Appendix 11.1

Dating of Early Neolithic sites in the Zagros and adjacent regions

Includes all Early Neolithic (Pre-Pottery) sites in the Eastern Fertile Crescent for which ^{14}C dates have been reported (certainly including publications up to and including 2015). The below analyses were used to produce Figure 11.3, for which only the reliable dates were used. The figure indicates the complete range of occupation, and it is possible that the actual occupation at each site was shorter, but it is 68% and 95% likely to fall within the box and lines, respectively. In addition, it should be kept into consideration that not all deposits may have yielded samples for dates, so that occupation may also have been longer. They grey boxes give dating based on other evidence like stylistic comparison of archaeological material or stratigraphy where this is significantly different from the reliable ^{14}C dates (e.g. if the material found clearly indicates a Neolithic date but this is not reflected in the ^{14}C dates. Detailed information is available below. Most notably: For Chogha Golan, the earliest and latest dates have not been reported as ^{14}C dates, but as calibrated dates only, which are indicated here. For East Chia Sabz the earliest and latest sediments have not yet been dated, but material culture indicates the site likely was occupied until at least c. 7000/6800 cal BC. For Tepe Guran the two youngest dates are out of their stratigraphic context. For Shimshara, the Late Neolithic deposits have not been reliably dated and the grey bar is an indication of occupation into the Late Neolithic as suggested by the archaeology. At Ali Kosh only bone carbonate samples are available. Finally, the dates for M'lefaat and Nemrik 9 are unreliable.

Abdul Hosein (Central Zagros)

The six available ^{14}C dates from Adbul Hosein are all unreliable, as the standard deviations are very large, and no material was reported (Pullar 1981; Marshall 2012). We therefore do not take this site into account in our absolute chronological comparison. In general, this site is thought to be Early Neolithic, with a chipped stone industry similar to Ganj Dareh and Asiab (Voigt and Dyson Jr. 1992).

Ali Kosh (SW Iran)

There are as many as 33 ^{14}C dates for Ali Kosh (Table 1) (Zeder and Hesse 2000; Böhner and Schyle 2002-2006; Zeder 2005; Marshall 2012; Weninger *et al.* 2013), but most of these are problematic. Most of the samples analysed in the 1960s have large to very large standard deviations, and were mostly mixed charcoal/seeds and ash or charred bone samples. The set of fourteen newer analyses (with the Beta-prefix) appear more reliable, but were conducted on charred bone (Zeder and Hesse 2000; Zeder 2005). This is not always a problem (Lanting *et al.* 2001) hence we take them into account, but they should be taken with caution (they are consequently indicated in grey in Fig. 11.3).

The site's occupation is divided into three phases, from old to young: the aceramic Bus Mordeh and Ali Kosh phases, and the ceramic Mohammad Jaffar phase. The ^{14}C-dates are in rough agreement with this phasing, but there is also much overlap between dates from different phases, while within each phase, dates are often not in order of their depth (Fig. 1). Beta-118721 is clearly too old for its associated late-Ali Kosh context; it was found towards the top of this phase, while its date is older than any of the Ali Kosh or Bus Mordeh dates. Beta-108256 appears too young for the Bus Mordeh phase it came from. Several of the Ali Kosh and Mohammad Jaffar phase dates are overlapping; however, without detailed information on the samples and their association with their contexts, it is difficult to know which ones may be erroneous or intrusive. Are Beta-177124 and Beta-188722 intrusive in the Ali Kosh phase, or are Beta-118720 and Beta-118719 too old for their Mohammad Jaffar contexts? Or, are the 'phases' perhaps overlapping chronologically? Because of these stratigraphic inconsistencies, a sequential Bayesian model only gives an acceptable agreement index (>60), when the above mentioned Beta-118721 and Beta-108256 as well as either the two late Ali Kosh, or the two early Mohammad Jaffar dates are left out.

Typological comparisons are only of limited help here. The Bus Mordeh phase was thought, based on typological comparisons, to be contemporary with early sites like Ganj Dareh, Karim Shahir, and Zawi Chemi (Voigt and Dyson Jr. 1992). While it is not clear how reliable the ^{14}C dates are, they at least clearly indicate that occupation at Ali Kosh only started later. The Ali Kosh phase was reported to have a similar chipped stone industry as the Bus Mordeh phase and "general PPNB characteristics" (Voigt and Dyson Jr. 1992). The Mohammad Jaffar phase, finally, has chaff-tempered buff-coloured ceramics, which have been compared to Tepe Guran level J-D Standard Painted Ware and the linear style at Sarab (Voigt and Dyson Jr. 1992). This is in rough agreement with the two 7th millennium dates for this phase at Ali Kosh.

For our purposes now, this is not too important: we can conclude that if these dates are indeed reliable (which needs to be confirmed with bone collagen or charred plant material samples), the BM and (earlier) AK phases are roughly contemporaneous with occupation at Bestansur (most likely just after Sheikh-e Abad), while the MJ phase/ later AK phase is roughly contemporary with Shimshara. There is a group of dates which coincides with the earlier (CZAP) levels at Shimshara (the dates that are overlapping between the AK and MJ phases), and there are two dates which are probably at least roughly contemporary with the later, Hassuna, Shimshara phases.

Table 1. All ^{14}C dates of Ali Kosh (Zeder and Hesse 2000; Böhner and Schyle 2002-2006; Zeder 2005; Marshall 2012; Weninger et al. 2013). Where quality-check criteria (see main text) are problematic, this is indicated in red.

Lab no	**$^{14}C \pm 1\sigma$**	**material**	**phase + depth (cm)**	**assessment**	**cal BC (1σ)**	**cal BC (2σ)**
Beta-137024	8410 ±50	charred bone	BM, 680-710	Questionable: charred bone	7546-7382	7576-7356
Beta-177126	8530 ±40	charred bone	BM, 680	Questionable: charred bone	7589-7550	7597-7529
Beta-122721	8540 ±90	charred bone	BM, 635	Questionable: charred bone	7651-7499	7793-7358
Beta-108256	8000 ±50	charred bone	BM, 546	Questionable: charred bone, not in agreement with stratigraphy	7048-6829	7062-6706
Beta-118724	8340 ±100	charred bone	AK, 380-400	Questionable: charred bone	7528-7200	7577-7091
Beta-118723	8490 ±90	charred bone	AK, 280-300	Questionable: charred bone	7600-7472	7716-7336
Beta-137021	8450 ±70	charred bone	AK, 250-270	Questionable: charred bone	7581-7480	7594-7355
Beta-177124	8050 ±40	charred bone	AK, 230	Questionable: charred bone	7075-6840	7129-6823
Beta-118722	8110 ±80	charred bone	AK, 210-230	Questionable: charred bone	7300-6864	7347-6777
Beta-118721	8720 ±100	charred bone	AK, 180-200	Questionable: charred bone, not in agreement with stratigraphy	7938-7601	8201-7583
Beta-118720	8140 ±70	charred bone	MJ, 130-140	Questionable: charred bone	7290-7053	7446-6838
Beta-177122	7550 ±40	charred bone	MJ, 90-100	Questionable: charred bone	6450-6399	6473-6271
Beta-118719	8130 ±70	charred bone	MJ, 70-80	Questionable: charred bone	7290-7047	7349-6831
Beta-137020	7100 ±70	charred bone	MJ, 50-60	Questionable: charred bone	6047-5904	6096-5803
H-1833/O-1833	8425 ±180	charcoal	AK	Unreliable: large sd, analysed 1960s		

