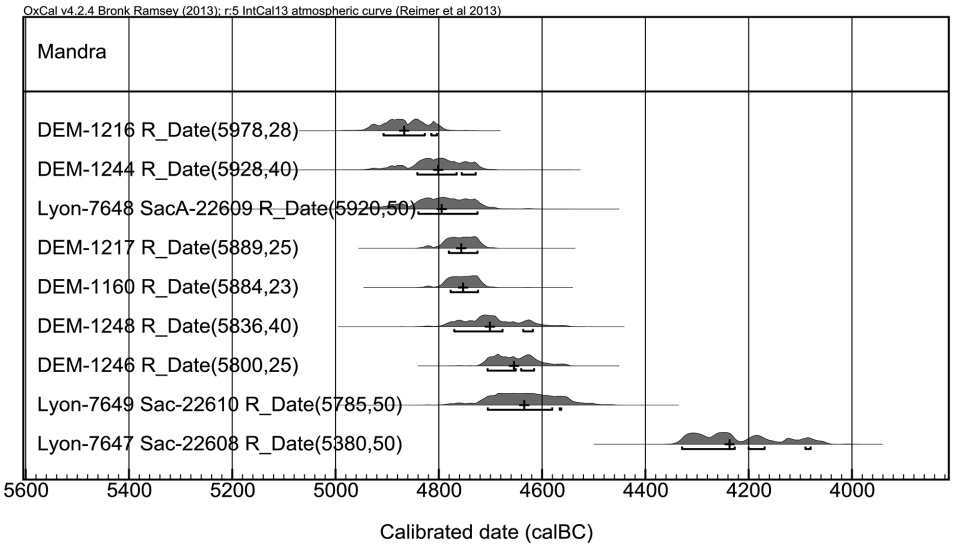


***Fig. 16. Mandra: radiocarbon dates from levels I–III of the LN II and from level V of the FN/Ch (*Toufexis 2000; forthcoming*).***

(*Weißhaar 1989.139*) for which ten dates were published as 'uncalibrated BC'. Therefore, the value 1950 must be added to the given dates to obtain the initial BP-value. When modelled, the six dates for the end of the phase fall within the range 4600 and 4500 cal BC (Fig. 18).

