For the Wadi Arabah Project Website (http://www.wadiarabahproject.man.ac.uk/)
and the critique of the paper: Levy, T. E., R. B. Adams, M. Najjar, A. Hauptmann, J. A. Anderson, B. Brandl, M. Robinson, and T. Higham. 2004. Reassessing the chronology of Biblical Edom: new excavations and 14C dates from Khirbat en-Nahas (Jordan). *Antiquity* 78:863-876.

May 16, 2005

How many fortresses do you need to write a preliminary report? Or response to Edom and the Early Iron Age: review of a recent publication in Antiquity

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Scholarly criticism is one of the best catalysts for productive debate and from this perspective, we welcome Eveline van der Steen and Piotr Bienkowski's review. It is unfortunate that the criticism of the ANTIQUITY paper was stimulated by a premature press release. Many of van der Steen and Bienkowski's concerns about our work at KEN (and much more!) are answered in the forthcoming papers to be published in the volume, *The Bible and Radiocarbon Dating – Archaeology, Text and Science* (London: Equinox). We suggest that as soon as page proofs are ready for this book, that van der Steen and Bienkowski (and other scholars interested in the debate) be given the proofs so that the debate can move from the informal Internet debate here on the Wadi Arabah web site to a published forum in one our peer reviewed journals such as ANTIQUITY, BASOR (Bulletin of the American Schools of Oriental Research), LEVANT, etc. Further, we hope that a Highland – Lowland Iron Age Edom radiocarbon dating project can be inititated with all the researchers working in the area. An finally, it is our hope that we can continue the debate about the nature of the Iron Age polity in Edom in the near future.

As to the critique on the Wadi Arabah web site, we have to say we were expecting this kind of reaction and we see nothing wrong with that. We were aware that what we are suggesting goes against the dominant view that has pervaded over Iron Age archaeology in Jordan for the past three decades. There is one particularly observant point made in Eveline van der Steen and Piotr Bienkowski's review of the recent report in ANTIQUITY (2004 302:865-79) concerning the University of California – Department of Antiquities of Jordan sponsored excavations at the Iron Age site of Khirbat en-Nahas (KEN) that needs to be addressed first. Namely, that the work at KEN has attracted a great deal of attention due to the publication of the ANTIQUITY article due to a premature press release issued by McMaster University in McMaster Daily News, dec. 20, 2004. This press release was a total surprise to us. In September 2004 an international symposium on Radiocarbon Dating and the Iron Age of the southern Levant organized by two of us (Levy and Higham) at the Oxford Centre for Hebrew and Jewish Studies, where a large number of specialists in Levantine archaeology, Biblical Studies, Egyptology and Radiocarbon dating gathered for three days of intense debate. The results of the conference will be published this coming November, 2005, by Equinox

Publishing Ltd in London (http://www.equinoxpub.com/books/showbook.asp?bkid=123). At the conference, opened with remarks from H.R.H. Prince Hassan Ibn Talal presented by Ghazi Bisheh, former director general of the Department of Antiquities of Jordan, *Biblical Archaeology Review*'s editor asked for a popular article about the significance of KEN in light of the conference presentations about the site (Levy et al in press; Higham et al in press). At the time, the answer was simple – no, we are not ready to raise the issue in the popular press. Unfortunately, the proverbial 'can of worms' has been opened and we are now having to live with it. We hope that the ANTIQUITY paper will be read in the context in which is was published – the first research report on the 2002 excavations at Khirbat en-Nahas.

Figure 1: Lowland Edom: Aerial view of Khirbat en-Nahas, view southeast. Note the large square fortress (ca. 73 x 73 meters), black copper slag deposits and the numerous remains of collapsed buildings on the site surface. Photo: JHF Project (1999), UCSD Levantine Archaeology Laboratory.

We were unjustifiably accused by the authors of the critique in having a hidden agenda or "not-articulated chronological assumptions." In this regard, we want to make it clear that our main interest in early Edomite history is the study of the impact of copper production on the formation of the Edomite state (however it may be defined) and its political and social institutions. This study is part of our broader research goal of a deeptime study of social complexity and the impact of archaeo-metallurgy on this process starting from the Neolithic period. Of course we are aware of the "chronological assumptions" mentioned by the authors of the critique and in this connection we want to say that it would be very unprofessional from our side to discard any of the available non-archaeological sources such as the Bible. We work as researchers and we do our archaeological investigations accordingly; if any of the "established truths" from archaeology or historical texts will be proved or disproved in the course of these investigations, it is our duty to do the follow-up and to make the results available to the scholarly community.

