The history of the camel bone dating project

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ABSTRACT
The results obtained by the AMS laboratory in Oxford for the 'Camel Bone Dating Project' are summarized and discussed.

RÉSUMÉ
L'histoire du projet de datation des os de dromadaire.
Les résultats obtenus par AMS au laboratoire de datation radiocarbone d'Oxford à partir du projet "datation des os de chameau" sont résumés et discutés ci-dessous.

INTRODUCTION

The stimulus for the Camel Bone Dating Project was the discovery of a mandible of a camel amongst the animal bones excavated in 1982 from Shiqmim, a Chalcolithic site situated in the north-western Negev Desert between Beersheva and the Mediterranean (Grigson 1987, 2008; Levy 1987). Like most Chalcolithic sites of the southern Levant Shiqmim was considered to belong to the fourth millennium BC, although with calibration their dates have been pushed back into the fifth millennium.[1] The bone was said to be securely stratified and I enthusiastically began to fantasize about trans-desert transport, the first true pastoral nomadism. However I knew that if anything in archaeology is really neat, or just what you want, it is probably untrue. That is, I had already come *not* to believe in 'Optimistic Archaeology'. The Radiocarbon Accelerator Unit had recently been set up at Oxford; here was the ideal specimen, it could be directly dated, sampled and not destroyed (after all one does not come across Chalcolithic camels every day). My pessimism was, alas, only too justified, the date came out at Shiqmim: camel mandible: OxA-135 1740±150 AD.

The calibrated date is 1459-1950 AD, i.e. modern! It seemed sensible to get some more direct dates. So I sent off for application forms and filled in a proposal. This is what I wrote:

'*Camels are thought to have been present in the wild state in the Near East and in North Africa in the Early Upper Pleistocene and then to have died out in both areas in the Late Upper Pleistocene, returning only as domestic animal. The most usually accepted dates for their introduction being that put forward by Albright of about 1100-1000 BC, although Zeuner considered 1,800 BC more likely. The idea of the present project is to test whether these two main suppositions have any scientific validity.*

If camels really were absent in the area in the Late Upper Pleistocene and early Holocene it would be extremely interesting, in the context of the wide-spread discussions about Pleistocene extinctions, to know the date at which this happened and whether it was true of the entire area. There is little prospect of obtaining any Pleistocene material; from the Arabian Peninsular, but if it can be shown that camels were there in the Early Holocene it would be reasonable to suppose that they were also there in the Upper Pleistocene, and indeed camel domestication may have taken place in Arabia itself.

One criterion for domestication is when an animal appears suddenly in the archaeological record in an area which is outside the geographical range of its wild forbear. If it can be established that the wild camel was absent in North Africa and in the Middle East, but that the camel reappeared suddenly in the Middle Holocene, it would be reasonable to suppose that this was as a domesticate.

The use of camels for transport was an extremely important development in human history as it allowed the initiation of long-distance trade across desert areas in which travel had previously been impossible. The use of camels as sources of food (particularly milk products) as well as for transport made actual habitation of the desert feasible. Both aspects must be closely related to the origins of nomadism in these areas.

Camel bones occur only in very small numbers in archaeological sites (because they were used primarily for transport and their secondary products, rather than for meat). They are common in the area today, and so the intrusion of camel bones into archaeological sites is not only possible, but quite likely (as the dating of the 'Chalcolithic' camel jaw at Shiqmim – OxA-135 210±150 bp - tells us). This means that camel remains have to be dated individually when scientific verification of their dating is required.'

It was enough to convince the members of the 'Oxford Radiocarbon Dating Accelerator Unit Programme Advisory Panel', who (I have been told on the best authority) fell about laughing at the mere mention of camels and it was approved without dissent. That was in 1984. Some of my colleagues eagerly passed their camel bones on to me, I set about chasing the others, wrote countless letters, made countless phone calls, interviewed bored archaeologists, re-excavated bones from crumbly boxes in Museum basements and eventually came up with 27 camel bones from archaeological sites. The first thirteen samples were submitted for dating to the Oxford Laboratory and the results published in 1987. Nine more samples were submitted in 1986, but no dates were obtained

1. All the calibrated dates set out in this paper were calculated using the OxCal v4.1.7 IntCal 09 calibration curve @ 95% probability (Bronk Ramsey 2009); for further details of calibrated dates see Bronk Ramsey *et al.* 2014: 29-32.

from them as collagen was either too low or missing altogether. After this it was decided to date only burnt bone and only three of the five bones submitted were deemed suitable, the date from one of these conflicted with the date from same site (Sihi 210/10) obtained earlier, so both bones were re-dated in 1992.[2]

Details of the results are given in the Appendix; they are not encouraging, very few of the bones could be reliably dated, largely on account of lack of collagen, nevertheless *some* of the results merit further discussion.