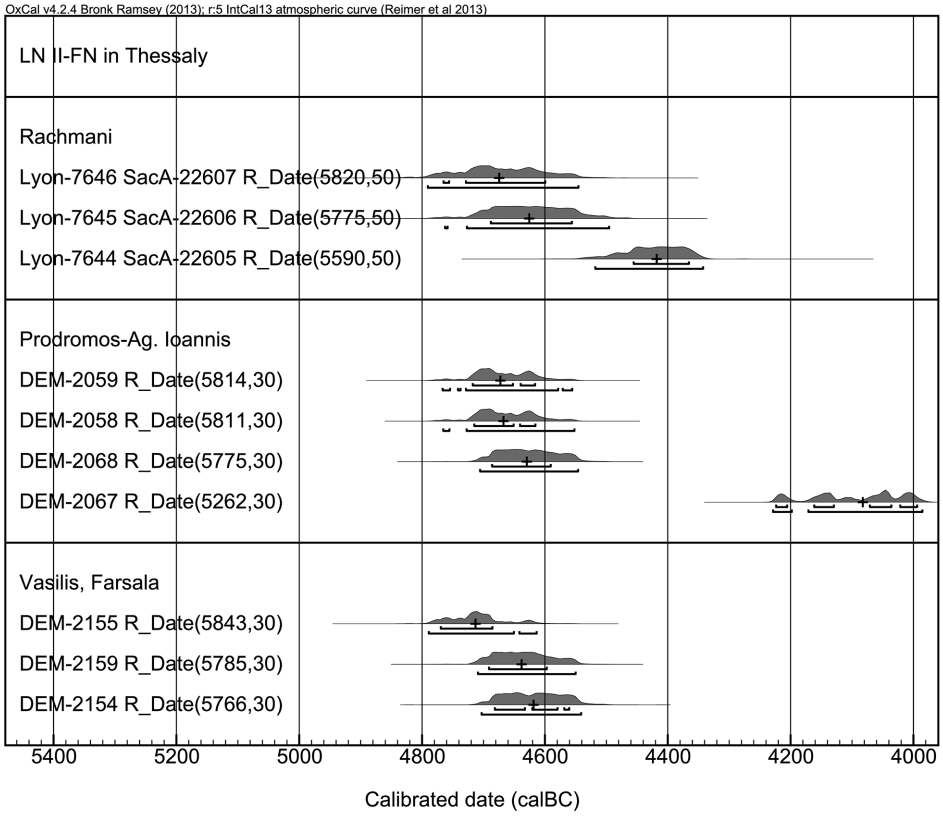


***Fig. 17. Thessalian sites with eight dates from the LN II before 4500 cal BC and two dates from the FN/Ch after 4500 cal BC (*Maniatis *et al.* 2016.Tab. 1*).***

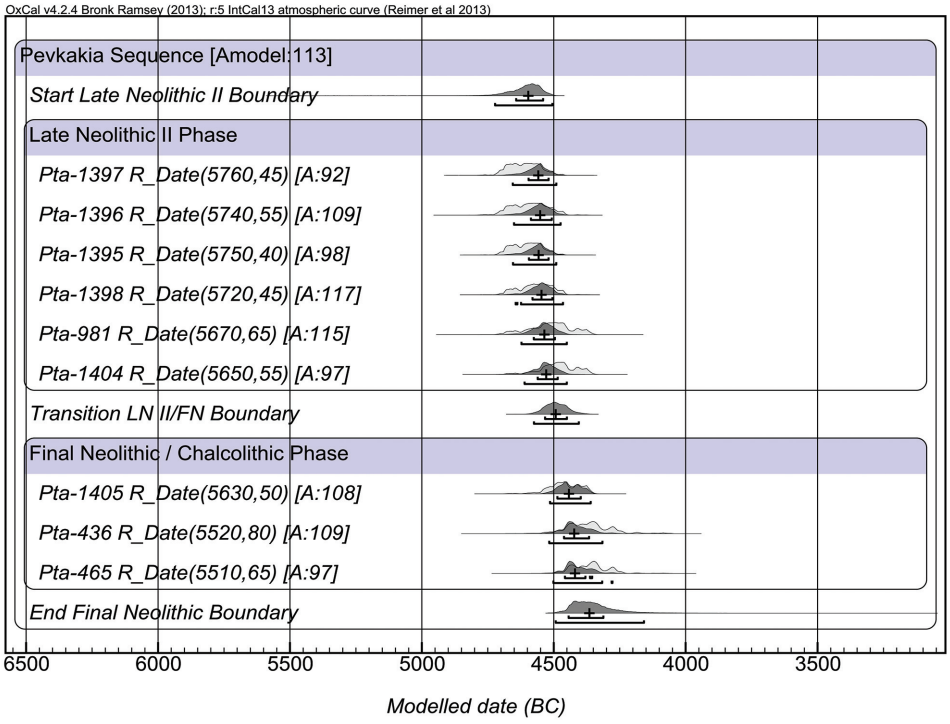


***Fig. 18. Pevkakia Magoula: modelled dates from the end of the LN II and the early FN/Ch, excluding the outlier Pta-435 (*Weißhaar 1989; Reingruber, Thissen 2016*).***

