Abstract
Archaeological excavations on the western part of the Central Iranian Plateau, known as the Qazvin Plain provides invaluable information about the sedentary communities from early occupation to the later prehistoric era. Despite the past archeological data, chronological studies mostly rely on the relative use of the Bayesian modeling for stratigraphically-related radiocarbon dates. The current paper provides a new model for excavations and the chronological framework based on new radiocarbon dating of the six key archeological enclosures in the Qazvin plain. A Bayesian analysis of these data is presented on a site-by-site basis to give the best chronologies. Finally, all dates are combined into a single model of the chronology of the Qazvin Plain from the Late Neolithic to the Iron Age. The procedure aims to use the Bayesian model to predict the
transition points between the archaeologically-defined periods with the highest possible precision, to redefine the existing chronology for the Qazvin Plain.

Keywords: Chronology, Qazvin Plain, Late Neolithic, Iron Age, Radiocarbon Dating, Bayesian Modeling.

Introduction
Archaeological excavations on the western part of the Central Iranian Plateau, known as the Qazvin Plain, have been carried out since the 1970s, with the aim of understanding the transition from hunter-gatherer societies to more sedentary communities, and the subsequent rise of social complexity (Fazeli et al., 2005; Fazeli et al., 2009). Although several of these studies have used radiocarbon dating to support the ceramic chronologies, few have applied Bayesian modeling to stratigraphically-related radiocarbon dates (Ramsey, 2008), which is freely available through OxCal (https://c14.arch.ox.ac.uk). An exception is the recent re-working of the dates from Tall-i Mushki, Marv Dasht Plain, by Nishiaki (2010).

These studies have been limited by having relatively few radiocarbon dates available for any particular site. As part of a larger collaboration between ICHTO and RLAHA, in which we have produced approximately 300 new radiocarbon dates for prehistoric, historic, and Islamic Iran, we publish 57 new dates from Tepe Chahar Boneh (15), Tepe Ebrahim Abad (15), Tepe Sagzabad (12) and Tepe Shizar (15). Fig. 1 indicates the location of these sites in the Qazvin Plain. Firstly, we present a Bayesian analysis of these data on a site-by-site basis to give the best site chronologies according to present information. We then re-analyze radiocarbon dates from other sites on the Qazvin Plain published by other laboratories - Tepe Zagheh (9 from Waikato and 4 from Gif-sur-Yvette); Tepe Ghabrestan (7 from Waikato and 7 from Gif-sur-Yvette) and add to the analysis of our dates from Tepe Sagzabad a further 4 dates from Gif-sur-Yvette. In this paper, we have used OxCal v. 4.1.7 (Bronk Ramsey, 2009) with the calibration data from Intcal2009 (Reimer et al., 2009), and have adopted the convention of quoting all modeled dates at $2\sigma$ (95% confidence), but have also quoted the ‘most likely age range’ for the modeled transitions dates at $1\sigma$ (68% confidence), and, for ease of discussion, we
also quote the median age of the modeled range.

Finally, we combine all 88 dates into a single model of the chronology of the Qazvin Plain from the Late Neolithic to the Iron Age. The aim is to use the Bayesian model to allow us to predict the transition points between the archaeologically-defined periods with the highest possible precision, in order to refine the existing chronology for the Qazvin Plain. Our intention in the future is to extend this procedure to other sites on the Central Plateau, and also to other regions of Iran, and to use these regional models to detect any time-transgressive behavior in the transition between different regions.

2. Discussion

2.1. Tepe Chahar Boneh

Chronologically and based on the ceramic finds, Tepe Chahar Boneh is related to the Late Neolithic I (c. 6000-5600 BC) and II (c. 5600-5200 BC) periods. One of the key archaeological problems within the north Central Iranian Plateau is the lack of evidences for the Mesolithic and also the Early Neolithic periods. It was hoped that Chahar Boneh or Tepe Ebrahim Abad (see below) might provide evidence of ceramic Neolithic occupation. Whilst both sites have provided us with securely dated stratigraphs and architectural and artefactual sequences covering over 800 years of occupation, neither demonstrates evidence for this early occupation. Tepe Chahar Boneh was identified during the settlement survey undertaken in 2003, and is located at 1279 m above sea level, 3.3 km to the southeast of Zagheh and 4.2 km southeast of Ghabrestan Tepe, southeast of Boein Zahra. The site lies within a shallow depression, and covers an area of 2000 m² – or 4000 m² including surrounding scatters – and is being encroached upon by modern agriculture. On the surface of the site painted Buff and Red Ware sherds were visible, marking the site as the earliest example of the ceramic Neolithic of Iran (Fazeli et al., 2009). In order to study the chronology of the site, eight trenches of 2x2 meters were excavated on different parts of the site in 2006. However, despite two months of excavations, few architectural remains or coherent contexts could identify. Instead, we found a series of cultural contexts which were interspersed with natural accumulations.

Seventeen samples of unidentified charcoal from Tepe Chahar Boneh were dated at the Oxford Radiocarbon Accelerator Unit. Two samples failed to produce sufficient carbon for dating, leaving six usable dates for the Late Neolithic I and nine dates from the Late Neolithic II (Table 1).

The radiocarbon data therefore consist of 15 dates from Trenches I, III, IV, V, VI and VII. Several of the dates come from the same
context (two from Context 109, Trench I; two from Context 306, Trench III; three each from Contexts 508 and 510, Trench V). Since the aim is to provide a modeled estimate for the age of the transition from LNI to LNII at Tepe Chahar Boneh, and no single trench covers this transition, we have constructed a phase model consisting of a sequence of two phases (LNI and LNII), within which all dates from the same context were considered as sub-phases. The transition between LNI and LNII was initially modeled as a single event, but in the model shown here (Fig. 2) was divided into ELNI (end of LNI) and SLNII (start of LNII) because there appeared to be a gap between these two periods.

From this model, the start of the Late Neolithic I at Tepe Chahar Boneh occurs at or before 6191 – 5908 cal BC (6058 – 5934 cal BC at 68% confidence, median 6014 cal BC). This is a reasonable estimate for the start of the LN I period. The end of the Late Neolithic I is given as 5773 – 5468 cal BC (5736 – 5618 cal BC at 68% confidence, median 5669 cal BC) and the start of LNII is 5402 – 5233 cal BC (5367 – 5260 cal BC at 68%, median 5322 cal BC). This indicates a hiatus of perhaps 350 years between LNI and LNII at Chahar Boneh, at least in terms of the contexts dated. Taking the E boundary as a terminus ante quem estimate for the end of the LNII phase at Chahar Boneh, this suggests an end date of some time after 5296 – 5104 cal BC (5270 – 5184 cal BC at 68% confidence, median 5215 cal BC). This indicates that the LN II period may have been rather short at Chahar Boneh (perhaps only lasting one or two hundred years).

On this evidence, therefore, we can date the LNI period at Chahar Boneh to approximately 6000 to 5700 cal BC, and LNII from 5300 to 5200 cal BC. The calibrated and modeled dates for this site are shown in Table 2.

### 2. 2. Tepe Ebrahim Abad

Tepe Ebrahim Abad is about 20 km south of Qazvin in the northern half of the plain at an altitude of 1232 meters above sea level. This hill was identified in 1963 during a comprehensive survey by Hassan Fazeli Nashli (Fazeli et al., 2009). It is approximately 250 × 250 metres in area and its height is 8 metres from the surface of the surrounding land. Three trenches were sunk into this ancient hill in 2006. Trenches I and II reached virgin soil, but despite a search to a depth of approximately 7.5 metres Trench III failed to reach virgin soil (Fazeli et al., 2009). The radiocarbon dates are listed in Table 3.