H-1845/O-1845	8250 ±175	organic material	AK	Unreliable: large sd, analysed 1960s, material vague		
H-1848/O-1848	7770 ±330	organic material	AK	Unreliable: large sd, analysed 1960s, material vague		
I-1489	7660 ±170	charred seeds and ash	BM, 690, basal level	Unreliable: large sd, 1960s, ash		
I-1490	9950 ±190	charcoal	AK, 270	Unreliable, large sd, 1960s		
I-1491	8100 ±170	charcoal and ash	AK, 260	Unreliable: large sd, 1960s, ash		
I-1494	7820 ±190	charcoal and ash	MJ, 150	Unreliable: large sd, 1960s, ash		
I-1495	7220 ±160	charcoal and ash	MJ, 90	Unreliable: large sd, 1960s, ash		
I-1496	7380 ±130	charred seeds and ash	BM, 525	Unreliable: large sd, 1960s, ash		
O-1816	8425 ±180	charcoal	AK, 10	Unreliable: large sd		
OxA-1773	7830 ±90	charred bone	BM	Unreliable: charred bone in 1990s		
OxA-1774	7950 ±110	charred bone	BM	Unreliable: charred bone in 1990s		
OxA-1775	7480 ±90	charred bone	BM	Unreliable: charred bone in 1990s		
S-1174	8850 ±210	charcoal	AK	Unreliable, large sd, 1960s		
S-1246	8410 ±200	charcoal	AK	Unreliable, large sd, 1960s		
SI-160	8920 ±100	seeds, *Proposis* sp.	MJ	Questionable: Proposis may be intrusive, 1960s, not in agreement with stratigraphy	8253-7954	8293-7746
SI-160R	8890 ±200	seeds, *Proposis* sp.	MJ	Unreliable, large sd, 1960s		
SI-207	7740 ±600	charcoal	AK, final phase	Unreliable, very large sd, 1960s		
UCLA-750D	9900 ±200	charcoal	BM, 680	Unreliable, large sd, 1960s		

sd: standard deviation

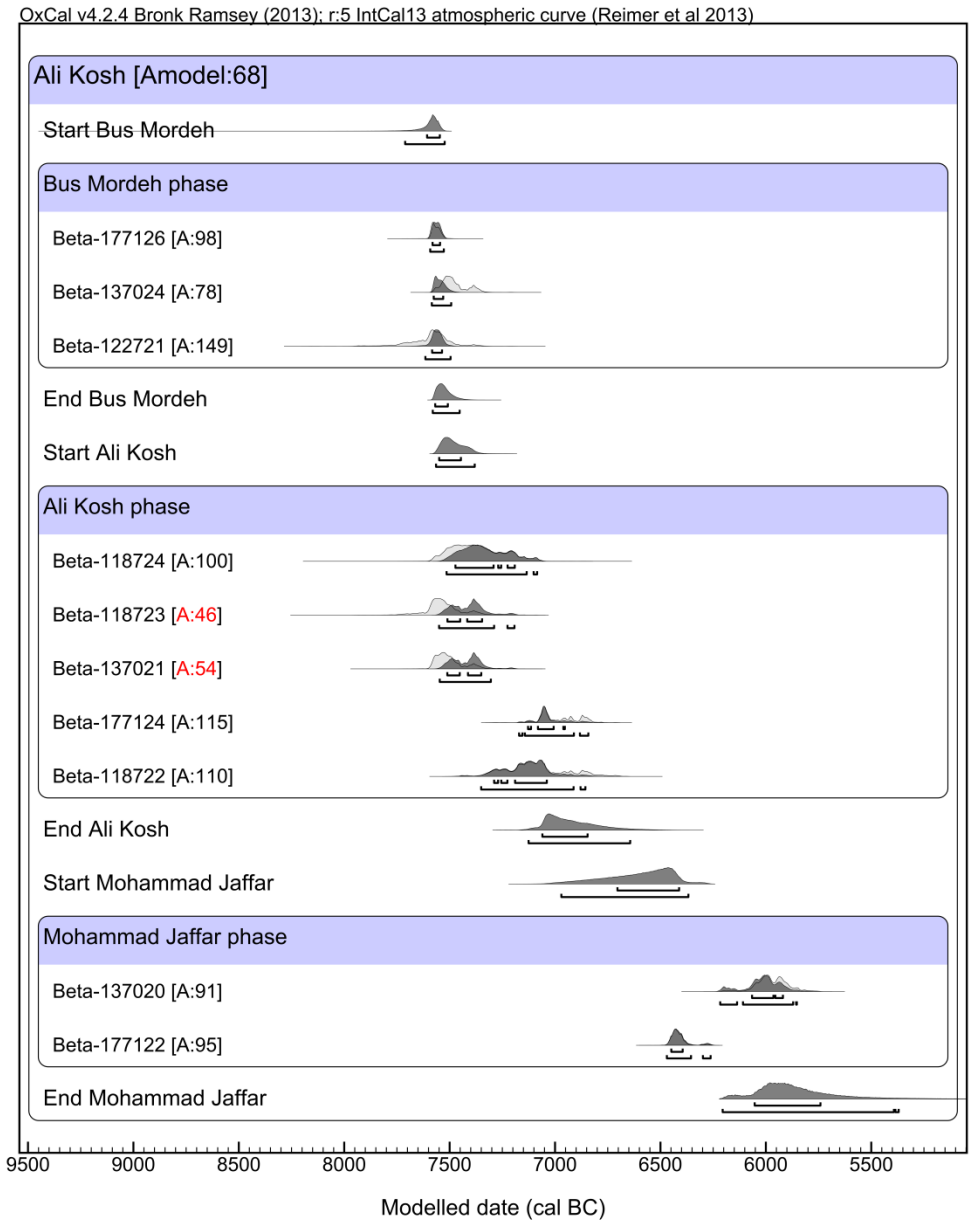

Fig. 1. Ali Kosh ^{14}C dates per phase, without Beta-118721, Beta-108256, Beta-118720 and Beta-118719. In this model, the two oldest MJ phase dates have been left out. It is uncertain if this is correct.

Asiab (Central Zagros)

Initially, there were seven, only partly reliable, ^{14}C-dates for Asiab (Böhner and Schyle 2002-2006; Zeder 2005; Marshall 2012; Weninger *et al.* 2013), but recently new dates were published (Bangsgaard *et al.* 2019) (Table 2). Three of the original dates are on bone collagen and were conducted in the 1970s, and therefore unreliable. This is also clear from the large

standard deviations and the deviating dates. The remaining four original dates appear reliable: they have acceptable standard deviations and the three bone collagen samples were analysed in the 2000s. One of these dates is not in agreement with the stratigraphy though, as it is the lowest of the samples, yet it gives a date of *c.* 2000 ^{14}C-years younger than the other dates. It is therefore likely to be intrusive and it is not taken into account here. The three remaining dates are in agreement with the stratigraphy, but an old wood effect cannot be ruled out for the charcoal date (its species and size were not reported). The youngest two dates are inverted when looking at their mean, but they overlap considerably when looking at the 1σ and 2σ date ranges.

The eight recently published dates (Bangsgaard et al. 2019) come from in situ deposits and are reliable. However, they are all on wood so that an old wood effect cannot be excluded, although the consistency of the dates would argue against that. Moreover, at least one sample was derived from a twig.

The three original reliable dates indicate occupation is likely to have taken place sometime between the end of the 9th and the early 8th millennium cal BC, but standard deviations were large. The new dates are clustering more tightly and indicate an earlier date of between *c.* 9660-9300 cal BC (Bangsgaard et al. 2019), in rough agreement with charcoal sample GrN-6434. As such, the site is probably contemporaneous with Sheikh-e Abad, especially if indeed occupation at that site was continuous between Trench 1 and Trench 2 levels.

Table 2. Asiab ^{14}C dates (Böhner and Schyle 2002-2006; Zeder 2005; Marshall 2012; Weninger et al. 2013; Bangsgaard et al. 2019). The modelled dates come from a charcoal outlier model that was run in OxCal 4.2 for the original dates and from Bangsgaard et al. 2019 for the recently analysed dates.

Lab no	**^{14}C ± 1σ**	**material**	**details**	**depth (cm)**	**assessment**	**cal BC (1σ)**	**cal BC (2σ)**	**model 1 (2s)**	**model 2 (2σ)**
AAR-26656	10024 ±50	Charcoal	*Amygdalus*		Reliable	9745-9416	9808-9344	9648-9363	9660-9343
AAR-26653	9980 ±39	Charcoal	*Amygdalus*		Reliable	9651-9360	9670-9316	9365-9317	9397-9301
AAR-26652	9959 ±30	Charcoal	*Amygdalus*		Reliable	9448-9328	9653-9309	9363-9318	9395-9302
AAR-26654	9940 ±37	Charcoal	Salicaceae		Reliable	9443-9316	9652-9293	9357-9310	9389-9294
AAR-26657	9900 ±56	Charcoal	Indet. twig		Reliable	9439-9286	9653-9257	9648-9363	9660-9343
AAR-26655	9917 ±27	Charcoal	*Amygdalus* Boar pit		Reliable	9373-9304	9442-9295	9440-9352	9451-9330