CB1, MOSTAGEDDA, CAVE C (NORTHERN UPPER EGYPT OR MIDDLE EGYPT DEPENDING ON TERMINOLOGY)

Although the cemetery excavated by Guy Brunton in the early twentieth century was considered to be largely Predynastic, this did not include the material the Cave C which was situated 1½ miles further up a nearby wady. He wrote that the deposit inside the cave in which the camel bones were found had been very disturbed by jackals or foxes and indeed the majority of the other bones were identified as those species. The deposit contained one sherd of Predynastic pottery, one Predynastic flint, and several sherds described as Protodynastic, 17th Dynasty and 22nd Dynasty. At first it was considered that the date obtained, 730 bc (now calibrated as 1259-407 CAL BC) was both minimal and unreliable because of the low collagen level, but it was re-estimated as 20mg/gm (Housley per. comm.) and seems to be a good date after all, though the brackets are very wide. This is probably earlier than the Persian Period (525-404 BC), when camels are said to have been introduced into Egypt, although some people maintain that camels were not brought into use in Egypt until the Ptolomaic Period (332-30 BC), right at the end of the first millennium (Midant-Reynes and Braunstein-Silvestre 1977).

However two direct dates for the camel in Egypt were obtained by the Accelerator Unit for Peter Rowley-Conwy in 1986 - a mandible and some dung from Qasr Ibrim in Lower Nubia yielded dates of 520±160 bc (971-196 CAL BC) and 740±90 bc (CAL 1114-551 BC) (Hedges *et al.* 1987); the second date shows that camels were being utilized in the first millennium BC, and the presence of their dung within the settlement certainly indicates a domestic animal (Rowley-Conwy 1988). It must be remembered that Qasr Ibrim lies far to the south in Egyptian Nubia: it does not follow that the camel was present in the rest of the country. It is possible that camels were first introduced into North Africa from S.W. Arabia via the Horn and would therefore have arrived in Nubia before reaching the rest of Egypt. There is still no evidence for their use in Lower, Middle or Upper Egypt before the first millennium BC

CB3, JERICHO TELL, PALESTINE

Excavated in the 1950s by Kathleen Kenyon. The camel metapodial condyle which was submitted for dating came from a Middle Bronze Age level in Trench I, Stage XLIV, period lviii (Kenyon and Holland 1983: 53-54) and with the other faunal remains from the site was reported on by Juliet Clutton-Brock (1979). When calibrated the date (2900±160 bc) spans the fourth millennium (4037-3121 CAL BC), however it is based on such a small concentration of collagen (3.1mg/gm) that it *cannot* be relied upon. Even if the camel bone had been truly Middle Bronze Age (early second millennium BC) it would have been the earliest camel known from the Holocene of the Levant; one suspects intrusion from a later level in this multi-period site.

CB4 AND CB5, TELL NEBI MEND IN SYRIA

Two camel bones excavated by Peter Parr in the 1970s produced dates of 130±90 bc (359 CAL BC-71 CAL AD) and 270 bc (506-5 BC), but only the first had enough collagen (23.3mg/gm) to be reliable and indicated that it probably come from the Hellenistic period rather than the expected Late Iron Age (Grigson in prep).

2. For problems relating to the dating of bone see Hedges and Law (1989).

CB7, JEBEL NAKHSH JN/1, QATAR

A hyaena den excavated by Peter Andrews in 1983. The camel axis contained quite a high concentration of collagen (34mg/gm), so the date 580±200 AD (1016-1950 CAL AD) is probably reliable. The deposits had been much disturbed and some of the bones were thought to have been modern, though it had been hoped that the camel bone would be proved earlier (Andrews pers. comm.; Andrews 2008).