The Chronological Bias in the Iron Age Archaeology of Edom

Until quite recently, the Iron Age chronology of Edom rested on the discovery of a single clay seal impression found at the highland site of Umm el-Biyara during Mrs. Crystal Bennett's excavations in the 1960s (Bennett 1966a, 1966b). The seal contains the name of Qos-Gabr (the man of God Qos) known from the 7th century BC Assyrian annals of Esarhaddon [Prism B, ca. 673-2 BC, Pritchard 1969:291] and the first campaign of Ashurbanipal [Cylinder C, ca. 667 BC, Pritchard 1969:297; Bienkowski 1992a]. Scholars have taken the discovery of this extra-biblical text fragment to date the associated pottery found with the seal. As Bienkowski (1992a:99) pointed out some years ago with regard to Iron Age ceramics in Edom, the seal impression of Qos-Gabr provides the date to which, or not later than which, the ceramic assemblage can be attributed to (*terminus post quem*) and it doesn't indicate just how early that assemblage dated back to in time. In fact, Bienkowski (ibid:110) also alerted readers that unpublished radiocarbon dates from the German Mining Museum's soundings at Khirbat en-Nahas (KEN) indicated much earlier dates for the Iron Age in Edom. However, Bienkowski's caution and the later publication of the report on the soundings at KEN in German (which included radiocarbon dates – Engel 1993, Fritz 1996) fell on deaf ears. Bennett's dating of the Iron Age in Edom to the 7th and 6th centuries BC became the accepted standard for the Iron Age archaeology of this part of Jordan. A host of studies concerning Iron Age Edom were produced based on the assumptions established by the relative dating of Umm al-Biryara (see photo below; Bennett and Bienkowski 1995, Hart 1989, Oakshott 1978 and 1983, Pratico 1985 and 1993) and even more recent studies continue to work under the late 7th – 6th centuries BC assumption for the emergence of the Edomite kingdom (Bienkowski and Bennett 2003, and most recently, Crowell 2004 and Porter 2004).

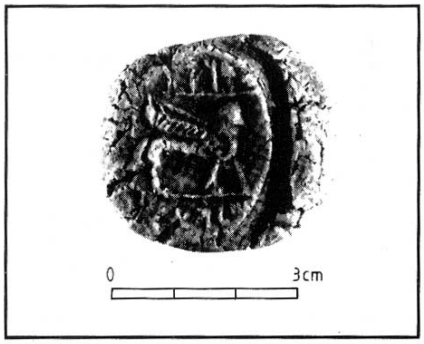

Figure 11.2 Seal impression from Umm el-Biyara, restored as 'Qos-Gabr, King of Edom'.

Figure 2: Seal impression from Umm el-Biyara reading ‘Qos-Gabr, King of Edom’ (source: Bienkowski, P. Editor. 1992. *Early Edom and Moab - The Beginning of the Iron Age in Southern Jordan*. *Sheffield Archaeological Monographs 7*. Sheffield: J.R. Collis Publications.