Since two of the three trenches (I and II: Figs. 3-4) contain dates in stratigraphic sequence that straddle a chronological boundary (Late Neolithic II to Transitional Chalcolithic I), we have first modelled each sequence separately to derive a modelled age for this transition in each trench. We have then
produced a site model based on a sequence of two phases (LN II and TC I), each of which contains a number of independent phases (three LN II dates from Trench III, six LN II and three TC I from Trench II, and two LN II plus one TC I from Trench I).

**Trench I**
The three radiocarbon dates are in stratigraphic sequence, two in LN II and one TC I, but none of the dates are close to the base of the LN II sequence or the top of the TC I levels, so will not provide good estimates for the start of the LN II or the end of the TC I. Using a sequence model with a transition (T) inserted between the LN II and TC I phases, and inserting a start and end boundary gives the calibrated and modeled dates shown in Figure 6. The modeled date for the transition from LN II to TC I ('T') is 5276 - 5082 cal BC (5257-5164 cal BC at 68% confidence, median 5208 cal BC). The upper part of the sequence (the TC I period) is chronologically ambiguous in this sequence (i.e., shows significant bimodality), indicating that the TC I period is poorly constrained in this sequence.

**Analysis of Tepe Ebrahim Abad by Archaeological Phase**
From Trenches I and II we can conclude that the LN II to TC I transition most probably occurred sometime around 5200 BC. In order to use all the information from the 15 radiocarbon dates, we have constructed a model which defines all four of the available TC I dates as a single phase (but retaining the stratigraphic sequence of the three dates from Trench II), and the remaining 11 LN II as a single preceding phase (but with the stratigraphic sequence retained for each trench), with a transition T (LN II-TC I) between them.

This model (Fig. 7 and Table 4) also has poor agreement in the upper (TC I) section, as was noted in the model for Trench I, but the boundary T is well-defined, at 5203 – 5061 cal BC (5158-5076 cal BC at 68% confidence,
median 5122 cal BC). This is probably the best estimate of age of the LN II-TC I transition from Tepe Ebrahim Abad, and suggests that this transition occurred at some time between 5150 and 5050 cal BC. The start of the sequence (but, for stratigraphic reasons, not necessarily the start of the LN II period) is estimated at 5641 – 5480 cal BC (5560 – 5491 cal BC at 68% confidence, median 5534 cal BC). The end (but again not necessarily the end of TC I) is modeled at 5191 – 4875 cal BC (5057 – 4957 cal BC at 68% confidence, median 5008 cal BC). We can conclude that the LN II period at Tepe Ebrahim Abad had begun by c. 5500 cal BC, and the TC I period ended sometime after c. 5000 cal BC.

2.3. Tepe Shizar

The mound of Tepe Shizar is 19m high and is located in a corridor valley linking the Central Plateau with the central Zagros Mountains. It is located about 35 km south of the city of Takestan, near a village with the same name (Shizar). In 2006, a stratigraphic trench was opened in the site but despite excavating a 17m cultural layer, the team could not reach to the virgin soil (Valipour, 2006). 52 and 53 contexts were recorded in Trench I and II, respectively. Trench II was situated directly below Trench I (layer 1052 in Trench I and layer 2003 in Trench II are common) and we can therefore consider them as a single sequence. Trench I covers the two main periods of the Early, Middle (Red slipped ware), and Late Bronze (Polychrome ware) and Iron Age. Because of the lack of charcoal samples, the team could not date the whole sequence of Trench II, but based on the ceramic sequence there is continuity of site occupation with the Kura-Arex ceramic types of burnished dark grey wares of the Early Bronze Age. Based on this observation, the cultural materials of Trench II at Tepe Shizar cover the Middle and Late Chalcolithic, and the Early Bronze Age. The Early Bronze age potteries are comparable with those in Ismaeil-Abad and Duran-Abad in Qazvin plain, Yanik and Haftovan in Northwestern Iran and Gurab, Godin IV and Pissa in Hamadan province. The polychrome potteries of the Late Bronze Age at Shizar, with respect to their forms and decorations, are similar to those in Haftovan Tepe of northwestern Iran and Tepe Sagzabad of the Qazvin Plain (Mostafapour, 2011: 121-4).

The data consist of 15 radiocarbon dates, seven from Trench I and eight from Trench II (Table 5).

The stratigraphs for Trenches I and II are shown in Fig. 8. In order to use all the information from the 15 radiocarbon dates, we assumed a continuous stratigraphy between Trenches I and II, and constructed a model which defines a Middle and Late Chalcolithic period (defined solely from Trench II), a
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continuous Bronze Age phase from both Trenches (with five dates in the Early Bronze Age and two in the Late Bronze Age), and an Iron Age I phase with a sequence defined from Trench I. The boundaries EC (End of Chalcolithic), SEBA (Start of Early Bronze Age), EEBA (End of Early Bronze Age), SLBA (Start of Late Bronze Age) and T (LBA to IA I transition) were inserted into the model. The two boundaries EC and SEBA were used because there is an obvious gap between the latest Chalcolithic date and the Early Bronze Age date, although the stratigraphy shows (Fig. 8) that there are several undated layers in this gap, so this does not imply a hiatus. Likewise, the inserted boundaries EEBA and SLBA were inserted because there are no dates associated with the MBA layers, although from the stratigraphy these occupy more than a metre of deposit and at least 11 contexts.

This model converges extremely well, and suggests (Fig.9, Table 6) that the boundary for the start of the Middle Chalcolithic occurred sometime between 3978–3703 cal BC (most likely range 3970–3907 cal BC, median 3937 cal BC), and the start of the Early Bronze Age was between 3246–2658 cal BC (most likely range 2947–2725 cal BC, median 2864 cal BC).

Because of the gap between these two boundaries of some 1000 years with no dates, these dates do not necessarily define the end of the Chalcolithic or the beginning of the Early Bronze Age at this site – all that can be said is that the end of the Chalcolithic period is some time after c. 3900 cal BC, and the Early Bronze Age began some time before c. 2850 cal BC.

Likewise, the boundary inserted at the end of the Early Bronze Age (EEBA) is modeled at 2570 – 2139 cal BC (most likely date 2556 – 2391 cal BC, median 2451 cal BC), and that at the start of the Late Bronze Age at 2311 – 1692 cal BC (most likely date 1978 – 1705 cal BC, median 1882 cal BC). The uncertainty in the upper bound of EEBA and the lower bound of SLBA is again due to a lack of dated contexts in the intervening c. 500 years. The stratigraphy (Fig. 8) suggests that the Middle Bronze Age occupies this period. The boundary (T) inserted between the Late Bronze Age and Iron Age I layers gives a modelled date of 1714 – 1535 cal BC (most likely range 1661 to 1571 cal BC, median 1618 cal BC). This is extremely well-constrained by the LBA date of context 1021 and the IA I date of context 1016.