CB9, HUMMAL (EL KOWM), SYRIA

This site has been under investigation since at least the 1970s. The metapodial fragment submitted for dating was one of several brought to Juliet Clutton-Brock for identification by F. Hours and Lorraine Copeland; it was said to date from the Middle or Upper Palaeolithic (Hours 1982, Clutton-Brock pers. comm.), but the collagen content was too low for dating. The reason for mentioning it here is that a large number of camel bones from the same site, dating from the Lower Palaeolithic to the Upper Palaeolithic, have recently been excavated, and identified as *Camelus dromedarius* as well as a new, giant, camel species confined to the Mousterian levels; which appears to have been of much the same size as the large camel from Farah II mentioned below (Schmid pers. comm.; Martini 2011; Le Tensorer *et al.* 2007).

CB10, FARAH II, ISRAEL

Excavated in 1976-78 by Isaac Gilead and Caroline Grigson and thought to date from the Late Middle Palaeolithic (Gilead & Grigson 1984). The camel bones were exceptionally large, much larger than those of modern animals and those recorded from Holocene sites (see Hummal above). Four of the bones were the subject of a paper: 'A very large camel from the Upper Pleistocene of the Negev Desert' published in the *Journal of Archaeological Science*, in which they were tentatively assigned to *Camelus thomasi* (Grigson 1983). A fifth bone from the same assemblage, part of the shaft of a tibia, was subsequently identified as camel and submitted for dating, but as with many of the other bones from Palaeolithic sites the collagen level (3.9mg/gm) was too low for dating.

CB12, TABUN CAVE, ISRAEL

Excavated in 1929-35 by Dorothy Garrod, from Middle Palaeolithic levels. This camel metapodial distal condyle was not noted by the original faunal analyst Dorothea Bate (Bate 1937), but many years later it was identified by Sebastian Payne (Payne and Garrard 1983), who found it in the Palaeontology Department of the Natural History Museum in London, marked Tc (= Tabun, Level C) in a drawer which also contained bones of the fossil *Dicerorhinus*. He noted that its condition was the same as other bones from Level C. However in the course of dating it was found to have a suspiciously high concentration of collagen (62mg/gm) and the date showed that it was modern, 890±70 bc (780-1154 CAL AD), and clearly intrusive.

CB13, MUGHARET-EL-EMIREH, ISRAEL

A Palaeolithic cave excavated by Turville Petre in 1925-26. The bones were said to have been sealed under a layer of travertine, but the fourth upper premolar of a camel identified by Dorothea Bate (1927) was dated at 1110±120 bc (1608-979 CAL BC). If taken at face-value this would make the Palaeolithic attribution unlikely; however the concentration of collagen was rather low (13mg/gm), so the date should not be considered reliable.

CB2 AND CB26, SIHI 217/107, SAUDI ARABIA

A large shell midden on the Tihama Plain by the Red Sea, discovered and excavated by Juris Zarins and his colleagues in the 1980s (Zarins *et al.*1981; Zarins & Zahrani 1985; Zarins & al-Badr 1986). Bones retrieved from the excavation were taken to the Natural History Museum in London for identification by Juliet Clutton-Brock; they included eight fragments of bones of camels, including parts of a mandible and a maxilla – all burnt.

The AMS date obtained from the camel mandible, 6250±200 bc (then calibrated at about 7000 BC, re-calibrated as 7587-6659 CAL BC) was completely unexpected, but was enthusiastically accepted as the first directly dated Early Holocene camel in Arabia, thus answering one of the original questions posed in the grant application, though of course its domestic status could be not ascertained. The fact that the bone was charred added to the perceived value of the date, as dates obtained on charred bone were considered to be particularly reliable. Although several other dates had been obtained on marine shell from the site which indicated formation of the midden during the second millennium BC, it was concluded that the camel bones and perhaps a small proportion of the rest of the midden derived from a brief Aceramic Neolithic occupation of the late seventh millennium. The result was published in the *Journal of Archaeological Science* (Grigson *et al.*1989); that little crumb of pessimism not yet in evidence.

However there was little in the way of artifactual evidence to support a Neolithic attribution and various authorities began to question the early date. It is now thought that Sihi was one of the northernmost sites of the Subr/Sihi complex of S.W. Arabia and the Yemen and that the entire complex dates from late second millennium (Edens and Wilkinson 1998; see also Vogt and Buffa 2005). Zarins himself omitted the date from his review of radiocarbon dates in the southwest Asia arid zone (Zarins 1992).

