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Molluscs in the Levantine Upper Palaeolithic: implications for modern human diets and subsistence behaviour

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Chapter 4 • The Ksâr 'Akil chronology questioned

The paper that forms Chapter 3 (Bosch et al. 2015a) has been criticized by Douka et al. (2015). This chapter presents a short summary of their critiques and our published reply (Bosch et al. 2015b) as well as some additional remarks and suggestions as to how to move forward the debate on the chronology of Ksâr 'Akil.

4.1. Summary of Douka et al.'s critiques

Douka et al.'s (2015) criticisms revolve around two main points: (1) the way in which the Bayesian model was constructed; namely, they argue that it lacks consistent boundaries between phases and that we used incompatible approaches to determine the robustness of the model (i.e., using both agreement indices and outlier detection; and (2) they believe that our knowledge of the stratigraphy was inadequate.

The argumentation by Douka et al. (2015) is partly based on an inaccurate representation of our data set. For example, Douka et al. claim we did not build adequate boundaries into our model. Our boundaries in fact represent the archaeological layers and phases of the sequence as defined by the excavators (e.g., Ewing 1947) and by scholars who subsequently studied the material (for a summary, see Bergman and Goring-Morris 1987). However, excluding the lower boundary issue, to which is discussed below, the two models for the Ksâr 'Akil chronology presented by Douka et al. (2013) used the same amount of boundaries, especially in the lower part of the model where our age estimates diverge the most (Fig. 4.1). In other cases, they used even fewer, as their preferred model uses broader phases (e.g., MP, IUP) conflating—and mixing—the dates from different layers within a phase.