2.4. Tepe Sagzabad

Tepe Zagheh, Tepe Ghabristan and Tepe Sagzabad form a group of three closely-related sites in the Qazvin Plain, 60 km south of the modern town of Qazvin in Zanjan province, 140 km west of Tehran. Zagheh is 2 km east of Sagzabad, and Ghabristan is 300 m west of Sagzabad.
They were excavated in the 1970s by E. O. Negahban (Negahban 1976, 1977 & 1979). Tepe Sagzabad is one of the few sites in the north central Iranian Plateau to show evidence of continuous settlement during the Bronze and Iron Ages, and is therefore an important site to study the transition from Bronze to Iron. Accordingly, Trenches II and IV from the 2008 excavation were selected for dating, respectively in the north east and southern areas of the site (Fazeli Nashli et al., 2011). Nine charcoal samples were submitted from Trench II and 8 from Trench IV, with a further sample from context 5006 in Trench V. Unfortunately results were only obtainable for seven samples from Trench II (including one with a very low yield) and five from Trench IV, as listed in Table 7.

**Trench II**

Trench II has one date from the base of the Late Bronze Age sequence, and six from Iron Age I - only five are marked on the stratigraphy (Fig. 10): context 2006 is not shown but is assumed to be between 2005 and 2011/2014. A sequence through these dates with a boundary inserted between the LBA and IA I layers gave a poorly-constrained date of 1676 – 1472 cal BC (95%) for this transition, which is undoubtedly due to the presence of only one date early in the LBA phase, at least 3 m below the stratigraphic boundary. This single date (context 2034) is, however, at the base of the sequence, so the S boundary in the model gives a reasonable if poorly constrained estimate for the start of the LBA at this site – 2219 – 1554 cal BC at 95%, or 1841 – 1564 cal BC at 68%, with a median of 1730 cal BC. Convergence on this model is poor due to the presence of OXA-X-2323-10, which is noticeably out of order (see Figure 13). Given that the laboratory labeled this an OxA-X number (which signifies a date of doubtful reliability - see note below Table 7), it would be reasonable to omit this sample from further consideration, although it is unlikely to affect the modeled boundary dates very significantly.

**Trench IV**

Only five dates were obtained from this trench, with two at the base from the Late Chalcolithic contexts, one on the top of the Late Bronze Age levels, and two from within the Iron Age I (Fig. 11). A sequence was put through these dates, with a boundary at the end of the Late Chalcolithic (ELC), at the beginning of the Late Bronze Age (SLBA), and one (T) between the LBA and IAI. As might be predicted from the position of the single LBA date in the stratigraphy, the ELC and SLBA are poorly constrained, but the LBA/IAI transition is modelled to 1492 – 1221 cal BC (later than in Trench II, although just overlapping: Figure 12). From the stratigraphy (Figure 11), the earliest Late Chalcolithic context (4027) is at
the base of the sequence, so the modelled start date (S) is a reasonable estimate of the beginning of the LC at this site. This gives a modelled age of 4049 – 3537 cal BC (95%), or 3728 – 3548 cal BC (68%), with a median of 3667 cal BC.

Tepe Sagzabad Modeled by Archaeological Period

Since both sections are relatively short and have an unknown relationship, we have modeled all the dates from Tepe Sagzabad by archaeological period (two LC dates, two LBA dates and eight Iron Age I dates) rather than by stratigraphic position. Each period is considered as a phase in the model, but with the stratigraphic sequence within each trench retained within the phase description. Boundaries were inserted as for Trench IV (ELC, SLBA, T). There are nine additional radiocarbon dates for Tepe Sagzabad available in the literature. Mashkour et al. (1999) give four dates measured by Gif-sur-Yvette, France, on animal bone from the Iron Age layers at Sagzabad. These are from the excavations in 1970 and 1974. They also list three dates from Sagzabad measured by Bovington and Masoumi (1972) at the Tehran University Nuclear Centre (TUNC-13, TUNC-8 and TUNC-9), and a further two which they appear to misattribute to Ghabrestan (TUNC-11 and TUNC-7), but which in the original publication are described as being from Sagzabad Cemetery, Trench A. All these dates are listed in Table 8.

Mashkour et al. (1999), however, state that the dates from Tehran University cannot be compared with other dates because they were ‘not adjusted for biological fractionation ($\delta^{13}C$)’. This refers to the necessity to correct radiocarbon dates to a common value of $\delta^{13}C$ (-25‰) to account for differential fractionation in the material dated compared to the calibration standards (wood), which has routinely been done on all dates since the late 1970s (Walker 2005, 25-6). Given the date at which the TUNC dates were measured, this seems a reasonable assumption, and we too have therefore omitted these dates.

Initially using only the OxA dates, the model gives ELC as 3698 – 2756 cal BC, the median of which (c. 3550 cal BC) may be a reasonable estimate for the end of the Late Chalcolithic at this site. The start of the Late Bronze Age is still poorly defined (2647 – 1511 cal BC), but transition T (the Late Bronze Age/Iron Age I boundary) is modeled as 1582 – 1453 cal BP. We can combine the Gif-sur-Yvette dates with this model by including them as a phase (i.e., having no declared internal order) within the phase that is Iron Age I (there is no stratigraphic relationship between the Gif-sur-Yvette dates and the OxA dates, nor is there any obvious internal structuring). We have also taken the opportunity to omit sample OxA-X-
2323-10 from the sequence within Trench II. This larger model has little effect on the boundary dates for the lower part of the sequence, but does alter the upper part somewhat. The sequence begins in the Late Chalcolithic at 4124 – 3537 cal BC at 95% (most likely range 3736 – 3549 cal BC, median 3671 cal BC), with the end of the Late Chalcolithic modeled at 3698 – 2730 cal BC at 95% (most likely range 3676 – 3465 cal BC, median 3542 cal BC). The start of the Late Bronze Age is modeled at 2827 – 1524 cal BC (most likely range 1938 – 1546 cal BC, median 1781 cal BC). The upper boundary of the modeled date for ELC and the lower boundary for SLBA are extremely poorly constrained because there are no dates between c. 3500 – 2700 cal BC in the model. The transition from LBA to IA I is modeled at 1539 – 1337 cal BC (most likely range 1486 – 1417 cal BC, median 1451 cal BC), and the end of the sequence is pushed forward in time to 1106 – 844 cal BC (most likely range 1042 to 919 cal BC, median 980 cal BC).

2.5. Tepe Zagheh

The main objectives in the re-excavation of Zagheh in 2001 were to ascertain the settlement size of the site, demonstrate the craft areas and collect radiocarbon samples. Eight trenches were opened, of which five reached virgin soil. Ten dates have been published from the Transitional Chalcolithic I sequence of Trench A (with a defined stratigraphic order), done by the Radiocarbon Dating Laboratory, University of Waikato, New Zealand (Fazeli et al., 2005:44-5), reproduced in Table 10.