A fragment of the maxilla from Sihi (CB 26) was among the second batch of camel bones submitted for AMS dating and produced an unwelcome result, 450±80 AD (397-665 CAL AD) a date which was equally unacceptable archaeologically and which cast doubt on the validity of seventh millennium date obtained on the mandible. A fragment of a burnt camel mandible (CB23) from a similar site to Sihi, CB 23 Sabya Qadim 217/177, also produced a late date, 160±80 bc (370 CAL BC- 48 CAL AD).

So in 1992 it was decided to re-run both of the dates from Sihi using the same bones.

The second date (CB2-2) obtained on the mandible, 415±60 AD (412-640 CAL AD) was completely different from the original date of 6250 bc The two dates for the maxilla were reasonably close to one another - CB26-2, 265±60 AD (230-535 CAL AD) compared with 450 AD, and consistent with the second date on the mandible. One suspects intrusion of burnt camel bones into this shallow site in the early centuries AD.

In their comments on the Camel Dating Project (Bronk Ramsey *et al.* 2014: 29-32.) John Gowlett and Rupert Housley wrote: '*One should first realize that charred bones are very variable samples, with examples ranging from very lightly charred specimens to those that are fully burnt and thus either blackened in oxygen-deficient fires, or oxidized to the consistency of cremated bone (i.e. very cracked and blue-white in colour). Apart from climatically elevated temperatures, the heat from the fire may have influenced the state of the chemical fraction that is dated. If, for example, low collagen bones are burnt in a reducing environment the resulting 'elemental carbon' could derive from a mixture of indigenous bone collagen and the exogenous soluble and insoluble organic materials such as dissolved humic and/or fulvic acids in the groundwater. The result would have a high potential for bias... As regards the repeat measurements, differential contamination would tend to produce variable age results and so consistency between analyses on the same bone would suggest either a uniform level of contamination (inherently improbable) or no contamination. In situations like this one should then turn to the archaeological context to assess the overall degree of confidence in the age analyses.*' (Housley pers. comm., June 2004.)

CB27, TIMNA SITE 30, ISRAEL

Excavated in 1974-76 by Beno Rothenberg. This smelting camp on the edge of the Wadi Arabah was dated by Rothenberg to the Late Bronze/Early Iron transition, because it contained some similar pottery to another site in the same complex which had been securely dated to this period by the presence of some Egyptian inscriptions (Rothenberg 1980). A large number of camel bones were retrieved (Grigson 2012) and a partially burnt proximal phalanx submitted for dating.

The dating of the Timna bone was not without problems; Rupert Housley wrote: *The Timna sample was initially treated as a burnt bone but since only the very tip of the bone was burnt, not enough charred bone could be removed to give a date. We therefore decided to sample the uriburnt part and found it had a collagen concentration of 7 mg/gm. This is not high but neither is it very low. One thing which should make this date more reliable than the previous unburnt camel dates is that a better purified chemical fraction - ion-exchanged gelatin - was dated. The previous pretreatment method (namely decalificatlon, acid hydrolysis of the insoluble residue, treatment of the hydrolysed amino-acids with activated charcoal, end subsequent purification of the amino-acids by ion-exchange chromatography) did occasionally give problems when used on bones from certain environments. There are two reasons for this. One is because hydrolysis of the insoluble residue did sometimes release amino-acids bound up in humic complexes. The second is because hydrolysis in the presence of carbohydrates sometimes led to the formation of amino-sugar condensation products which, to an extent, co-eluted with the amino-acids during chromatography. In cases where the 'collagen' is low, and/or the bone was heavily contaminated, the result would be a biased date. The new methods used on OxA-2165, which centre around the formation of gelatin, enable separation of the collagen from potentially contaminating amino-acid-bearing substances and carbohydrates before hydrolysis to amino-acids. As far as we can tell, provided good, pure gelatin can be obtained there is a good chance the date is fine.* (Housley pers. comm., 2 February 1990).

The date came out as 700 bc (1023-516 CAL BC), that is Iron II. The date was rejected by Rothenberg who considered that the bone must have been intrusive. However a large suite of dates has recently been obtained from charcoal in the same site (Ben-Yosef 2010) which agree quite closely with the AMS camel date. Pathological evidence from the bones themselves as well as commonsense indicates that the camels at Timna were domesticated work-animals involved in the processing of copper ore and its distribution. If the date originally proposed of Late Bronze/Iron I been confirmed, they would have been amongst the earliest domestic camels identified in the Levant, as it is the Iron II date for this particular bone makes perfect sense, as does the dating of the entire site from the charcoal dates to the late Iron I and early Iron II periods (Grigson 2012).

