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Synchronising Middle Bronze Age Jordan With Egypt Using Radiocarbon Data

Introduction

The historical framework and basis for absolute dating in the southern Levant during the Bronze Age is still the Egyptian historical chronology (Beckerath 1997; Kitchen 2000; Hornung, Krauss and Warburton 2006; Krauss and Warburton 2009). The relative chronological terminology (Early, Middle and Late Bronze Ages with various sub-phases) can be linked via archaeological synchronisms or textual sources with Egypt. It can thus be incorporated into the political chronology of Egypt, which in turn provides absolute dates for archaeological contexts, settlement layers or strata of various sites of the southern Levant.

However, material exchange and written sources are not evenly distributed through space and time. While there is a lot of data, both archaeological and textual — e.g. the Egyptian presence at certain key sites of Late Bronze Age Palestine with enough Egyptian imports for archaeological synchronisation like Tell el-Ajjul (Gaza), or textual sources which have been used to synchronise Levantine destruction horizons with certain campaigns of Egyptian kings (e.g. the destruction of Megiddo by Thutmose III) — for other periods and regions adequate archaeological and textual sources may be lacking, although we know that a certain level of contact had been established (e.g. the Early and Middle Bronze Age Jordan Valley). Nevertheless, a precise knowledge of space and time is necessary in order to understand human behaviour; correctly synchronised chronologies are therefore a prerequisite for any historical research.

Radiocarbon dating has been extensively used for earlier periods, i.e. Chalcolithic and Early Bronze Age, during which minimal archaeological exchange took place between Egypt and the southern Levant. There is not as much data for later periods, i.e. Middle and Late Bronze Ages, and radiocarbon dates are usually compared to current absolute date estimations, using a high, middle or low chronology, or are directly compared with the Egyptian historical chronology, which is itself an interpretation based on texts, king-lists and / or astronomical observations. However, radiocarbon dating together with a Bayesian probability approach is a powerful tool for providing the basis of absolute dating and inter-regional synchronisation.

In what follows, the beginning of the Middle Bronze Age east of the Jordan river as represented by published radiocarbon dates from Pella and Tall al-Ḥayyāt is discussed in order to demonstrate the capability of this method and its potential impact on historical and archaeological research. Calibration was done using OxCal 4.1 and the internationally recommended calibration curve IntCal09 (Bronk Ramsey 1994, 1995, 2001, 2009; Reimer *et al.* 2009).

Pella, Tall al-Ḥayyāt and the Beginning of the Middle Bronze Age

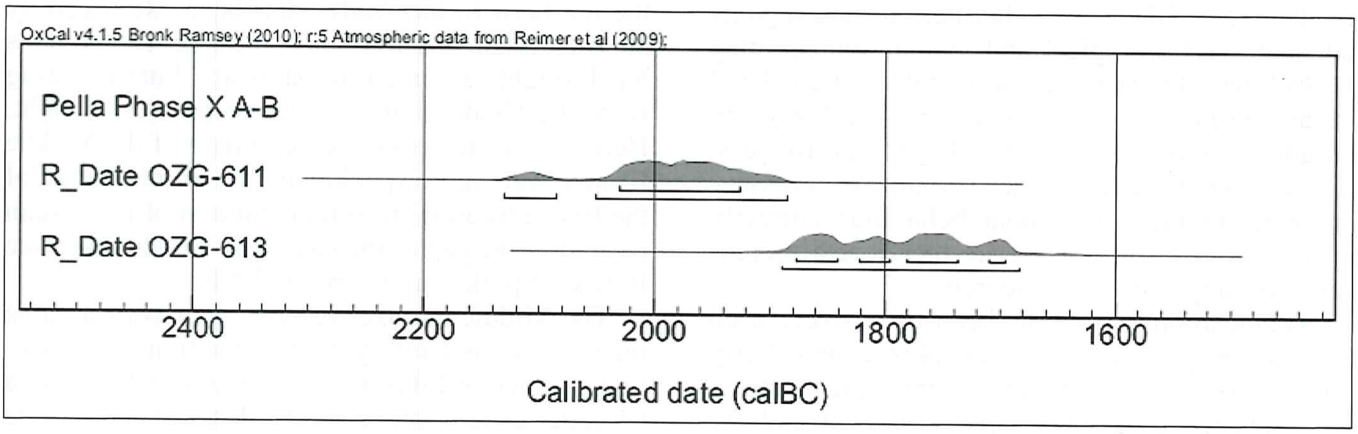
The site of ancient Pella, modern Ṭabaqat Faḥl in the northern Jordan Valley, has been excavated by an Australian mission since the late 1960s. This has brought settlement remains and burials dating from the Chalcolithic to Islamic periods to light. Here we will focus on the beginning of the Middle Bronze Age, more specifically the absolute date of the first substantial re-settlement east of the Jordan river after the gap of the late Early Bronze Age (see Bourke, Sparks and Schroder 2006).