The top context (1) was said to be disturbed. Constructing a simple sequence through all ten of these dates fails – context 1 is clearly incongruent with the sequence. Omitting this date does allow a model to be run, although the overall agreement index is not good (Figure 14). The modeled boundaries suggest the sequence starts (context 47) at 5786 – 5246 cal BC (median c. 5400 cal BC) and ends (context 7) at 4448 – 3931 cal BC (median c. 4300 cal BC). There are two other published sources of radiocarbon dates from Tepe Zagheh (Table 11). Mashkour et al (1999) published four dates done by Gif-sur-Yvette, said to be from Late Neolithic contexts at Zagheh. Bovington and Masoumi (1972) also published two dates from Tepe Zagheh measured at the Tehran University Nuclear Centre radiocarbon laboratory (TUNC), but for the reasons given above we have not included these in our modelling. Combining the four dates from Gif-sur-Yvette assigned to the Late Neolithic with the Transitional Chalcolithic I sequence of Trench A (omitting ZH01, as above), using the four LN dates as a phase within the sequence and declaring a boundary T between the LN and the Transitional Chalcolithic, produces a
very unsatisfactory model (Figure 15). Clearly the four LN dates are later than or at least contemporary with the Transitional Chalcolithic dates from Trench A. Combining these four dates as a separate phase within the Transitional Chalcolithic gives a more acceptable model (Figure 16), suggesting the Gif-sur-Yvette dates are better thought of as being Transitional Chalcolithic. This is consistent with the statement in Fazeli et al. (2005, 43), that Zagheh ‘was a Transitional Chalcolithic site with no Late Neolithic material’. This addition has a small effect on the modeled start and end dates of the sequence at Tepe Zagheh (Table 12), suggesting that the dated phases began between 5607 and 5240 cal BC (95%), most likely range 5464 – 5296 cal BC, median 5384 cal BC, and ended between 4451 and 4103 cal BC (95%), most likely range 4430 – 4269 cal BC, median 4324 cal BC, giving the site a dated lifespan of around 1000 years.

2.6. Tepe Ghabrestan

In the first season of re-excavation of Ghabrestan in 2002, eleven trenches were exposed in the northern, southern and western areas of the mound and further five in the central region of previously excavated area. Dates for the Early Chalcolithic and Middle Chalcolithic sequences for Trench L34 at Tepe Ghabrestan have been produced by the Radiocarbon Dating Laboratory, University of Waikato, New Zealand (Table 13: Fazeli et al., 2005:68). These dates form a single sequence, with a transition (T) inserted at the boundary of the Early Chalcolithic and the Middle Chalcolithic. The model (not shown, since it is included in the discussion below) gives the date of this transition as between 4036 and 3819 cal BC.

Mashkour et al. (1999) list seven dates done by Gif-sur-Yvette on animal bone from Ghabrestan, from the excavations in 1970, 1973 and 1974 (Table 14). They also list two dates done by TUNC (TUNC-11 and TUNC-7) as being from Ghabrestan, but according to the original data in Bovington and Masoumi (1972) they are from Sagzabad Cemetery Trench A. However, for the reasons discussed above, we have not included the TUNC dates in our analysis.

Since these Gif-sur-Yvette dates are not from Trench L34, it is not possible to relate them stratigraphically to the dates in Table 13. However, the depths of six of the seven samples in Table 14 are given as 30-40 cm (Gif-10411) to 180-185 cm (Gif-10408). It is clear that all the Waikato dates in Table 10 come from contexts which are deeper than approximately 2 m (context 7), above which is labeled as Late Chalcolithic.

It may be reasonable to assume that the dates in Table 14, despite coming from different Trenches, are all from the top 2 m, and
are all Late Chalcolithic. To test this, a model was constructed which uses the model described above from Trench L34 as a sequence, but then has all seven dates in Table 14 as a phase (i.e., of undefined internal relationship) above these, with a boundary (T2) inserted, which corresponds to the assumed position of the MC-LC transition at Tepe Ghabrestan. This model converges well (Figure 17, Table 15), and suggests that the beginning of the Early Chalcolithic sequence at Tepe Ghabrestan is 4869 – 4184 cal BC at 95%; most likely range 4481 – 4270 cal BC, median 4391 cal BC.

The Early Chalcolithic –Middle Chalcolithic boundary (T) is virtually unchanged from the above model at 4036 – 3811 cal BC at 95%; most likely range 3996 – 3874 cal BC, median 3941 cal BC. The boundary between the Middle and Late Chalcolithic (T2, assuming that the dates published by Mashkour et al. (1999) can be assigned to the Late Chalcolithic) is modeled at 3923 – 3702 cal BC at 95%; most likely range 3846 – 3665 cal BC, median 3783 cal BC. This is very close to the upper boundary used in the model above (3951 – 3643 cal BC at 95%), which we assume is close to the end of the Middle Chalcolithic from the stratigraphy in Trench L34. The boundary E in Figure 17 might be taken as the end of the Late Chalcolithic at Tepe Ghabrestan (certainly the end of the dated sequence), but is heavily influenced by a single late date (Gif-10409). The modeled age is 2879 – 2329 cal BC; most likely range 2851 – 2610 cal BC, median 2700 cal BC), but Figure 16 suggests that a date before 3000 cal BC might be more accurate.

3. Chronology of Qazvin Plain from Late Neolithic to Iron Age

Table 16 shows a summary of the dates for the modeled boundaries at each site on the Qazvin Plain. As discussed above, because of the different sample availability and stratigraphic constraints at each sites, not all these modeled boundary estimates are of equal reliability or precision. We have indicated this by putting dates in italics in Table 16 if we feel they may be less well-constrained than the others. Unfortunately, no single site covers the entire period, but there is some chronological overlap between some sites. If we take the Qazvin Plain as a chronologically coherent region, we may be able to produce a single model from all six sites which gives better definition of these transition dates, using all the dates from Oxford, and those published by Gif-sur-Yvette and Waikato.

As noted above, however, the dates from Gif-sur-Yvette relating to both Tepe Zagheh (assigned to Late Neolithic, but most likely to be Transitional Chalcolithic) and Tepe Ghabrestan (probably Late Chalcolithic, but not securely so) are unreliably linked contextually
to the other dates, and we have therefore not included them in this analysis. The total dataset therefore consists of 77 dates from the six sites [Tepe Chahar Boneh (15), Tepe Ebrahim Abad (15), Tepe Ghabrestan (7, by Waikato), Tepe Sagzabad (12 from Oxford and 4 from Gif-sur-Yvette), Tepe Shizar (15) and Tepe Zagheh (9, from Waikato, omitting one date from a disturbed context)], covering the Late Neolithic I to the Iron Age I.

The model was based on a sequence, using the cultural periods (LNI, LNII, TCI, EC, MC, LC, EBA, MBA, LBA and IA I) as the defined phases, and using the dates from each site which had dates of that period as sub-phases within each phase. No assumptions were made about the relative order of these sub-phases (since they were from separate sites), but the stratigraphic sequences discussed above were used to order the dates within each sub-phase, if available. The results are summarized in Table 17 and Figure 18, which show the modeled ages for each of the inserted boundaries. As general observations, from Figure 18 it can be seen that there appears to be a gap between the end of the Late Neolithic I and the beginning of the Late Neolithic II, and the Transitional Chalcolithic I period appears to have lasted approximately 1000 years (probably because we are missing contexts dated to the Transitional Chalcolithic II).

We have no dates for the Middle Bronze Age, although the gap of c. 800 years which exists between the end of the Early Bronze Age and the beginning of the Late Bronze Age would easily accommodate the MBA. On current evidence, the Late Bronze Age appears extremely brief – perhaps only lasting less than a hundred years. It must be noted, however, that such observations are critically dependant on very few dates, even within this data set, and the model assumes a ‘step function’ transition from one period to the next, which is almost certainly not the case.

**4. Conclusion**

Excavations of the archaeological sites of Zagheh, Ghabrestan and Sagzabad have provided basic information to study long term of cultural developments within the central plateau of Iran. However, lack of c14 dates and a secure stratigraphic record have resulted in an incorrect chronological framework for the above sites. Before this study, no absolute and relative method followed for the chronology and archaeologists tried to propose a general picture of chronology rather than narrowing it into the chronometric dating. The results of the present study can be summarized as follows:

1. The study reveals the Neolithic period of the Qazvin plain based on the stratigraphic sequences of the two sites of Ebrahim Abad and Chahar Boneh. The two sites belongs to the latest phases of Neolithic period and there is
still no information about the earlier pre-ceramic Neolithic in the northern Central Plateau of Iran.

