PROTO-NEOLITHIC AND NEOLITHIC CULTURES IN THE MIDDLE EAST—THE BIRTH OF AGRICULTURE, LIVESTOCK RAISING, AND CERAMICS: A CALIBRATED ^{14}C CHRONOLOGY 12,500–5500 cal BC

O Aurenche[1] • P Galet[2] • E Régagnon-Caroline[1] • J Évin[2]

ABSTRACT. We present for the first time a fully calibrated radiocarbon chronology of Proto-Neolithic and Neolithic cultures in the Middle East covering the time range from 12,500 to 5500 cal BC. A total of 1300 ^{14}C dates were evaluated, leading to the selection of 731 reliable dates. These were calibrated in a special collective approach presented in a series of graphs. The ^{14}C dates are derived from 160 sites across the Middle East. The period with Proto-Neolithic cultures began around 12500 cal BC and lasted for more than 4000 years. The true Neolithic, with agriculture and livestock breeding, appeared just before 8000 cal BC, subsequently spreading across a wide area within just a few hundred years. Ceramics first occurred around 7000 cal BC. The Mesopotamian cultures that emerged around 6000 cal BC started the urban revolution.

INTRODUCTION

The first attempt based on radiocarbon data to challenge the chronology of the development of Proto-Neolithic and Neolithic cultures in the Middle East was published in 1987 (Aurenche et al. 1987). Initially, a theoretical calendar was developed, based on stratigraphic and archaeological information. This led to the establishment of the succession of cultures, i.e. a relative chronology presented in the *Atlas des Sites du Proche Orient* (ASPRO, Hours et al. 1994). Subsequently, this chronology was compared with the results of ^{14}C dating from the same sites. Such an approach is likely to produce elements of an absolute chronology.

Then, a total of 598 available dates were screened and only 317 were used, selected according to criteria of quality control. The available dates were evaluated on the basis of physical reliability, including the nature of the sample, treatment, and the quality of the laboratory. In addition, the archaeological reliability was also screened, including the nature of the context, and conditions of the excavation. The selection process is explained in Evin et al. (1990; see also van der Plicht and Bruins 2001).

Justification for another detailed evaluation 15 years later is obvious for several reasons. We now have twice as many dates for the above periods, which significantly improves the statistical validity of the individual cultures and stages. From the 1300 ^{14}C dates available, we selected 731 reliable dates (see Table 1). However, the principal reason is that with the further development of calibration curves all dates from the Proto-Neolithic and Neolithic cultures can now be calibrated. In the late 1980s the calibration curves only covered the younger periods in the above time range. Nowadays the whole sequence that includes the truly momentous developments of the beginning of agriculture and livestock breeding as well as the beginning of pottery making can be studied by calibrated ^{14}C dating.[3]

STATISTICAL PRESENTATION OF THE DATES

Besides the dramatic increase in the number of available ^{14}C dates, current computer technology has also led to a qualitative improvement of the way in which we can present the findings. It seemed

[1]UMR 5647-GREMMO, CNRS et Université Lumière-Lyon 2, Maison de l'Orient, 7 rue Raulin, 69007 Lyon, France. Email: olivier.aurenche@mom.fr.

[2]Laboratoire de Datation ^{14}C, Université Claude Bernard-Lyon 1, 43 Bd du 11 Novembre, 69100 Villeurbanne, France

[3]Text translated by Jan Onoszko. To view all the dates see the database on the website: http://carbon14.univ-lyon1.fr.

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opportune to profit from the capacity of computers to handle large amounts of data. If we want to verify the cultural succession in relation to a series of ^{14}C dates, it is imperative that we represent those dates in a single graph. In order to draw such a graph it was necessary to take into account the variable uncertainties that may affect our measurements. Thus, in order to "correct the inconvenience of having to make allowances for uncertainty" Gasco (1994) suggested weighting dates within each histogram to take into account their margins of error. The use of this weighting principle enabled us to add more dates to the graphs.

Table 1 Number of reliable dates available in 1986 and in 2000 for each period P1 to P9 (see also the figures). Periods 7–9 are not covered in this article.