The Middle Bronze Age city is of considerable importance, as the Egyptian execration texts mention a prince of Pihilum (Pella) named ᶜApiru-ᶜanu (Posener execration text E 8; Posener and van de Walle 1940: 68). It has been suggested that this refers to the MB I city represented in Area III (East Cut) Phase X (Bourke, Sparks and Schroder 2006: 9). However, due to limited archaeological exchange between the northern Jordan valley and Egypt during this period, an archaeological synchronisation is difficult, if not impossible. Phase XB and A of Pella are associated with the construction of a monumental city wall consisting of a mud-brick superstructure on a stone foundation and represent the earliest Middle Bronze Age remains in Area III. The ceramic material shows parallels with the "Palace" and "post-Palace" phases at Aphek and Phases XIII and XII at Megiddo, placing Pella Phase XB and A in the latter half of the MB I period (Bourke, Sparks and Schroder 2006: 16-21; Fischer 2006: 227). Based on these ceramic parallels, Bourke, Sparks and Schroder (2006) have suggested a date in the 19th century BC for the beginning of the Middle Bronze Age settlement at Pella. More explicitly, Fischer (2006: 238) suggested a date around the middle of the 12th dynasty in Egypt.

Until now only two radiocarbon dates from MB I contexts at Pella have been published. These are from Area XXXII and are regarded as being contemporary with Area III (East Cut) Phase XB and A (OZG-611 from Locus 6514 and OZG-613 from Locus 2503; Bourke 2006: 243, Table 1). Calibrated age ranges for OZG-611 falls between 2031 and 1927 at 1σ (68.2 % probability) and between 2131 and 2086 or 2052 and 1886 at 2σ (9.9 % and 85.5 % probability respectively), while OZG-613 seems to be considerably younger with dates falling between 1877 and 1696 (with four distinct peaks) at 1σ (68.2 % probability) and between 1890 and 1684 at 2σ (95.4 % probability) (FIG. 1).

Owing to the shape of the calibration curve, calibrated age ranges for these samples cover more than 200 years on the time-line and are therefore not of much help with regard to chronological investigations. Moreover, it seems that these two samples do not represent the same point in time, as OZG-613 is considerably younger than OZG-611 with barely any overlap. Unfortunately, the respective materials of these two samples are not stated in the publication. It is still unclear whether or not these observations might be explained by one short-lived sample (e.g. seed) and one older sample (e.g. inner rings of a tree). For our purposes, *viz.* to date the beginning of the Middle Bronze Age settlement east of the Jordan river as accurately as possible, these two dates are of no further use.

However, a few miles west of ancient Pella, the remains of the Middle Bronze Age rural settlement of Tall al-Ḥayyāt provide sufficient evidence for more precise dating (Falconer and Fall 2006). The excavators discovered part of a temple and domestic architecture with six settlement phases dating from the end of the Early Bronze Age to the end of the Middle Bronze Age (EB IV-MB IIC). While Phase 6 was dated to EB IV and was represented only by pottery and chipped stone with a total absence of architecture, the earliest Middle Bronze Age remains date to Phase 5, when a mud-brick shrine was constructed. This was successively enlarged during Phases 4 to 2; Phase 1 was only represented by domestic architecture. Phase 5 was considered broadly contemporary with or slightly earlier than the earliest Middle Bronze Age settlement in Pella Area III (East Cut) Phase XB and A. The excavators dated the beginning of Phase 5 to around 2000 and the beginning of Phase 4 to around 1900 BC (Falconer and Berelov in Falconer and Fall 2006: 62-63).

