

THE END OF THE CHALCOLITHIC PERIOD IN THE SOUTH JORDAN VALLEY: NEW ^{14}C DETERMINATIONS FROM TELEILAT GHASSUL, JORDAN

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ABSTRACT. This article reports on 12 new accelerator mass spectrometry (AMS) dates from the latest phases of the Chalcolithic period occupation (late 5th millennium cal BC) at Teleilat Ghassul, type site for the south Levantine Ghassulian Chalcolithic culture. The new AMS dates from Teleilat Ghassul favor an amendment to a previous suggestion (Bourke et al. 2001), that all significant occupation at the site had ceased by 4000/3900 cal BC. This end-date should now be amended to 3900/3800 cal BC. Follow-up statistical modelling sourced to published ^{14}C data drawn from a wide selection of south Levantine Chalcolithic period sites (Bourke 2001; Burton and Levy 2001) raises the possibility that Chalcolithic period occupation had ceased at virtually all major centers by 3800/3700 cal BC. This, in turn, suggests that the new data bearing on the end-date for occupation at Teleilat Ghassul may reflect a more widespread horizon of abandonment in the southern Levant.

INTRODUCTION

Traditionally, the transition from the Chalcolithic period to the Early Bronze Age (EBA) in the southern Levant has been placed around the middle of the 4th millennium BC (Weinstein 1984; Joffe and Dessel 1995). However, recent radiocarbon determinations from Chalcolithic period Teleilat Ghassul suggested an end-date for occupation at that site around the end of the 5th millennium cal BC (Bourke et al. 2001:1221). The new dates from Ghassul were consistent with unexpectedly early 4th millennium cal BC dates for the earliest phases of the EBA at Afridar (Braun 2000; Braun 2001:1290), Tell Shuna North (Bronk Ramsey et al. 2002:82–84), and Chalcolithic Aqaba (Görsdorf 2002).

These new dates suggested a transition between the Chalcolithic and the EBA between 300 and 500 yr earlier than traditionally assumed, sharply truncating the length of the Chalcolithic period and (more problematically) greatly increasing the length of the already relatively sparsely occupied EBA I period (Braun 2001:1282). Were this new scenario to have wide application in south Levantine archaeology, whole periods (such as Joffe and Dessel's "Terminal Chalcolithic") would have to be subsumed into earlier Chalcolithic horizons (Burton and Levy 2001:1223–1224) and the early phases of the succeeding Early Bronze Age (e.g. EBA IA–B) greatly lengthened and significantly reworked (Braun 2001).

It was, therefore, a matter of some importance to examine in more detail the suggestion that the final horizon of occupation at Teleilat Ghassul did indeed come to an end around 4000/3900 cal BC. To further investigate this issue, another 12 short-life botanical samples, drawn from relevant contexts, were processed at the ANSTO Accelerator Mass Spectrometry (AMS) Centre in 2001/2002. Most samples derive from the latest Chalcolithic strata in 4 widely separated areas of the site, allowing us to determine for the first time a reliable end-date for occupation across the entire 20 hectare ruinfield.