CONCLUSIONS

Rupert Housley and John Gowlett summed up the problems encountered with the Camel Bone Dating Project in these words:

'In a sense the camel bone dating project was always going to be a technically challenging one. In the case of the unbumt specimens. the problem of low collagen bone, and the influence this has on the ^{14}C dating process, is now well known (Hedges and van Klinken 1992 - and references therein) and is especially relevant. High temperatures associated with the climate of this region of the World are not conducive to high bone protein preservation and there would be a high expectation, that except for the most recent of faunal specimens all bones would have low to negligible preserved protein levels. In many cases this has occurred precluding any age determination from being obtained, however even where protein preservations were low yet adequate to yield an age, there is no certainty that the determination is unbiased. This is because diagenesis of the bone protein causes breakdown of the bone amino acids permitting chemical cross-linking with carbonaceous molecules in the burial environment that may be of a different age. The result is a biased age unconnected to the time of death of the animal. Except where results derive from uncharred bones with medium to high collagen levels (thereby almost certainly belonging to comparatively recent specimens) a degree of caution should be exercised when considering the significance of the results.' (Housley pers. comm. June 2004).

It is a pity that so many of the camel bones submitted, including all those from Arabia, yielded either unreliable dates or none at all. One unfortunate result is that the first date obtained on the Sihi mandible published in 1989 has latterly been widely disseminated across the Internet as the earliest dated camel in Arabia. I have to take most of the responsibility for the delay in publication of the revised date, but even if it had appeared sooner, I doubt if it would have been possible to eradicate references to the earlier result.

My early pessimism has alas been partially justified, but nevertheless a few good dates have been achieved and much has been learnt about the possibilities and limitations of the direct dating of animal bones from arid environments.

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APPENDIX: THE CAMEL BONE DATING PROJECT – SUMMARY OF RESULTS

Details of the results are set out in this order. — Camel Bone Project reference no., site and country; (2) date of excavation and excavator; (3) where stored and accession no. ('Tübingen' = Archaeozoological Laboratory of the Institute for Palaeo- and Protohistory and Medieval Archaeology, Tübingen University); (4) bone; (5) identified by; (6) expected date/period and references; (last line) Laboratory no., date bp, and calibrated date BC/AD based on OxCal v4.1.7 IntCal 09 calibration curve @ 95% probability (Bronk Ramsey 2009).

Result 1984. Gillespie *et al*. (1985). Radiocarbon dates from the Oxford AMS system: Archaeometry Datelist 2. *Archaeometry* 27(2), 245.

Shiqmim, Israel; (2)1982 T. E. Levy / C. Grigson; (3) Israel Antiquities Authority, Shiqmim; (4) mandible; (5) Grigson; (6) 4th millennium (Grigson 1987; Levy 1987).
OxA-135 210 ± 150; 1459-1950 AD

Results <1987. Hedges *et al*.(1987). Archaeometry 2 datelist 6. *Archaeometry* 29(2), 289-306.

CB1 Mostagedda Cave C, Egypt; (2) 1928 G. Brunton; (3) Natural History Museum London, Mammal Section, 84.524; (4) metatarsal condyle; (5) J. Clutton-Brock; (6) Predynastic (Brunton 1937).
OxA-964 2680 ± 160; 1259-407 CAL BC

CB2 Sihi 217/10, Saudi Arabia; (2) c1983 J. Zarins; (3) ?; (4) mandible fragment, burnt; (5) J. Clutton-Brock; (6) c2000 bc (Zarins *et al*.1981; Zarins & Al Zahrani 1985; Zarins & Al-Badr 1986; Grigson *et al*.1989; Grigson *et al*.2012).
OxA-983 8200 ± 200; 7587-6659 CAL BC

CB3 Jericho Tell, Palestine; (2) 1952-58 K. Kenyon; (3) Natural History Museum London, Mammal Section, 1974.6254; (4) metapodial, distal; (5) J. Clutton-Brock; (6) Middle Bronze (Clutton-Brock 1979; Kenyon & Holland 1983).
OxA-965 4850 ± 160; 4037-3121 CAL BC

CB4 Tell Nebi Mend Trench V, Syria; (2) c1978 P. Parr; (3) University College London Institute of Archaeology, TNM V 4170.; (4) lunate; (5) Grigson; (6) Late Bronze/Early Iron (Grigson in prep.).
OxA-966 2080 ± 80; 359 CAL BC-71 CAL AD