2. All relative chronologies of the three sites of Zagheh, Ghabristan and Sagzabad have been revised and for example while the previous relative chronology of Ghabristan suggested it starting at 5200 BC, the current study corrects this to c.4390 BC.

3. From 2001 onward some key sites in the Qazvin Plain have been excavated for chronological purposes but in spite of the many advantages of the new research we still need further studies to complete the chronological sequences of the following periods:

   i) It is very important to date any site of the transitional Chalcolithic phase, c. 4600 – 4300 BC. No transitional Chalcolithic sites (Phase II) of the three plains of Kahsan, Tehran and Qazvin have not been dated by c14. Some sites such as Ebrahim Abad, Zagheh and Sialk do not cover the cultural materials of this period and although Cheshmeh-Ali has very good sequences of this period it has not been dated by c14. It is important to note that our information about the latest phase of the Transitional Chalcolithic period is still based on vertical excavation and it is crucial to secure more data from horizontal excavation.

   ii) Although the current information indicates some chronometric dates of the Late Chalcolithic period, but in general, the beginning and end of this period in the Qazvin Plain is not known.

   iii) There is a large gap in the cultural sequences on the Qazvin Plain from c. 3540 to 1780 BC from the key sites of Ghabrestan and Sagzabad. In the Central Iranian Plateau, this period coincides with major climate changes, earthquake activity, and varying sedimentation styles which may have affected human settlement (Schmidt et al., 2011; Berberian et al., 2012). Further chronological studies will be very valuable to determine if such archaeological gaps are caused by natural disasters or the lack of adequate research.

Acknowledgements

The archaeological research and c.14 dating programs have been supported by a number of persons and institutions. The authors wish to acknowledge the Research Centre of the Cultural Heritage Organization of Iran, University of Tehran, the British Institute of Persian Studies and the Iranian Centre for Archaeological Research. We are indebted to Seyyed Mohammad Beheshi, Seyyed Taha Hashemi, Massoud Azarnoush, Seyyed Mehdi Mousavi Kohpar for their all endless support and help. We also wish to thank Alan Hogg and Dan Potts for providing unpublished $\delta^{13}$C values for the dates from the Radiocarbon Dating Laboratory, University of Waikato, NZ.

Finally we wish to thank the British Academy
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References


Chronology for the Neolithic Settlement of Tall-I Mushki, Marv Dasht Plain, Fars, Iran”. *Iran* XLVIII: 1-10.


Figure 1. Map showing Location of the Qazvin plain archaeological sites and other neighbours locations in North half of Iran.

Figure 2. Calibrated and modelled dates for Chahar Boneh LNI and LNII.
Figure 3. Stratigraphic section of Tepe Ebrahim Abad Trench I with location of radiocarbon samples.

Figure 4. Stratigraphic section of Tepe Ebrahim Abad Trench II and location of radiocarbon samples.
**Figure 5.** Calibrated and Modelled dates for Ebrahim Abad Trench I.

**Figure 6.** Calibrated and Modelled dates for Ebrahim Abad Trench II.
Figure 7. Calibrated and Modelled dates for Tepe Ebrahim Abad classified by archaeological phase.
Figure 8. Stratigraphic sections of Tepe Shizar Trenches I and II with contexts selected for C14 dating.

Figure 9. Calibrated and modelled dates from Tepe Shizar assuming a single sequence from Trench II to Trench I.
Figure 10. Stratigraphic section of Tepe Sagzabad Trench II with contexts selected for C14 dating.
Figure 11. Stratigraphic section of Tepe Sagzabad Trench IV with contexts selected for C14 dating.

Figure 12. Calibrated and modelled dates for Tepe Sagz Abad Trench IV.
Figure 13. Calibrated and modelled dates for Tepe Sagzabad based on archaeological periods, including dates from Gif-sur-Yvette.
Figure 14. Calibrated and modelled sequence, Trench A, Tepe Zagheh, using 9 of 10 Waikato dates.

Figure 15. Dates from Trench A at Tepe Zagheh combined with dates from Gif-sur-Yvette, modelled as Late Neolithic.
Figure 16. Dates from Trench A at Tepe Zagheh combined with dates from Gif-sur-Yvette, modelled as Transitional Chalcolithic.

Figure 17. All dates from Tepe Ghabrestan, including those published by Mashkour et al. (1999) as a Late Chalcolithic phase.
Figure 18. Modelled Boundary Dates for all sites on the Qazvin Plain.

Table 1. Radiocarbon Dates from Tepe Chahar Boneh

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<th>OxA</th>
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### Table 2. Calibrated and modelled dates for Chahar Boneh LNI and LNII

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Table 3. Radiocarbon dates from Tepe Ebrahim Abad.

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<th>Material</th>
<th>δ¹³C</th>
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<td>-</td>
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Lab Comment:
* OxA-17585. This sample produced a very low pretreatment yield. After pretreatment using the regular ORAU treatment of an acid-base-acid sequence the yield was only 20.4 mgs from over 200 mgs of starting material. This is much lower than we would normally expect. When the treated material was combusted for graphitization, the sample yielded only 7.1% carbon (we would expect this normally to be ~60%). This suggests either that the sample was poorly preserved and possibly highly degraded (we did note that it appeared to be poor quality), or that it was only partially composed of charcoal, with the remainder made up of low carbon sediment. This date should therefore be looked at with caution.
|----------|-------|------------|-----------|--------|--------|--------|--------|--------|--------|--------|--------|-----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-----------|--------|--------|--------|--------|--------|--------|--------|--------|
Table 5. Radiocarbon dates from Tepe Shizar.

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<th>Phase</th>
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<td>3333 ± 29</td>
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* Comment: Very low carbon content
Table 6. Calibrated and modelled dates from Tepe Shizar assuming a single sequence from Trench II to Trench I.

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<td></td>
</tr>
<tr>
<td>OxA-18206</td>
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<td>-3801</td>
</tr>
<tr>
<td>OxA-18207</td>
<td>-4032</td>
<td>-3801</td>
</tr>
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<td>Phase</td>
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<td></td>
</tr>
<tr>
<td>OxA-18334</td>
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<td>-3810</td>
</tr>
<tr>
<td>OxA-18208</td>
<td>-4047</td>
<td>-3951</td>
</tr>
<tr>
<td>Boundary S</td>
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<td></td>
</tr>
<tr>
<td>OxA-18206</td>
<td>-4020</td>
<td>-3962</td>
</tr>
</tbody>
</table>
Table 7. Radiocarbon dates from Tepe Sagzabad.