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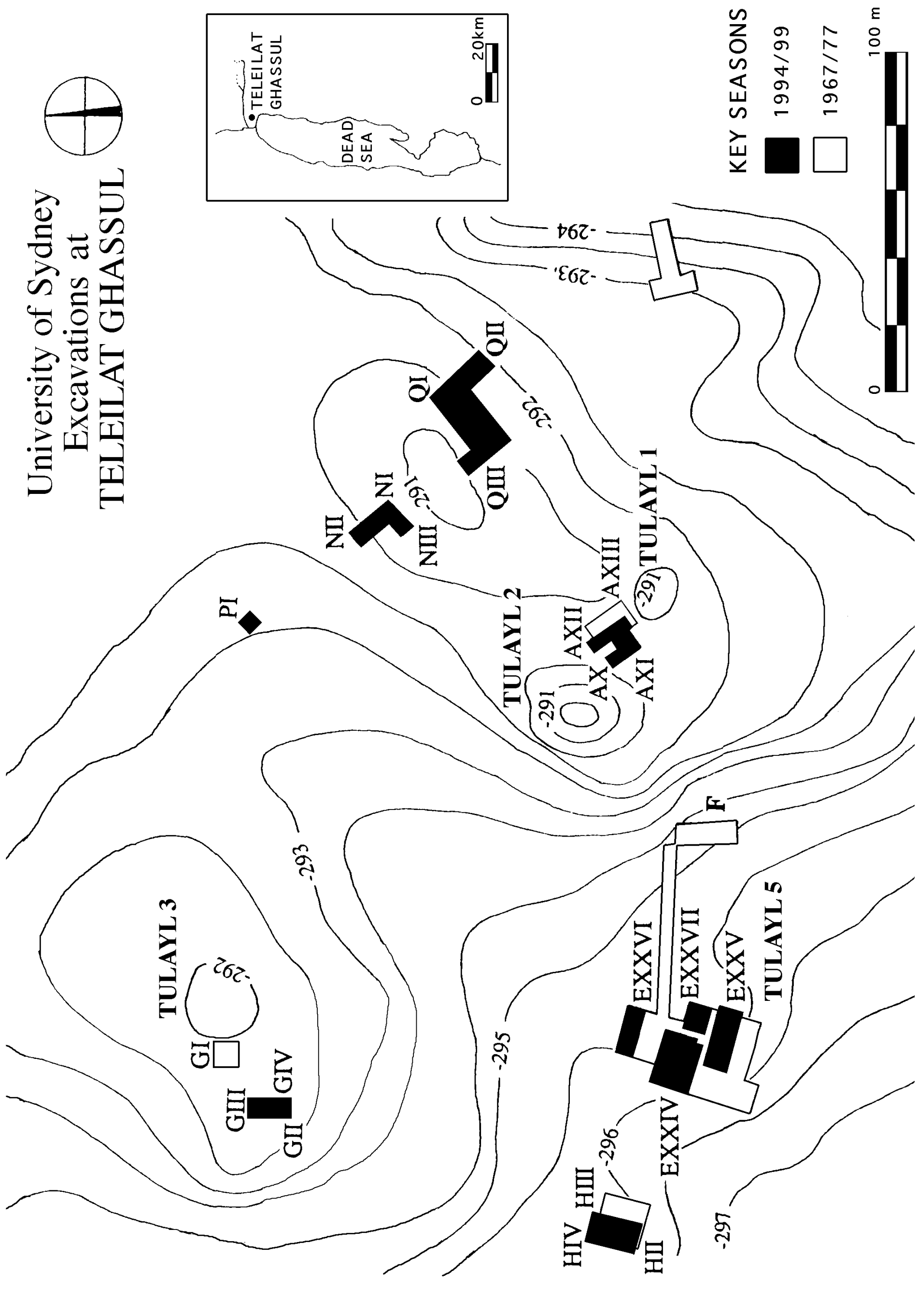

Figure 1 Plan of the University of Sydney excavation areas at Teleilat Ghassul

PREVIOUS LATE CHALCOLITHIC PERIOD ^{14}C DATES FROM TELEILAT GHASSUL

Before the current assays, 7 ^{14}C dates were known from the latest archaeological horizons at Teleilat Ghassul (Table 1). One derives directly from J Basil Hennessy's University of Sydney excavations in the 1970s (Hennessy 1982); three were taken from standing sections in the 1980s (Neef 1990); and three come from most recent work at the site (Bourke et al. 2001). While the Hennessy (SUA) and Bourke (OZD) assays come with reliable context details, the Groningen (GrN) materials (of necessity) have less specific context details, although they very probably derive from Hennessy Phase A horizons.

Table 1 Previous work: latest Chalcolithic ^{14}C dates from Teleilat Ghassul.