AAR-26659	9912 ±26	Char-coal	*Pistacia* Boar pit		Reliable	9368-9303	9441-9292	9438-9352	9446-9335
AAR-26658	9901 ±41	Char-coal	Salicaceae Boar pit		Reliable	9379-9292	9641-9265	9442-9352	9651-9327
GrN-6434	9755 ±85	char-coal		165-170	Reliable	9330-9144	9449-8839	9328-8778	9361-8531
Beta-159554	9380 ±60	bone	collagen	45-60	Reliable	8741-8573	8807-8474	9119-8602	9107-8483
Beta-159555	9480 ±80	bone	collagen	30-45	Reliable	9117-8639	9152-8576	9098-8488	9133-8603
UCLA -1714F	9050 ±300	bone	*Ovis / Capra*	150-160	Unreliable (bone 1970s)				
UCLA -1714B	8900 ±100	bone	*Ovis / Capra*	140	Unreliable (bone 1970s)				
UCLA -1714C	8700 ±100	bone	*Ovis / Capra*	120-140	Unreliable (bone 1970s)				
Beta-159552	7790 ±60	bone	collagen	75-90	Unreliable, not in agreement with stratigraphy				

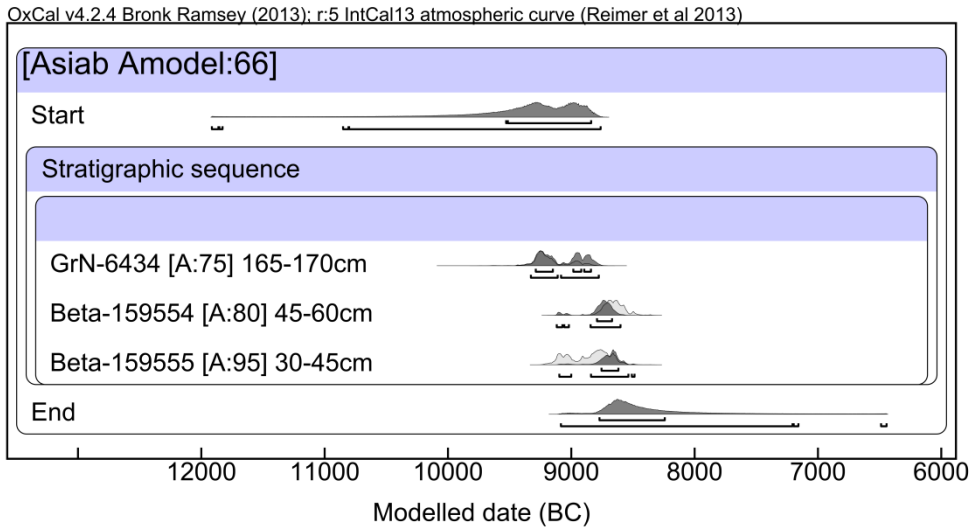

Fig. 2a Asiab ^{14}C dates by Zeder and Hesse, modelled according to stratigraphic order ('model 1'). An updated model can be found in Bangsgaard et al. 2019: Fig. 4.

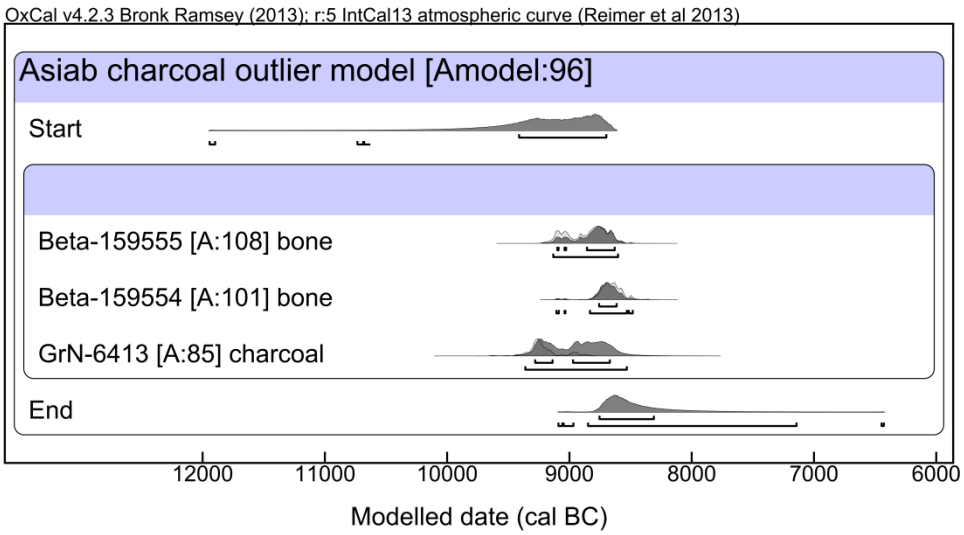

Fig. 2b Asiab ^{14}C dates by Zeder and Hesse, modelled as charcoal outlier model to account for the potential old wood effect of the charcoal sample ('model 2').

Chogha Bonut (SW Iran)

Ten ^{14}C dates are available for Chogha Bonut (Alizadeh 2003; Zeder 2005; Marshall 2012; Weninger *et al.* 2013). Three of these are on organic sediment and therefore unreliable, as also visible from the high dates for two of them and their large standard deviations considering they are AMS dates (see Marshall 2012). The other dates appear reliable, although for the three bone dates no context information is available, so that their association with their context cannot be judged.

All seven reliable or acceptable dates are in agreement with each other and could represent a short occupation span of less than 100 years between *c.*7100 and 7000 cal BC (the OxCal 'span' function gives 0-87 cal years in 1σ, and 0-260 cal years in 2σ). The dating is in agreement with the observation that the presence of stone vessel fragments may indicate that the site is contemporaneous with the Ali Kosh phase at Ali Kosh (Voigt and Dyson Jr. 1992). As such, the site may be contemporaneous with Bestansur Trench 13. It is very likely contemporaneous with the Aceramic phase at Shimshara, *if* this continues without break into the Ceramic phases there. Chogha Bonut also has 1.5 m of deposits with chaff-tempered, red-to-plum painted ceramics above the aceramic phase (Voigt and Dyson Jr. 1992), which remain undated.

Table 3. Chogha Bonut ^{14}C dates (Alizadeh 2003; Zeder 2005; Marshall 2012; Weninger et al. 2013).

Lab no	$^{14}C \pm 1\sigma$	material	phase	assessment	cal BC (1σ)	cal BC (2σ)	cal BC model 2s
Beta-105554	41930 ±1000	organic		Unreliable (large sd, age, material)			
Beta-104553	10980 ±100	organic		Unreliable (age, material)			
Beta-104552	8270 ±100	organic sediment	Aceramic	Unreliable (material)			
Beta-104555	8070 ±50	charred material	Aceramic	Reliable	7139-6841	7181-6819	7140-6924
Beta-106164	8170 ±60	charred material	Aceramic	Reliable	7290-7072	7345-7050	7158-7036
Beta-106165	8020 ±50	charred material	Aceramic	Reliable	7059-6830	7076-6709	7083-6916
Beta-106166	7950 ±50	charred material	Aceramic	Reliable	7027-6713	7041-6691	7072-6912
Beta-177132	8070 ±40	bone collagen		Acceptable (no context info)	7131-6858	7172-6829	7137-6954
Beta-177133	8120 ±40	bone collagen		Acceptable (no context info)	7142-7058	7294-7042	7137-7039
Beta-177134	8040 ±40	bone collagen		Acceptable (no context info)	7068-6838	7081-6813	7082-6920

sd: standard deviation

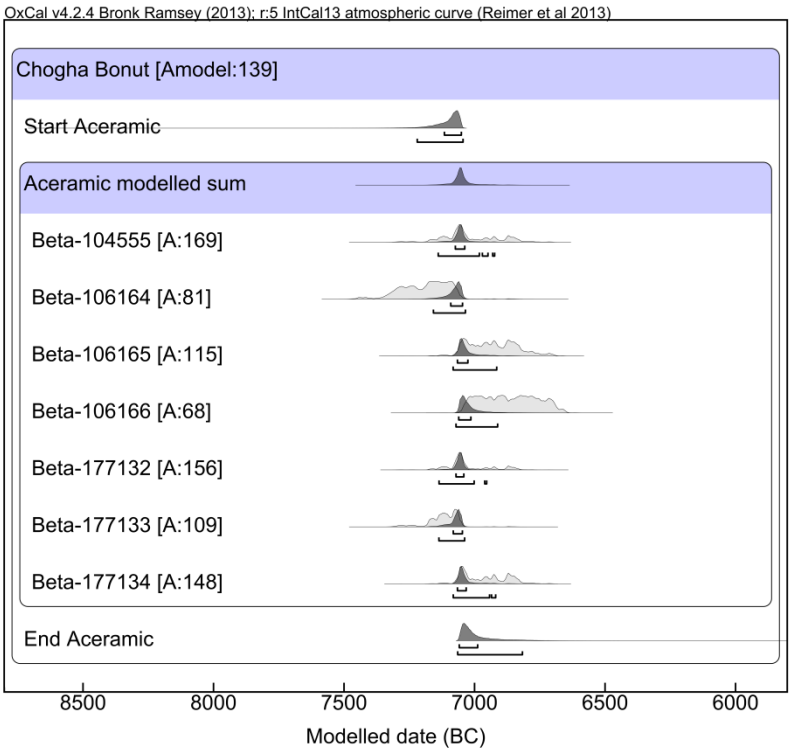

Fig. 3 Chogha Bonut aceramic period ^{14}C dates. It is visible that this phase potentially was only of short duration.