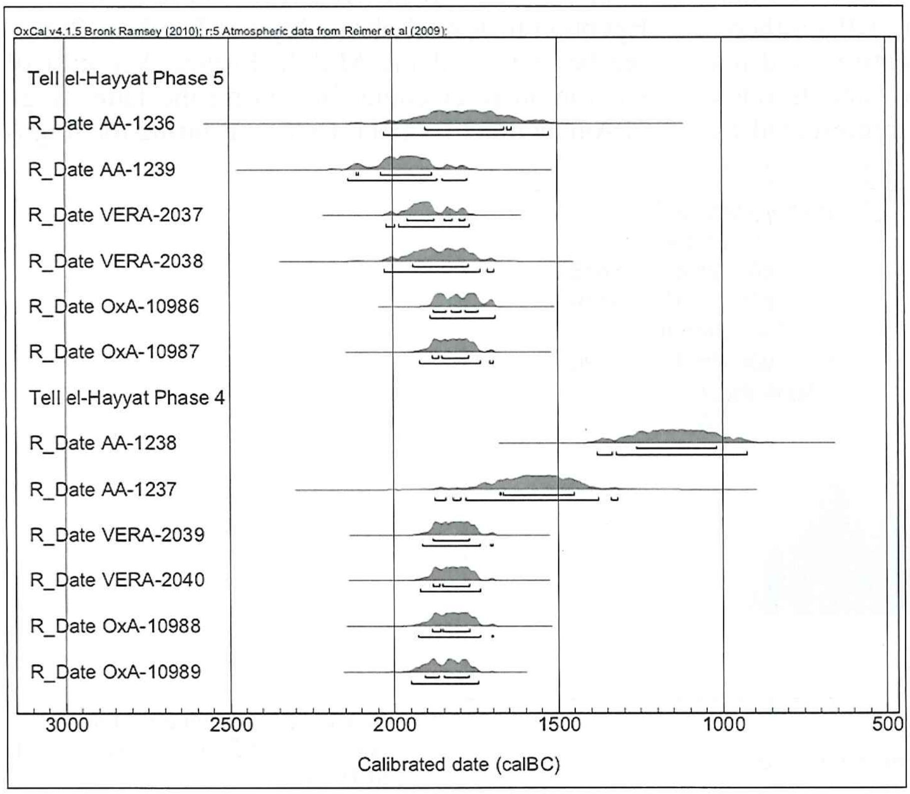


1. Calibrated radiocarbon dates for phases X B-A of Pella.

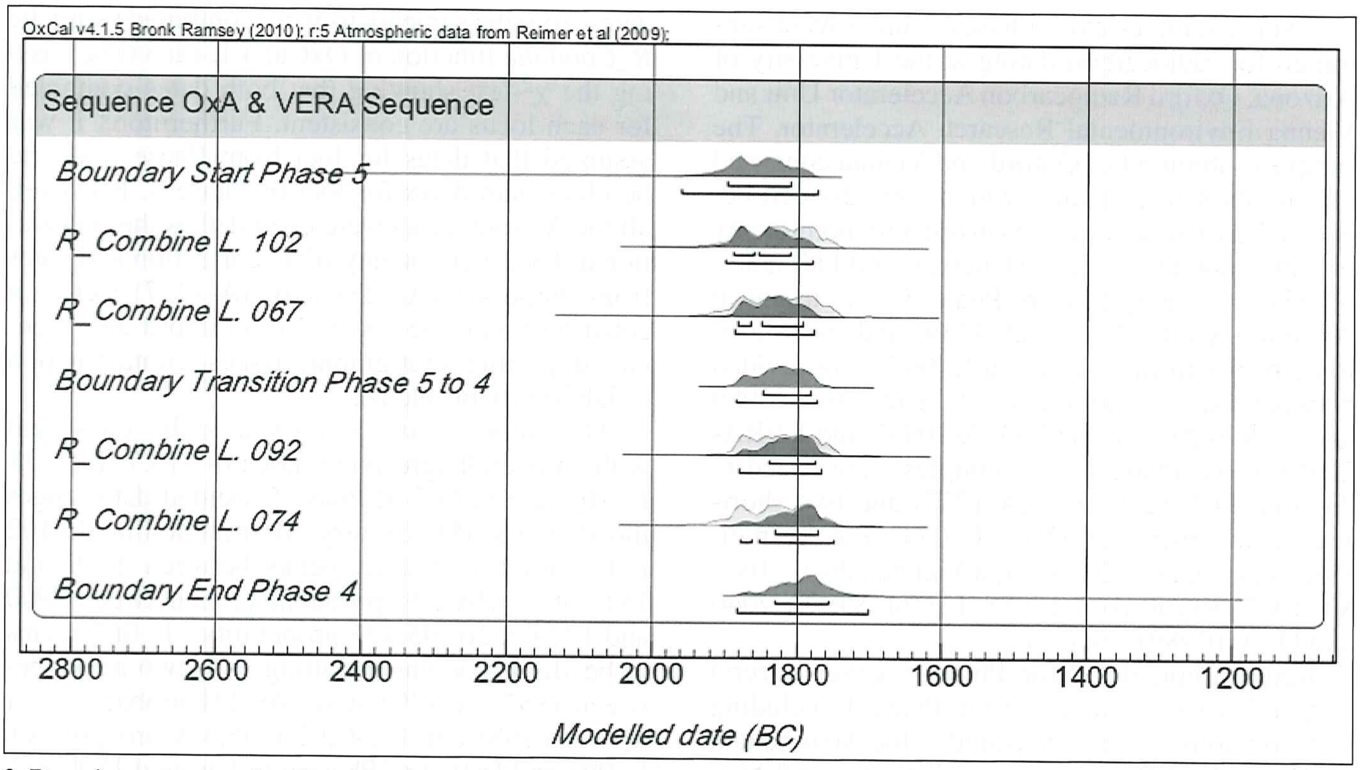
Twelve samples from Phases 5 and 4 were submitted for radiocarbon dating at the University of Arizona, Oxford Radiocarbon Accelerator Unit and Vienna Environmental Research Accelerator. The samples submitted to Oxford and Vienna consisted of four short-lived plants, which were divided between these two laboratories in order to monitor any possible laboratory offset (Falconer and Fall 2006: 62-63). Two samples from Phase 5 were tested in Arizona (AA-1236 and AA-1239) and two short-lived plants from L. 102 and L. 067 were divided between Oxford and Vienna (L. 102: OxA-10986 and VERA-2037; L. 067: OxA-10987 and VERA-2038). From Phase 4, two samples were tested in Arizona (AA-1238 and AA-1237) and two short-lived plants from L. 092 and L. 074 were again divided between the Oxford and Vienna labs (L. 092: VERA-2039 and OxA-10988; L. 074: VERA-2040 and OxA-10989) (FIG. 2).