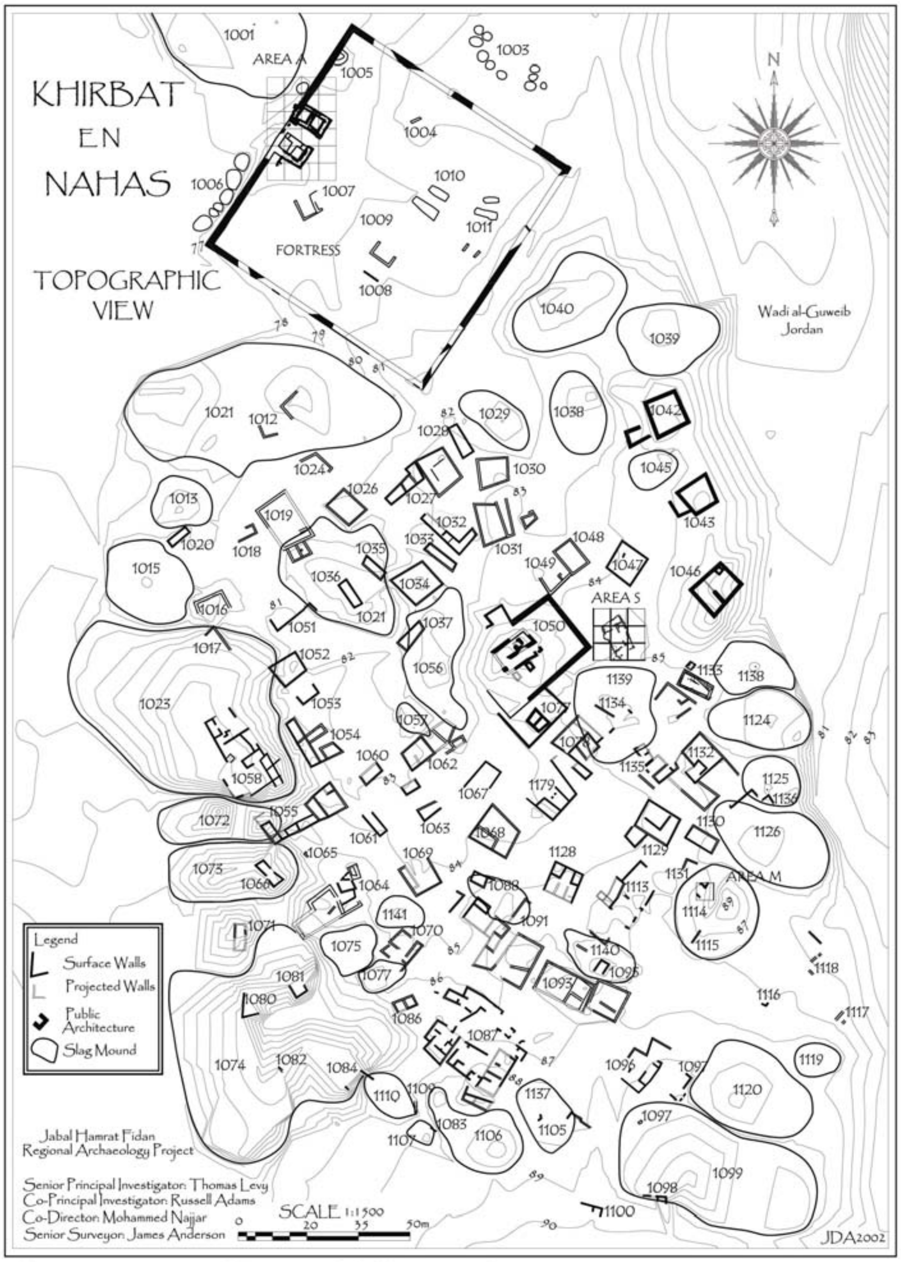

Figure 12: Topographic Map of Khirbat en Nahas.

Figure 3: Map of Khirbat en Nahas, Source: ANTIQUITY 2004 V. 78, N. 302: 869

The enthusiasm that Bennett's late dating of Iron Age Edom received by scholars in the late 1970s through the 1990s was in part against the views of the American archaeologist Nelson Glueck who pioneered archaeological surveys in Jordan and Iron Age excavations in Edom (Glueck 1938, 1939, 1940). Glueck took a more traditional viw of Levantine archaeology and tended to accept extensive texts in the Hebrew Bible as historical fact in a way that many later researchers believed to be biased (Dever 2000). Working in Edom, Glueck (1940:69, 86) firmly believed that the majority of Iron Age mining activities in the Faynan district that he documented could be dated to the 10th and 9th centuries BC.

In the early 1990s, working with published Iron Ag ceramic drawings, Israel Finkelstein (1992a, 1992b) suggested that indeed, there was ceramic evidence (collared rim jars) for an early Iron Age occupation in Edom that pushed back this occupation considerably earlier than the view of Bienkowski (1992a,b) and others. To help solve this chronological debate, which has profound implications for understanding the history and socio-economic processes that led to the rise of the Edomite "kingdom" – such as core-periphery relationships between Edom and the Assyrian empire on the one hand and Edom and neighboring small polities such as Israel and Judah on the other, it was decided that as part of the Jabal Hamrat Fidan project, large scale stratigraphic excavations would be carried out at the Iron Age copper production site of Khirbat en-Nahas.

The Highland – Lowland Dicotomy in Edom

The excavations at Khirbat en-Nahas should be examined as part of the very significant 'highland' vs. 'lowland' contrast in the Iron Age settlement of Edom. The marked environmental differences between the semi-arid/Mediterranean zone on the high plateau of Edom where famous Iron Age excavated sites such as Busayra (Bienkowski 2002) , Tawilan (Bennett and Bienkowski 1995), and Umm al-Biyara (Bennett 1966a,b) [see below photo for example of this highland site] are located and the lowland sites of the Faynan district such as Khirbat en-Nahas are situated in the hyper arid Saharo-Arabian desert zone. While this dichotomy must be compared and contrasted in the most objective ways, it does not mean these two zones of Edom were independent of each other. However, to parse out historical and anthropological process they must be objectively compared. Besides comparative quantitative studies of Iron Age artifact assemblages (especially ceramics), and stylistic comparisons between artifacts and architecture, radiocarbon dating offers the most objective method for establishing a much needed chronological framework for comparing the highland and lowland of Edom that will ultimately lead us to explaining Iron Age culture processes such as the emergence of complex societies in the region know to us from ancient Near Eastern texts – including the Hebrew Bible.