Chogha Golan (Central Zagros, 485m)

While eight dates have been published for Chogha Golan, only four of these have been reported as ^{14}C-dates (Riehl *et al.* 2012; Conard *et al.* 2013; Riehl *et al.* 2013). Those four dates appear reliable, with acceptable standard deviations, are on short-lived material, and in agreement with stratigraphy (Table 4). However, no detailed context information has yet been provided so that the functional relation with the context is unsure.

The other four dates, which comprise the oldest as well as the youngest dates, were only reported in calibrated years BP, and no material is given (they are perhaps likely to be on seeds considering the context of the paper they were published in) (Riehl *et al.* 2013). As such, it is difficult to assess their reliability, but if we assume tentatively that they are reliable, the site would overlap in occupation almost exactly with Sheikh-e Abad, as the Chogha Golan dates bracket the site's dating between 9790 ±187 cal BC and 7687 ±54 cal BC. Jani is also contemporaneous with part of the Chogha Golan occupation (*c.* levels AH II-IV). Where both the calibrated and uncalibrated dates are given, there is a slight discrepancy between this and the Riehl *et al.* 2013 paper, and it is likely that the dates in the Riehl *et al.* paper were calibrated with a different calibration curve and/or programme.

Table 4. Chogha Golan ^{14}C dates (Riehl et al. 2012; Conard et al. 2013; Riehl et al. 2013).

Lab no	**^{14}C ± 1σ**	**material**	**details**	**phase**	**assessment**	**calibrated date BC ***	**cal BC (1σ)**	**cal BC (2σ)**
KIA-45647				AH XII	Unreliable (missing)	9790 ±187		
KIA-44944				AH XI	Unreliable (missing)	9104 ±129		
KIA-43836	9425 ±45	charred seeds	*Hordeum*	AH VIII	Acceptable	8706 ±53	8756-8639	8816-8572
Erl-14839	8887 ±37	charred seeds	*Hordeum*	AH IV	Acceptable	8087 ±94	8204-7975	8235-7879
Erl-14838	8870 ±40	charred seeds	*Hordeum*	AH III	Acceptable		8201-7959	8224-7833
Erl-14840	8805 ±38	charred seeds	Poaceae	AH III	Acceptable	7889 ±81	7960-7761	8185-7730
Beta-335610				AH II	Unreliable (missing)	7881 ±82		
Beta-335608				AH I	Unreliable (missing)	7687 ±54		

*based on cal BP dates in Riehl *et al.* 2013

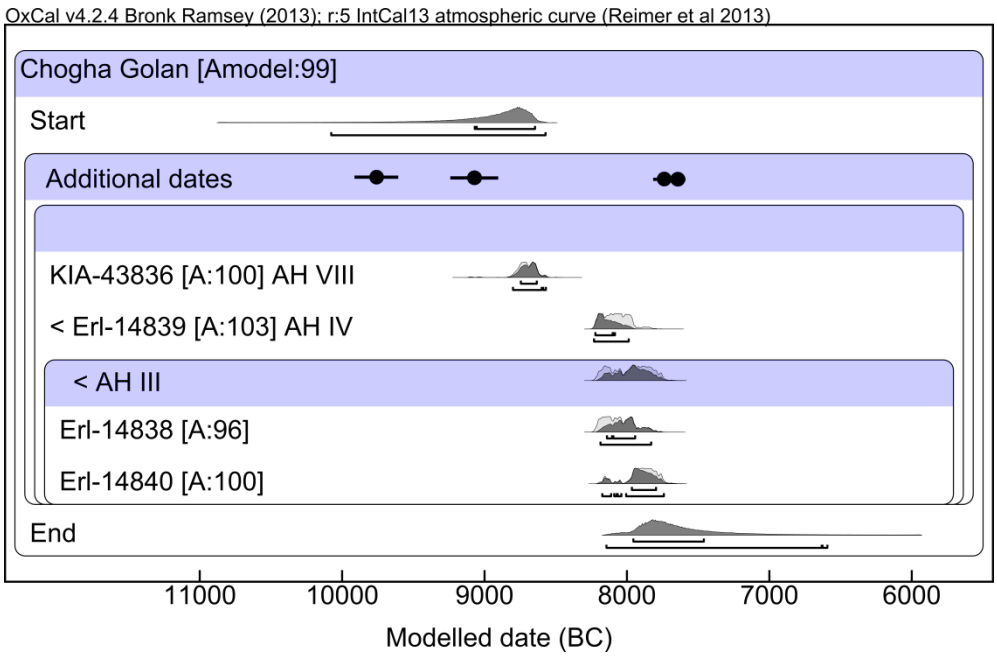

Fig. 4 Chogha Golan ^{14}C dates, in stratigraphic order. ^{14}C dates that were only reported in calibrated form are indicated as the mean (black dot) with 1 standard deviation.

Chogha Sefid (SW Iran)

All ten dates of this site are problematic. They were analysed in the 1970s, no material has been reported, and seven of the dates have standard deviations that are larger than 100 ^{14}C years (Marshall 2012). Of the three dates with smaller standard deviations, two dates of the same ("Sefid") phase are over 3000 ^{14}C-years apart, so the dates are clearly not in agreement with the stratigraphy. We therefore do not take this site into account in our comparative chronological exercise.

East Chia Sabz (Central Zagros, 360m)

Nine ^{14}C-dates are available for this site (table 5) (Darabi *et al.* 2011; Riehl *et al.* 2012; Darabi *et al.* 2013). These all appear reliable, although no detailed context information is available yet. The oldest date is probably on seeds, and so is the youngest date, so that there is no old wood problem with these. The charcoal dates are in agreement with the seed dates. The ^{14}C dates are generally in agreement with the sample depth, although samples OxA-21028, OxA-21029, and OxA-20994 seem of a similar age, while they are derived from between 1.94 and 2.17m deep; however, this could simply represent rapid deposition.

With the current information, the site can be dated roughly between 8500 and 7700 cal BC, and as such is contemporaneous with Sheikh-e Abad and Jani. The oldest deposit dated so far is still 1.4m above virgin soil, so the site is likely to be older than the current dating suggests. The latest currently available date is 1.99m below the topsoil, so that the site is also likely to end later than suggested by the current dates (Darabi *et al.* 2013). A date of *c.*7000-6800 cal BC has been suggested for the later layers, because of the presence of obsidian and marble (Darabi *et al.* 2013). These later layers of the site are therefore likely to be also contemporaneous with Bestansur and Shimshara.

Table 5. East Chia Sabz ^{14}C dates (Darabi et al. 2011; Riehl et al. 2012; Darabi et al. 2013).

Lab no	**^{14}C ± 1σ**	**material**	**phase**	**assessment**	**cal BC (1σ)**	**cal BC (2σ)**
Erl-14835	9228 ±39	charred seeds? Fabaceaea	Trench II	Acceptable; no detailed context information. Short-lived?	8538-8348	8559-8313
OxA-21032	9225 ±40	charcoal	Trench II, C2046, between phase V and VI. 1.4m above virgin soil (3.80m depth)	Reliable, potential old wood effect	8537-8346	8556-8311
OxA-21031	9180 ±40	charcoal	Trench II, C2044, between phase V and VI?? 3.42m depth	Reliable, potential old wood effect	8438-8305	8537-8292
OxA-21030	9015 ±39	charcoal	Trench II, C2042, between phase V and VI?? 2.95m depth	Reliable, potential old wood effect	8279-8237	8299-8015
Erl-14836	8928 ±37	*Pistacia* shell	Trench I	Acceptable; short-lived; no detailed context information	8235-7991	8247-7967
OxA-21028	8830 ±45	charcoal	Trench II, C2028, between phase III and IV. 1.94m depth	Reliable, potential old wood effect	8171-7796	8205-7753
OxA-21029	8830 ±45	charcoal	Trench II, C2037, phase IV?? 2.17m depth	Reliable, potential old wood effect	8171-7796	8205-7753
OxA-20994	8750 ±45	charcoal	Trench II, C2026, phase III. 1.99m depth	Reliable, potential old wood effect	7937-7682	7955-7611
Erl-14837	8709 ±37	charred seeds? Fabaceae	Trench III	Acceptable, no detailed context information	7748-7614	7934-7598

