INTERPRETING RADIOCARBON DATES FROM NEOLITHIC HALAI, GREECE

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ABSTRACT. Archaeological investigations at Halai, a small city-state on the sea coast of East Lokris in Greece, have been carried out since 1986 by the Cornell Halai and East Lokris Project (CHELP). The town's acropolis, first inhabited in the Neolithic period, was in Greco-Roman times a political and cultural center controlling and serving a considerable territory. Radiocarbon dating of charred material unearthed from Neolithic deposits indicate that the Neolithic occupation probably lasted from about 6000 to 5300 BC. Details of dating are somewhat problematic, however, because of outlying determinations and lack of close agreement between determinations from the same or stratigraphically comparable material.

INTRODUCTION

Halai (38°39′42″N, 23°11′06″E) was a small city-state (*polis* or *polisma*) in Archaic through Late Roman times (600 BC–AD 600). Its acropolis is located on the southwest shore of the North Euboean Gulf in the modern village of Ayios Ioannis Theologos ("Theologos" in short, Figure 1). The town's territory (*chora*) extended over some 54 km^2. From about 6000–5300 BC, a Neolithic village flourished on what was later to become the acropolis.

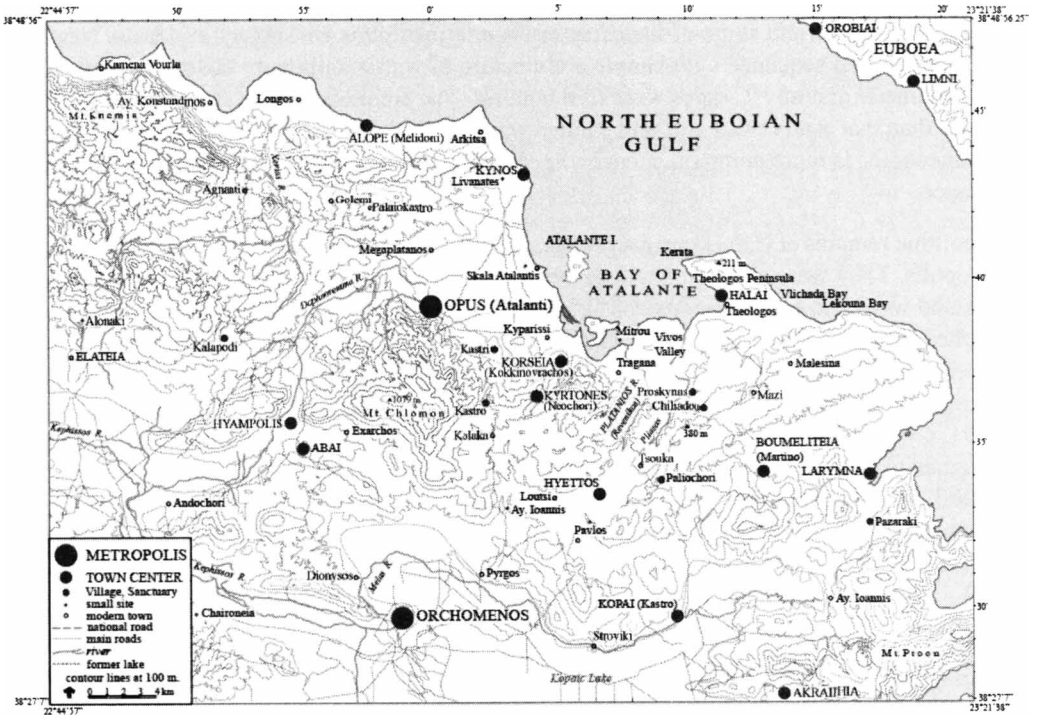

Figure 1 Map of Opuntian Lokris and surrounding regions

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The Neolithic town of Halai was first excavated around the time of the First World War and renewed work has taken place since 1990 by the Cornell Halai and East Lokris Project directed by John Coleman (1992, 1999). The town was founded around the time of the transition from the Early Neolithic (EN) period to the Middle Neolithic (MN) period and was abandoned in the earliest phase of the Late Neolithic (LN I) period. The site has an area of houses densely packed both horizontally and in vertical sequences of up to 3, with later ones built immediately on top of the ruins of earlier ones (Figures 2–5, buildings I–VII). The excavations are contributing to our knowledge of Greece in a formative period and in particular to our understanding of the social life of people at a seaside town and how they interacted with their environment and with other towns.

The earlier stages of the Neolithic period are not well documented in central Greece (the region between Thessaly and the Peloponnese) (Perlès 2001). Besides Halai, the only open sites with earlier Neolithic deposits known in any detail in central Greece are Orchomenos (Kunze 1931), Elateia (Weinberg 1962), and Nea Makri (Pantelidou-Gopha 1991, 1995). Early excavations in Phokis at Ayia Marina (Soteriades 1911) and in Boeotia at Chaironeia-Valoumenou (Soteriades 1908) did not lead to published stratified sequences, and recent excavations at Ayios Vlasis in Phthiotis are not yet published. An extensive Neolithic sequence is known at Sarakenos Cave (Sampson 2008), but stratigraphic details are as yet scanty. Late Neolithic sequences are also known at Kitsos Cave in Attica (Lambert 1981), Corycian Cave in Phokis (Touchais et al. 1981), and Skoteini Cave in Euboea (Sampson 1993).