What is missing from the critique of our work is an acknowledgement of the significance of the KEN excavation report in ANTIQUITY for this being the first attempt to apply radiocarbon dating to stratified archaeological deposits from Iron Age architectural constructions in Edom. As such, we need radiocarbon determinations from the highland sites of Busayra, Tawilan, Umm al-Biyara and others. We would suggest that a major highland-lowland Iron Age radiocarbon dating project be established for Edom given the interest generated by the present discussion. The main problem of dating Iron Age sites in Edom has been, until the recent excavations at KEN, what may be called a 'highland-centric' view of the Iron Age archaeology of the region. As most of the stratified excavations in Edom have taken place up on the plateau, there has been more of a 'bird's eye view' of the region's archaeology rather than a 'worm's eye' view from the bottom of the region looking up. Standing at the bottom and looking up, we suggest that the Iron Age chronology on the plateau of Edom has been dominated by the discovery of a single artifact – the seal impression found at Umm al-Biyara that reads 'Qos-Gabr, King of Edom' that according to Piotr Bienkowski (1995:44-45)- "Qos-Gabr (or Qaus-gabri) is probably the king who is mentioned twice in Assyrian inscriptions: on Prism B of Esarhaddon, which is dated 673-672 BC[i] and in a description of the first campaign of Ashurbanipal, dated 667 BC, indicating a 7th century BC date for the associated pottery and small finds." From our understanding, this single seal impression, which can apparently be dated absolutely based on Assyrian epigraphic data, served as the single chronological anchor for dating the Iron Age pottery of Edom. We would suggest that one anchor is not sufficient and that radiocarbon dating projects, like the one at KEN can provide a more objective framework for establishing the much needed chronological ladder to test theories about history and anthropology in Edom.

Figure 4 - Highland Edom: View of Iron Age excavations at Umm al-Biyara in the Petra district (photo by T.E. Levy)

The Fortress at Khirbat en-Nahas

With regard to some of the specific archaeological criticisms made by van der Steen and Bienkowski, we will try to address some of them here. They use the term "possible fortress" and consistently place the word fortress in quotation marks as if there is some doubt as to our identification of the function of the structure. Back at the turn of the last century scholars such as Alois Musil (Musil 1907) and later, Nelson Glueck (Glueck 1935), identified the large square structure located at the northern aspect at KEN as a fortress (see map of KEN). Our excavations confirm the identification of the structure as an Iron Age fortress with a typical Iron II four-room gate. Although a more comprehensive study of the fortress is presented in the forthcoming volume mentioned above, in the spirit of transparency, we will present here two tables that summarize comparisons of the KEN gate with other Iron II gates from the southern Levant and a size comparison of the fortress at KEN with other Iron Age desert fortresses in Israel, Jordan and Egypt (Sinai).

Table 1: Characteristics of Selected South Levantine Iron Age Four-Chamber Gate. Sources: Herzog 1992, Levy et al 2004; A. Mazar, Pers. Comm.)

Site	**Façade (m)**	**Depth/Width (m)**	**Passage width (m)**	**Depth of Chambers (m)**	**Width of Chambers** (m)	**Date of Construction**
Megiddo IVA	25	15.5	4.2	3	8.2	Late 9th – 8th C. BCE
Beersheva V	20.8	12.6	4.2	3	6	End10th or 9th C. BCE
Beersheva III	16.6	13.6	3.6	3	5	Early 8th C. BCE
Tel Dan	29.5	17.8	3.7	4.5	9	9th C. BCE foundation?
Ashdod 10	16.5	13.75	4.2	2.4	3.8	End of 11th or Early 10th C. BCE
Tell en-Nasbeh (Early)	15	12	4	1.8	4.4	No hard data
Khirbat en-Nahas	16.8	10.6	3.63	2.9	3	10th C. BCE

The fortress gate at KEN is part of this south Levantine Iron Age architectural tradition. In terms of the size of the KEN fortress, Table 2 below summarizes much of data of fortified sites from the south Levantine desert zones:

Table 2: Selected Desert Fortresses in the Negev, Sinai and Wadi Arabah [Sources: Site = (Cohen and Cohen-Amin 2004, Herzog 1992); (Beit-Arieh 1999, Herzog 1992)

Fortress	Shape	Size (in meters)
Northern Negev		
Arad	Square	50 x 50
Uza	Rectangular	42 x 51
Horvat Tov	Square	30 x 40
Tel Ira VII	Irregular shape	100 x 320
Negev Highlands		
Horbat Rachava (Site 1)	Oval	60 x 70
Horbat Ha-Ru'ah (Site 8)	Oval	42 x 50
Mezudat Nahal 'Aqrav (Site 35)	Oval	40.25 x 45.5
'Ein Qadeis (Site 44)	Oval	37.5 x 52.5
Tira (Site 4)	Irregular shape	32 x 78
Refed (Site 3)	Irregular shape	42 x 57
Horvat Haro'ah (Site 8)	Fortlet w/ mudbrick towers	8 x 12
Beerotiyim (Site 19)	Fortlet w/ mudbrick towers	11.31 x 16.13
Har Gizron (Site 45)	Fortlet w/ mudbrick towers	3.76 x 4
Sinai		
Quseima 'Aharoni' fortress	Oval	26 x 28
Kadesh Barnea (earliest)	Oval	26 x 28
Kadesh Barnea	Rectangular	34 x 52
Wadi Arabah		
Yotvata	Trapezoid	40 x 64
Hatzevah	Square	100 x 100
Tell el-Kheleifeh	Square	45 x 45
Khirbat en-Nahas	Square	73 x 73