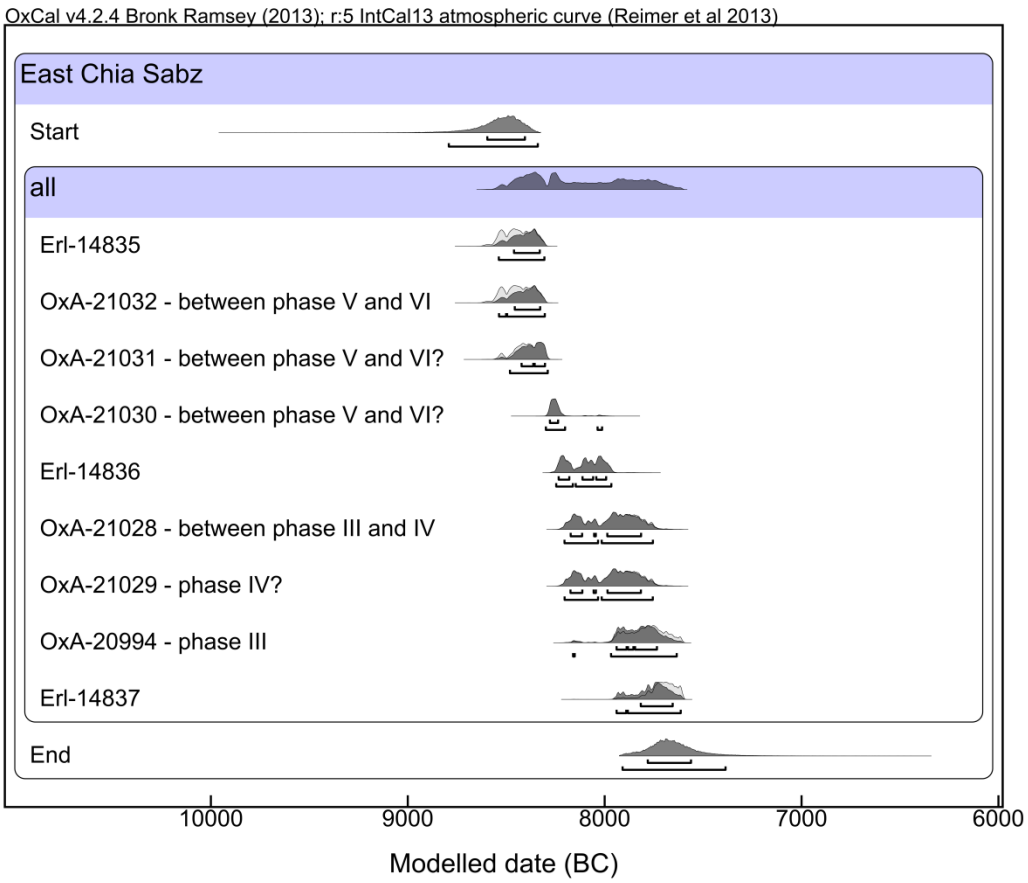

Fig. 5 East Chia Sabz ^{14}C dates. Stratigraphy only partially known, so not taken into account here.

Ganj Dareh (Central Zagros, 1350m)

There are 35 dates in total, but many of the pre-1980s dates have to be discarded (Marshall 2012). The site was recently revisited (Darabi *et al.* in press), but the new publications and potential new dates were not yet available to us at the time of writing.

Both GAK- dates are on bulk samples and have large standard deviations, while PI-1485, SI-922, and SI-923 also have large standard deviations. The SI-4000s series do not have their material reported and the shared error of 70 indicates that not all error factors were taken into account when calculating this, thus potentially underrepresenting the actual error (Marshall 2012; see also van der Plicht and Bruins 2001:1163). The OxA- dates are on charred seeds but have relatively large errors of 100-110 ^{14}C years. The Beta-series on bone collagen appear reliable (Zeder and Hesse 2000; Zeder 2005). The latter are interesting, as they are on all five phases, but appear to indicate a very short occupation of the site only. If this was indeed the case, the remaining, apparently reliable, two SI-dates would be too late.

Looking only at the Beta-dates, the site would be occupied between *c.*8150 and 7850 cal BC, but a shorter span of occupation (until as short as just over 100 cal years) around 8000 cal BC would be possible. Ganj Dareh is thus likely contemporaneous with Jani and Sheikh-e Abad Trench 2.

Table 6. Ganj Dareh ^{14}C dates (Zeder 2005; Marshall 2012).

Lab no	**$^{14}C \pm 1\sigma$**	**material**	**phase**	**assessment**	**cal BC (1σ)**	**cal BC (2σ)**
Beta-108247	8830 ±50	bone collagen	level E, depth 665-675 cm	Reliable	8173-7795	8207-7749
Beta-108246	8870 ±50	bone collagen	level E, depth 580-585 cm	Reliable	8204-7956	8231-7816
Beta-108248	8900 ±50	bone collagen	level E	Reliable	8217-7974	8248-7842
Beta-108249	8840 ±50	bone collagen	level E	Reliable	8183-7825	8210-7756
Beta-108245	8940 ±50	bone collagen	level D, depth 580-600 cm	Reliable	8246-7990	8268-7963
Beta-108244	8840 ±50	bone collagen	level D, depth 430-460 cm	Reliable	8183-7825	8210-7756
Beta-108243	8920 ±50	bone collagen	level C, depth 460-480 cm	Reliable	8231-7984	8269-7941
Beta-108242	8940 ±50	bone collagen	level B, depth 280-300 cm	Reliable	8246-7990	8268-7963
Beta-108241	8720 ±50	bone collagen	level B, depth240-260 cm	Reliable	7788-7611	7939-7601
Beta-108240	8780 ±50	bone collagen	level B, depth 220-240 cm	Reliable	7951-7747	8179-7613
Beta-108239	8930 ±60	bone collagen	level B, depth 165-180 cm	Reliable	8241-7982	8280-7846
Beta-108238	8780 ±50	bone collagen	level A, depth 180-200 cm	Reliable	7951-7747	8179-7613
OxA-2102	8690 ±110	charred seeds (*Hordeum*)	level E	Questionable: large sd	7937-7591	7937-7591
OxA-2101	8850 ±100	charred seeds (*Hordeum*)	level D	Acceptable	8204-7827	8252-7662
OxA-2100	9010 ±110	charred seeds (*Hordeum*)	level C-D	Questionable: large sd	8310-7970	8532-7795
OxA-2099	8840 ±110	charred seeds (*Hordeum*)	level B	Questionable: large sd	8203-7793	8250-7615
GAK-807	10400 ±150	charcoal, ash, earth	level E, base of tell	Unreliable: bulk sample, large sd		
GAK-994	8910 ±170	charcoal, ash, earth	Level D, 1 m above GAK-807	Unreliable: bulk sample, large sd		
P-1484	8968 ±100	charcoal	level D, base of phase 1, -6.20 m	Questionable: analysed before 1980s	8283-7971	8344-7752
P-1485	9239 ±196	charcoal	level C, phase 2, -4.50 m	Unreliable: large sd		
P-1486	8888 ±98	charcoal	level B, phase 4, -2.10 to -2.40 m	Questionable: analysed before 1980s	8236-7874	8282-7726

SI-4732	8590 ±70	n.d.	level A	Unreliable: material unknown		
SI-4733	8525 ±70	n.d.	level B	Unreliable: material unknown		
SI-4734	8110 ±70	n.d.	level B	Unreliable: material unknown		
SI-4735	8460 ±70	n.d.	level B	Unreliable: material unknown		
SI-4736	8450 ±70	n.d.	level C	Unreliable: material unknown		
SI-4737	8650 ±70	n.d.	level C	Unreliable: material unknown		
SI-4738	8485 ±70	n.d.	level D	Unreliable: material unknown		
SI-4739	8140 ±70	n.d.	level D	Unreliable: material unknown		
SI-4740	8535 ±70	n.d.	level D	Unreliable: material unknown		
SI-4741	8950 ±70	n.d.	level D	Unreliable: material unknown		
SI-922	8570 ±210	charcoal	level E, 670-680 cm	Unreliable: very large sd		
SI-923	8625 ±195	charcoal	level E, 750-760 cm	Unreliable: large sd		
SI-924	8640 ±90	charcoal	level E, 760-780 cm	Questionable: analysed before 1980s	7784-7578	7962-7524
SI-925	8385 ±75	charcoal	level E, below 780 cm, below SI-924	Questionable: analysed before 1980s	7536-7356	7584-7193