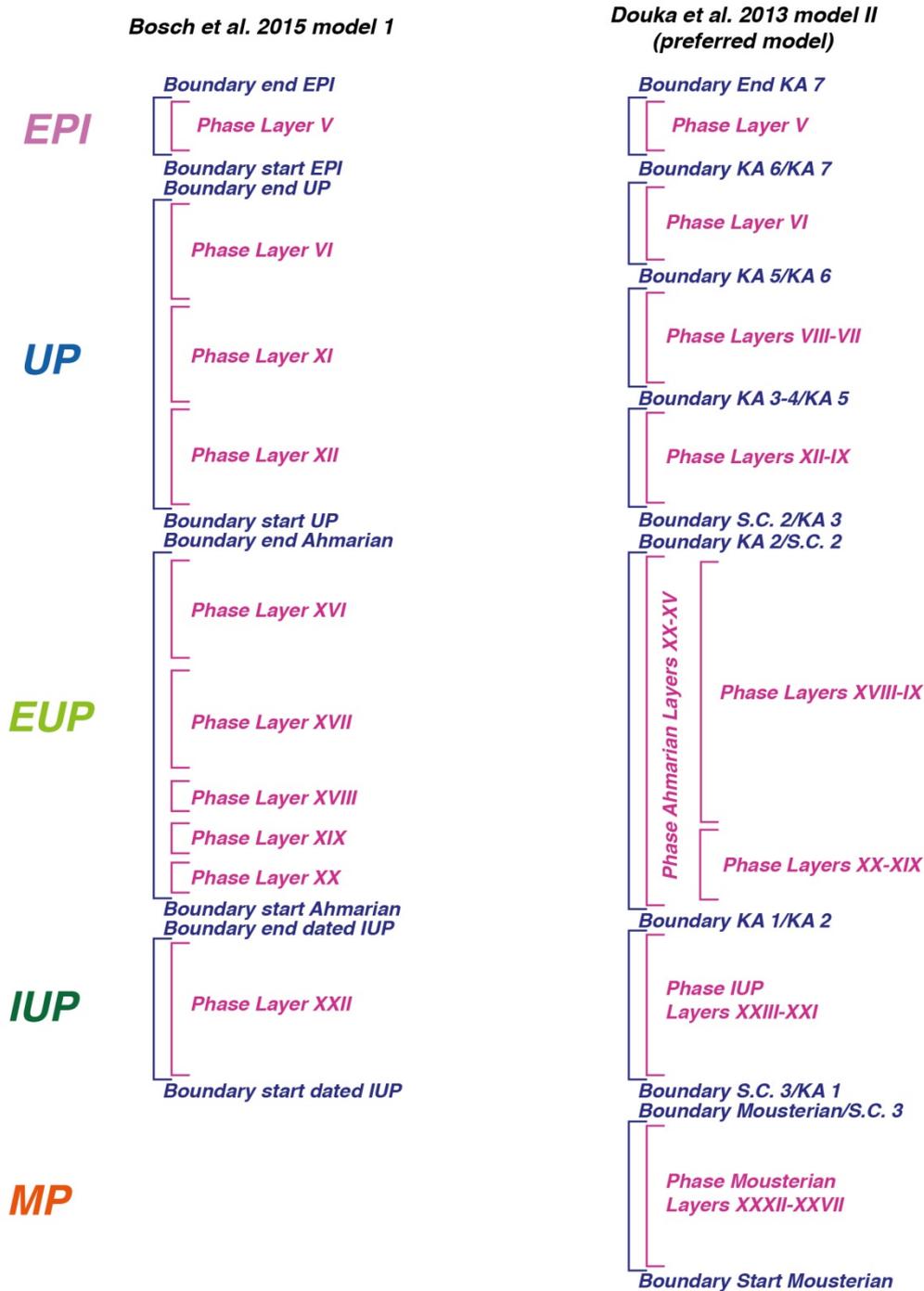


Figure 4.1: Schematic of the Bayesian models of Bosch et al. (2015a) and Douka et al. (2013) showing the placement of boundaries (blue) and phases (pink). The models used are Bosch et al.'s (2015a) Model 1 and Douka et al.'s (2013) preferred Bayesian Model II. Left column shows technocomplexes at Ksâr 'Akil as used by Bosch et al. (2015a). Abbreviations: MP: Middle Palaeolithic, IUP: Initial Upper Palaeolithic, EUP: Early Upper Palaeolithic (Early Ahmarian), UP: Upper Palaeolithic, EPI: Epipalaeolithic. Abbreviations used in Boundary and Phase labels after Bosch et al. (2015a) and Douka et al. (2013).

Douka et al. (2015) further state that we did not take into account the difficulties of correlating the material from the 1930s and 1940s excavations, even though we clearly state in the supplementary material (Chapter 3) that we did do so on the basis of unpublished lists made by the original excavators that have been used in several publications dealing with the Ksâr 'Akil fauna (e.g., Hooijer 1962; Kersten 1991). Moreover, Douka et al. state that six of our twelve dates between Layers XVIII and XVI are 100% outliers, where in fact there are only two. In addition, they ignore the fact that these specific dates were deemed as potentially compromised through other, independent types of analyses, namely amino acid racemization and oxygen isotope analyses. Importantly, they claim that if their critiques are taken into consideration the model would show significantly different results. However, newly created models taking Douka et al.'s critiques into consideration (i.e., one using only outlier detection, one using only the agreement indexes, and both with and without the dates from the 1940s) provide similar age estimations as in our original publication (Bosch et al. 2015a), especially for the IUP. These results, therefore, have reinforced our original conclusions rather than rejected them.

Another issue is the lower-boundary reference, which requires some explanation. Douka et al. have argued that the 'date call' for the Ethelruda fossil, which coincides with the start of the IUP, should have been constrained with a so-called lower boundary and that the lack of this lower boundary skews the oldest possible age of the fossil back in time, which is evident from Figure 1 of our paper (Bosch et al. 2015a). However, as there are no dates for the lowest part of the IUP, there are no chronological data that can back up placing such a boundary. Higham and Douka have argued that we should have either (1) placed a virtual boundary, i.e., a 'start of the undated IUP' boundary, or (2) taken into consideration available dates for the underlying Middle Palaeolithic part of the sequence. However, as we pointed out in our reply (Bosch et al. 2015b), the outcome of placing a virtual lower boundary not substantiated by chronological data would be an artefact of the modelling rather than representing the actual chronology. The second option would be to use dates from the underlying Middle Palaeolithic part of the sequence as practiced by Douka et al. (2013). Such an approach is questionable, as it uses of dates of uncertain provenience (i.e., unclear position in the stratigraphy) and/or dates obtained from potentially compromised samples (e.g., layers of brown sediment possibly of organic origin) (Vogel and Waterbolk 1963; Mellars and Tixier 1989). Further at our disposal are U-series dates that were reported to be potentially subject to open system behaviour (van der Plicht et al. 1989) and radiocarbon ages on highly diagenetically altered shells (Douka et al 2013a), which

are by some deemed unreliable (Stutz et al. 2015). Therefore, neither of these ‘solutions’ is without problems.