Our critics say "so far nothing else has been found in southern Transjordan to justify the incorporation of the Khirbet en-Nahas 'fortress' in a larger polity." In discussing the archaeology of the Hashemite Kingdom of Jordan, we can not separate it from the other side of the border – namely, Israel and Palestine. We suggest that there was a network of at least three 10th – 9th century BCE fortresses involved in the movement of Iron Age copper produced in the Faynan district. These include Khirbat en-Nahas, the lower levels at Tell el-Kheleifeh (Glueck 1940) and Hatzevah (Cohen and Yisrael 1995). There are problems with the old excavations of Glueck and the lack of a final Hatzevah publication. However, given the assumptions in Iron Age ceramic dating for Edom outlined above, the jury may have to be brought back to examine Pratico's (1993) re-dating of Tell el-Kheleifeh to the late phases of the Iron Age. The similarity between the gates at KEN and Tell el-Kheleifeh are too similar to be ignored and there are unpublished radiocarbon dates from Hatzevah (Y. Yisrael personal communication) that demonstrate a 10th – 9th century BCE occupation there. Thus, there must have been a constellation of three IA fortresses in the 10th – 9th centuries in the Wadi Arabah that were intimately involved in the copper trade at this time from the Faynan source area to the Mediterranean in the west (via Hatzevah) and in the south, perhaps along Red Sea trade routes and overland to Arabia, via Tell el-Kheleifeh. As seen in Table 2, after Hatzevah, KEN is the largest IA fortress in the south Levantine desert zone. We agree that 'one fortress does not make a kingdom.' However, KEN is part of a network of IA sites in the Faynan district (Levy et al 2003), and the triangle of fortresses in the Wadi Arabah no doubt had links with the web of Iron Age settlements in both the lowland and highland of Edom. This is not the place to debate the nature of the IA complex society in Edom (i.e., kingdom, tribal state, conical clan, developed chiefdom, rank society, etc.) – however, we welcome this debate in the future.

There may be some merit in our critics suggestion there must be transparency in the presentation of the dates and "other chronological data they have used." We did publish the two IA scarabs with all the necessary parallels. However, our critics do not discuss the significance of these important chronological data. For example, samples of the "Chariot, Archer, or Hunting Scene" scarab (KEN Basket: 6438, Locus: 316 see bottom scarab in photo) have been found in Iron IB deposits at Gezer (Strata XIII-XI), at Beth Shean VI-V (Iron IA-IB), Tell el-Farah south and many other sites. The scarabs, metal arrowheads and radiocarbon dates push us into the 10th and earlier centuries. We could discuss the other scarab and other artifacts but this is only meant to be a short response.

Figure 5 – Scarabs from KEN (source ANTIQUITY 2004: 875.

We wanted very much to include a discussion of the Iron Age pottery assemblage from KEN but our ceramic specialist did not want to include it in the ANTIQUITY paper. When that didn't happen, we wanted to include summaries of the ceramic assemblage found in each strata at KEN for the forthcoming volume on radiocarbon and the Iron Age – but it was not ready in time for inclusion in that book. We are currently preparing a monograph publication on KEN that will be published with the Czech Institute for Egyptology that we hope to submit this summer. Inshallah, the ceramics from KEN will be presented there.

Radiocarbon dating at KEN in Light of the Critique

The original draft of the ANTIQUITY paper contained a "Methods" section, in which the Bayesian analysis was published. Unfortunately this was not included in the final paper solely for reasons of brevity. The basis of the Bayesian[1] calibration method is deceptively simple, yet mathematically complex. The reader is referred to any number of publications outlining the mathematical basis of the technique (e.g., Buck *et al*. 1996 (and references therein); Christen 1994; Christen and Buck 1998; Nicholls and Jones 1998, 2001; Zeidler *et al*., 1998). The methods are attractive because they allow associated archaeological information to be taken into account in the chronometric analysis, in an explicit, statistically-rigorous way. Archaeologists are familiar with the way in which stratigraphically constrained materials are submitted for radiocarbon dating and information of this kind is made explicit in the analysis.