	Ref	Lab	Date BP	2 σ cal BC	Material	Context phase/area
1	Hennessy 1982	SUA-511	5655 ± 120	4765–4250	Wood	Phase A/E
2	Bourke 2001	OZD030	5550 ± 165	4725–4040	Grain	Phase A/Q
3	Bourke 2001	OZD033	5455 ± 60	4399–4219	Grain	Phase A/G
4	Bourke 2001	OZD034	5340 ± 70	4262–4035	Grain	Phase A/G
5	Neef 1990	GrN-15194	5330 ± 25	4254–4040	Wood	Phase A/A
6	Neef 1990	GrN-15195	5270 ± 100	4334–3937	Wood	Phase A/E
7	Neef 1990	GrN-15196	5110 ± 90	4051–3697	Dung	Phase A/A

The first of these dates (SUA-511) is a pooled mean from 3 separate assays (SUA 511a–c), all taken from 1 large wooden beam (Bourke et al. 2001:1218). The beam formed part of the collapsed roof of Sanctuary A, the larger building in the Area E sanctuary complex (Hennessy 1982:56; Bourke 2001:130–133). The destruction horizon was interpreted by Hennessy as marking the end of substantial occupation in Area E (Hennessy 1989: 234–235). The next 3 dates (OZD030 and OZD033–034) derive from Late Chalcolithic horizons in northern Area G and eastern Area Q, although the large standard deviation in OZD030 (due to small sample size) renders it of little use to our deliberations.

The final 3 dates (GrN-15194 to 15196) were taken from Hennessy's standing sections in Areas A and E by Reindeer Neef a decade after excavations had ceased. However, Neef provided Hennessy with clear photographs of the areas from which his samples were taken (Neef 1988), which theoretically allow a reasonably reliable context to be allocated to each of the samples. GrN-15194, identified as olive wood by Neef, was taken from baulk material equivalent to excavated Phase A deposits in Hennessy trench A II (Hennessy 1969:3–4). GrN-15196, composed of threshing and dung material according to Neef, comes from a closely related context. Neef accounted for the variance in date between GrN-15194 and GrN-15196 as due to the different materials sampled. GrN-15195, identified as olive wood by Neef, comes from the southern end of Hennessy trench E XXIII (Hennessy, personal communication) and is probably best associated with late occupational horizons in the area.

The 7 ^{14}C determinations previously assayed derive from latest occupational horizons in 3 widely separated areas of the site (Areas A, E, and G). While some doubt must still adhere to Neef's GrN contexts, they are likely to sample latest Chalcolithic (Phase A) occupational horizons. However, they do not sample Hennessy's hypothetical Phase A+ horizons as Blackham (2002:80–81) has recently suggested, since these horizons were not present in either Areas A or E (Hennessy, personal communication).

TECHNICAL DATA: PREPARATION AND PROCESSING

All samples presented in this study were ^{14}C dated at the AMS facility at ANSTO (Fink et al., forthcoming). To remove contamination, the standard AAA method (Mook and Streurman 1983) was employed. Pretreated samples were then converted to CO_2 by combustion at 900 °C for 5 hr in a sealed tube in the presence of precleaned CuO and Ag wires. Graphite targets were prepared by reducing CO_2, using zinc (400 °C) and iron (600 °C) catalysts in the presence of a small amount of hydrogen. Finally, the graphite was loaded into an aluminium sample holder ready for the AMS measurement. The technical details of these methods are described in Hua et al. (2001).

The $^{14}C/^{13}C$ isotopic ratio was measured relative to the internationally accepted HOxI standard material (Stuiver 1983). Corrections were then applied for the spectrometer background, for the contamination incorporated during the preparation of the graphite target, and for the isotopic fractionation. Using the corrected radioisotopic ratio, the conventional ^{14}C age was calculated and finally calibrated using the CALIB software (Stuiver and Reimer 1993) and the tree-ring dataset of Stuiver et al. (1998).

Table 2 Twelve new AMS dates from Late Chalcolithic Teleilat Ghassul.