Radiocarbon dates for Phase 5 cover several hundred years, as do dates from Phase 4, including some obvious outliers measured in the Arizona lab. In this study, a Bayesian probability approach was used in order to gain more precise dates (for the Bayesian method see Steier and Rom 2000; Weninger *et al.* 2006; Bronk Ramsey 2009). Since the results from Oxford and Vienna proved consistent, dates from the same locus were combined using the *R_Combine* function of OxCal 4.1, each time passing the χ^2-test showing that both dates combined for each locus are consistent. Furthermore, it was assumed that dates for loci from Phase 5 should be older than dates for loci of Phase 4. However, all the Arizona dates were excluded as the publication did not mention any σ^{13}C-correction and dates from Phase 4 (AA-1238 and AA-1237) were not consistent with the results from Oxford and Vienna, suggesting stratigraphic issues, contamination or laboratory problems.

This short sequence proved to be consistent with an overall agreement index of 118.7 (FIG. 3). L. 102 and L. 067 of Phase 5 yielded date ranges mostly in the 19th century. After modelling, L. 102 falls with two distinct peaks between 1889 and 1811 at 1σ (68.2 % probability) or between 1900 and 1779 at 2σ (95.4 % probability). L. 067 seems to be slightly younger, falling with two peaks between 1882 and 1793 at 1σ (68.2 % probability) or between 1888 and 1779 at 2σ (95.4 % probability). L. 092 and L. 074 of Phase 4 fall around 1800 BC. After modelling, L. 092 falls between 1839 and 1777 at 1σ (68.2 % probability) or between 1880 and 1766 at 2σ (95.4 % probability). L. 074 falls between 1830 and 1771 at 1σ (68.2 % probability)



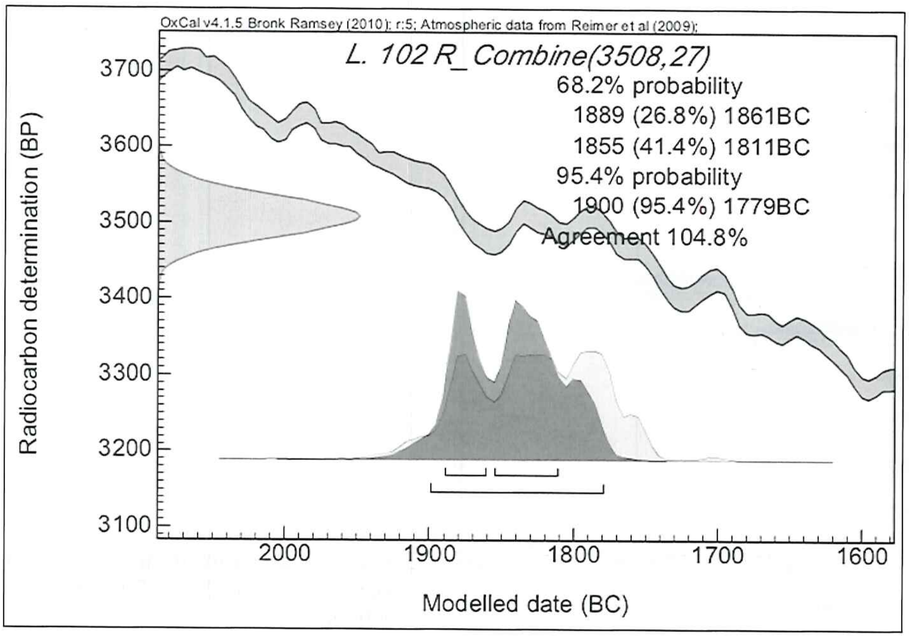
2. Calibrated radiocarbon dates for phases V and IV of Tall Abū al-Kharaz



3. Bayesian sequence of radiocarbon data and respective transitions (boundaries) for phases 5 and 4 of Tall al-Ḥayyāt.

or with two distinct peaks between 1877 and 1751 at 2σ (95.4 % probability).

The earliest possible date for Phase 5 at Tall al-Ḥayyāt and therefore also for the earliest substantial Middle Bronze Age settlement at Pella therefore lies somewhere in the 19th century (and not around 2000 as stated by Falconer and Berelov (Falconer & Fall 2006: 62–63), as represented by L. 102 from Phase 5 (FIG. 4). Is it possible to get a more precise date in terms of Egyptian chronology? If we compare the time span from 1889 to 1811 (1σ-range for L. 102 from Phase 5) with the Egyptian historical chronology of Kitchen (2000), the beginning of the Middle Bronze Age east of the Jordan river could fall during the latter reign of Amenemhet II (1911-1876), or during the reigns