Let us take as an example the context Stratum S4 from KEN – the building linked to slag processing discussed in the ANTIQUITY paper. We know this is an archaeological event that can be dated by the selection of a suitable piece of organic material whose age-at-death (and hence cessation of uptake of ^{14}C) is inferred as being close to the time of the archaeological event of the occupation and deposition of that stratum. Four variables assume importance in the dating and Bayesian modeling of the samples from this and other contexts. First, the *prior*. This represents the archaeological information available concerning the sample and its unknown calendar date (termed θ). In this case, we have no concrete information about the age of this specific context, but we do have information about its position relative to other samples within the excavated sequence. We know that it is earlier than the deposition of samples to be dated from strata 2 and 3, (ie. for the series of samples that $\theta_1 < \theta_2 < \theta_3$). This is important archaeological information, then, that can be included in the Bayesian chronometric analysis to come. Second, the *data*. This is the radiocarbon determination from stratum S4 obtained in Oxford (OxA-12169), which produced a radiocarbon age of 2899±27 BP. The data acts through a distribution called, third, the *likelihood*. This refers to the unknown calendar date expressed when the radiocarbon age is converted into calendar years using the calibration curve, and the statistical uncertainty associated with it. Finally, the *posterior*. This gives the information obtained about θ as a probability function, based upon the prior and likelihood distributions. A larger posterior probability occurs when the grouped calibrated dates agree with the data and are plausible in the light of the prior input into the model. In the case of Area S, we had four stratum and four radiocarbon likelihoods from each, so an appropriate model for this archaeological sequence was constructed and is shown in Figure 6, alongside that from Area A. Bayesian analysis is mathematically intensive and analysis is only possible using computer programmes, such as BCal (Buck *et al*., 2003), which incorporate simulation-based statistical tools called MCMC (Markhov Chain Monte Carlo). For the user (the archaeologist), these tools are now widely available and utilized in chronometric analysis.

[1] Bayesian methods are named after the Reverend Thomas Bayes whose seminal work "An essay towards solving a problem in the doctrine of chances" was published posthumously in 1763 (Buck *et al*., 2003).

What is interesting and crucially important is the use of suitably structured analysis models because when utilizing the Bayesian approach we are forced to make our model assumptions explicit through the prior. This has drawn attention to the fact that there are no true neutral assumptions that can be made in statistical analysis, Bayesian or otherwise, and that any model assumptions will have a real influence on the result. Once again, this is discussed in much greater details in some chapters in the forthcoming book, T*he Bible and Radiocarbon dating* (Higham *et al*., in press, Bronk Ramsey, in press). If our model assumptions are invalid or inappropriate then the resulting analysis can give misleading results.

Methods:

In the model developed for the ANTIQUITY paper, certain mathematical symbols are used to describe the stratigraphic phases and boundaries at the site (Figure 6 below). α_n and β_n represent the beginning and ending dates of phase $_n$. By analyzing the posterior probabilities for these parameters, we are able to consider the modeled distribution of ages corresponding with *termini post* and *ante quem*, and also to test issues of contemporeneity and span. α_8 therefore represents the probability distribution immediately prior to the deposition of S2a in Area A, while the late phase boundary of this level is represented by β_8. The probability distribution α_5— β_5 would represent the elapsed time span of Stratum 4 in Area S, and so on. In addition to this, we can use our prior knowledge, not just of the archaeological sequence but also of the dated materials, to ascribe a probability as to whether or not a dated sample is likely to be an outlier in the model. It could be, for example, that the variation in certain radiocarbon determinations might be due to sample constituent or contamination problems about which we had a prior hunch. Outlier analysis is described by Christen (1994) in some detail. We ascribed a prior outlier probability of 10% to each radiocarbon determination (after Buck, Higham and Lowe (2003) to assess whether or not there were potential outliers. The low prior probability was given because of our knowledge of the screening of the charcoal samples and our sampling of external tree rings where possible. Nevertheless, the possibility of there being outliers was entertained. The resulting posterior probabilities were not significant and therefore we conclude there are no outliers in the dataset.

The radiocarbon likelihoods for each AMS measurement as simulated in BCal are shown in Table 3 (below). The most likely calendar date range (or ranges) for each parameter is represented by highest posterior density (HPD) regions, given at 95% probability. In Figure 7, an example of a posterior probability density plot is given for one of the determinations (OxA-12342; represented by θ_6 in the model). The HPD region for this corresponds to 1055—915 BC at 95% prob. Note that the distribution is multi-modal, but that the highest probability (as shown on the *y* axis) is associated with *c*. 960-980 BC.