ANSTO code	Material	Graphite mass (mg C)	$\delta^{13}C$ (PDB)	^{14}C age [BP]	2 σ calibrated age [BC]	Relative probability
OZF418	Cereal grain	2.25	–24.5	5750 ± 40	4698–4496 cal BC	98.5%
OZF419	Cereal grain	0.66	–21.9	5490 ± 40	4369–4248 cal BC	88.2%
OZF420	Cereal grain	2.29	–23.2	5395 ± 40	4337–4219 cal BC	71.5%
OZF421	Cereal grain	2.02	–25.0	5870 ± 40	4808–4667 cal BC	91.8%
OZF422	Cereal grain	2.04	–22.2	5505 ± 40	4403–4320 cal BC	64.2%
					4293–4252 cal BC	20.2%
					4450–4416 cal BC	15.6%
OZF423	Cereal grain	2.37	–24.2	5370 ± 40	4202–4048 cal BC	53.7%
					4329–4216 cal BC	46.3%
OZG248	Olive stone	1.09	–26.2	5510 ± 40	4405–4321 cal BC	66.9%
					4450–4415 cal BC	17.7%
					4290–4253 cal BC	15.3%
OZG249	Olive stone	1.33	–26.4	5475 ± 40	4369–4237 cal BC	91.9%
OZG250	Olive stone	1.58	–23.9	5445 ± 40	4355–4227 cal BC	98.4%
OZG251	Olive stone	1.46	–23.3	5110 ± 45	3982–3792 cal BC	100.0%
OZG252	Olive stone	1.98	–23.5	5335 ± 60	4260–4037 cal BC	85.4%

THE NEW DETERMINATIONS AND THE SEQUENCE AT GHASSUL

Each of the 12 new samples consisted of short-lived plant remains, either carbonized cereal grains or olive stones (Table 2). The olive stones are "single entity samples" (Ashmore 1999), but the cereal grain samples consisted of between 3 and 5 individual grains. Samples are drawn from discrete concentrations of ashy material wherever possible and brick debris layers are generally avoided. This strategy aims at reducing the likelihood of sampling residual materials. Ongoing archaeobotanical work at Ghassul (Bourke et al. 2000:79–84; Meadows, forthcoming) demonstrates the persistence of spatial and temporal patterns in the incidence of plant remains, even in secondary contexts. This suggests that even if some of the dated grains were residual, they were probably derived from nearby contexts and are very nearly contemporaneous with the contexts in which they were found. The coherence of the sequence of ^{14}C results from Area G (see below) reinforces our belief that few, if any, of the dated grains were significantly older or younger than their contexts.

The 12 new determinations include 6 samples from the latest archaeological horizon (Phase A) across the site. They are drawn from 4 widely separated areas (two each from Areas E and Q, and one each from Areas H and N). Three samples come from slightly earlier (Phase B–C) horizons (two from Area E and 1 from Area G). The final 3 samples derive from significantly earlier horizons (one each from Areas A, H, and N).

All six of the latest (Phase A) ^{14}C results are broadly comparable, and reinforce earlier suggestions that significant occupation across the site came to an end by 4000/3900 cal BC. One of the 2 samples (OZG251) from the easternmost area of excavations (Area Q) might suggest a slight modification to this view. The sample (OZG251) comes from a pit (F.18) cut into the latest (Phase A) occupational horizon, making it one of the very latest deposits in Area Q. While it is possible that OZG251 could simply be an outlier in an otherwise relatively homogenous Phase A grouping, it is probably best to regard it (along with sample OZF423, which derives from the earliest Phase A living/work surface in Area Q) as delimiting the maximum span of the Phase A occupational horizon in Area Q. Given the similar reading from Neef's (less reliably contexted) sample of short-lived material (GrN-15196) from Area A, it suggests that the final end-date for occupation at the site should be amended from its previously suggested 4000/3900 cal BC to a slightly later 3900/3800 cal BC date.

The 3 earlier (Phase B–C) assays are stratigraphically coherent in relation to Phase A determinations. That being said, given the broadly similar stratigraphy and material assemblages of OZF418 and OZG249, the quite early date of the former comes as something of a surprise. This suggests that although carefully selected short-life material was employed, it may nonetheless have been residual in the Phase B courtyard assemblage (Bourke et al. 2000:47). The Phase B–C determination from Area G (OZG250) is stratigraphically and radiometrically earlier than 1 later assay (OZD034) and stratigraphically and radiometrically later than 3 earlier (OZD031–033) determinations (Bourke et al. 2001:1220). This would suggest that the Area G radiometric sequence is internally coherent and provides for the first time a reliable chronology for the full occupational history of Tulayl 3, extensively excavated by Pontifical Biblical Institute (PBI) archaeologists in the 1930s (Lee 1973:168–176).