4. Sequenced combined radiocarbon data for L. 102 from phase 5 of Tall al-Ḥayyāt.

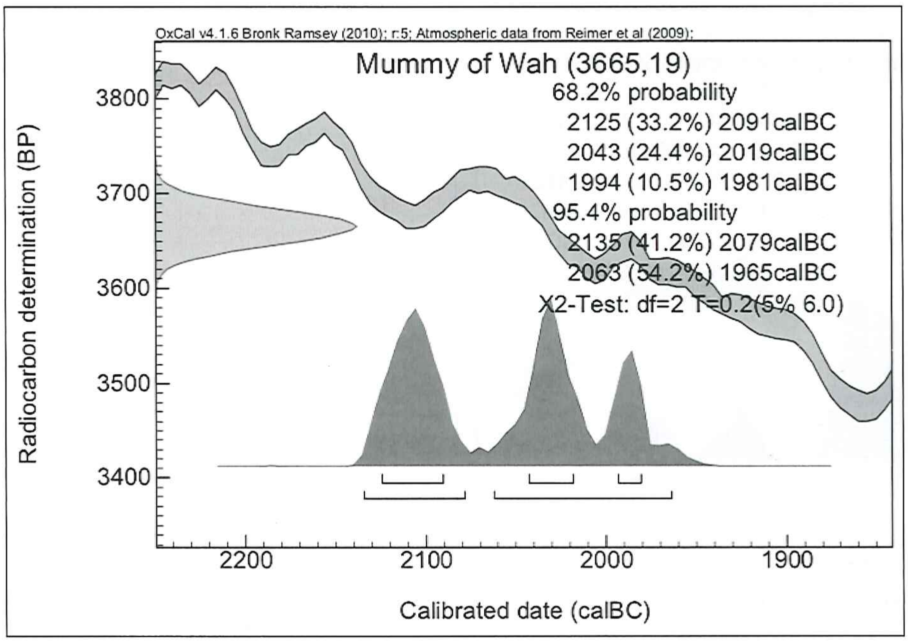
of Senwosret II (1878-1872), Senwosret III 1872-1853) or Amenemhet III. However, based on the low chronology of Hornung, Krauss and Warburton (2006), this date range would also include part of the reign of Senwosret I in the early 12th dynasty, but would make Amenemhet III nearly impossible.

Despite the problem that one has to pick one chronology and exclude another, all historical chronologies of Egypt are based on interpretations of texts and other written sources, and are therefore subject to many possible errors. Furthermore, one should try not to mix chronological methodologies. In the following discussion we will compare our date for the older context of Phase 5 (L. 102) with selected radiocarbon data from Egypt, *viz.* (1) data from the mummy of Wah from the late First Intermediate Period or very early Middle Kingdom, (2) short-lived samples from the pyramid of Senwosret II and (3) data from the radiocarbon model for Egyptian chronology established by Bronk Ramsey and Dee.

The data from the mummy of Wah were published by Cockitt and David (2007). Wah was an official of Meket-Re, a high ranking magistrate during the late First Intermediate Period or early 12th dynasty. Linen strips found in his tomb in western Thebes bear the marking "Year 5" and "Year 6" of an unknown king, possibly Mentuhotep III Seankhkare (Winlock 1940: 258). However, Arnold (1991) dated this tomb to the time of Amenemhet I, first king of the 12th dynasty, some twenty years later. There are several reasons that make such a date unlikely, including the following radiocarbon data (see also Höflmayer 2010: 322-324). Three samples from the mummy itself (parts of the brain and skin) were submitted to Oxford for radiocarbon dating. Since all three samples represent the same point in time (the death of Wah), these samples were combined using the *R_Combine* function of OxCal 4.1. The combined dates are consistent and come down to three peaks at 1σ, *viz.* 2125-2091 (33.2 % probability), 2043-2019 (24.4 % probability) and 1994-1981 (10.5 % probability), or two possible age ranges at 2σ, *viz.* 2135-2079 (41.2 % probability) or 2063 - 1965 (54.2 % probability) (see FIG. 5).

The fifth year of Mentuhotep III should fall *ca.* 1990 according to Beckerath (1997) and Kitchen (2000), or *ca.* 1953 according to Hornung, Krauss and Warburton (2006). At 1σ, the last peak (1994-1981) is in good agreement with the historical chronology of von Beckerath and Kitchen, whereas the date of *ca.* 1953 is well outside the 2σ-margin for the mummy of Wah. Therefore we accept the youngest peak of the 1σ-margin as the correct one.

Our second comparison comes from the pyramid of Senwosret II. Short-lived samples were tested at the Eidgenössische Technische Hochschule, Zürich and Desert Research Institute, Nevada (Bonani *et al.* 2001). Samples which came from freshly fallen bricks were excluded in the present study to avoid any possible contamination (DRI-2947, ETH-13924, DRI-2971). However, two other dates from