	P1	P2	P3	P4	P5	P6	P7	P8	P9
1986	25	41	87	55	36	24	23	4	22
2000	88	128	172	116	67	49	36	49	26

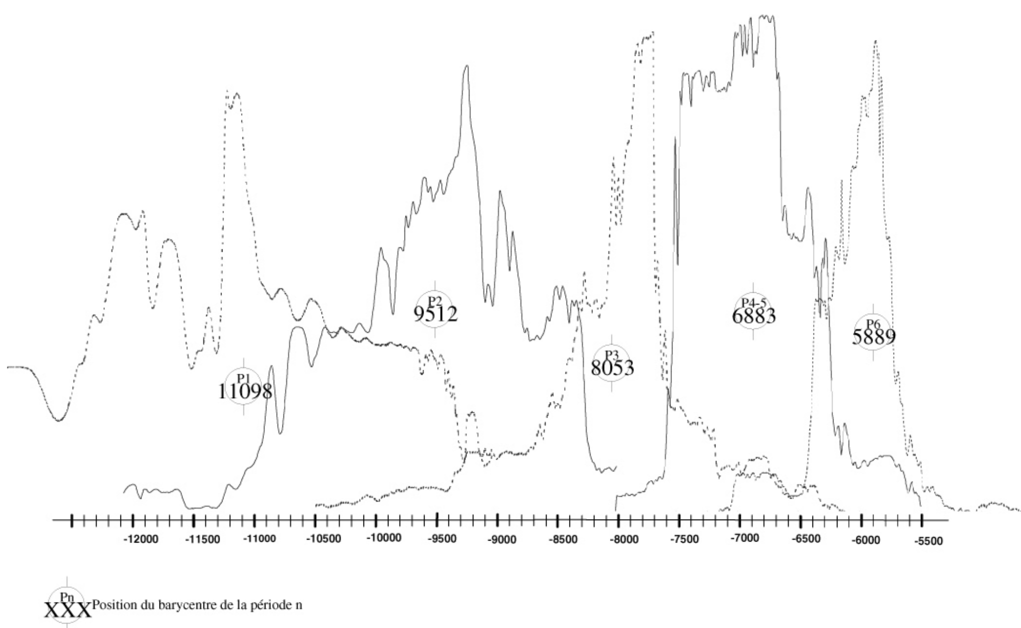

Figure 1 Cumulative curves of probability for calibrated dates in the first six periods of the ASPRO chronology Hours et al. 1994.

In our current study (Figure 1 above) we implemented the following methodology: 1) all dates deemed to be reliable are converted into sidereal years by a calibration program that uses the most up to date graphs drawn up in the field of dendrochronology (Stuiver et al. 1998), 2) each date, thus, generates a curve that is correct to 95% probability; the dates are summed in value files (a scale of 10 years was chosen to smooth out the shape of the data without visibly altering the form), 3) the sum of the values is calculated by computer to order and regroup the dates. The weight for each group of values is calculated, 4) the ability to read the final probability curve is aided by omitting the smaller weights and by the impression of the barycentre (point of application of the resultant of all the weights of a period,

$g = \frac{1}{n}\sum_{i=1}^{n} x_i$, named central point below).

This method of presenting large numbers of dates is considered valuable. Hence, this particular computer program is used for all calibrated dating of many dates for each period distinguished in this article. First, the graphical curve for each period is established. Subsequently, the series of dates coming from each site are represented in the form of horizontal lines (Figures 2–8). The normal lines indicate the 1 sigma (68% probability) range, whereas the dotted lines found at either side extend the range to 2 sigma (95% probability). Moreover, we checked that the main peaks of probability nearly always occurred within the 1 sigma range (normal lines). Dates with a margin of error of more than 2% of the measurement taken were eliminated.

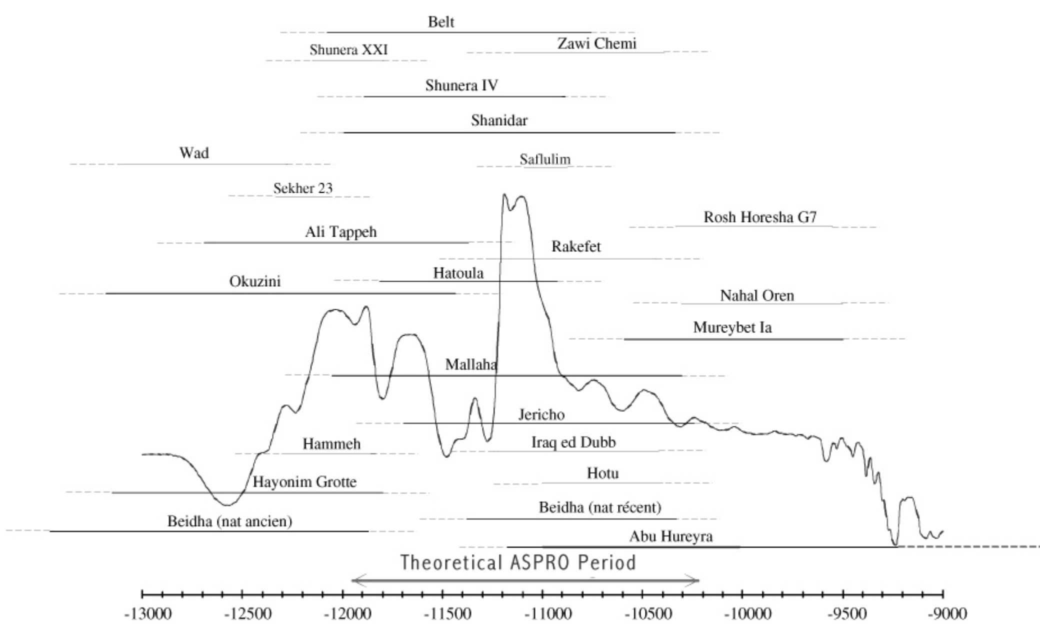

Figure 2 Cumulative curves of probability for Period 1 and the chronological position of the main sites

COMMENTARY ON THE RESULTS DRAWN FROM THE STATISTICS

Period 1 (Figure 2)