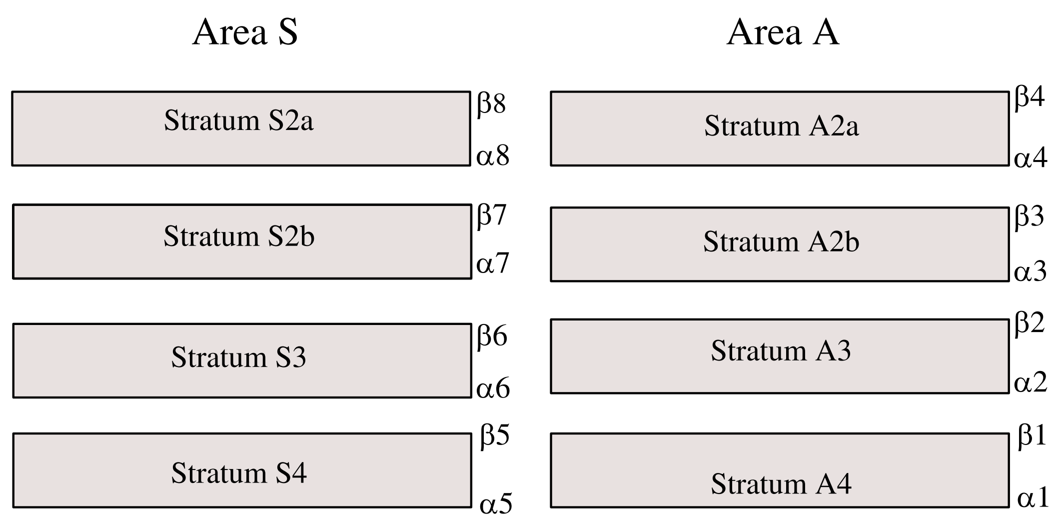

Figure 6: Calibration model for Areas A and S at KEN.

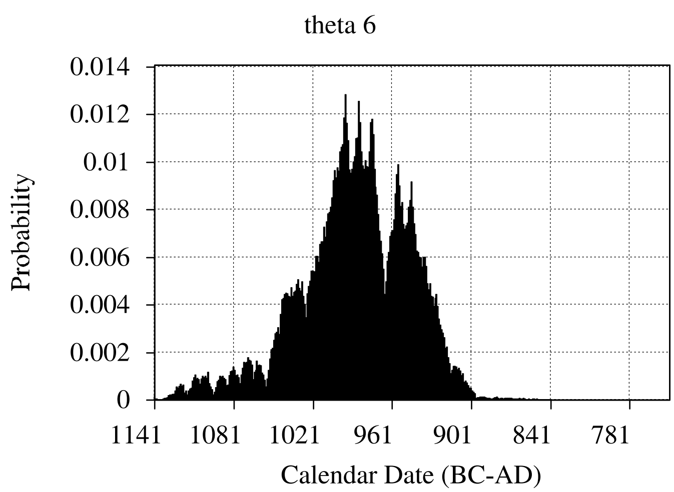

Figure 7: Posterior probability density plot for θ_6 in the model (OxA-12342)(Table 3).

Model parameter	**OxA number**	**HPD region (BC/AD) (95% prob.)**
θ_1	OxA-12365	1215 to 1180 BC, 1160 to 940BC (multi-modal distribution)
θ_2	OxA-12366	1005 to 870 BC (960, 925 BC)
θ_3	OxA-12637	920 to 815 BC (885 BC)
θ_4	OxA-12368	890 to 790 BC (835 BC)
θ_5	OxA-12169	1260 to 1240 BC, 1215 to 1200BC, 1195 to 1020

		BC (multi-modal distribution)
θ_6	OxA-12342	1055 to 915BC (multi-modal distribution)
θ_7	OxA-12168	970 to 830 BC (895 BC)
θ_8	OxA-12274	900 to 765BC (815 BC)

Table 3: Individual HPD regions for each determination given at 95% probability and rounded to five years. The figure in brackets represents the modal value, the year(s) associated with the highest probability, except in cases where the distribution is multi-modal as in Figure 7.

Parameter	**HPD intervals (BC/AD) (95% prob.)**
β_4	885 BC to 415AD (mode 810 BC)
β_8	890BC to 560AD (mode 806 BC)
α_1	4040 BC to 935BC (mode 1122 BC)
α_5	3115 to 1015BC (mode 1193 BC)

Table 4: HPD regions for the parameters associated with the periods immediately post- and pre-dating settlement at KEN (see model in Figure 6 for parameters).