n.d.: no data; sd: standard deviation

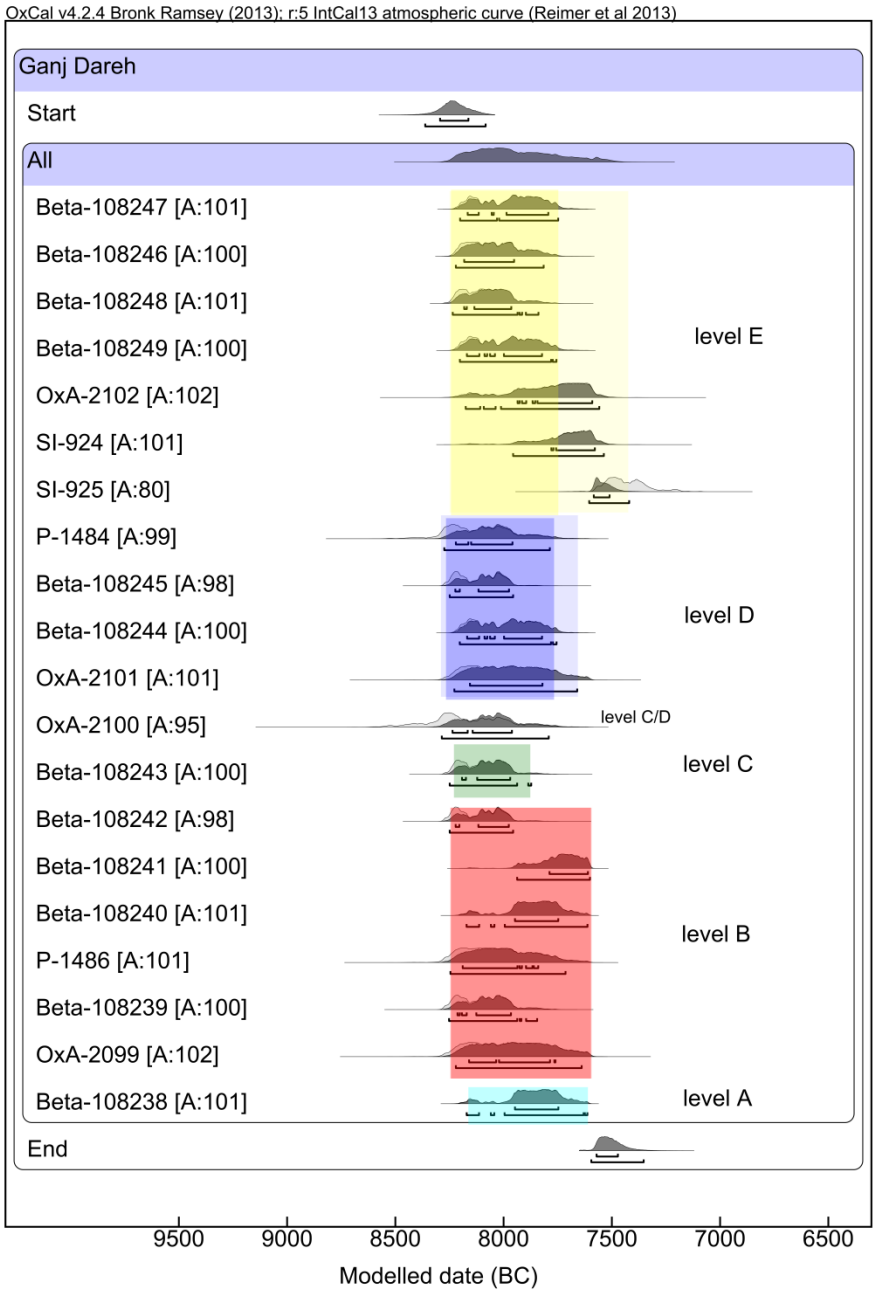

Fig. 6 Ganj Dareh reliable ^{14}C dates. Colours indicate the 2σ ranges of the different phases, with darker shades for the Beta-series only, which has a narrower range for phase E and D. Note that the phases are overlapping in date, indicating a rapid succession of occupation layers.

Jarmo (Zagros Foothills, 800m)

While there are 22 dates for Jarmo, unfortunately these are (almost) all unreliable. They were all analysed in the 1960s/70s and 21 of the dates have standard deviations above 100 ^{14}C yrs. The remaining date may be reliable, but was conducted on organic temper in pottery (GrN-

6353, 7655±75 uncal ^{14}C yrs). This date is 6514 ±65 cal BC, and based on this, and the type of pottery, it is certainly possible that Jarmo overlaps in date with Shimshara. It is however unknown how old the aceramic layers of Jarmo are. A new dating and sampling programme by UCL (www.ucl.ac.uk/archaeology/people/staff/fuller) may bring answers in the near future.

M'lefaat (North Iraq, 290m)

All twelve ^{14}C-dates from M'lefaat have large standard deviations. There is a set of very early dates, but these all have standard deviations of 140 and above. Of the five later dates on lentils, three have standard deviations of between 100 and 130. While still unreliable, these give an indication that the site was occupied in the second half of the 10th mill. BC (see also Benz n.d., who gives 9660-9220 BC for the earliest lentil dates, and 9250-8840 BC for the later lentil date). Also based on the material culture, the site is likely to have been occupied at a similar time as the early levels at Sheikh-e Abad, but seems to have started later.

Nemrik 9 (North Iraq, 340m)

There are as many as 81 dates for this site (Kozlowski 1994; Benz n.d.), but unfortunately most have very large standard deviations. 43 dates have a standard deviation of 150 ^{14}C yrs or higher, and a further 22 of over 100. Furthermore, four dates are older than 20,000 years and are thus clearly erroneous. Of the remaining 11 dates, three are on shell or possibly on shell and are therefore also unreliable. Of the further remaining dates, seven were flagged by the excavator as inconsistent with the phasing (Watkins 1989 cited by Benz n.d.). In sum, the dating of this site is too problematic to interpret with any certainty. It can be roughly said that the site probably dates to the 10th millennium BC, which is also borne out by the similarities with PPNA sites like Qermez Dere and Jerf el Ahmar, Hallan Çemi and Körtik Tepe (Benz n.d.). Benz (n.d.) gives 9800-9400, 9200-8600, and 8500-8270 cal BC, and a potential Younger Dryas/Epipalaeolithic phase (for which some dates are available), for the site, but this is assuming that those dates with standard deviations between 100 and 150 and flagged as inconsistent with the stratigraphy can be accepted.

Qermez Dere (North Iraq, 300m)

The six ^{14}C dates from Qermez Dere all appear reliable in that they were conducted on reliable material (charred seeds), and have acceptable standard deviations and δ^{13}C values (Böhner and

Schyle 2002-2006; ORAU 2014; Benz n.d.). The oldest date, however, should probably be discarded, as it was conducted on the same context as OxA-3752, which gave a 1700 ^{14}C-yr younger date that is in better agreement with the typological development (Benz n.d.).

Based on the remaining ^{14}C dates, there were two occupation phases (Benz n.d.), although the excavator interpreted the remains as a rapid succession (cited by Benz n.d.). Because of a calibration curve plateau, it is hard to know precisely when the site was occupied, but there is an early 10th millennium and a late 10th/early 9th millennium phase (Benz n.d.). Within the 2σ range, the excavator's scenario is still possible, if occupation accumulated between *c.* 9400 and 9200 cal BC, which is within the range of all 2σ ranges, but a shorter than *c.* 200 yr occupation span would not be in agreement with the ^{14}C-dates anymore ("span" function gives 276-1218 in 2s, 530-1044 in 1s). The site is likely contemporaneous with early Sheikh-e Abad (Trench 1).

Table 7. Qermez Dere ^{14}C dates (Böhner and Schyle 2002-2006; Art" 2014; Benz n.d.).