<table>
<thead>
<tr>
<th>OxA</th>
<th>Location</th>
<th>Context</th>
<th>Phase</th>
<th>Material</th>
<th>δ(^{13})C</th>
<th>Date (Uncal BP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OxA-20663</td>
<td>Trench II</td>
<td>2006</td>
<td>IA I</td>
<td>charcoal</td>
<td>-23.7</td>
<td>2912 ± 31</td>
</tr>
<tr>
<td>OxA-20661</td>
<td>Trench II</td>
<td>2008</td>
<td>IA I</td>
<td>charcoal</td>
<td>-25.6</td>
<td>2935 ± 29</td>
</tr>
<tr>
<td>OxA-20662</td>
<td>Trench II</td>
<td>2015</td>
<td>IA I</td>
<td>charcoal</td>
<td>-22.6</td>
<td>3041 ± 30</td>
</tr>
<tr>
<td>OxA-20548</td>
<td>Trench II</td>
<td>2017</td>
<td>IA I</td>
<td>charcoal</td>
<td>-25.7</td>
<td>3082 ± 32</td>
</tr>
<tr>
<td>*OxA-X-2323-10</td>
<td>Trench II</td>
<td>2020</td>
<td>IA I</td>
<td>charcoal</td>
<td>-22.5</td>
<td>3329 ± 36</td>
</tr>
<tr>
<td>OxA-20547</td>
<td>Trench II</td>
<td>2022</td>
<td>IA I</td>
<td>charcoal</td>
<td>-25.9</td>
<td>3162 ± 34</td>
</tr>
<tr>
<td>OxA-20738</td>
<td>Trench II</td>
<td>2034</td>
<td>LBA</td>
<td>charcoal</td>
<td>-23.9</td>
<td>3362 ± 34</td>
</tr>
<tr>
<td></td>
<td>Trench IV</td>
<td>4004</td>
<td>IA I</td>
<td>charcoal</td>
<td>-23.3</td>
<td>3021 ± 28</td>
</tr>
<tr>
<td>OxA-20658</td>
<td>Trench IV</td>
<td>4010</td>
<td>IA I</td>
<td>charcoal</td>
<td>-26.5</td>
<td>2990 ± 29</td>
</tr>
<tr>
<td>OxA-20546</td>
<td>Trench IV</td>
<td>4016</td>
<td>LBA</td>
<td>charcoal</td>
<td>-23.1</td>
<td>3225 ± 30</td>
</tr>
<tr>
<td>OxA-20659</td>
<td>Trench IV</td>
<td>4026</td>
<td>LC</td>
<td>charcoal</td>
<td>-26.5</td>
<td>4909 ± 33</td>
</tr>
<tr>
<td>OxA-20657</td>
<td>Trench IV</td>
<td>4027</td>
<td>LC</td>
<td>charcoal</td>
<td>-24.2</td>
<td>4791 ± 32</td>
</tr>
</tbody>
</table>

* Only 3.2% = low carbon yield (not charcoal)

Table 8. Other published radiocarbon dates from Tepe Sagzabad (Mashkour et al. 1999). TUNC dates (Tehran University Nuclear Centre) originally published by Bovington and Masoumi (1972).

<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Site/year</th>
<th>Trench/ square</th>
<th>Level/ Depth</th>
<th>Sample</th>
<th>δ(^{13})C</th>
<th>Age BP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gif-10347</td>
<td>SAG 1974</td>
<td>O XXI/2</td>
<td>L XIII</td>
<td>Bone (equid, cattle)</td>
<td>-18.0</td>
<td>2950 ± 40</td>
</tr>
<tr>
<td>Gif-10348</td>
<td>SAG 1974</td>
<td>N XXI/2</td>
<td>L IX</td>
<td>Bone (equid, caprine)</td>
<td>-19.2</td>
<td>2945 ± 45</td>
</tr>
<tr>
<td>Gif-10349</td>
<td>SAG 1970</td>
<td>A</td>
<td>L XXIV previous XIII</td>
<td>Bone (equid)</td>
<td>-18.0</td>
<td>2915 ± 60</td>
</tr>
<tr>
<td>Gif-10350</td>
<td>SAG 1970</td>
<td>A</td>
<td>L XXX previous VII</td>
<td>Bone (equid)</td>
<td>-19.6</td>
<td>2820 ± 30</td>
</tr>
<tr>
<td>TUNC-13</td>
<td>SAG 1970</td>
<td>A</td>
<td>L III</td>
<td>Burnt wood</td>
<td></td>
<td>3696 ± 62</td>
</tr>
<tr>
<td>TUNC-8</td>
<td>SAG 1970</td>
<td>A</td>
<td>L II</td>
<td>Burnt wood</td>
<td></td>
<td>4086 ± 66</td>
</tr>
<tr>
<td>TUNC-9</td>
<td>SAG 1970</td>
<td>A</td>
<td>L I</td>
<td>Burnt wood</td>
<td></td>
<td>4426 ± 69</td>
</tr>
<tr>
<td>TUNC-11</td>
<td>SCM 1970</td>
<td>A</td>
<td>268</td>
<td>Burnt wood</td>
<td></td>
<td>6083 ± 84</td>
</tr>
<tr>
<td>TUNC-7</td>
<td>SCM 1970</td>
<td>A</td>
<td>160</td>
<td>Burnt wood</td>
<td></td>
<td>3665 ± 61</td>
</tr>
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</table>
Table 9. Calibrated and modelled dates for Tepe Sagzabad based on archaeological period, including dates from Gif-sur-Yvette

<table>
<thead>
<tr>
<th>Period</th>
<th>Unmodelled (BC/AD) (95.4%)</th>
<th>Modelled (BC/AD) (68.2%)</th>
<th>Modelled (BC/AD) (95.4%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>from</td>
<td>to</td>
<td>median</td>
</tr>
<tr>
<td>Boundary E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gif-10350</td>
<td>-1070</td>
<td>-898</td>
<td>-972</td>
</tr>
<tr>
<td>Gif-10349</td>
<td>-1302</td>
<td>-932</td>
<td>-1119</td>
</tr>
<tr>
<td>Gif-10348</td>
<td>-1304</td>
<td>-1013</td>
<td>-1164</td>
</tr>
<tr>
<td>Gif-10347</td>
<td>-1299</td>
<td>-1026</td>
<td>-1171</td>
</tr>
<tr>
<td><strong>Phase Gif</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OxA-20663</td>
<td>-1252</td>
<td>-1010</td>
<td>-1105</td>
</tr>
<tr>
<td>OxA-20661</td>
<td>-1261</td>
<td>-1042</td>
<td>-1150</td>
</tr>
<tr>
<td>OxA-20662</td>
<td>-1406</td>
<td>-1213</td>
<td>-1317</td>
</tr>
<tr>
<td>OxA-20548</td>
<td>-1425</td>
<td>-1268</td>
<td>-1356</td>
</tr>
<tr>
<td>OxA-20547</td>
<td>-1504</td>
<td>-1326</td>
<td>-1441</td>
</tr>
<tr>
<td><strong>Sequence Trench II</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OxA-20660</td>
<td>-1389</td>
<td>-1133</td>
<td>-1288</td>
</tr>
<tr>
<td>OxA-20658</td>
<td>-1371</td>
<td>-1126</td>
<td>-1233</td>
</tr>
<tr>
<td><strong>Sequence Trench IV</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Phase Iron Age I</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boundary T</td>
<td>-1486</td>
<td>-1417</td>
<td>-1539</td>
</tr>
<tr>
<td>OxA-20738</td>
<td>-1741</td>
<td>-1535</td>
<td>-1654</td>
</tr>
<tr>
<td>OxA-20546</td>
<td>-1606</td>
<td>-1427</td>
<td>-1488</td>
</tr>
<tr>
<td><strong>Phase Late Bronze Age</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boundary SLBA</td>
<td>-1938</td>
<td>-1546</td>
<td>-2827</td>
</tr>
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<td>Boundary ELC</td>
<td>-3676</td>
<td>-3465</td>
<td>-3698</td>
</tr>
<tr>
<td>OxA-20659</td>
<td>-3764</td>
<td>-3641</td>
<td>-3684</td>
</tr>
<tr>
<td>OxA-20657</td>
<td>-3646</td>
<td>-3520</td>
<td>-3567</td>
</tr>
<tr>
<td>Boundary S</td>
<td>-3736</td>
<td>-3549</td>
<td>-4124</td>
</tr>
<tr>
<td><strong>Sequence</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 10. Radiocarbon dates for Tepe Zagheh Trench A produced by Radiocarbon Dating Laboratory, University of Waikato, NZ (unpublished data on $\delta^{13}$C values kindly provided by Alan Hogg and Dan Potts).