CB5 Tell Nebi Mend (no locus), Syria; (2) c1978 P. Parr; (3) University College London Institute of Archaeology, TNM 0; (4) humerus, dist; (5) Grigson; (6) Late Bronze/Early Iron (Grigson in prep.).
OxA-967 2220 ± 90; 506-5 CAL BC

CB6 Tell el-Duweir (Lachish III), Israel; (2) 1932-38 O. Tufnell; (3) Natural History Museum London, Mammal Section; (4) metacarpal; (5) J. Clutton-Brock; (6) Iron Age (Bate 1953).
insufficent material

CB7 Jebel Nakhsh JN/1, Qatar; (2) 1983 P. Andrews; (3) Natural History Museum London, Palaeontology Department; (4) mandible fragment; (5) Andrews; (6) Early Holocene (Andrews pers.comm.).
OxA-1000 580 ± 200; 1016-1952 CAL AD

CB8 Ain el Assad, Jordan; (2) 1983? G. Rollefson; (3) Field Museum Chicago, PM 48217; (4) metatarsal, distal; (5) Turnbull; (6) Prepottery Neolithic (Rollefson 1980).
insufficent material

CB9 Hummal (El Kowm), Syria; (2) 1980 F. Hours / L. Copeland; (3) ?; (4) metapodial fragment; (5) J. Clutton-Brock; (6) Middle/Upper Palaeolithic (Hours 1982; Clutton-Brock pers. comm.; Le Tensorer *et al*. 2007).
collagen too low

CB10 Farah II, Israel; (2) 1978 Gilead; (3) Hebrew University, Farah 612; (4) tibia, shaft; (5) C. Grigson; (6) Middle Palaeolithic (Grigson 1983; Gilead & Grigson 1984).
collagen too low

CB11 Azraq C-Spring, Jordan; (2) 1950s J. Waechter; (3) Natural History Museum London Palaeontology Dept., M 26962; (4) metapodial, fragment; (5) J. Clutton-Brock; (6) Middle Palaeolithic (Clutton-Brock 1970 and pers. comm).
OxA-961 >3340 ± 200; >2198-1129 BC

CB12 Tabun C, Israel; (2) 1929-34 D. Garrod; (3) Natural History Museum London Palaeontology Dept., M 42604; (4) metapodial, dist; (5) S. Payne; (6) Middle Palaeolithic (Bate 1937; Payne & Garrard 1983).
OxA-962 1060 ± 70; 780-1154 AD

CB13 Mugharet-el-Emireh, Israel; (2) 1925 F. Turville-Petre; (3) Natural History Museum London Palaeontology Dept., M 16858; (4) Upper premolar; (5) S. Payne; (6) Middle/Upper Pal trans (Bate 1927).
OxA-963 3060 ± 120; 1608-979 CAL BC

Results <1990 unpublished; except for CB23 and CB26 (Bronk Ramsey, C., Higham, T. F. G., Brock, F., Baker, D., Ditchfield, P. & Staff, R. A. (2014). *Radiocarbon dates from the Oxford AMS System: Archaeometry Datelist* 35, 29-32. Published online: 10 November 2014. DOI: 10.1111/arcm.12134).

CB14 Maysar 6, Oman; (2) 1981, G. Weisgerber; (3) ?Tübingen; (4) proximal phalanx; (5) H.-P. Uerpmann; (6) Early Bronze Age (Uerpmann & Uerpman 2002; 2008; 2012).
collagen too low

CB15 Maysar 22 (grave), Oman; (2) 1980, G. Weisgerber; (3) ?Tübingen; (4) astragalus; (5) H.-P. Uerpmann; (6) Bronze or Iron Age (Uerpmann & Uerpmann 2002).
no collagen

CB16 Umm an-Nar, Abu Dhabi; (2) 1983, W. Y. al-Tikriti / E. Hoch; (3) ?Tübingen; (4) scapula; (5) H.-P. Uerpmann; (6) Early Bronze Age (Hoch 1979; Uerpmann & Uerpmann 2002, 2008, 2012; Al-Tikriti 1985; Frifelt 1991, 1995; Beech *et al*.2009).
no collagen