The 3 earlier phased determinations from Areas A, H, and N are broadly in line with stratigraphic positioning, although the earliest date provokes some comment when detailed material cultural affiliations are examined. In Area H, OZF421 records a surprisingly early date for basal levels in this westernmost area of excavations, given the previous cultural attribution to Early Chalcolithic (Phase F–G) horizons (Bourke et al. 2000:56). It may well be that the small cultural assemblage from the base of the H II sondage has been mis-attributed, if the assemblage is Late Neolithic (Hennessy H–I) as the ^{14}C determination would suggest. If so, it would seem that Late Neolithic occupation was far more extensive across the site than previously assumed (Bourke 1997:405). Alternatively, if the material assemblage is Early Chalcolithic as previously stated, then OZF421 may have sampled material residual from the mixed wash deposits that lay at the base of the sondage (Bourke et al. 2000:55–56).

The close agreement between current Phase D determinations (OZF422 and OZG248) and previously reported assays OZD028–029 (Bourke et al. 2001:1220) would suggest that Areas A and N have relatively similar stratigraphic histories and that the radiometric date (about 4400 cal BC) for the earliest phase (Phase D) of the Late Chalcolithic period in both areas is secure.

BAYESIAN MODELLING AND GHASSULIAN CHRONOLOGY

Calibration of the individual ^{14}C results suggests that Phase A dates to at most a century or two either side of 4000 cal BC and that Ghassul was abandoned by 3800 cal BC, if not earlier. The use of Bayesian techniques of chronological modelling (Buck et al. 1996) provides a means of visualizing the calendar ages of the ^{14}C samples and of estimating the date of events that cannot be dated

Table 3 Archaeological contexts and phasing.

Site context	ANSTO code	BP age	Calibrated age	Site phasing
EXXV 2.13	OZF417	5450 ± 40	4332–4257 BC	Hennessy Phase A
EXXV 4.9	OZF418	5750 ± 40	4666–4544 BC	Hennessy Phase B–C
EXXIV 12.12	OZF419	5490 ± 40	4360–4268 BC	Hennessy Phase A
HIII 2.10	OZF420	5400 ± 40	4309–4158 BC	Hennessy Phase A
HII 3.31	OZF421	5870 ± 40	4780–4698 BC	Hennessy Phase F–G
NI 15.11	OZF422	5500 ± 40	4420–4279 BC	Hennessy Phase D
QI 17.18	OZF423	5370 ± 40	4296–4094 BC	Hennessy Phase A
AXIII 1.5	OZG248	5520 ± 40	4429–4336 BC	Hennessy Phase D
EXXVII 2.40	OZG249	5490 ± 50	4378–4268 BC	Hennessy Phase B–C
GIV 30.43	OZG250	5440 ± 40	4327–4247 BC	Hennessy Phase B–C
QIII 7.3	OZG251	5100 ± 50	3946–3818 BC	Hennessy Phase A
NIII 3.1	OZG252	5320 ± 60	4233–4059 BC	Hennessy Phase A

directly by the ^{14}C method. It must be emphasized that such estimates depend heavily on the known or assumed relative ages of the ^{14}C samples and will change under different sets of assumptions.

The simplest model is the bounded phase, which is based on the assumption that the dated samples are drawn evenly from a continuous phase of activity (Bronk Ramsey 2000). Probability distributions for the dates of the beginning and end of this phase can be calculated using the program OxCal (Bronk Ramsey 1995, 1998). If the results of all short-lived samples are placed in a bounded phase (i.e. excluding SUA-511 and GrN-15194), the end-date falls in the range 4040–3690 cal BC (95% probability). There is a 49% probability that the end-date falls before 3900 cal BC, a 73% probability that it falls before 3850 cal BC, and an 88% probability that it falls before 3800 cal BC.