Problems remain in understanding the Neolithic cultural sequence and chronology in central Greece, especially the transitions from Early to Middle Neolithic and from Middle to Late Neolithic. At Orchomenos and Corycian Cave, the stratigraphy was unclear. Although the excavations at Elateia produced an important cultural sequence dated to some extent by radiocarbon, the excavation was very limited and some of the excavator's interpretations are subject to debate. Nea Makri produced a cultural sequence with simple architecture of wattle-and-daub, but the pottery is rather local in character and no ^{14}C dates were forthcoming. The architecture at Halai is more completely preserved than that at any other site, and painted ware, which provides better evidence for dating and interconnections, is more common. Hence, the ^{14}C dates from Halai are potentially of considerable importance.

The Neolithic remains at Halai were accessible almost exclusively in area F, near the western end of the acropolis. They were excavated within trenches, numbered F1, F2, etc. The trenches were contiguous and were laid out in various configurations, depending in part on what was already visible in trenches from the earlier expedition. The samples for ^{14}C dating, like other excavated items, were given unique "field numbers" (Table 1). The initial capital letter is the area, and it is followed by the trench number and a lower case letter that represents the year the sample was excavated (a = 1990, b = 1991, c = 1992, etc.). Next, in parentheses (or within a circle when written by hand) is the number assigned to each individual excavation unit (EU), which was usually a specified volume of earth excavated over whatever part of the trench the excavator determined according to the apparent stratigraphy. The final number is assigned by the excavator to individual items or group of items within each EU: e.g. F2c(118)216 is field number 216 in excavation unit 118 of trench F2, excavated in 1992.

The ^{14}C evidence has to be understood and interpreted within the broader context in which phasing and dating are established at an archaeological site that was occupied for a long span of time. Stratigraphy, that is observations and reconstructions of sequences of deposits of soil and, when architectural remains are present, of building activities, is the basic tool for the establishment of a

Table 1 Halai Neolithic ^{14}C dates in stratigraphic order (listed from earlier to later within deposits with more than 1 determination). Each mean pooled age of the preceding samples, marked with italics, was averaged using the CALIB 6.0.1 program.