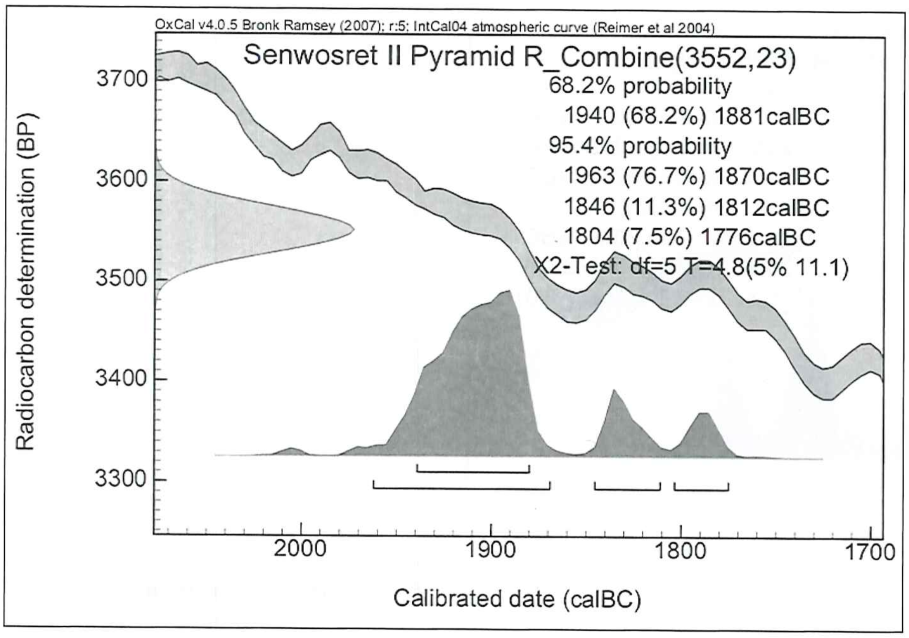
5. Combined radiocarbon data for the mummy of Wah.

a twig and palm wood fragment were included (ETH-13928 and ETH-13932). Altogether six samples were combined using the *R_Combine* function of OxCal 4.1, giving a date between 1940 and 1881 at 1σ (68.2 % probability) or two possible age ranges at 2σ, *viz.* 1963-1870 (76.7 % probability), 1846-1812 (11.3 % probability) or 1804-1776 (7.5 % probability).

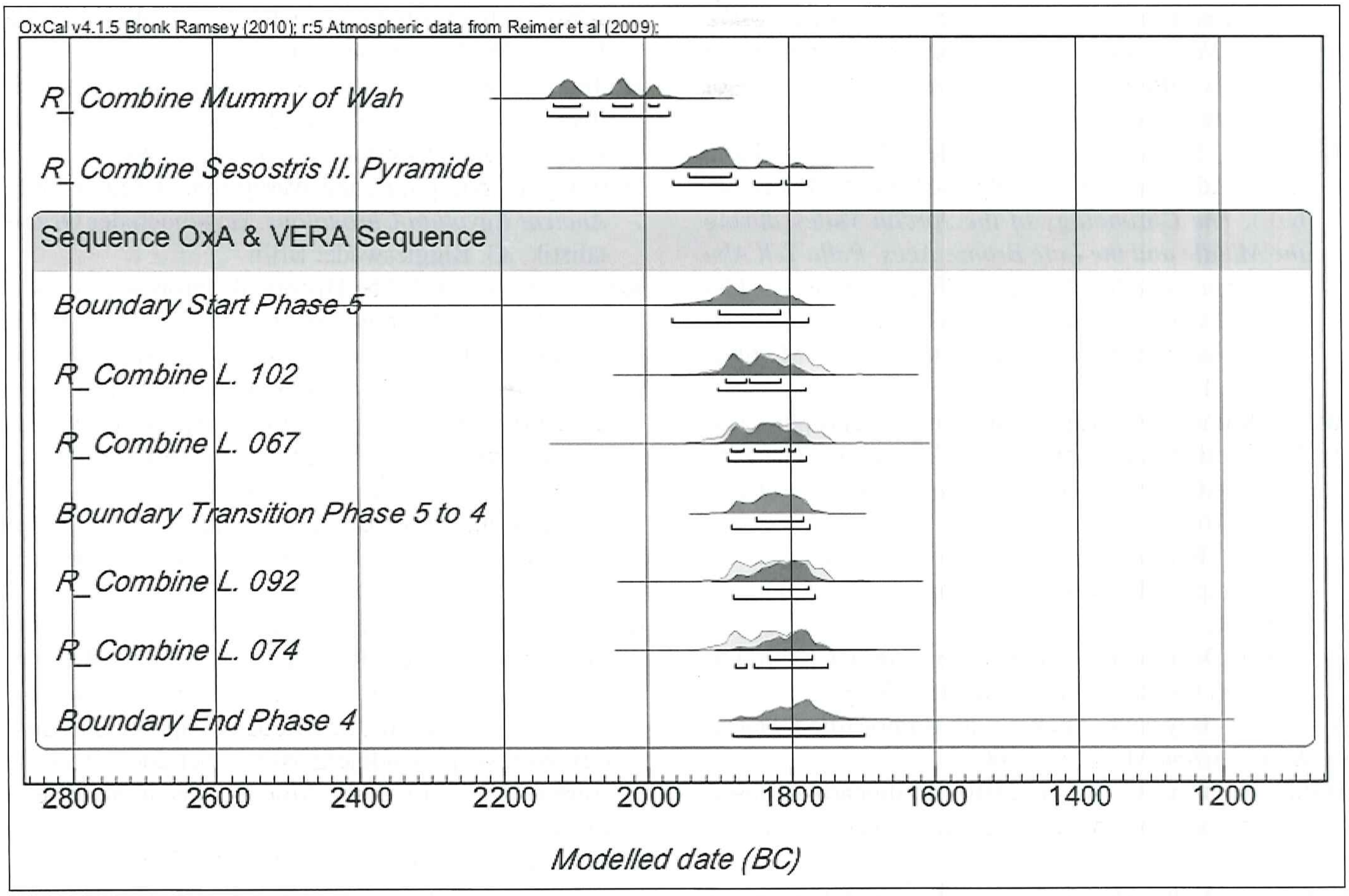
According to the Egyptian chronology of Kitchen (2000) and von Beckerath (1997), the dates for Senwosret II should fall between *ca.* 1882 and 1872, whereas Hornung, Krauss and Warburton (2006) argued for a date range between 1845 and 1837. Both date ranges are in agreement with at least the 2δ-ranges for the combined dates for the six samples from the pyramid of Senwosret II (FIG. 6). The dates of Kitchen and von Beckerath fall at the younger end of the first peak, whereas the second peak represents the dates proposed by Hornung, Krauss and Warburton. However, as the low chronology does not seem to be in agreement with the mummy of Wah, it is argued here that the first (large) peak represents the true date of the respective samples. Indeed, the low chronology is not compatible with Middle Kingdom radiocarbon dates from the Oxford-based project on Egyptian chronology and radiocarbon dating directed by Bronk Ramsey (see Bronk Ramsey *et al.* 2010).