A more sophisticated version of the model assumes not only that the samples are representative of a continuous phase of activity, but that samples in earlier strata are actually older than samples in later strata. One result, OZF-418, is clearly inconsistent with this proposition[1] and evidently represents residual material from an earlier stratum. This is not surprising given the relatively low incidence of plant remains in Area E (Meadows, forthcoming). However, if this result is regarded as a *terminus post quem* for phases B–C, the model shows that the remaining results can accurately date their contexts (Figure 2).

Under this model, the end-date is estimated to fall in the range 4040–3710 cal BC (95% probability). There is a 46% probability that the Chalcolithic at Ghassul ends before 3900 cal BC, a 69% probability that it ends before 3850 cal BC, and an 86% probability that it ends before 3800 cal BC. The probability that the Chalcolithic ends before 3950 cal BC, however, is only 14%. Therefore, our current estimate for the date of abandonment is between 3950 and 3800 cal BC. Although this is slightly later than the 4000–3900 cal BC previously proposed (Bourke et al. 2001:1221), it remains significantly earlier than the traditional date (approximately 3500 cal BC) of the Chalcolithic–EBA transition (Joffe and Dessel 1995:514). New ^{14}C data from Tell Shuna North (Bronk Ramsey et al. 2002:82–84) are broadly consistent with the Ghassul results.

The model structure, which is defined by the OxCal keywords and brackets at the left of Figure 2, assumes that the Phase H–I samples are older than Phase E–G samples, which in turn, are older than

[1] This is indicated by an unsatisfactory overall index of agreement (A = 34.7%), well below the threshold level of 60%, and a negligible individual index of agreement (0.6%) for the result OZF-418.