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Lab No.</th>
<th>Context No.</th>
<th>Depth (cm)</th>
<th>Sample</th>
<th>$\delta^{13}$C</th>
<th>Result (BP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZH01</td>
<td>WK12854</td>
<td>1</td>
<td>2</td>
<td>Charcoal</td>
<td>-25.3</td>
<td>6154 ± 49</td>
</tr>
<tr>
<td>ZH02</td>
<td>WK12855</td>
<td>7</td>
<td>44</td>
<td>Charcoal</td>
<td>-24.0</td>
<td>5489 ± 45</td>
</tr>
<tr>
<td>ZH03</td>
<td>WK12856</td>
<td>11</td>
<td>50</td>
<td>Charcoal</td>
<td>-25.7</td>
<td>5936 ± 69</td>
</tr>
<tr>
<td>ZH04</td>
<td>WK12857</td>
<td>16</td>
<td>95</td>
<td>Charcoal</td>
<td>-23.7</td>
<td>6152 ± 46</td>
</tr>
<tr>
<td>ZH05</td>
<td>WK12858</td>
<td>17</td>
<td>111</td>
<td>Charcoal</td>
<td>-24.9</td>
<td>6124 ± 46</td>
</tr>
<tr>
<td>ZH06</td>
<td>WK12859</td>
<td>35</td>
<td>140</td>
<td>Charcoal</td>
<td>-25.4</td>
<td>5991 ± 65</td>
</tr>
<tr>
<td>ZH07</td>
<td>WK12860</td>
<td>38</td>
<td>170</td>
<td>Charcoal</td>
<td>-24.5</td>
<td>6233 ± 48</td>
</tr>
<tr>
<td>ZH08</td>
<td>WK12861</td>
<td>45</td>
<td>255</td>
<td>Charcoal</td>
<td>-25.6</td>
<td>6169 ± 78</td>
</tr>
<tr>
<td>ZH09</td>
<td>WK12862</td>
<td>45</td>
<td>305</td>
<td>Charcoal</td>
<td>-24.4</td>
<td>6410 ± 50</td>
</tr>
<tr>
<td>ZH10</td>
<td>WK12863</td>
<td>47</td>
<td>460</td>
<td>Charcoal</td>
<td>-24.3</td>
<td>6295 ± 47</td>
</tr>
</tbody>
</table>
Table 11. Other published radiocarbon dates from Tepe Zagheh by Gif-sur-Yvette (Mashkour et al. 1999). TUNC dates (Tehran University Nuclear Centre) originally published by Bovington and Masoumi (1972).

<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Site/year</th>
<th>Trench/ square</th>
<th>Level/ Depth</th>
<th>Sample</th>
<th>δ¹³C</th>
<th>Age BP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gif-10226</td>
<td>TZ 1973</td>
<td>TT FGX</td>
<td>325-335</td>
<td>Bone (cattle)</td>
<td>-18.6</td>
<td>6100 ± 60</td>
</tr>
<tr>
<td>Gif-10343</td>
<td>TZ 1994</td>
<td>A8/4</td>
<td>35</td>
<td>Bone (caprine)</td>
<td>-17.7</td>
<td>5930 ± 70</td>
</tr>
<tr>
<td>Gif-10344</td>
<td>TZ 1973</td>
<td>D IX</td>
<td>110-130</td>
<td>Bone (mammal)</td>
<td>-17.7</td>
<td>5883 ± 75</td>
</tr>
<tr>
<td>Gif-10345</td>
<td>TZ 1970</td>
<td>F IX</td>
<td></td>
<td>Bone (cattle)</td>
<td>-17.8</td>
<td>5900 ± 55</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Site/year</th>
<th>Trench/ square</th>
<th>Level/ Depth</th>
<th>Sample</th>
<th>δ¹³C</th>
<th>Age BP</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUNC-10</td>
<td>TZ 1970</td>
<td>F X</td>
<td>Level I</td>
<td>Burnt wood</td>
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<td>4909 ± 73</td>
</tr>
<tr>
<td>TUNC-12</td>
<td>TZ 1970</td>
<td>F X</td>
<td>289</td>
<td>Burnt wood</td>
<td></td>
<td>7147 ± 91</td>
</tr>
</tbody>
</table>

Table 12. Calibrated and Modelled dates from Trench A at Tepe Zagheh combined with dates from Gif-sur-Yvette, modelled as Transitional Chalcolithic.

<table>
<thead>
<tr>
<th>Modelled (BC/AD) (95.4%)</th>
<th>Umodelled (BC/AD) (95.4%)</th>
<th>Modelled (BC/AD) (68.2%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>from</td>
<td>to</td>
</tr>
<tr>
<td>Boundary E</td>
<td>-4430</td>
<td>-4269</td>
</tr>
<tr>
<td>WK12855</td>
<td>-4449</td>
<td>-4257</td>
</tr>
<tr>
<td>WK12856</td>
<td>-5001</td>
<td>-4619</td>
</tr>
<tr>
<td>WK12857</td>
<td>-5220</td>
<td>-4961</td>
</tr>
<tr>
<td>WK12858</td>
<td>-5211</td>
<td>-4946</td>
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<tr>
<td>WK12859</td>
<td>-5043</td>
<td>-4722</td>
</tr>
<tr>
<td>WK12860</td>
<td>-5311</td>
<td>-5056</td>
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<tr>
<td>WK12861</td>
<td>-5311</td>
<td>-4912</td>
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<tr>
<td>WK12862</td>
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<td>-5312</td>
</tr>
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<td>-5375</td>
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</table>

Sequence

Phase Trench A

<table>
<thead>
<tr>
<th>Phase</th>
<th>from</th>
<th>to</th>
<th>median</th>
<th>from</th>
<th>to</th>
<th>from</th>
<th>to</th>
<th>from</th>
<th>to</th>
<th>median</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIF-10345</td>
<td>-4934</td>
<td>-4618</td>
<td>-4774</td>
<td>-4836</td>
<td>-4715</td>
<td>-4934</td>
<td>-4618</td>
<td>-4774</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GIF-10344</td>
<td>-4938</td>
<td>-4553</td>
<td>-4758</td>
<td>-4848</td>
<td>-4621</td>
<td>-4938</td>
<td>-4554</td>
<td>-4758</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GIF-10343</td>
<td>-4998</td>
<td>-4618</td>
<td>-4812</td>
<td>-4900</td>
<td>-4721</td>
<td>-4998</td>
<td>-4619</td>
<td>-4813</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GIF-10226</td>
<td>-5213</td>
<td>-4849</td>
<td>-5030</td>
<td>-5205</td>
<td>-4936</td>
<td>-5213</td>
<td>-4849</td>
<td>-5029</td>
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</table>

Phase GIF

<table>
<thead>
<tr>
<th>Phase</th>
<th>from</th>
<th>to</th>
<th>median</th>
<th>from</th>
<th>to</th>
<th>from</th>
<th>to</th>
<th>from</th>
<th>to</th>
<th>median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boundary S</td>
<td>-5464</td>
<td>-5296</td>
<td>-5607</td>
<td>-5240</td>
<td>-5384</td>
<td></td>
<td></td>
<td></td>
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</table>
Table 13. Radiocarbon date ranges for trench L34, Tepe Ghabrestan produced by Radiocarbon Dating Laboratory, University of Waikato, NZ (unpublished data on δ13C values kindly provided by Alan Hogg and Dan Potts).