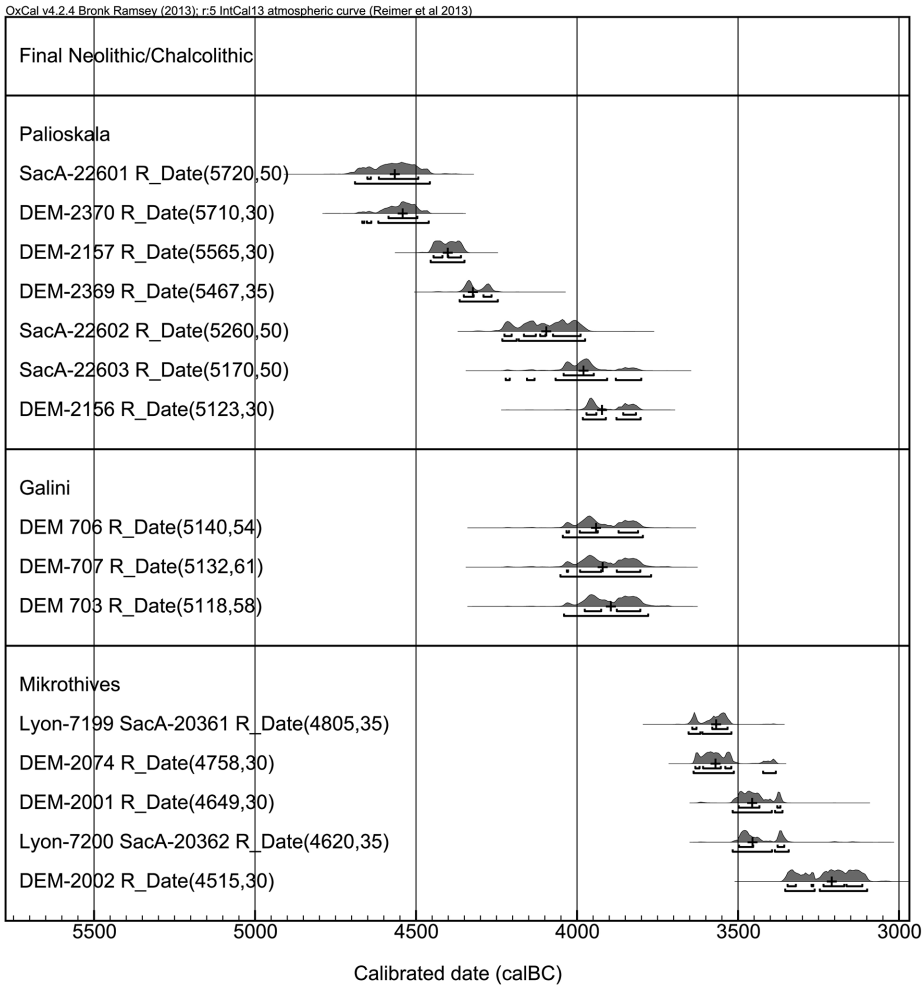


***Fig. 19. Radiocarbon dates for the FN/Ch between 4550 and 3300 cal BC (*Toufexis 2016; Maniatis *et al.* 2016*).***

The transition from the LN to the FN/Ch around 4500 cal BC is also supported by the new dates from Palioskala (*Toufexis 2016.371, Tab. 1; Maniatis* et al. *2016.Tab. 1*): the two oldest dates shortly before 4500 cal BC belong to the LN II (Fig. 19).

Although the terminology for the 'Dimini culture' evokes consistency and continuity among the different phases and sub-phases, only the final stage of the 'Dimini culture' is represented in the excavated levels of the eponymous site. One single date with a huge standard deviation 5630±150 BP (Lab. No. not given) covers the time between 4680 and 4340 cal BC and is therefore not suitable for evaluation (*Reingruber, Thissen 2016*).

## The Final Neolithic/Chalcolithic (4500–3300 cal BC)

In a pan-regional, Southeastern European perspective, the terminology for the 5th and 4th millennia is rather contradictory. Between 4600/4500 and 4200/4000 cal BC, the heyday of the Copper Age or Eneolithic in the Balkans (with the cultures Gumelniţa, Karanovo VI and Varna) had been reached (*Todorova 1995*). Beside the appearance of innovative techniques mostly related to the exploitation of metals (copper, gold and – only in the Aegean – silver), social transformations also allow a separation of this period from the proper Neolithic Age (*Souvatzi 2008*). Therefore, in this article the term Chalcolithic is used synonymously for Final Neolithic.

In Thessaly, the final dates for the LN 'Dimini culture' around 4500 cal BC also define the start of the ensuing 'Rachmani culture'. This is confirmed by the modelled sequence from Pevkakia Magoula, where three samples date the FN/Ch to 4500–4300 cal BC (Fig. 18). Also, single dates from the sites of Rachmani and Prodromos-Magoula Agios Ioannis fall into the second half or even the end of the 5th millennium (Fig. 17). The sample for the youngest date from Mandra (Fig. 16) was derived from a pit dug into the fill of a LN ditch. However, this youngest phase is re-

presented mainly by surface material.