Lab no	**^{14}C ± 1σ**	**material**	**context, phase**	**assessment**	**cal BC (1σ)**	**cal BC (2σ)**
OxA-3753	11990 ±100	charred seeds (fragments)	CBR, lower layers	Reliable as date, but appears too old for context	12042-11788	12136-11631
OxA-3752	10145 ±90	charred seeds (*Lens*)	CBR, lower layers	Reliable	10054-9563	10166-9402
OxA-3756	10115 ±95	charred seeds (Vicieae)	RDM, phase 5	Reliable	10013-9462	10120-9368
OxA-3755	9710 ±85	charred seeds (*Lens*)	RDI, phase 6	Reliable	9282-8925	9301-8825
OxA-3757	9640 ±85	charred seeds (*Lens*)	RDN phase 6	Reliable	9230-8845	9260-8790
OxA-3754	9580 ±95	charred seeds (*Lens*)	RCK phase 3	Reliable	9144-8817	9248-8713

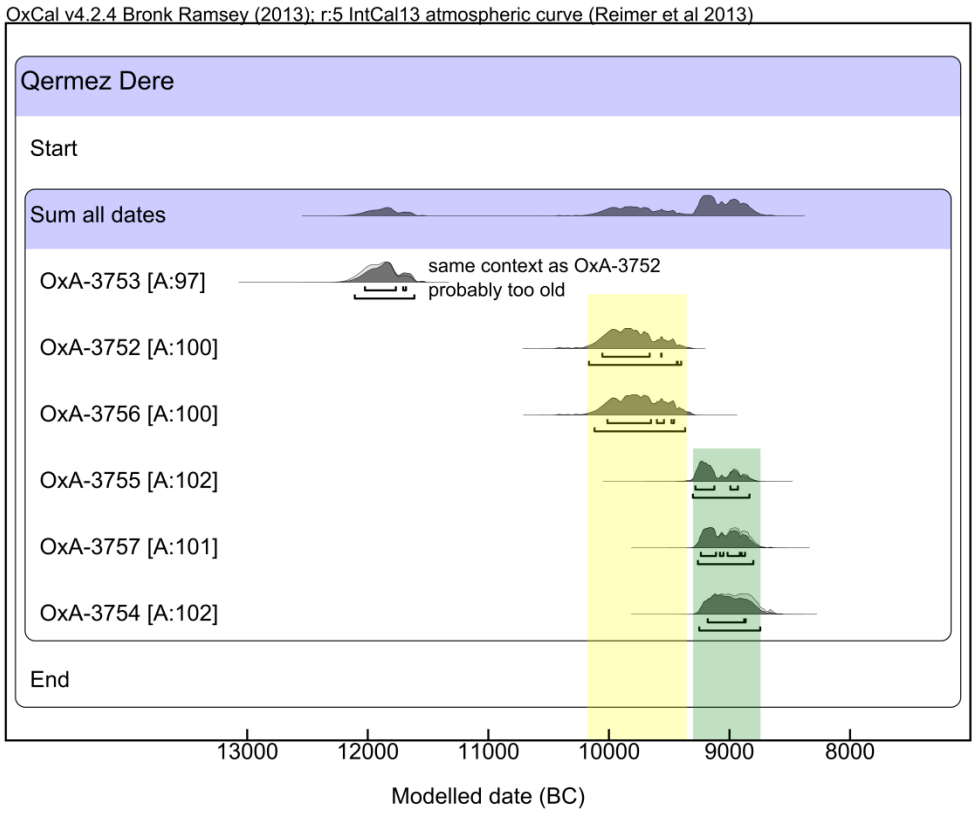

Fig. 7. Qermez Dere ^{14}C dates. The oldest date should probably be discarded, as it comes from the same context as OxA-3752, which is much younger and more in agreement with the material culture and the other dates. The yellow and green colours indicate two potentially different phases.

Sarab (Central Zagros, 1400m)

There are eight dates for Sarab, four analysed in the 1960s and four in the 1990s/2000s (Böhner and Schyle 2002-2006; Zeder 2005; Marshall 2012). UCLA-1714A is unreliable, as there was no standard deviation reported and it concerns a bone sample which was analysed in the 1960s. The other three 1960s dates are questionable in their reliability, as it is not clear if bulk samples were used, while Marshall (2012: p.254) marked them as "possible contamination" because of their association with snail shell and bone. It is nonetheless interesting that they are in rough agreement with the later dated samples. These samples, with the Beta-prefix, appear reliable, but their association with their contexts cannot be assessed with the currently available information. Nonetheless, they have got an assigned phase, and are in rough agreement with the sequence. Beta-159549 is an exception to this, as it is assigned to the oldest phase (level 5) but has a younger date than Beta-159550 (level 4) and Beta-159548 (level 3). In general, the

site appears to have been occupied from the late 8th or early 7th millennium BC until *c.*6300 cal BC. While this youngest date comes from the upper level, it should ideally be confirmed with more dates. It is also not clear how many deposits exist below and above the excavated levels, but the designation of "level 1" as such suggests this is the uppermost level. The site is interesting: Except for the interpretation of its early levels as representing transhumant herders (Hole 1987), it is one of the last Neolithic sites known higher up in the Central Zagros.

Table 8. Sarab dates (Böhner and Schyle 2002-2006; Zeder 2005; Marshall 2012).

Lab no	**^{14}C ± 1σ**	**material**	**phase**	**assessment**	**cal BC (1σ)**	**cal BC (2σ)**
Beta-159550	8070 ±60	bone	Level 4	Reliable	7142-6837	7288-6771
P-466	7956 ±98	charcoal (+black soil?)	level 5	Questionable: bulk sample? Analysed in 1960s.	7032-6710	7127-6600
Beta-159548	7950 ±60	bone	Level 3	Reliable	7028-6710	7047-6682
UCLA-1714A	7850 (sd n/a)	bone		Unreliable: bone analysed in/before 1970s, no standard deviation reported.		
Beta-159549	7800 ±60	bone	Level 5	Reliable, but inconsistent with stratigraphy	6692-6529	6816-6477
P-467	7644 ±89	charcoal (+black soil?)	level 1	Questionable: bulk sample? Analysed in 1960s. Inconsistent with stratigraphy.	6590-6434	6658-6266
P-465	7605 ±96	charcoal (+black soil?)	level 4	Questionable: bulk sample? Analysed in 1960s.	6588-6393	6640-6252
Beta-159547	7470 ±70	bone	Level 1A	Reliable	6414-6255	6456-6221

sd: standard deviation

Tell es-Sawwan I (North Iraq)

Nine ^{14}C dates are available for Tell es-Sawwan, two for the oldest level, level I, and the remainder for level III (Bernbeck 1994; Böhner and Schyle 2002-2006). Pr-180 is not reliable, as no material has been reported and the date has a large standard deviation. The three dates with prefix P- were analysed in the 1960s and should be taken with caution. P-857 is problematic, as it comes from the oldest level, but yet is the youngest date. It may therefore be intrusive. P-856 also appears to be out of stratigraphic order, as it is older than the other level III dates. However, this could also be caused by inter-laboratory differences.

Table 9. Tell es-Sawwan I ^{14}C dates.

Lab no	$^{14}C \pm 1\sigma$	material	phase	assessment	cal BC (1σ)	cal BC (2σ)
P-857	6808 ± 82	charcoal	level I	Unreliable: 1960s, very inconsistent with stratigraphy		
P-855	7456 ±73	charcoal	level I	Questionable: 1960s	6396-6251	6458-6115
BM-1435	7015 ±66	charcoal	level II-III	Acceptable	5985-5841	6010-5751
BM-1438	6980 ±59	charcoal	level III	Acceptable	5974-5792	5985-5742
BM-1437	7037 ±69	charcoal	level IIIA	Acceptable	5993-5846	6027-5756
BM-1436	7052 ±57	charcoal	level IIIA	Acceptable	5999-5889	6031-5796
BM-1434	7069 ±66	charcoal	level III	Acceptable	6013-5891	6062-5803
P-856	7299 ±86	charcoal	level III	Questionable: 1960s and inconsistent with stratigraphy	6236-6065	6368-6017
Pr-180	7246 ±146	n.d.	level III	Unreliable: no material reported and large standard deviation		

n.d.: no data

Tepe Guran (Central Zagros, 1000m)

There are 17 ^{14}C-dates for Tepe Guran (Zeder 2005; Marshall 2012; Weninger *et al.* 2013). The three dates from the 1960s (with prefix 'K-') are unreliable, as they have large standard deviations and were not adjusted for fractionation (Marshall 2012). The more recent analyses on bone collagen (Zeder 2005)('Beta-' prefix) appear reliable as ^{14}C-dates, but are not strictly in stratigraphic order.

The site is divided into levels A-V. Levels A-C are Islamic and Bronze Age, and levels D-V are Neolithic, with level V located directly above virgin soil (Mortensen 2014). The archaeology is only represented by a 4 x 3-4m sounding with adjacent 1.5m wide step trench and a small additional sounding (Mortensen 2014). In the main sounding, the lowest, mostly aceramic levels V-Q are represented by probably semi-permanent or seasonal wood or reed shelters. Levels P-N have mud-walled structures as well as huts, and ceramics now also occur (the earliest sherds were found in level S, but they only become numerous from level O onwards). From level M onwards, mud-walled houses are universal (Mortensen 2014).