Sample nr	EU nr	Date (BP)[a]	Cal BC age 1σ, 2σ	$\delta^{13}C$ (‰)	m asl[b]	Coll. date (d/m/yr)
A. Samples from deposits assigned to single stratigraphic/chronological stages at Halai						
Early Neolithic/Early Middle Neolithic (EN–Early MN)						
Trench F2, Stratum 1, Upper, Late EN/Early MN, 1.00 m asl (1, a, ii)						
A-7271	F2c(168)580	7325 ± 160	6370–6060, 6470–5890	–24.3	1.00	28/7/1992
Trench F9, "Room 22," Lower levels, 0.72–0.75 m asl, Earlier MN or earlier (8, a, i)						
AA-25330	F9g(154)184	7340 ± 55	6250–6100, 6360–6070	–22.9	0.75	26/7/1996
Beta-102909	F9g(155)191	6870 ± 50	5830–5710, 5880–5660	–25.5	0.72	26/7/1996
Trench F9, Bld III, ~Stratum 1 in F2, 0.85–0.88 m asl, Late EN–Early MN (8, b, ii)						
Beta-102908	*F9g(97)357*	*7010 ± 50*	*5980–5840, 6000–5770*	*–25.9*	*0.88*	*25/7/1996*
Beta-102901	*F9g(65)4d-4f*	*6950 ± 50*	*5890–5770, 5980–5730*	*–24.8*	*0.86*	*10/7/1996*
Pooled mean1		**6980 ± 35**	**5967–5809, 5978–5759**			
Earlier Middle Neolithic (Earlier MN)						
Trench F2, Stratum 2, 1.28–1.38 m asl, Earlier MN (1, b), hearth near E corner in S quadrant						
A-7272	F2c(173)581c	7785 ± 180*	7020–6450, 7130–6250	–23.3	1.37	29/7/1992
A-7268	F2c(127)275	7530 ± 200	6410–6040, 6600–5810	–24.9	1.28	13/7/1992
A-7622	*F2c(173)581c*	*7065 ± 75*	*6020–5850, 6070–5770*	*–25.8*	*1.37*	*29/7/1992*
A-7267	*F2c(124)250*	*6905 ± 90*	*5890–5720, 5980–5640*	*–25.2*	*1.34*	*10/7/1992*
Beta-66803	*F2c(173)581b*	*6850 ± 70*	*5800–5660, 5880–5630*	*–25.0*	*1.37*	*29/7/1992*
Pooled mean2		**6939 ± 45**	**5874–5750, 5970–5727**			
Later Middle Neolithic (Later MN)						
Trench F2, Stratum 3, Later MN (1, c)						
Small hearth in W quadrant, 1.70 m asl						
A-7266	F2c(121)263	7285 ± 145	6350–6010, 6440–5890	–21.4	1.70	9/7/1992
Hearth near middle of trench, 1.69 m asl						
A-7264	F2c(118)216	6980 ± 170	6010–5720, 6210–5570	–26.3	1.69	8/7/1992
Hearth in S quadrant ("Chimney"), 1.70–2.16 m asl						
A-7269	F2c(139)361	8560 ± 200*	7940–7360, 8220–7140	–18.8	1.88	16/7/1992
A-7265	*F2c(119)222*	*7070 ± 165*	*6070–5760, 6250–5640*	*–24.2*	*1.93*	*8/7/1992*
A-7270	*F2c(148)426*	*6935 ± 170*	*5540–5080, 5640–4950*	*–24.6*	*1.70*	*21/7/1992*
Beta-66802	*F2c(139)400*	*6750 ± 60*	*5710–5630, 5740–5560*	*–25.0*	*1.88*	*20/7/1992*
Pooled mean3		**6802 ± 54**	**5730–5650, 5790–5620**			
Trench F10, "Strip 2," ~Stratum 3 in F2, 1.91 m asl, Later MN (4, a, i)						
Beta-102910	*F10g(88)429*	*7050 ± 50*	*5990–5890, 6020–5810*	*–24.5*	*1.91*	*24/7/1996*
A-9459	*F10g(88)428*	*6955 ± 120*	*5980–5730, 6050–5640*	*–25.5*	*1.91*	*24/7/1996*
Pooled mean4		**7036 ± 46**	**5985–5886, 6010–5809**			
Trench F9, W and SW of Bld III, 1.49–1.61 m asl, Later MN? (8, e, i)						
AA-25328	F9g(79)50	5395 ± 65*	4340–4080, 4350–4050	–26.6	1.51	17/7/1996
Earlier Late Neolithic I (Earlier LN I)						
Trench F10, Upper levels of F10 and extensions NE to "wall BL," 1.97–2.11 m asl (4, e, i)						
A-7274	F10c(25)121	12,870 ± 380*	14,440–12,720, 14,770–12,150	–12.2	2.00	30/7/1992
B. Samples from deposits that could not be assigned to single stratigraphic/chronological phases						
MN						
Trench F9, N scarp area and north corner, 2.00–2.09 m asl (8, d, ii)						
A-9457	F9g(89)315	7750 +495/ –465*	7280–6100, 7790–5680	–26.2	2.09	23/7/1996
Beta-102907	F9g(89)316	7020 ± 50*	5980–5850, 6000–5790	–26.3	2.09	23/7/1996
Later MN–Earlier LN I						
Trench F9, Bld. III, 1.09 m asl (8, b, iii)						
AA-25329	F9g(88)325	7230 ± 55	6210–6030, 6220–6010	–23.3	1.09	23/7/1996

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Table 1 Halai Neolithic ^{14}C dates in stratigraphic order (listed from earlier to later within deposits with more than 1 determination). Each mean pooled age of the preceding samples, marked with italics, was averaged using the CALIB 6.0.1 program. *(Continued)*

Sample nr	EU nr	Date (BP)[a]	Cal BC age 1σ, 2σ	$\delta^{13}C$ (‰)	m asl[b]	Coll. date (d/m/yr)
LN I						
Trench F10, Upper levels of F10 and extensions NE to "wall BL," 2.19 m asl (4, e, ii)						
A-7273	*F10c(16)87*	*6615 ± 75*	*5620–5490, 5700–5390*	—	*2.19*	*28/7/1992*
Trench F101, SE strip, 1.65–2.00 m asl, 1.87 m asl (5, b, ii)						
AA-25331	*F101g(45)162*	*6550 ± 70*	*5610–5470, 5620–5370*	*–25.3*	*1.87*	*23/7/1996*
Pooled mean5		**6580 ± 51**	**5603–5482, 5617–5475**			
LN I–Archaic						
Trench F101, 2.16 m asl, not included in catalog of stratified deposits						
A-7275	F101c(19)83	9805 ± 310*	9800–8790, 10,430–8350	–17.3	2.19	9/7/1992

[a] * = outlier.

[b] m asl = meters above sea level.

site's relative chronology. At Halai, sequences of building remains could not be closely coordinated with sequences of deposits of soil and the artifacts that they contained because most buildings were in close proximity to one another and/or had been damaged both in ancient times and during the earlier excavations. Hence, building sequences (i.e. those of buildings I–VII) were mostly determined by observations of the relative positions of the structures themselves (i.e. buildings or walls superimposed on one another, wall foundations of adjacent buildings resting at the same or different levels, walls bonding with or abutting one another, etc.), rather than by the continuity or discontinuity of layers of earth and debris or the dating of the pottery and other artifacts found in association with particular buildings and walls. Although buildings were constructed in vertical sequences (one immediately on top of another) on at least 3 adjacent plots of ground, the chronology of the sequences appears to have differed from plot to plot (i.e. no disaster seems to have occurred that led to widespread destruction and rebuilding).