CB17 Ra's Ghanada, Abu Dhabi; (2) 1983, W. Y. al-Tikriti; (3) ?Tübingen; (4) pisiform and scaphoid; (5) H.-P. Uerpmann; (6) Bronze Age (Uerpmann & Uerpmann 2002; Al-Tikriti 1985).
no collagen

CB18 Bat, Oman; (2) 1986, K. Frifelt; (3) ?Tübingen; (4) long bone splinters; (5) H.-P. Uerpmann; (6) Iron Age (Frifelt 1985; Brunswig 1989).
no collagen

CB19 Hili 8, Abu Dhabi; (2) 1983, S. Cleuziou; (3) ?Tübingen; (4) proximal phalanx; (5) H.-P. Uerpmann; (6) Bronze Age (Uerpmann & Uerpmann 2002, 2012; Cleuziou 1980).
collagen too low

CB20 Madamagh, Jordan; (2) 1983, H.-P. Uerpmann; (3) ?Tübingen; (4) distal phalanx; (5) H.-P. Uerpmann; (6) Upper/Epi-palaeolithic (Schyle & Uerpmann 1988; Uerpmann 1996).
no collagen

CB21 Gilf Kebir, Egypt; (2) 1980, H.-J. Pachur; (3) ?Tübingen; (4) astragalus and calcaneum; (5) H.-P. Uerpmann; (6) Neolithic? (Kuper 1989; Schön 1989; Van Neer & Uerpmann 1989; no mention of camel).
no collagen

CB22 Laqiya Area, northern Sudan; (2) ?1980, R. Kuper; (3) ?Tübingen; (4) lunate; (5) H.-P. Uerpmann; (6) ? (Kuper 1981, 1989; Van Neer and Uerpmann 1989; no mention of camel).
collagen too low

CB23 Sabya Qadim 217/177, Saudi Arabia; (2) 1984, J. Zarins; (3) ?; (4) mandible, burnt; (5) Clutton-Brock; (6) 'Tihama Neolithic' (Zarins pers. comm.; Grigson *et al*.2012).
OxA-2163 2110 ± 80; 370 CAL BC - 48 CAL AD

CB24 Tell Arad, Israel; (2) ?date, Y. Aharoni / R.Amiran; (3) Israel Antiquities Authority; (4) 2 phalanges; (5) L. K. Horwitz; Bronze Age (Lernau 1978; Amiran 1978).
not accepted

CB25 Ben Tal Cave C, Israel; (2) 1986, Goren; (3) Israel Antiquities Authority; (4) metapodial distal condyle; (5) L. K. Horwitz; (6) -.
not accepted

CB26 Sihi 217/10 (another), Saudi Arabia; (2) c1983, J. Zarins; (3) ?; (4) maxilla fragment, burnt; (5) J. Clutton-Brock; (6) 6250±200 bc (Zarins *et al*.1981; Zarins & Al Zahrani 1985; Zarins & Al-Badr 1986; Grigson *et al*.2012).
OxA-2164 1500 ± 80; 397-665 CAL AD

Results <1992. Bronk Ramsey, C., Higham, T. F. G., Brock, F., Baker, D., Ditchfield, P. & Staff, R. A. (2014). *Radiocarbon dates from the Oxford AMS System: Archaeometry Datelist* 35, 29-32. Published online: 10 November 2014. DOI: 10.1111/arcm.12134.

CB27 Timna Site 30, Israel; (2) 1974-76, Rothenberg; (3) Israel Antiquities Authority, Timna Cam 1; (4) proximal phalanx, partially burnt; (5) Grigson; (6) 1400-1200 BC (Grigson 2012; Rothenberg 1980).
OxA-2165 2650 ± 90; 1023-516 CAL BC

CB2/2 Sihi 217/10 (repeat), Saudi Arabia; (2) c1983, J. Zarins; (3) ?; (4) mandible fragment, burnt; (5) Clutton-Brock; (6) (Zarins *et al*.1981; Zarins & Al Zahrani 1985; Zarins & Al-Badr 1986; Grigson *et al*.1989).
OxA-3795 1535 ± 60; 412-640 CAL AD

CB26/2 Sihi 217/10 (repeat), Saudi Arabia; (2) c1983, J. Zarins; (3) ?; (4) maxilla fragment, burnt; (5) Clutton-Brock; (6) (Zarins *et al*.1981; Zarins & Al Zahrani 1985; Zarins & Al-Badr 1986; Grigson *et al*.1989).
OxA-3796 1685 ± 60; 230-535 CAL AD