In sidereal years, this period begins about 12,500 cal BC and ends towards 9500 cal BC. The duration is, thus, longer than the imagined theoretical period. There are two noticeable peaks: the first one around 12,000 cal BC applies to the Ancient Natufian culture found in the Levant, as confirmed by the dates from Hammeh, Mallaha, Beidha, the Hayonim cave or El Wad. It is interesting to note that sites further east that belong to different cultures such as Belt (the Trialetian culture), Shanidar (the Zarzian culture) or Okuzini are also occupied during this period. Ali Tappeh, on the Caspian

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Sea, like Belt, present problems of methodology, because the results in the GX laboratory are given with a large statistical interval (350–450 years) that weakens their reliability. However, these dates are coherent with the stratigraphy and we notice that they are grouped in an interval that is compatible with dates found in other cultures that we can therefore consider as being contemporary.

The second peak, around 11,000 cal BC corresponds to the Recent Natufian culture where the majority of sites are found. The central point of the period is at around 11,098 cal BC. Rosh Horesha, Nahal Oren, Mureybet, and Abu Hureyra stand out as being of a somewhat later Natufian culture. The two sites on the Euphrates mark the northern boundary of the Natufian region. At Abu Hureyra though, most of the dates are clustered between 11,000 cal BC and 10,000 cal BC, a series of accelerated dates (OxA) would suggest occupation continued there until beyond 9500 cal BC. These could be indicative of a problem with the samples or the stratigraphy. At Mureybet, occupation would have taken place between 10,600 cal BC and 9600 cal BC.

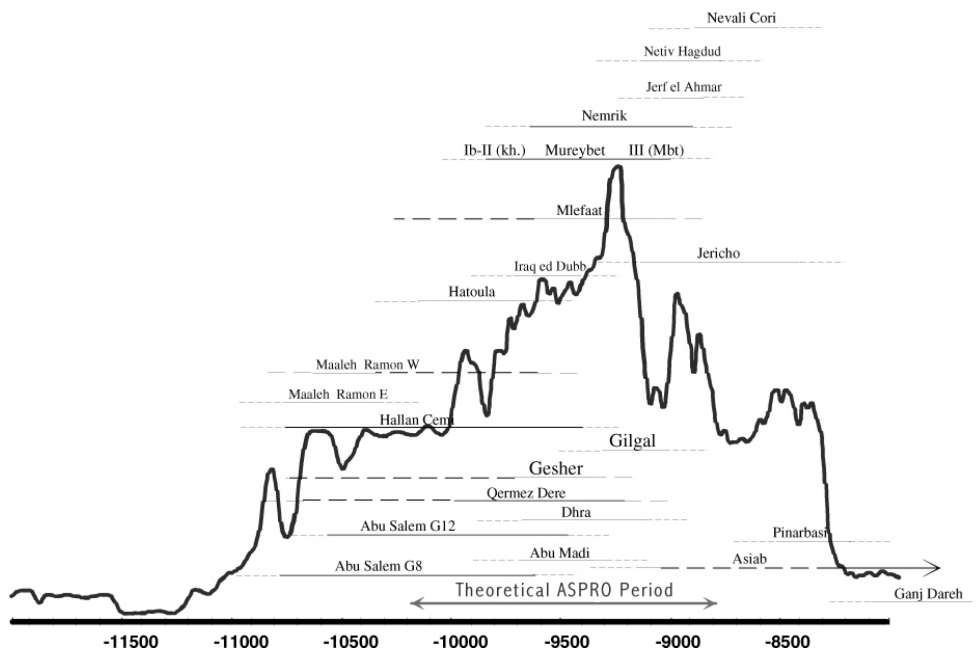

Figure 3 Cumulative curves of probability for Period 2 and the chronological position of the main sites

Period 2 (Figure 3)

As was also found for the previous period 1, the theoretical duration of Period 2 should be lengthened. Period 2 began about 10,500 cal BC and it lasted until at least 8300 cal BC. Thus, there was a large overlap with the end of the preceding Period 1, which is significant. However, the main peak of Period 2, about 9200 cal BC, falls squarely within the existing theoretical period and the central point is at 9512 cal BC. The dates highlight the succession of cultures very well: the Khiamian culture developed between 10,500 cal BC and 9800 cal BC, rather earlier than is usually acknowledged, as can be seen, for example, by Mureybet or Hatoula. This was followed by the Mureybetian culture (in the Northern Levant) and the Sultanian culture (in the Southern Levant), which lasted about 9800 cal BC to 8800 cal BC. These were evidently two contemporary cultures found at the same two sites,

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as well as at various other sites such as Gilgal, Gesher, Dhra, Netiv Hagdud, Iraq ed Dubb for the Sultanian culture, or Jerf el Ahmar for the Mureybetian culture.

The chronology of the phases of occupation at Mureybet can be subdivided in the following way: Phase Ia (Late Natufian culture, cf. Period 1 between 10,600 cal BC and 9600 cal BC) partly overlaps Phases Ib and II (Khiamian culture) around 10,000 cal BC to 9500 cal BC, and these precede the Phase III (Mureybetian culture) between 9500 cal BC and 8800 cal BC. The occupation of Jerf el Ahmar, about 9300–8900 cal BC corresponds well with the end of the Mureybetian era, which is confirmed by material elements of the culture.