The basic stratigraphic divisions used at Halai, and the relative chronology they provide, were therefore based primarily on sequences of deposits and layers of earth and debris not closely related to particular buildings. The best sequence was that in trench F2, a 4 × 4 m trench where debris had built up fairly steadily during the whole lifetime of the site to a depth of about 2 m. The trench was outdoor space during most of the time that deposits accumulated, and it was used for various domestic tasks, often involving small fires and ovens. Much of the digging in trench F2 took place in one or another of four 2 × 2 m quadrants.

The stratigraphy in trench F2 was divided for convenience into 5 vertical strata datable in chronological terms from lowest to highest to Late EN/Early MN, Earlier MN, Later MN, Earlier LN I, and Later LN I. The stratigraphic divisions could not be reliably extended very far beyond the edges of trench F2 by direct observation, however, because the layers were interrupted by the plethora of walls and buildings in the other trenches, which hindered our making direct stratigraphic interconnections. Hence, although the stratigraphic sequence in trench F2 provides a chronological yardstick for dating the whole site, it is not a very precise yardstick because the chronological relationships between the strata in trench F2 and the other trenches can mostly be determined only indirectly by archaeological means, namely study of the chronological development of the pottery and other artifacts in the best-documented stratigraphic sequences and comparison of those artifacts and development with the artifacts and sequences in the other less well-documented sequences.

The series of ^{14}C dates from Halai provides a good general picture of the absolute chronology of the site. We had hoped that they would also contribute to some long-standing questions of detail, such as the calendar date of the beginning of the Late Neolithic phase in Greece, and allow us to better follow the processes of change in artifacts and building practices during the life of the site. To make such a contribution, however, the dates of the samples would have to be in close agreement with the stratigraphic divisions and the chronological terms with which they can be associated.

RESULTS AND DISCUSSION

About 100 samples of carbonized material were collected during excavation as possible candidates for ^{14}C dating, of which 26 were eventually analyzed (Coleman 1999). The determinations were obtained from 2 different laboratories (the Laboratory of Analytical Geochemistry at the University of Arizona, A- or AA-, and Beta Analytic Inc., Beta-) using both conventional and accelerator mass spectrometry (AMS) techniques. All samples underwent the usual acid-alkali-acid chemical pretreatment to remove contaminants prior to measurement. They are listed here in ascending order by trench number and within trenches in rough chronological order from earlier to later. The dating of the excavation unit (EU) in cultural terms and brief descriptions based on the excavators' notes are given for each sample. Stratum numbers are also given for samples from trench F2. Some deposits could not be assigned to a single stratigraphic division and samples from them were therefore datable only in general terms (e.g. to LN I rather than to Earlier LN I or Later LN I; Table 1, Part B).

Sample Descriptions

Trench F2 (Figure 2)

S1. A-7271 F2c(168)580: Stratum 1, Late EN/Early MN. The sample came from the scarp between the N and E quadrants of the 4 × 4 m trench during the removal of a layer of earth beneath a distinctive thick yellow clay floor associated with wall BJ at an elevation of ~1 m asl (Figure 3).

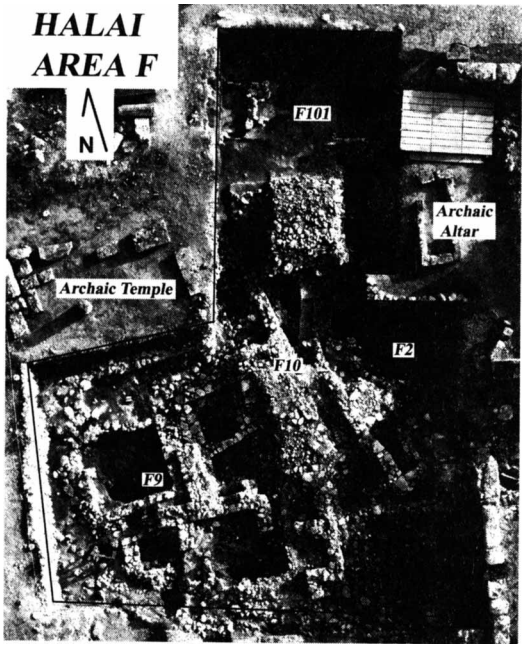

Figure 2 Balloon photograph of Neolithic remains in area F

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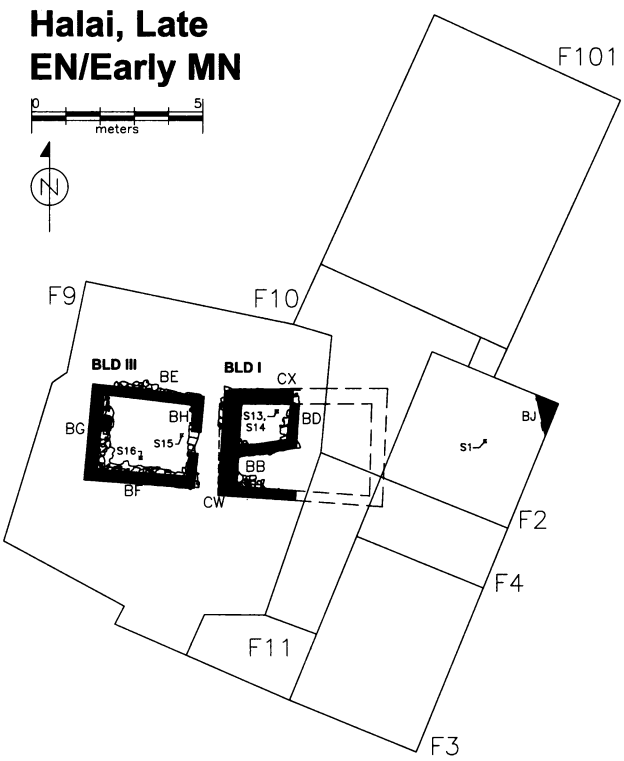