If we compare the date for the mummy of Wah and the date for the pyramid of Senwosret II with L. 102 from Tall al-Ḥayyāt Phase 5 (FIG. 7), it is clear that the beginning of the Middle Bronze Age east of the Jordan river falls after the late first Intermediate Period or early Middle Kingdom as represented by the mummy of Wah. Hence, a date for the earliest substantial settlement of the Middle Bronze Age east of the Jordan during the 12th dynasty seems assured. Having said that, there is barely any overlap between the large peak at the pyramid of Senwosret II and L. 102 of Tall al-Ḥayyāt (the peak for Senwosret II ends at 1870 and that of L. 102 starts at 1900, both at the very ends of the 2σ-ranges), making a date for the beginning of Middle Bronze Age settlement east of the Jordan in the time of Senwosret II or later highly probable, seemingly ruling out the times of Senwosret I and Amenemhat II.

More important is the comparison with data from the Oxford-based project "Radiocarbon dating and the Egyptian chronology" (Bronk Ramsey *et al.* 2010). For this project, more than 200 new samples were tested. On the basis of the known succession of Egyptian kings and their reign lengths, a Bayesian model was created which resulted in radiocarbon-based calculations for the most likely accession dates of certain kings. According to these dates, three kings may be contemporary with the start of Phase 5 at Tall al-Ḥayyāt: Senwosret II, Senwosret III and Amenemhat III. Calculation of the most probable dates for these kings' accessions resulted in 1890-1868 for Senwosret II, 1884-1860 for Senwosret III and 1844-1820 for Amenemhat III (each at 1σ, which is in perfect agreement with the dates of the Egyptian historical chronology as



6. Combined radiocarbon data for pyramid of Senwosret II.



7. Radiocarbon data for the mummy of Wah and the pyramid of Senwosret II compared to the Bayesian sequence for phases 5 and 4 of Tall al-Ḥayyāt.

suggested by von Beckerath and Kitchen). This result is also in agreement with our conclusions, based on the comparison of Tall al-Ḥayyāt Phase 5 with short-lived samples from the pyramid of Senwosret II.

Conclusions and Perspectives

The only useful temporal reference system for eastern Mediterranean cultures during the Bronze Age remains the Egyptian historical chronology. However, radiocarbon dating has the potential to contribute to chronological questions and inter-regional chronological research. It is particularly useful for periods and regions with marginal exchange of material culture, as it can be used to check and refine date estimations based on archaeological evidence.

For the earliest substantial settlement of the Middle Bronze Age east of the Jordan river, represented by Phase XA - B at Pella and Phase 5 at Tall al-Ḥayyāt, radiocarbon data suggest that these most likely began post-1900 and not around 2000 as previously proposed. This would be contemporary with the reigns of Senwosret II, Senwosret III or Amenemhat III, i.e. the mid-12th dynasty in Egypt. This conclusion is based on comparisons of radiocarbon data alone, rather than interpretations of texts or archaeological exchange.

Bibliography

Arnold, D. 1991. Amenemhat I and the Early Twelfth Dynasty at Thebes. *Metropolitan Museum Journal*: 26: 5-48.

Beckerath, J. v., 1997. *Chronologie des pharaonischen Ägypten. Die Zeitbestimmung der ägyptischen Geschichte von der Vorzeit bis 332 v. Chr.* Mainz am Rhein: Philipp von Zabern. (Münchener ägyptologische Studien; 46).