Another interesting result of our investigation is the evidence that the occupation of Iraquian Djezireh and the higher valleys of the Tigris and the Euphrates (where the sites of Hallan Cemi, Qermez Dere, M'lefaat and Nemrik can be found) occurred at the same time as the occupation of the Levant, albeit with different cultures. Though less well documented than this latter region, Djezireh underwent an autonomous but parallel development. On the other hand, the occupation of the Anatolian plateau (Pinarbasi) and of Zagros (Asiab, with the exception of one isolated date which stratigraphically is much older, and Ganj Dareh) does not appear to happen until after 8500 cal BC.

Period 3 (Figure 4)

This period is a particularly crucial time, during which the true Neolithic, characterized by the revolutionary beginning of agriculture and livestock breeding, became established (Aurenche and Kozlowski 1999). This development was accomplished around 8000 cal BC during a phase that is called "middle PPNB" in the Levant. The central point for dates in this period is 8053 cal BC.

Three different groups of sites become apparent. The oldest belong to the Early PPNB[4], with the continued occupation of Mureybet (Phases IVa and b) between 9200 and 8000 cal BC, at Aswad (Phases Ib and II) between 9200 and 7600 cal BC, and also at Nemrik between 9200 and 7200 cal BC. Other sites are "new" and belong to the same cultural phase: that's the case for Horvat Galil in the southern Levant, Djaade, lower Cayonu, Nevali Cori, situated on the middle stretches of the Euphrates, and Gobekli in the northern Djezireh. These were occupied between 9200 and 8200 cal BC. The re-occupation of Okuzini appears to be contemporaneous. These dates partly overlap those of preceding cultures (cf. Period 2) and this lack of precision means we cannot put a more accurate date for the period of transition. Using the current data, the Early PPNB stretched from 9200 to 8300 cal BC.

However, it is certain that all sites clustered from 8400 to 8000 cal BC belong to the following phase, the Middle PPNB, and, in theory, were familiar with agriculture and livestock breeding. That was the case in the Levant and in the high valleys of the Tigris and the Euphrates, in Jericho, Beidha, Ain Ghazal, Abu Hureyra, Halula, Hemar, Cafer, Cayonu, Jilat 7 and 26, Reu'el, Yiftahel. During the same period the Neolithic also appeared to have reached the Anatolian plateau (Asikli) and Zagros (Ganj Dareh). The Middle PPNB can thus be dated from 8400 to 7500 cal BC.

The third group of sites was wrongly placed within this period using the ASPRO chronology (Hours et al. 1994). These sites are distinct in two ways[5]: 1) by the chronology of their occupation as shown by the table, and 2) by the fact that culturally they belong to the "Late PPNB". This is the case for Azraq 31, Basta, Jilat 13, Bezet. Logically, they ought to be transferred to Period 4. The areas of

[4]Their names can be seen in italics on the left hand side of Figure 4.
[5]Their names can be seen in italics on the right side of Figure 4.

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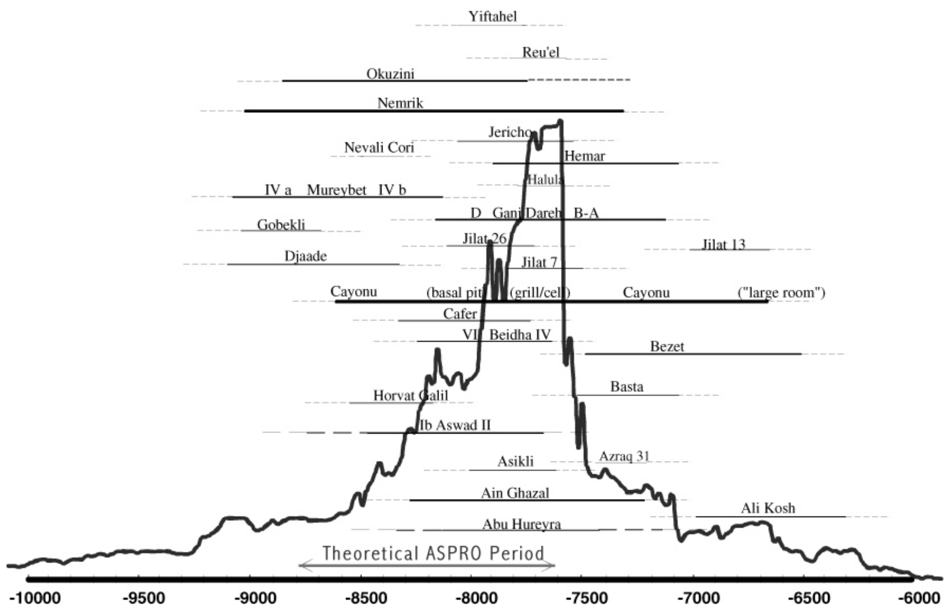

Figure 4 Cumulative curves of probability for Period 3 and the chronological position of the main sites

overlap would thus be shortened and the chronological sequence would regain its coherence. But for the provisional purposes of demonstration, they appear in both the graphs for Period 3 and Period 4.