In the Balkans, shortly before 4000 cal BC, the long-lived tell-sites were abandoned. Information for the following centuries of the Transitional Period (*Todorova 1995.89*) is meagre (but compare *Tsirtsoni 2016*). Also, in the Northern Aegean (*Maniatis 2014; Maniatis* et al. *2014*) and in Thessaly the time around and after *c.* 4200/4000 cal BC is extremely difficult to grasp. The scarcity of dates until *c.* 3750 cal BC coincides partly with a huge plateau in the calibration curve that impedes a precise determination of single dates. In this plateau fall the three youngest dates from Palioskala (*Toufexis 2016*; Fig. 19). Judging by these dates and the dates from Galini, this phase of the FN/Ch probably lasted until 3750 cal BC (yet the stratigraphical sequence in Galini is complicated by post-depositional disturbances: *Toufexis 1999*). 4200/4000 cal BC can provisionally be regarded as a turning point also for Thessaly, but the final evaluation of the Palioskala site will certainly shed more light on this still dark chapter in Thessalian prehistory (a period that may have been coeval with the Transitional Period in Bulgaria). With the dates from Mikrothives, a final stage of the FN/Ch period can be contoured between 3750 and 3300 cal BC. Therefore, for the moment it is impossible to go further than to state that three groups of dates from Palioskala, Galini and Mikrothives might reflect three stages of the FN/Ch: at 4500–4200/4000 cal BC, at 4200/4000–3750 cal BC and at 3750–3300 cal BC. More reliable dates are definitely needed to fill in the huge gaps and to understand the transition to the Early Bronze Age (and here again, Palioskala will offer valuable insights).

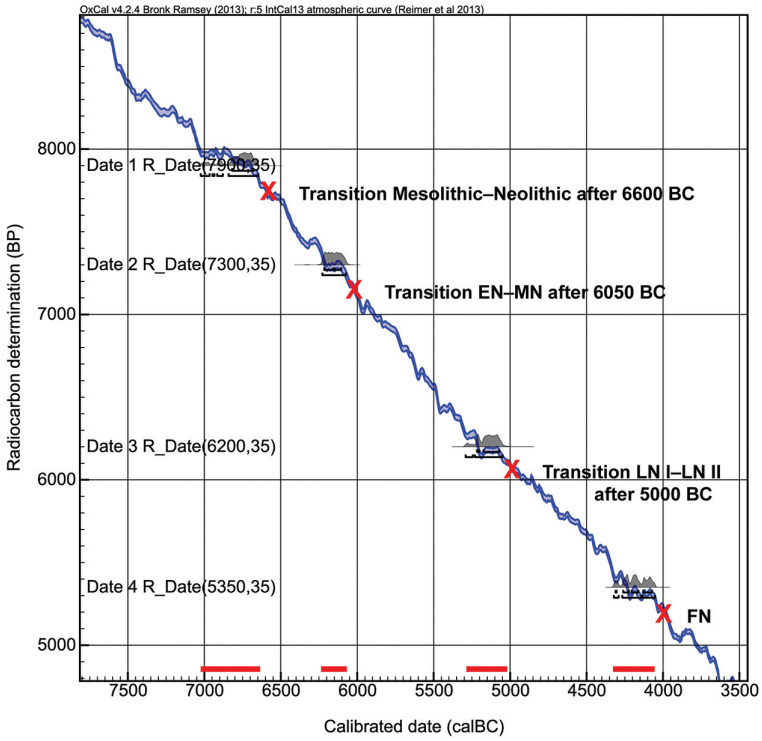


***Fig. 20. Calibration curve with wiggles (accentuated by fictional 'Dates 1–4') resulting in different plateaus that cover several centuries (red bars on the cal BC-line); transitions between Neolithic phases are marked with red crosses.***

## Discussion

From Thessaly, only two sites provided radiocarbon sequences suitable for statistical analysis (Achilleion and Pevkakia Magoula). Certainly, Bayesian modelling cannot be self-sufficient: it is an instrument, a method for obtaining more refined information on the duration of phases, especially on their boundaries. It is self-evident that the more data available for future analysis, the more reliable the results will be. Therefore, all conclusions based on this method are provisional and subject to continuous adjustments.