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Lab No.</th>
<th>Depth (cm)</th>
<th>Context No.</th>
<th>Result (BP)</th>
<th>Sample</th>
<th>δ13C</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>GB01</td>
<td>WK12847</td>
<td>233</td>
<td>7</td>
<td>5045 ± 61</td>
<td>Charcoal</td>
<td>-24.2</td>
<td>MC</td>
</tr>
<tr>
<td>GB02</td>
<td>WK12848</td>
<td>273</td>
<td>8</td>
<td>5041 ± 44</td>
<td>Charcoal</td>
<td>-25.8</td>
<td>MC</td>
</tr>
<tr>
<td>GB03</td>
<td>WK12849</td>
<td>343</td>
<td>11</td>
<td>5140 ± 68</td>
<td>Charcoal</td>
<td>-24.5</td>
<td>MC</td>
</tr>
<tr>
<td>GB04</td>
<td>WK12850</td>
<td>372</td>
<td>12</td>
<td>5071 ± 83</td>
<td>Charcoal</td>
<td>-24.9</td>
<td>MC</td>
</tr>
<tr>
<td>GB05</td>
<td>WK12851</td>
<td>380</td>
<td>14</td>
<td>5188 ± 46</td>
<td>Charcoal</td>
<td>-25.2</td>
<td>EC</td>
</tr>
<tr>
<td>GB06</td>
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<td>455</td>
<td>24</td>
<td>5310 ± 47</td>
<td>Charcoal</td>
<td>-25.1</td>
<td>EC</td>
</tr>
<tr>
<td>GB07</td>
<td>WK12853</td>
<td>495</td>
<td>28</td>
<td>5475 ± 45</td>
<td>Charcoal</td>
<td>-21.5</td>
<td>EC</td>
</tr>
</tbody>
</table>

Table 14. Gif-sur-Yvette radiocarbon dates from Tepe Ghabrestan (Mashkour et al. 1999).

<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Site/year</th>
<th>Trench/ square</th>
<th>Level/Depth</th>
<th>Sample</th>
<th>δ13C</th>
<th>Age BP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gif-10227</td>
<td>SCM 1970</td>
<td>A   L XXII</td>
<td>Bone (equid, caprine)</td>
<td>-19.6</td>
<td>4530 ± 45</td>
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<tr>
<td>Gif-10409</td>
<td>SCM 1973</td>
<td>E/J15 100</td>
<td>Bone (equid, cattle)</td>
<td>-17.3</td>
<td>4130 ± 50</td>
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</tr>
<tr>
<td>Gif-10408</td>
<td>SCM 1973</td>
<td>E/J15 180-185</td>
<td>Bone (equid)</td>
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<tr>
<td>Gif-10225</td>
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<td>E/J15-407 200-210</td>
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<td>4730 ± 70</td>
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<tr>
<td>Gif-10411</td>
<td>SCM 1973</td>
<td>EA/G14 30-40</td>
<td>Bone (equid, caprine, mammal)</td>
<td>-17.8</td>
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<tr>
<td>Gif-10412</td>
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<td>Gif-10410</td>
<td>SCM 1974</td>
<td>K xx/3 85-90</td>
<td>Bone (cattle)</td>
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Table 15. Calibrated and Modelled dates from Tepe Ghabrestan, including those published by Mashkour et al. (1999) as a Late Chalcolithic phase.

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<th>Unmodelled (BC/AD) (95.4%)</th>
<th>Modelled (BC/AD) (68.2%)</th>
<th>Modelled (BC/AD) (95.4%)</th>
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Table 16. Modelled Transition Dates for Each Site on the Qazvin Plain.

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<th>Tepe Ghabrestan</th>
<th>Tepe Sagzabad</th>
<th>Tepe Shizar</th>
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Table 17. The Modelled Transition Dates for all six sites on the Qazvin Plain.

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<th>Boundary</th>
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<th>68% confidence</th>
<th>Median (cal BC)</th>
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<td>5519-5387</td>
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<td>Late Neolithic II to Transitional Chalcolithic I</td>
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<td>4377-4279</td>
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گاهنگاری دشت قروین از نوسنجی متأخر تا عصر اهن
بر مبنای داده‌های رادیوکربن جدید

مکر پولارد، حسین داوودی، ایمان مصطفی‌پور، حمیدرضا وی‌پور، حسن فاضلی‌نسلی

تاریخ پذیرش: ۱۳۹۱/۰۸/۰۶

پژوهش‌های باستان‌شناسی انجام شده در حوزه غرب فلات مرکزی ایران، در جابجایی که به‌نام دشت قروین شناخته می‌شود، اطلاعات ارزشمندی را در خصوص جوامع یکجانشین از نخبین استقرارها تا دوران‌های تاریخی فراهم اورده است. برخلاف پژوهش‌های باستان‌شناسی در گذشته، مطالعات گاهنگاری جهت استفاده و تبیین سن‌سنجی داده‌های بدست‌آمده از لایه‌ها، بیشتر بر مدل‌سازی محتوای احتمالات تأکید دارد. مقاله پیش روی بر اساس داده‌های سن‌پایی شده شش محوطه کلیسی دشت قروین، الگوی نوینی در خصوص کاوی‌ها و چهارچوب تازهای برای گاهنگاری دشت قروین ارائه نموده اند. پردازش محتوای احتمالات برای تک تک محوطه‌ها لحاظ گردیده تا منجر به بهترین و دقیق‌ترین گاهنگاری گردد. در نهایت نتایج سن‌سنجی‌ها جهت دست‌بایی به الگوی واحد برای گاهنگاری دشت قروین از نوسنجی متأخر تا عصر اهن با یکدیگر تلفیق گردیدند. هدف غایب این پژوهش این است که به مدت متمایزی احتمالات بتوان نقطه انتقالی مابین عصران شناخته شده‌

1. آزمایشگاه پژوهش‌های باستان‌شناسی و تاریخ هر، دانشگاه آکسفورد، انگلستان.
2. دانشجوی دکتری گروه باستان‌شناسی، دانشگاه تربت حیدریه.
3. دانشجوی دکتری گروه باستان‌شناسی، دانشگاه تهران.
4. گروه باستان‌شناسی دانشگاه شهید بهشتی.
5. گروه باستان‌شناسی دانشگاه تهران.
باستان‌شناختی در منطقه مورد مطالعه را مورد بازبینی مجدد قرار داد و گاه‌گزی دشت قزوین را دگرباره تیپین نمود.

واژگان کلیدی: گاه‌گزی، دشت قزوین، نوسانی متأخر، عصر آهن، گاه‌گزی رادیوکربن، الگوسازی منحنی احتمالات.