The most important result to be gleaned from the chronology of Period 3 is the rather accurate dating of the beginning of the true Neolithic between 8300 and 8000 cal BC. Moreover, it can be concluded that within less than 500 years (by 7500 cal BC) the true Neolithic had begun to spread to the whole of the Middle East.

Periods 4 and 5 (Figures 5–7)

All the dates for Period 4 (Figure 5) are well grouped between 7600 and 6400 cal BC with a central point at 7069 cal BC. Thus, the theoretical length of the period may initially be extended by 500 years. This period corresponds to the integration of Neolithic culture throughout the entire region. It includes the first occupation of lower Mesopotamia (Ali Kosh), as well as confirmation of occupation in Zagros (Jarmo) and on the Anatolian plateau (Catal, Can Hasan III, Suberde). In the Levant this phase is traditionally termed the Late PPNB, i.e. a Neolithic phase without ceramics. The latter criterion was adopted by ASPRO (Hours et al. 1994) to attribute sites to this period.

However, it has now become apparent that, in certain areas, ceramics appeared much *earlier* than we first imagined, while in other areas, the phase without ceramics lasted *longer* than we first imagined. In fact, a quick glance at the graph for Period 5 (Figure 6) shows us that, in chronological terms, the sites attributed to this period show significant overlap with those of Period 4. This overlap is related to several factors: a) the duration of the above periods has been shortened without the occurrence of a corresponding reduction in the statistical margin of error, b) a smaller number of available dates—67 as opposed to more than 100 for the preceding periods—due to a lack of long analogue series on certain sites as compared to preceding periods (see infra). Based on the available dates, the beginning of this period occurs about 7500 cal BC and it ends about 6000 cal BC. The central point is 6607 cal BC.

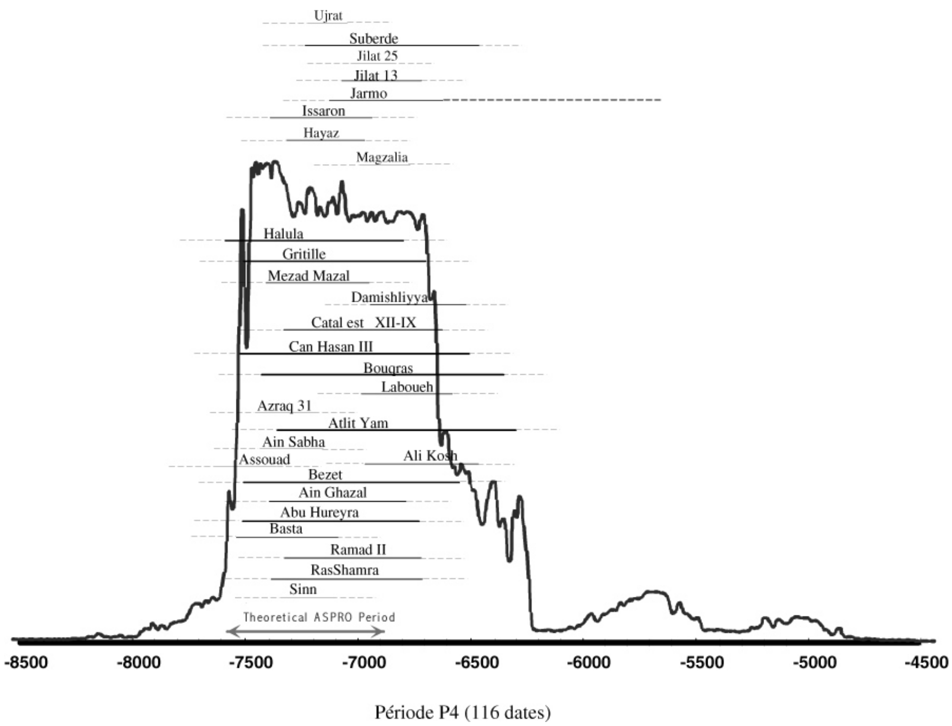

Figure 5 Cumulative curves of probability for Period 4 and the chronological position of the main sites

It would thus appear reasonable to regroup Periods 4 and 5 (Figure 7), which J Cauvin (Cauvin 1997) proposes anyway on cultural grounds. Despite this regrouping, we confirm by ^{14}C dating the stratigraphy of the following sites: Catal Hoyuk (level XII-IX between 7300 and 6800 cal BC, level VIII-II between 7200 and 6400 cal BC), Ain Ghazal (Late PPNB between 7400 and 6900 cal BC, PPNC between 7400 and 6500 cal BC), and Ramad (Ramad II between 7400 and 6700 cal BC, Ramad III between 6800 and 6700 cal BC).

Another most interesting phenomenon is highlighted by examining this series of dates: the simultaneous appearance of ceramics in various parts of the region around 7000 cal BC. This is the case at Bouqras, Damishliya, Kashkashok, Kumar in the Euphrates basin, at Guran and Sarab in the Zagros Mountains, and at Catal Hoyuk on the Anatolian plateau.

However, other regions, inhabited at the same time, did *not* feature ceramics: the Southern Levant (Ain Ghazal), the oases of the Syro-Jordanian steppes (Kowm 2, Naja, Burqu'), and the Iranian plateau (Sang-i-Chakhmak).