The two modelled sequences from Thessaly cover vital parts of the Neolithic Age: the sequence from Achilleion spans major parts of the EN and the MN, whereas the sequence from Pevkakia Magoula gave reliable results for the LN–FN/Ch transition. In addition to giving a good orientation for the probable duration of specific phases, these two sequences serve as TAQ and TPQ for the phases preceding and following them. Apart from this, they are especially helpful also regarding the appraisal of single, free-floating dates (both old and new dates available from different Thessalian sites). Together they contribute to a better understanding not only of the duration of periods and phases, but also of the transitions between them. Nevertheless, as has been shown for the early achievements of radiocarbon based chronological schemes, generalisations can always lead to imprecise results. This holds also true for this paper, especially regarding the LN and FN/Ch. To sum up, some provisional results are presented in Table 5.

The few and often ambiguous dates hamper a better interpretation of boundaries. Therefore, a more re-

| Abs. dates cal BC (rounded) | Archaeological periods and phases | Sites |
|---|---|---|
| 7000–6600 | Final Mesolithic | Theopetra Cave, Cyclops Cave |
| 6600–6500 | 'Initial Neolithic' | - (Identified mainly in circum-Aegean coastal and/or hilly areas) |
| 6500–6300 | EN I | Argissa M., Sesklo M. |
| 6280–6070 | EN II | Achilleion I–II, Sesklo, Larissa-Neraida |
| 6070–5980 | EN III / MN I | Achilleion IIIb, Otzaki |
| 5980–5750 | MN I | Achilleion IVa, Theopetra, Cyclops Cave, Koutroulou M., Platia M. Zarkou, Sykeon, Imvrou Pigadi, Lake Plastiras |
| 5750–5600 | MN II | Sesklo, Theopetra, Ag. Petros |
| 5600–5500 | MN III | Achilleion IVb, Sesklo, Theopetra |
| 5500–5300 | LN I (early) | Theopetra, Makrychori, Prodromos-M. Ag. Ioannis |
| 5300–5000 | LN I (late) | Theopetra, Makrychori |
| 4900–4700 | LN II (early) | Mandra |
| 4700–4500 | LN II (late) | Rachmani, Prodromos-M. Ag. Ioannis, Vasilis, Pevkakia M., |
| 4500–4250 | FN (Chalcolithic) | Rachmani, Pevkakia M., Palioskala, Mandra |
| 4250–3750 | FN (Chalcolithic) | Palioskala, Galini |
| 3750–3300 | FN (Chalcolithic) | Mikrothives |

***Tab. 5. General appraisal of periods and phases in Thessaly.***

fined delimitation of phases in terms of decades, not in terms of centuries, is impossible. In some cases, especially at the beginning and the end of the Neolithic, the calibration curve itself impedes the acquisition of more detailed results. Successive wiggles often form flat portions (so-called plateaus) that cover many centuries. They greatly influence the appraisal of certain dates, especially those in the Mesolithic–Neolithic transition between 7000 and 6600 cal BC (Fig. 20). At first sight, these dates seem to support the chronology with the Neolithic starting at 7000 cal BC (compare 'Date 1'). However, when such dates are modelled in line with methodologically well-founded procedures, their duration can be better evaluated. As has been shown by Bernhard Weninger *et al.* (*2014.Figs. 12–13*), the Neolithic starts at the Ulucak and Çukuriçi Höyük sites around 6650 cal BC, not at 7000 cal BC. Dates from Knossos X, Sarakenos and Franchthi, especially those obtained on short-lived grains, confirm this appraisal (*Reingruber 2015; Reingruber, Thissen 2016*). For Thessaly all dates available at the moment suggest that the Neolithic way of life started there only well after this plateau ended, around 6500 cal BC.

Other plateaus also occur again during the centuries preceding major transitions: this is the case before the transition from the EN to the MN ('Date 2') and before the LN I to LN II transition ('Date 3'). The interpretation of dates is greatly influenced by the plateau at the end of the 5th millennium ('Date 4'): these plateaus certainly distort to a certain degree the interpretation of the calibrated dates, especially when only single dates are available. Many more dates are needed to control for these shortcomings better, comparable to the dates obtained in Çatalhöyük (*Bayliss* et al. *2015.Tab. 1*) or Uivar (*Schier et al. 2016*).

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