Bonani, G. *et al.* 2001. Radiocarbon Dates of Old and Middle Kingdom Monuments in Egypt. *Radiocarbon* 43(3): 1297-1320.

Bourke, S. 2006. Pella and the Jordanian Middle and Late Bronze Ages. Response to Chapter IV. Pp. 243-256 in P. M. Fischer (ed.), *The Chronology of the Jordan Valley during the Middle and the Late Bronze*

Ages. Pella Tell Abu al-Kharaz and Tell Deir Alla. Wien: Verlag der Österreichischen Akademie der Wissenschaften (Contributions to the Chronology of the Eastern Mediterranean; 12).

Bourke, S., Sparks, R., and Schroder, M. 2006. Pella in the Middle Bronze Age. Pp. 9-58 in P. M. Fischer (ed.), *The Chronology of the Jordan Valley during the Middle and the Late Bronze Ages. Pella Tell Abu al-Kharaz and Tell Deir Alla.* Wien: Verlag der Österreichischen Akademie der Wissenschaften (Contributions to the Chronology of the Eastern Mediterranean; 12).

Bronk Ramsey, C. 1994. Analysis of Chronological Information and Radiocarbon Calibration: The Program OxCal. *Archaeological Computing Newsletter* 41: 11-16.

— 1995. Radiocarbon Calibration and Analysis of Stratigraphy: The OxCal Program. *Radiocarbon* 37: 425-430.

— 2001. Development of the Radiocarbon Calibration Program OxCal. *Radiocarbon* 43: 355-363.

— 2009. Bayesian Analysis of Radiocarbon Dates. *Radiocarbon* 51(1): 337-360.

Bronk Ramsey, C. *et al.* 2010. Radiocarbon-Based Chronology for Dynastic Egypt. *Science* 328: 1554-1557.

Cockitt, J. A. and David, A. R. 2007. The Radiocarbon Dating of Ancient Egyptian Mummies and Their Associated Artefacts: Implications for Egyptology. Pp. 43-43 in M. Cannata (ed.), *Current Research in Egyptology 2006. Proceedings of the Seventh Annual Symposium Which Took Place at the University of Oxford April 2006.* Oxford: Oxbow Books.

Falconer, S. E., and Fall, P. L. 2006. *Bronze Age Rural Ecology and Village Life at Tell el-Hayyat, Jordan.* Oxford: Archaeopress. (BAR International Series; 1586).

Fischer, P. M. 2006. The Essence of the Studies of Pella, Tell Abu al-Kharaz and Tell Deir 'Alla. Pp. 227-241 in P. M. Fischer (ed.), *The Chronology of the Jordan Valley during the Middle and the Late Bronze Ages. Pella Tell Abu al-Kharaz and Tell Deir Alla.* Wien: Verlag der Österreichischen Akademie der Wissenschaften (Contributions to the Chronology of the Eastern Mediterranean; 12).

Höflmayer, F. 2010. *Die Synchronisierung der minoischen Alt- und Neupalastzeit mit der ägyptischen Chronologie.* Dissertation. Universität Wien.

Hornung, E., Krauss, R. and Warburton, D. (eds.) 2006. *Ancient Egyptian Chronology.* Handbuch der Orientalistik, 83. Biggleswade: Brill.

Kitchen, K. A. 2000. The Historical Chronology of Ancient Egypt, a Current Assessment. Pp. 39-52. in M. Bietak, (ed.), *The synchronisation of civilisations in the Eastern Mediterranean in the second millennium B.C. Proceedings of an international symposium at Schloß Haindorf, 15th - 17th of November 1996 and at the Austrian Academy, Vienna, 11th - 12th of May 1998.* Wien: Verlag der Österreichischen Akademie der Wissenschaften (Contributions to the Chronology of the Eastern Mediterranean; 1).

Krauss, R., and Warburton, D. A. 2009. The basis for the Egyptian dates. Pp. 125-144 in D. A. Warburton (ed.), *Time's up! Dating the Minoan eruption of Santorini.* Acts of the Minoan Eruption Chronology Workshop, Sandbjerg, November 2007. Aarhus: Aarhus University Press (Monographs of the Danish Institute at Athens; 10).

Posener, G., and van de Walle, B. 1940. *Princes et pays d'Asie et de Nubie. Textes hiératiques sur des figurines d'envoutement du Moyen Empire ; suivis de remarques paléographiques sur les textes similaires de Berlin.* Bruxelles: Fondation Égyptologique Reine Élisabeth.

Reimer, P. J. *et al.* 2009. IntCal09 and Marine09 Radiocarbon Age Calibration Curves, 0-50,000 Years cal BP. *Radiocarbon* 51(4): 1111-1150.

Steier, P. and Rom, W. 2000. The Use of Bayesian Statistics for 14C Dates of Chronologically Ordered Samples: A Critical Analysis. *Radiocarbon* 42: 183-198.

Weninger, F. *et al.* 2006. The Principle of the Bayesian Method. *Ägypten & Levante* 16: 317-324.

Winlock, H. E. 1940. The Mummy of Wah Unwrapped. *The Metropolitan Museum of Art Bulletin* 35(12): 253-259.