Figure 3 Plan showing Late Early Neolithic/Early Middle Neolithic architecture and locations of ^{14}C samples.

The following 5 samples are from a hearth and its immediately surrounding area within stratum 2 at elevations between about 1.28–1.38 m asl. Stratum 2 is datable to the Earlier MN. The hearth was located close to the SE edge of the trench near the division between its S and E quadrants.

S2. A-7272 F2c(173)581a: The sample came from the S quadrant of the trench (Figure 3). It is a small sample taken when carbon first appeared in quantity while sweeping the cut above the "hearth."

S3. A-7268 F2c(127)275: The sample came from the E quadrant of the trench (Figure 3) during removal of a typical chocolate brown fill with yellow and carbon flecks. The fill was above a yellow clay floor associated with wall BJ. Above the floor, there was some evidence of rough shallow hearth structures.

S4. A-7622 F2c(173)581c: The sample came from the S quadrant of the trench (Figure 3). It was collected when it became apparent that there was an accumulation of carbonized matter in a shallow clay bowl partially surrounded by stones. The large stones protecting the perimeter of the basin area are among the largest found at any level.

S5. A-7267 F2c(124)250: The sample came from the E quadrant of the trench (Figure 3). It was collected during the removal of a dark gray layer full of carbon flecks and comprising several groups of scorched stones that had apparently been temporary hearths. The layer is probably an occupation deposit above a yellow clay floor associated with wall BJ. The sample itself was taken out of the center of a broad sheath of sooty, carbonized matter.

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S6. Beta-66803 F2c(173)581b: The sample came from the S quadrant of the trench (Figure 3).

S7. A-7266 F2c(121)263: Stratum 3, Later MN. The sample came from the N quadrant of the trench at ~1.70 m asl where a stone platform in red earth overlapped the division between N and W quadrants (Figure 4). The stone platform had been much disturbed by later activities. In hollows between the large tilted stones, small ash pits (the residue of temporary hearths) were found. This sample is connected with one of these hearths that was cut through at the limit of excavation.

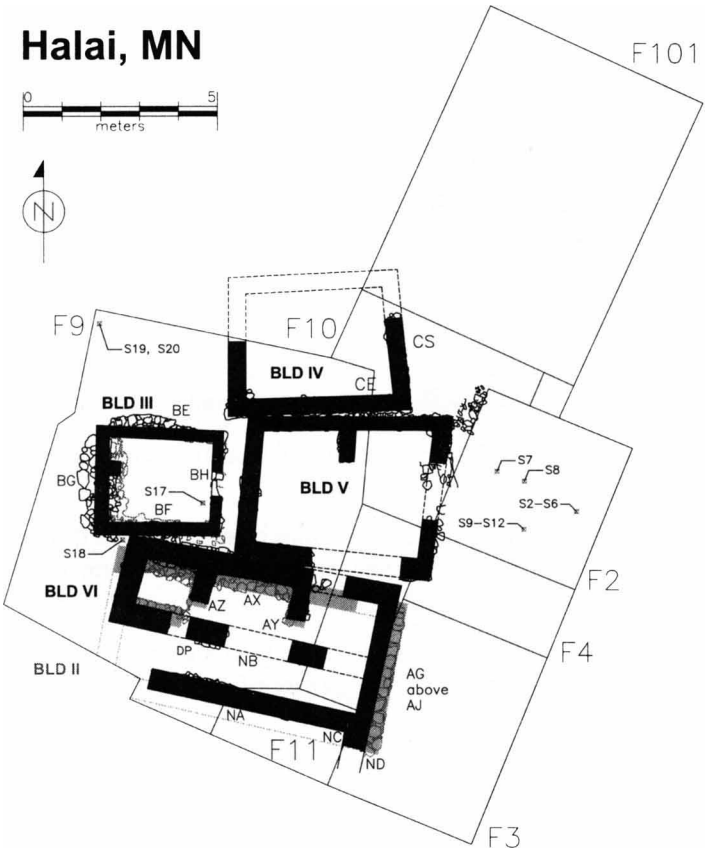

Figure 4 Plan showing Middle Neolithic architecture and locations of ^{14}C samples

S8. A-7264 F2c(118)216: Stratum 3, Later MN. The sample came from the E quadrant of the trench near the division between the E and N quadrants at ~1.69 m asl (Figure 4). It came from a streak of black carbon below a red mudbrick layer.