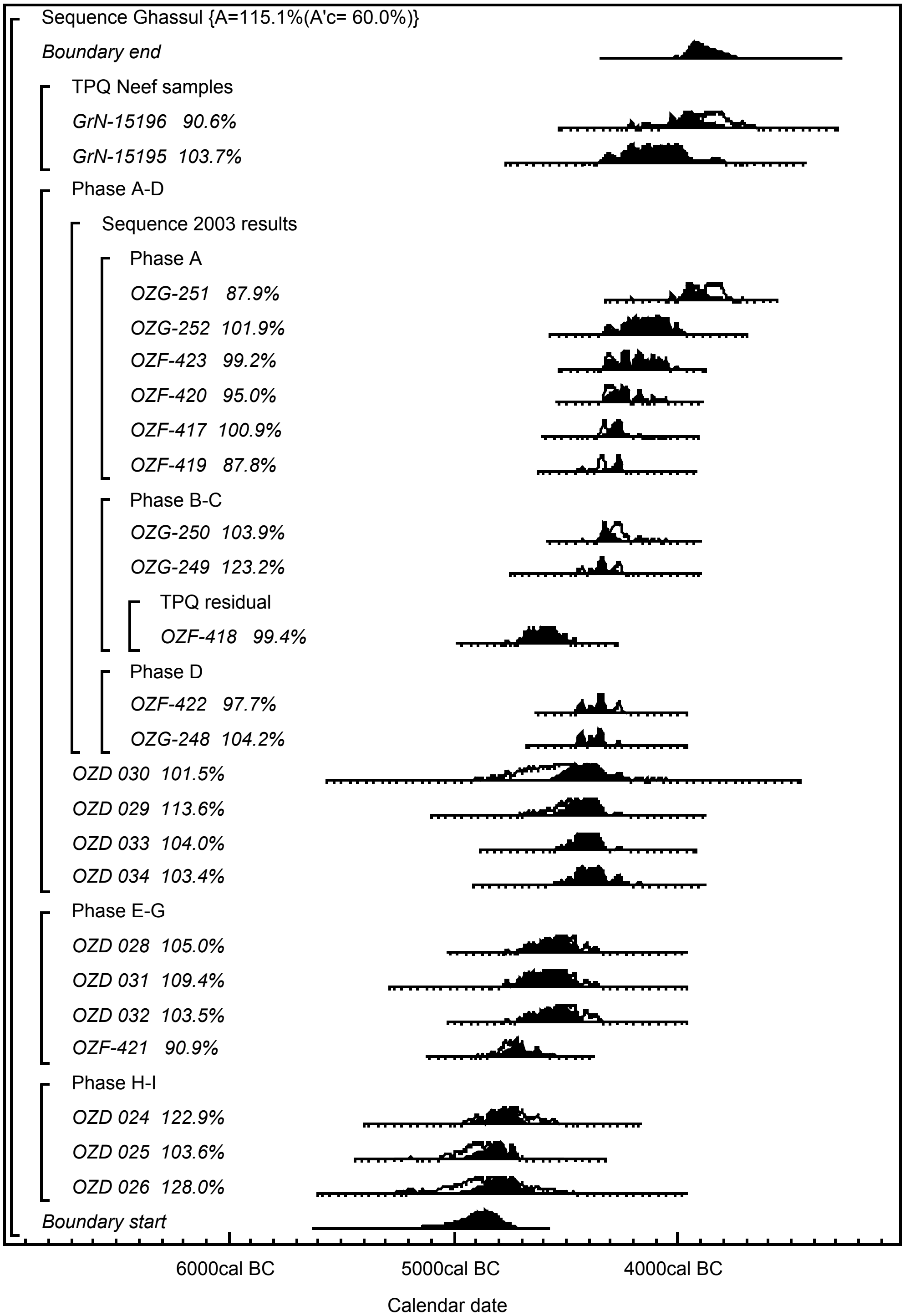

Figure 2 Modeled ^{14}C results for short-lived samples from Teleilat Ghassul

all Phase A–D samples. OZD-029, OZD-030, OZD-033, and OZD-034 are not assigned to a sub-phase within the Phase A–D group, but the 2002 results are placed in a sequence which assumes that the Phase A samples are more recent than the Phase B–C samples, which in turn, are more recent than the Phase D samples. Three results are treated as *termini post quem*: OZF-418, which the model assumes is older than the Phase A samples, and GrN-15195 and GrN-15196, which are assumed to pre-date the abandonment of the site. The distributions in outline show the calibration of the ^{14}C results by the probability method (Stuiver and Reimer 1993). The solid distributions are "posterior density estimates" of the actual age of each sample given its calibrated ^{14}C result and its age relative to the other dated samples. The distributions *Boundary start* and *Boundary end* are the estimated dates of the beginning and end of occupation at Ghassul given the ^{14}C results and the structure of the model.

DISCUSSION

The new dates from Teleilat Ghassul suggest that occupation at that site ended by 3800 cal BC at the latest, fully 300 yr earlier than the generally accepted end-point for the south Levantine Chalcolithic as a whole (Stager 1992; Joffe and Dessel 1995). Recent radiometric data bearing on the earliest phase of the succeeding Early Bronze Age at Afridar (Braun 2000, 2001) and Tell Shuna North (Bronk Ramsey et al. 2002:82–84) is nonetheless consistent with such a revision. While Braun's observations on the very real archaeological difficulties involved in the acceptance of such a revision are valid (Braun 2001:1281–1283), studies of the succeeding EB II–III period at Jericho (Bruins and van der Plicht 2001:1327) also report a 300-yr discrepancy between traditional and recent radiometric chronologies. Commentary on recent EB IV period dates from Tell Abu en-Niaj in the Jordan Valley (Bronk Ramsey et al. 2002:82) report a similar 300-yr difference between radiometric and traditional chronologies. Taken together, the recent radiometric data from Late Chalcolithic Ghassul, EB I Afridar and Tell Shuna North, EB II–III Jericho and EB IV Tell Abu en-Niaj are all consistent in suggesting the need for a significant upwards revision in the chronology of the Chalcolithic/EB I transitional period in the southern Levant.

CONCLUSION

The 12 new dates from Teleilat Ghassul have provided much needed data relating to the origins, site history, and eventual demise of the largest site occupied during the south Levantine Chalcolithic. A consideration of the latest dates suggests occupation ended around 3900/3800 cal BC. This is consistent with new assays bearing on the inception date and internal periodization of the succeeding Early Bronze Age.

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