Period 6 (Figure 8)

The curve of this graph is distinguished quite well from those of the two preceding periods. The beginning of Period 6 occurs about 6400 cal BC and ends about 5600 cal BC—a duration that is slightly longer than the theoretical period. The central peak around 5900 cal BC is not far from the central point at 5889 cal BC. Notwithstanding the comparatively smaller number of available dates, the beginnings of several, mainly Mesopotamian, cultures that are defined by ceramic assemblages, can at least be calibrated provisionally in a collective way. A number of sites confirm this approach,

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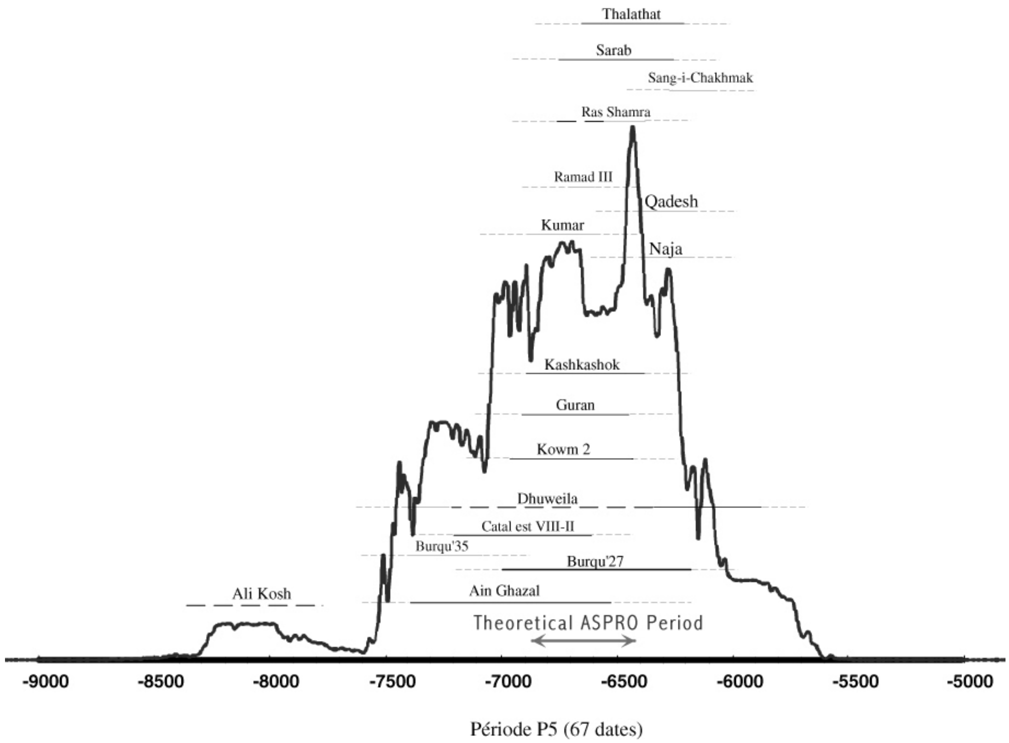

Figure 6 Cumulative curves of probability for Period 5 and the chronological position of the main sites

though only a tiny proportion of these so far produced reliable dates, many of which are isolated. Thus, the pre-Halaf sequence at Subhi Abiad is dated from 6200 to 5900 cal BC, followed by the Halaf sequence around 5900–5500 cal BC. The latter range is confirmed at Arpachiyah: 5900–5700 cal BC. These calibrated dates lend a certain credit to a single date between 6400 and 6200 cal BC obtained on a sample from Halaf itself, a long time after the excavation, at levels considered to be pre-Halaf (Altmonochrom). At Yarim I, the pre-Hassuna levels are dated between 6000 and 5900 cal BC, while at Sawwan, the level I (pre-Samarra) is dated around 6300–5800 cal BC, preceding the level III (Samarra), grouped between 6100 and 5900 cal BC.

At Oueili in southern Mesopotamia, the beginning of the Obeid sequence (Obeid O) is placed between 6400 and 6100 cal BC—a hypothetical date due to the significant statistical margin of error for the two available dates. Another cultural development (Obeid 1) occurred between 5700 and 5400 cal BC. It is most interesting to compare these well known ceramic sequences with other sequences that are less documented and scattered over a wide area, *but which seem perfectly contemporaneous*: Hacilar on the Anatolian plateau, Hajji Firuz and Yanik in the Zagros Mountains, Zaghe on the Iranian plateau, and Jeitun, Togolok, Chagylly in Turkmenistan.

The beginnings of ceramics in the Southern Levant seems to date to about 6400–6200 cal BC, if the only available date from Ain Rahub is reliable. In order to verify these hypotheses it would be necessary to have more detailed sequences. But we can already take 6000 cal BC (slightly before or slightly after) to be the starting point for the principle ceramic cultures of the ancient Middle East. These characteristics are traditionally part of the second phase of the Neolithic culture.