The following 4 samples are from within and around a small hearth or kiln (sometimes called the "chimney" during excavation) in stratum 3 in the NW part of the S quadrant of trench F2. The structure may be dated to the Later MN. A-7270 was outside the hearth at a level of ~1.70 m asl; the other samples were closely associated with the hearth, which was situated between about 1.92–2.16 m asl.

S9. A-7269 F2c(139)361: The sample comes from clearing out soot from the NE half of a "bowl" of hard-fired red clay (Figure 4). The bowl was at the bottom of a chimney structure made of small flat stones around a central opening. The chimney itself also produced soot.

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S10. A-7265 F2c(119)222: The sample comes from the removal of a collar of small squared stones around a hole 0.10 m in diameter located in the NW section of the S quadrant in trench F2 (Figure 4). The hole seemed to be a chimney rising from a collapsed kiln or furnace. It was filled with fine soot from the height of its discovery at 2.16 m down to a bowl of red clay at 1.92 m. It was taken from low down in the chimney structure in an attempt to avoid contamination.

S11. A-7270 F2c(148)426: The sample comes from a layer of red earth around the chimney (Figure 4). It was a segment of a branch with tree rings visible that sprang out from beneath a stone while the heap of hard red disintegrated/melted red mudbrick that surrounded the chimney was being scraped.

S12. Beta-66802 F2c(139)400: The sample came from the same location as A-7269 (Figure 4).

Trench F9 (Figure 2)

The following 2 samples came from similar contexts within use deposits in building I at ~0.72–0.75 m asl) and are datable to the Late EN/Early MN phase at the site.

S13. AA-25330 F9g(154)184: The sample came from a charcoal-packed layer, the SE corner of which was especially dark (Figure 3).

S14. Beta 102909 F9g(155)191: The sample came from a division between a red and a black earth layer at the E corner of trench F9. It was taken at the base of wall CX (Figure 3).

The following 2 samples are from early use levels in Building III at levels between 0.84 and 0.88 m asl, datable to the Late EN/Early MN phase at the site.

S15. Beta-102908 F9g(97)357: The sample came from a layer below a disintegrated white clay floor level comprising wet, packed soil with many carbon flecks. The sample was taken at the east side of building III ~0.20 m west of wall BH (Figure 3).

S16. Beta-102901 F9g(65)4d-4f: The sample was taken from a layer of heavy charcoal concentrations that were bordered by a "half moon" shaped series of stones close to the N side of wall BF (Figure 3). This area was a probable hearth.

S17. AA-25329 F9g(88)325: Later MN-Earlier LN I. The sample came from the middle period of use of building III beneath a platform surface adjacent to wall BH at ~1.09 m asl (Figure 4).

S18. AA-25328 F9g(79)50: Later MN? The sample came from a stratum adjacent to the S side of building III at ~1.49–1.61 m asl (Figure 4).

The following 2 samples are from the same location at ~2.00–2.09 m asl near the NW corner of trench F9, associated with a jumble of stones and disintegrated mudbrick, probably from a collapsed building. The archaeological context suggests a date within the MN period.

S19. A-9457 F9g(89)315: The sample came from a disintegrated mudbrick deposit (Figure 4).

S20. Beta-102907 F9g(89)316: The sample came from the same layer as the preceding (Figure 4).

Trench F10 (Figure 2)

The following 2 samples came from a deposit of fine black soot from the area of a small oven (sometimes called by the excavators the "baby kiln") at the E side of the trench at ~1.91 m asl. They are datable in archaeological terms to the Later MN phase.

S21. Beta-102910 F10g(88)429: The sample came from a hollow or pit adjacent to the NW edge of trench F10 (Figure 4). The pit was eventually revealed as that of a small oven.

S22. A-9459 F10g(88)428: This sample came from the same context as the preceding (Figure 4).

S23. A-7274 F10c(25)121: Earlier LN I. When collected, this was thought to be an important sample for the dating of the walls under the pavements in trench F10. It was taken from a layer of mud-brick detritus from wall CE, interspersed with charcoal fragments at ~1.97–2.11 m asl (Figure 5).

S24. A-7273 F10c(16)87: LN I. The sample came from a burnt deposit beneath a collapsed wall and on top of the socle of wall CE in the upper levels of trench F10 and its extension to the NE at ~2.19 m asl (Figure 5). The top layer of the socle produced evidence of burning probably as part of the destruction of the structure.