It is interesting that the majority of dates fall within the relatively restricted period of 8200 to 7800 ^{14}C years. A later date (*c.*7600 ^{14}C years) comes from the most recent Neolithic phase D. It is not clear if the two youngest dates (7200-7000 ^{14}C years) are connected to their contexts, as they are derived from levels F and K respectively, and therefore appear to be intrusive. Beta-

147116 appears too early for its level (L) while Beta-117121 appears too late for its level (V) (Marshall 2012), but they are in agreement with the general dating of the site. On the other hand, the oldest date (Beta-177177) comes from the lowest level V, which is directly above virgin soil, and the youngest date (not counting the potential intrusive dates discussed above) from the youngest Neolithic level D.

Because of these stratigraphic inconsistencies within the levels, it is difficult to date the separate levels. However, as a whole, the site can be dated to *c.*7400/7300 to either *c.*6500 cal BC, or, if those samples that are likely intrusive are taken as representing some form of site use, to *c.*6000/5900 cal BC. As such, the site is contemporaneous with Shimshara, and the earlier, aceramic levels are likely contemporary with the later (Trench 13) occupation at Bestansur.

The excavator discards the bone dates and dates the site, on basis of the earlier three ^{14}C-dates and the ceramics, to *c.*6700-5500 cal BC (Mortensen 2014). However, the ceramic comparisons are based on sites which are not always securely absolutely dated themselves, and which are in any case more in agreement with an older dating of the site (i.e. in agreement with the bone, or Beta-, dates). The 'Undecorated Greyish-brown Ware' of levels S to P, the earliest pottery at the site, has been compared to pottery from Ganj Dareh level D (Voigt and Dyson Jr. 1992; Mortensen 2014), which is dated to the early 8th mill. BC (see above). The 'Zagros Standard Painted Ware' of levels O to E has been compared to the undated lower pottery levels at Jarmo, and the early or SI levels at Sarab (Voigt and Dyson Jr. 1992). The latter has only been dated by a couple of dates, which nonetheless indicate a date roughly around 7000 BC, as do the Tepe Guran bone dates. Lastly, the 'red-burnished ware' or 'red-slipped ware', almost only found in levels F to D, has been compared to later Sarab (Voigt and Dyson Jr. 1992; Mortensen 2014), which is dated to the latter half of the 7th mill. BC. Therefore, these ceramic comparison, as far as they are valid, are in agreement with the Beta-series of dates for Guran, but not with the later, 6th mill. BC dates.

Table 10. Tepe Guran ^{14}C dates (Zeder 2005; Marshall 2012; Weninger et al. 2013; Mortensen 2014).

Lab no	**^{14}C ± 1σ**	**material**	**phase**	**assessment**	**cal BC (1σ)**	**cal BC (2σ)**
Beta-177177	8280 ±40	bone	V	Reliable	7452-7196	7468-7185
Beta-117121	7820 ±40	bone	V	Reliable, but may be intrusive	6734-6592	6816-6506
K-1006	8410 ±200	charcoal	U; 12-15 cm above virgin soil	Unreliable: large sd, unadjusted for fractionation, 1960s		

Beta-147120	8060 ±40	bone	U	Reliable	7080-6844	7140-6826
Beta-147122	8170 ±40	bone	T	Reliable	7247-7074	7306-7066
Beta-147119	8000 ±50	bone	R	Reliable	7048-6829	7062-6706
Beta-147118	8070 ±40	bone	Q	Reliable	7131-6858	7172-6829
Beta-147117	7890 ±40	bone	P	Reliable	6806-6654	7026-6641
Beta-147116	8130 ±40	bone	L	Reliable, but seems too old for level	7166-7062	7297-7047
Beta-147115	7940 ±40	bone	L	Reliable	7022-6701	7032-6691
Beta-147114	7080 ±50	bone	K	Reliable, but may be intrusive	6014-5901	6066-5838
Beta-147113	7950 ±40	bone	H	Reliable	7027-6756	7034-6697
Beta-147131	7810 ±40	bone	H	Reliable	6678-6599	6750-6510
K-879	7760 ±150	charcoal	H	Unreliable: large sd, unadjusted for fractionation, 1960s		
Beta-147112	7260 ±40	bone	F	Reliable, but may be intrusive	6208-6069	6222-6051
Beta-147111	7630 ±60	bone	D	Reliable	6562-6430	6599-6397
K-856	3170 ±120	charcoal	C	Unreliable: large sd, unadjusted for fractionation, 1960s		

sd: standard deviation

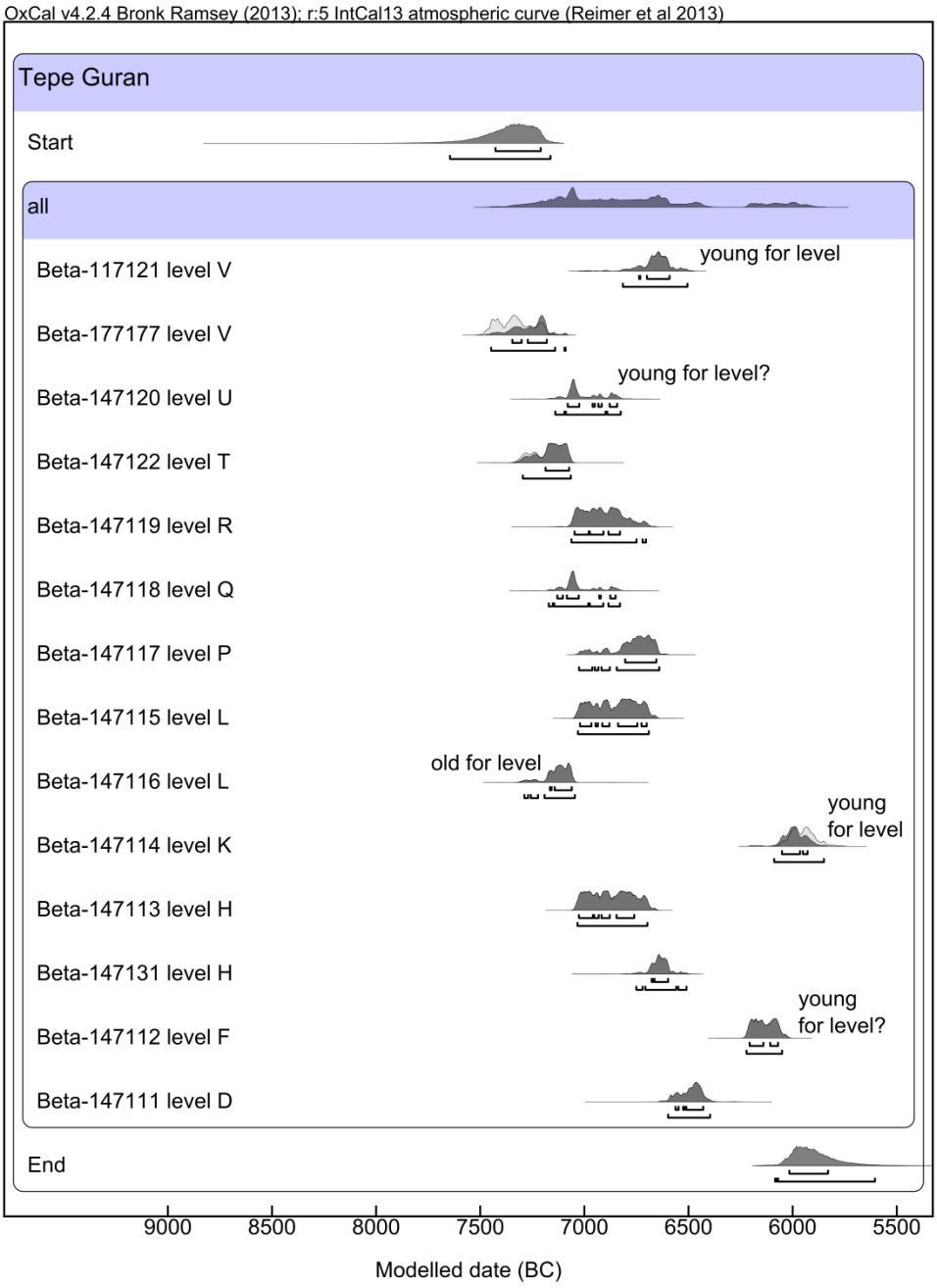

Fig. 8 Tepe Guran ^{14}C dates.

Tepe Siahbid (Central Zagros)

There are only two dates for (the later levels of) this site (Voigt and Dyson Jr. 1992; Böhner and Schyle 2002-2006; Marshall 2012; Weninger *et al.* 2013), and both are unreliable. P-442 has been done on a bulk sample ("charcoal and clay"), while for QU-1035 no material has been reported and the standard deviation is with 120 also not small.

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