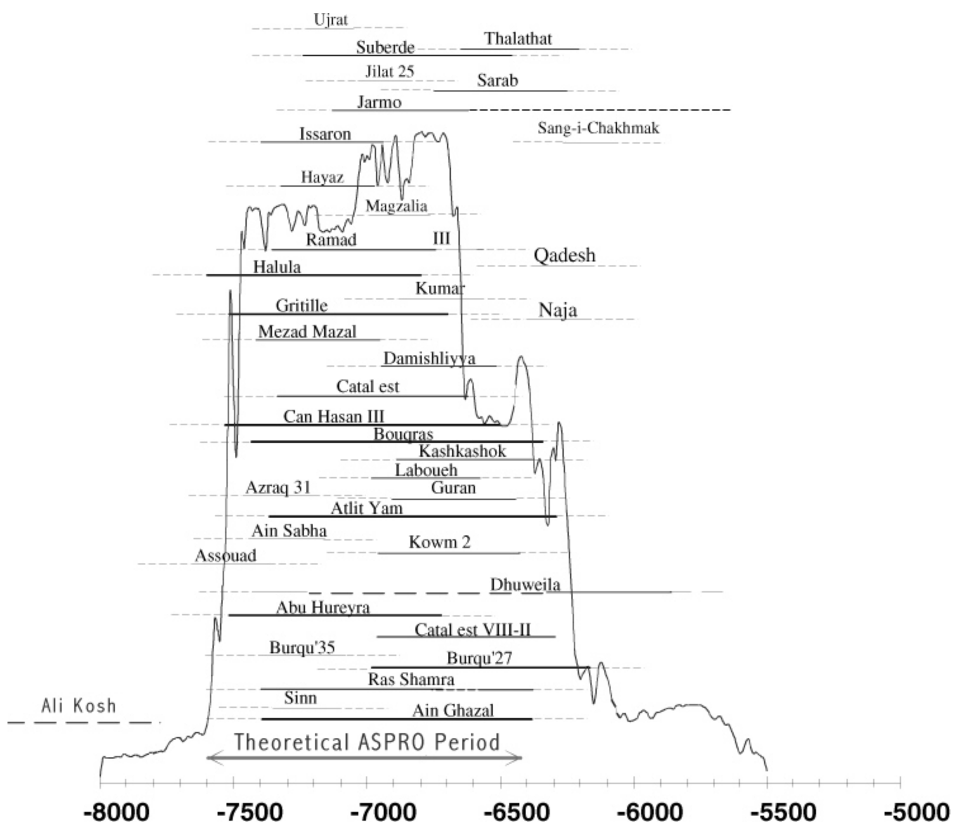

Figure 7 Cumulative curves of probability for Periods 4 and 5, and the chronological position of the main sites

COMMENTARY ON THE RESULTS OF CALIBRATION

One of the first results of this collective calibration process is the extension of the duration of the theoretical periods that were defined by the ASPRO chronology. It will be necessary to take this into account in future finds. We must also be aware of the overlap between periods. For reasons of clarity, each of the theoretical periods was given well-defined limits that, of course, are not representative of reality. The number of dates available to us to accurately position this long sequence chronologically is (still) relatively small. It does not yet allow us to reduce the areas of overlap. We have already seen how this inaccuracy forced us, provisionally, to merge two periods. The solution of these problems remains an objective in future investigations.

However, the difficulties are not only due to the small number of dates available. For instance, if we examine the curve of calibration (Figure 9) we notice the existence of rather flat areas in the curve. In these plateau periods the conversion of the BP date into real years leads to a wide age range in sidereal years, even if the BP date has a small sigma. On the other hand, for those periods in which the calibration curve has a steep gradient, even BP dates with a medium sigma may get upon calibration a rather precise date in sidereal years. Thus there are “good” and “bad” periods for using ^{14}C dating (Evin et al. 1995).

If we apply that principle to the Middle East, we find that, in terms of the reliability of sidereal dates, the following calibration periods are particularly satisfactory: 9400 to 9200 cal BC (second half of