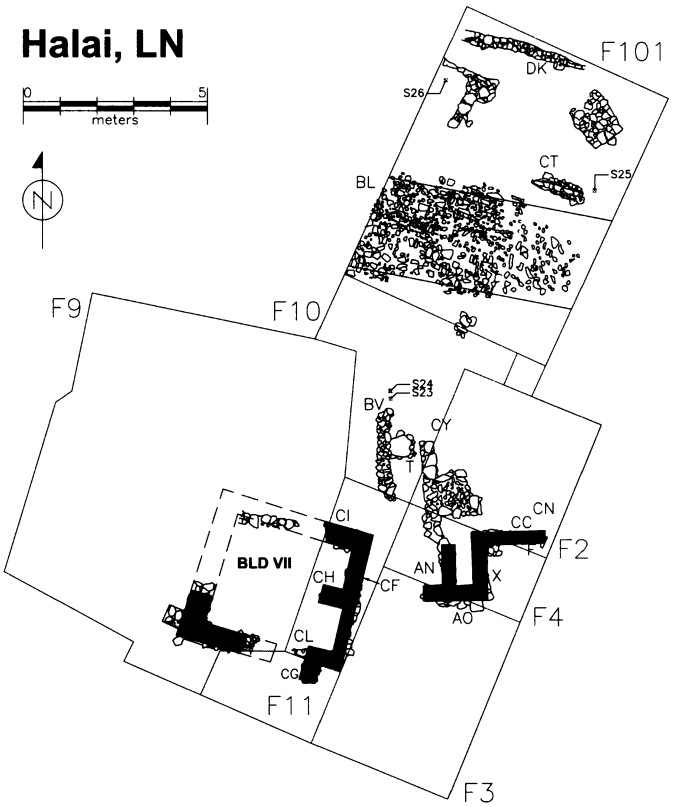

Figure 5 Plan showing Late Neolithic architecture and locations of ^{14}C samples

Trench F101 (Figure 2)

25. AA-25331 F101g(45)162: LN I. The sample came from an extended charcoal deposit beside the base of stone #7 of wall CT 0.73 m from scarp in trench F101 at ~1.87 m asl (Figure 5).

26. A-7275 F101c(19)83: Ceramic dating uncertain, mixed LN I-Archaic. The sample comes from a stone scatter toward the N side of trench F101 at ~2.16 m asl (Figure 5), which probably postdated the abandonment of the Neolithic settlement.

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Table 1 shows the Halai Neolithic ^{14}C dates in rough chronological and stratigraphic order from earlier to later, first (A) those from deposits that fall within chronological categories established on the basis of stratigraphic observations, and second (B) those from deposits that straddle the chronological categories. Multiple samples judged to be from single deposits are listed from earlier to later. All dates are from the major exposure of Neolithic deposits in area F, at the NW end of the site. The material from which the samples were taken could mostly not be identified precisely and was reported by the excavators simply as "charcoal," "ashy layer," "soot," etc. In most cases, the material came from deliberate burning in small open fire pits with diameters no more than 30–50 cm. The material burned in such fire pits was likely to have been short-lived, such as twigs and small pieces of wood and possibly food residue. In a few cases, the samples may have come from other types of fire such as accidental burning of buildings. All samples were removed with a clean steel spatula and wrapped in foil before being stored in a plastic bag.

Figure 6 shows the Halai calibrated ^{14}C dates in stratigraphic order from earlier to later within deposits in comparison with relative dating from stratigraphy. Calibration of the conventional ^{14}C dates was performed using the OxCal v 4.1 program (Bronk Ramsey 2009) and IntCal09 calibration curve (Reimer et al. 2009). Each mean pooled age of the preceding samples (Table 1) was averaged out using the CALIB 6.0.1 program (Stuiver and Reimer 1993) when the ^{14}C dates of the samples were statistically the same at 95% confidence. The outliers were excluded (those with asterisks in Table 1).

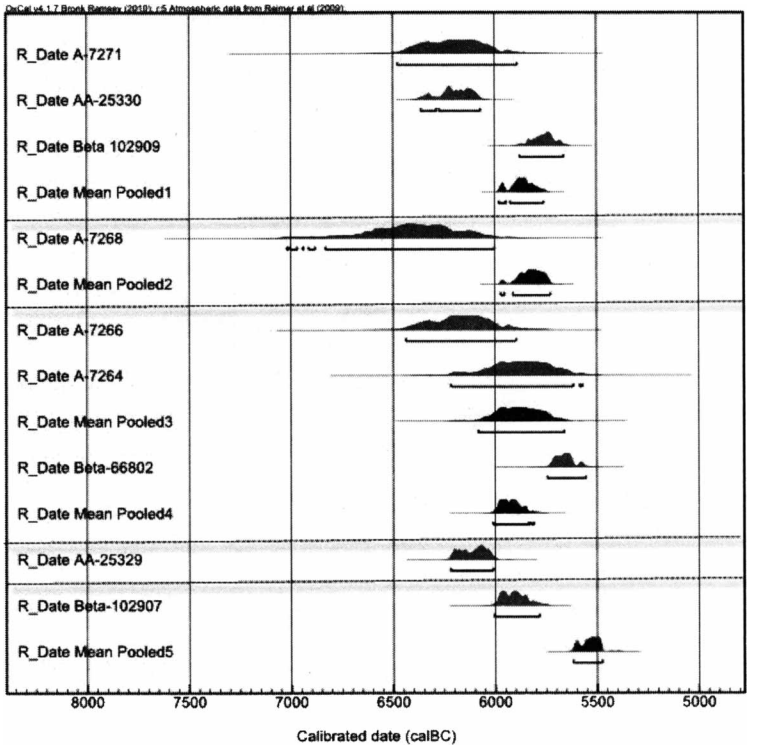

Figure 6 Sequence analysis of the Halai calibrated ^{14}C dates in stratigraphic order from earlier to later within deposits in comparison with relative dating from stratigraphy. Analysis performed using OxCal v 4.1 (Bronk Ramsey 2001) and the IntCal09 calibration curve (Reimer et al. 2009). The mean pooled data of the dates (darker color) where averaged out using the CALIB 6.0.1 program (Stuiver and Reimer 1993) when the ^{14}C dates of the samples were statistically the same at the 95% level. Outliers are excluded.