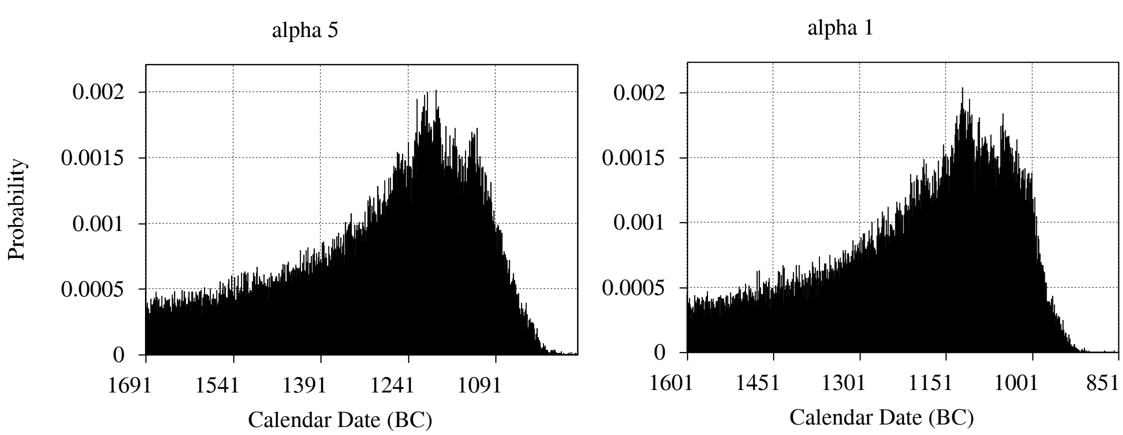

Figure 8: Posterior probability density plots for α_5 (time range prior to Stratum S4) and α_1 (time range prior to Stratum A4), at KEN.

We also analysed *termini post* and *ante quem* for KEN (Table 4). α_5 effectively represents a *terminus post quem* for occupation at Area S, while α_1 represents a *terminus post quem* for occupation at Area A. These suggest, therefore, that the highest probability is that Area S was occupied *after* 1190 BC and Area A *after* 1120 BC (in our paper, the former distribution was mistakenly stated as being *before* rather than *after*). A fuller methodological analysis would have made it obvious that this was not correct.

The discussion above is, we are afraid, rather moot in the light of more recent work, again forthcoming in some chapters of *The Bible and Radiocarbon Dating*. Further dating of many more samples from KEN has produced a rather fuller picture of the chronology of the site. We now have a total of 19 determinations from Area S and 15 determinations from Area A. In general, these results corroborate the chronometric story described here and in the *Antiquity* paper, improve significantly the precision of our analysis and increase our confidence in the chronology of the site.

The difference between the Cal BC date ranges in Table 1 of our *Antiquity* article, and the calendar age ranges discussed in the text itself, then, is due solely to the application of the Bayesian modeling. Table 1 simply represents radiocarbon calibrations, with no modelling. In the *Antiquity* text, the ranges represent posterior probabilities, computed in the light of the priors and the result of the modeled simulation of the data. The reason for the two determinations from Stratum S4 and A4a respectively being older than would apparently be the case on the basis of the likelihoods alone is simply that the contexts are constrained in the model as being archaeologically ‘earlier’ than the determinations above, which are not wholly different in terms of age.

One of the advantages of the Bayesian approach is that we can test alternative scenarios for our model, both in terms of varying priors and simulating new data. For example, what if we said that, rather than Strata S4 and S3 being separated, they were in fact archaeologically one unit, and the same for Strata A4a and A3? The HPDs for the two sets of determinations from each reanalysis are shown in Table 6. One can see that the HPD regions are quite sensitive to the priors used in the modeling. Now that the determinations are placed in the same context, rather than superimposed, the distributions for θ_1 and θ_5 are pushed towards the younger end of their original likelihood. This emphasizes the crucial importance of our prior assumptions in the Bayesian modeling of radiocarbon dates, but, for the purpose of this response, serves merely as an illustration of why there is this variation between the two sets of dates questioned by van der Steen and Bienkowski.

Model parameter	**OxA number**	**Model 1 (Figure 6): HPD region (BC/AD) (95% prob.)**	**Model 2: (strata S4/S3 combined, A3/A4 combined) HPD region (BC/AD) (95% prob.)**
θ_1	OxA-12365	1215 to 1180 BC, 1160 to 940BC (multi-modal distribution)	1045 to 909 BC (modal value: 970 BC)
θ_2	OxA-12366	1005 to 870 BC (960, 926 BC)	1013 to 900 BC (modal value: 960 BC)
θ_5	OxA-12169	1260 to 1240 BC, 1215 to 1200BC, 1195 to 1020	1191 to 976 BC (modal value: 1025 BC)

		BC (multi-modal distribution)	
θ_6	OxA-12342	1055 to 915 BC (multi-modal distribution)	1127 to 935 BC (modal value: 1000 BC)

Table 6: HPD regions obtained using two different models for KEN in which the determinations from strata S3 and S4 is combined into one strata, and the same for strata A3 and A4.

Concluding Remarks

We hope that our response to the response to our recent ANTIQUITY paper will promote more scholarly discourse that will ultimately help researchers solve many problems concerning the emergence, maintainance and collapse of one of the southern Levant's most fascinating ancient polities – Iron Age Edom. Perhaps sometime down the line, all researchers interested in the Wadi Arabah will join together in a major research project that focuses on radiocarbon dating and the Iron Age of this important border zone.

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