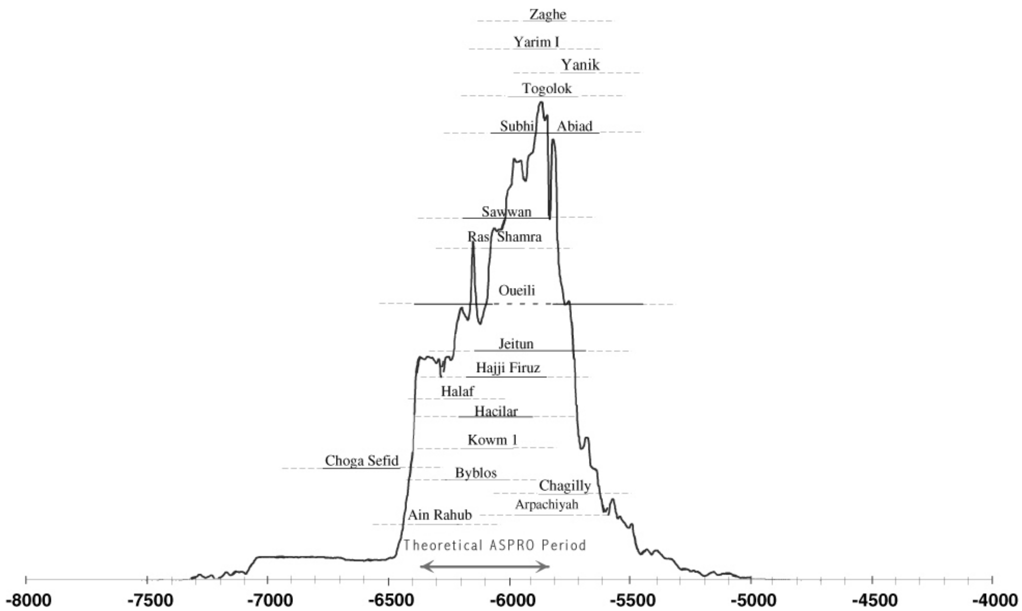

Figure 8 Cumulative curves of probability for Period 6 and the chronological position of the main site

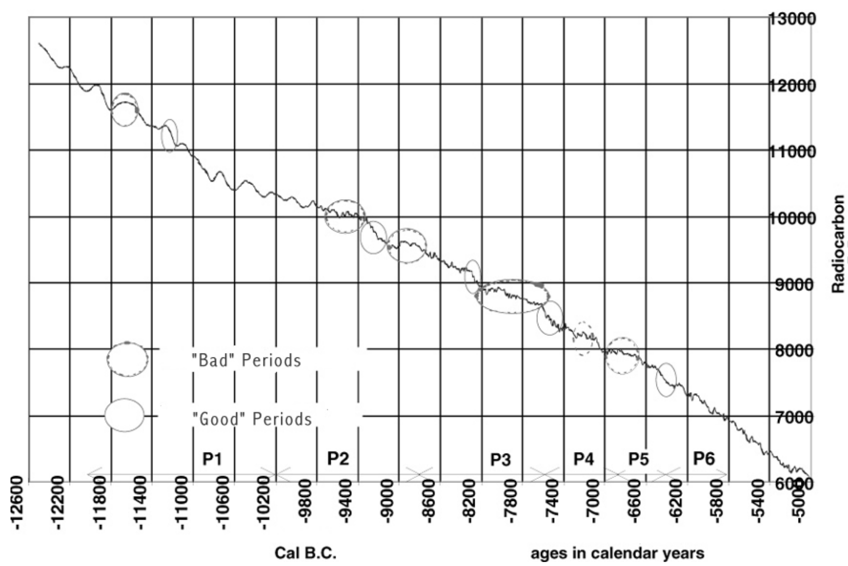

Figure 9 Curve of calibration between 12,000 cal BC and 5000 cal BC, showing “good” and “bad” periods for precise calibrated radiocarbon dating

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Period 2), 8400–8200 cal BC and 7700–7500 cal BC (the beginning and end of Period 3 respectively), 7100–7000 cal BC (end of Period 4), and from 6700 cal BC onwards (the end of Period 5). The whole of Period 6 (6500–5600 cal BC) and Period 7 (not studied here) can also be considered as favorable periods for ^{14}C dating.

On the other hand, unfavorable time periods include the beginning and end of Period 2 (9800–9400 cal BC and 9100–8800 cal BC). These two plateaus, on either side of a favorable period, only accentuate, albeit perhaps too much, the effect of extending the periods in real years. The reverse situation appears in Period 3, in which the beginning and end are well dated, but with a plateau area in the middle, between 8200 and 7600 cal BC. Regretfully, this is precisely the time when the true Neolithic culture with agriculture and livestock rearing began to establish itself throughout the Middle East.

The two plateaus of 7400–7200 cal BC and 7000–6700 cal BC may explain the wide field of overlap between Periods 4 and 5, which brought about their merger (cf. supra).

CONCLUSIONS

Despite the above uncertainties, there is a need for a general extension of the chronology. Particularly, the period that preceded the true Neolithic Age should be extended in time. We suggest calling this period the Proto-Neolithic, although its importance should not be exaggerated. It includes the Periods 1 and 2 of the ASPRO chronology.

The Proto-Neolithic begins about 12500 cal BC and ended about 8400 cal BC, spanning more than four millennia. Therefore, we must acknowledge that this period, which includes the Natufian in the Levant and other contemporary cultures in the East (Zarzian and Trialetian) and also the PPNA (Period 2) in the Levant, and other contemporary cultures in the East (Mlefatian and Nemrikian), is longer than we estimated until now.

This collective ^{14}C calibration of cultures, based on many dates, has enabled us to obtain convergent results. Thus, we can date several phenomena that are truly unique in the archaeological record:

1. The advent of the true Neolithic in the Middle East with the beginning of agriculture and livestock rearing, can reasonably be dated around 8000 cal BC or, more correctly, between 8300 and 8000 cal BC.
2. The “invention” of ceramics occurred around 7000 cal BC.
3. Finally, the beginnings of the “great” Mesopotamian cultures—the Obeid culture led directly to the urban phenomenon—took place around 6000 cal BC.
4. These results should encourage further investigations to date more precisely the chronological position of the cultures towards the end of the Neolithic (Periods 6 and 7), for which there are still not enough dates available at present.

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