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Twelve of the 26 determinations are from trench F2 (Figure 2), the site's best-stratified sequence. Two of these are outliers in the sense of being earlier than is likely in terms of our knowledge of the Neolithic period from sites all over Greece, and there are also problems with agreement of samples from the same material. Eight determinations are from trench F9 (Figure 2), which was largely excavated by the previous expedition and had suffered disturbances during the Late Roman period. Three of these are outliers on the older side and another is an outlier on the younger side. Four determinations are from trench F10 (Figure 2), of which 1 is an outlier on the older side. One of the 2 determinations from trench F101 (Figure 2) is an outlier on the earlier side.

From ^{14}C dating of comparable Greek sites, we anticipated that the overall timespan of the Neolithic settlement was ~6000–5300 BC. The results for Halai are roughly in agreement with these limits. Detailed interpretation of the Halai ^{14}C dates, however, is somewhat problematic. Although we hoped that our samples would allow a precise dating of the stratigraphic levels at the site within this timeframe, 5 of the determinations are outliers, 4 too early (A-7272, A-7269, A-7274, and A-7275) and 1 too late (AA-25328). It is worth noticing that all 4 too-early samples gave fluctuating $\delta^{13}C$ values (Table 1) higher than the –25.00‰ that is expected for charred material, indicating a possible contamination with dead carbon that maybe was not entirely removed by the applied chemical pretreatment. On the other hand, the $\delta^{13}C$ value of sample AA-25328 is lower than expected, insinuating probable contamination with modern carbon. Also, multiple dates from the same carbonized material (up to 5 samples: A-7272, A-7268, A-7622, A-7267 and Beta-66803 originating from the same hearth in trench F2) do not all overlap at 2σ, so that it is difficult to arrive at a precise date for the hearth. Additionally, the first of 2 "Earlier LN I?" samples (A-9457 and Beta-102907), which were run on the same material originating from the north corner in trench F9, seems too early, overlapping only at 2σ, and the deposit from which they come has actually been MN. Earlier digging had taken away most of the evidence. It is interesting to note that the Beta dates are almost always the latest in groups with multiple determinations. The Arizona dates with high uncertainty (±) tend to be earlier. In general, the 21 dates that come from deposits that can be assigned to one or another of these phases are not in close enough agreement to give plausible estimates for the duration of each phase. Consequently, we did not obtain the precision we had hoped for, for instance in estimating the beginning of the Late Neolithic period.

In the ^{14}C dating column of Table 2, the timespan of Late EN/Early MN (6370–5810 BC), Earlier MN (5870–5750 BC), and Earlier LN I (5600–5480 BC) archaeological phases are presented, based on the Halai ^{14}C dates at 1σ. Two of the phases at Halai, the Later MN and the Later LN I, lack entries because each was represented by only a single outlier (Table 1).

Table 2 Phasing and estimated dating for the Halai Neolithic settlement. The approximate thickness of each stratum in trench F2 is given in parentheses. Coleman provided the archaeological dating estimates, which are for the duration of each phase, based on the Halai ^{14}C dates and general consensus on dating of the Greek Neolithic. Facorellis provided the ^{14}C dating column based on the Halai ^{14}C dates at 1σ. Two of the phases at Halai, the Later MN and the Later LN I, lack entries in the ^{14}C dating column because each was represented by only a single outlier (Table 1).

Archaeological phase	Stratum in F2	Archaeological dating estimate	^{14}C dating
Late EN/Early MN	1 (0.50 m)	6100–5950 BC	6370–5810 BC
Earlier MN	2 (0.45 m)	5950–5800 BC	5870–5750 BC
Later MN	3 (0.35 m)	5800–5600 BC	
Earlier LN I	4 (0.45 m)	5600–5450 BC	5600–5480 BC
Later LN I	5 (0.50 m)	5450–5300 BC	

CONCLUSIONS

The Halai dates provide a plausible estimate for the overall life of the Neolithic settlement of ~6000–5300 BC but not close estimates of its individual phases. In general, they suggest that a single date from a complex site may be an outlier due to the uncertainty in the type or quality of the context, or to the unknown possible contaminants in the sample. Therefore, outlying dates may occur even on the same material that also produces acceptable dates. Because dating of the Greek Neolithic is already fairly precise and a sufficient number of "good" dates were obtained from Halai, we are able to recognize the inaccurate ones. However, our experience suggests that if the general chronological range of a site is unknown and only a few dates are obtained from it, archaeologists should exercise appropriate caution in their chronological estimates.

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