Instead, we had chosen to place a boundary (our lowest) just below the lowermost IUP layer for which we have a date (i.e., Layer XXII) and place the ‘date call’ for the start of the IUP and Ethelruda below this boundary. To ensure that the lack of a lower constraint does not influence the actual model, we ran several versions with and without this ‘date call’ and found no effective difference in the rest of the model. In our opinion, the ‘date call’ with its unconstrained start reflects what we know: (1) the fossil should be older than the date for Layer XXII and (2) with currently available dates, we have no way of assessing a lower age constraint. Because of the assumptions underlying this type of Bayesian model, the calculated upper boundary for the Ethelruda fossil is placed two standard deviations from the age estimation of the modelled ‘start of the dated IUP’ (i.e., our lowermost boundary) (see Bronk Ramsey 2000; Steier and Rom 2000). This assumed time lapse between the two events seems plausible, as there are several layers culminating in roughly a metre of deposits that divide them. Moreover, because these data are solely used as a *terminus ante quem* in our paper—we claim that the start of the IUP should be prior to 45.9 ka cal B.P.—the lack of lower constraint does not alter our interpretations. So although it is true, as Douka et al. point out, that if the model is configured in this way, Bayesian statistics cannot resolve the lower end of the ‘date call’, it does not change our conclusions.

4.2 Reply to Douka et al.: Critical evaluation of the Ksâr 'Akil chronologies¹

Our paper (Bosch et al. 2015a) proposes a new chronology for Ksâr 'Akil based on 16 accelerator mass spectrometry (AMS) determinations on shells. To minimize the possibility of dating diagenetically compromised samples, we conducted amino acid racemization analyses on the intracrystalline proteins, oxygen isotope analysis, and geochemical characterization of all dated shells. Our calibrated radiocarbon ages fit well with existing Levantine chronologies, but are up to 4,000 y older than Douka et al.'s (2013). Our paper explores several possibilities for this difference, whereas Douka et al. (2015) provide alternative explanations. They accept our radiocarbon ages as correct but question our sample selection and Bayesian modelling. Douka et al. (2015) question both the inclusion of samples from the 1940s excavations and our

¹ Published as: Bosch, M.D., Mannino, M.A., Prendergast, A.L., O'Connell, T.C., Demarchi, B., Taylor, S.M., Niven, L., Plicht, J.V.D., Hublin, J.-J., 2015. Reply to Douka et al.: Critical evaluation of the Ksâr 'Akil chronologies. *Proceedings of the National Academy of Sciences*, 112(51), E7035.

combined outlier analysis. Excluding the 1940s samples and running a manual outlier analysis (using 0.05 prior outlier probabilities without manual down-weighting) (Bronk Ramsey 2009) results in age ranges of 42.7–40.9 ka cal B.P. for the Egbert fossil and 44.9–43.6 ka cal B.P. for the start of the dated Initial Upper Paleolithic (IUP; Layer XXII). Thus, Egbert’s age estimation is slightly younger than in our paper (Bosch et al. 2015a), but the age estimations for the IUP do not change, and they support our original conclusions. The date for the Ethelruda fossil found in Layer XXV was modelled without a lower constraint, thus generating an age estimate that may be skewed backward in time. As suggested by Douka et al. (2015), placing start and end boundaries for the undated IUP allows the model to constrain the lower boundary of Ethelruda’s age range. We would not dispute that, but setting a lower constraint is problematic. Currently, there are no dates for the start of the IUP; thus, placing boundaries cannot be substantiated by any chronological data. Nonetheless, incorporating these boundaries in our model provides an age estimate for Ethelruda of 49.9–44.1 ka cal B.P., making it older than all European human fossils except Cavallo B [the context of which has been questioned (Zilhão et al. 2015)]. Douka et al. (2015) also propose including dates from lower in the sequence. We rejected this option, as all available dates are of uncertain provenience and/or obtained on compromised samples (Bosch et al. 2015a). Stutz et al. (2015) independently raised doubts on the Middle Paleolithic AMS dates by Douka et al. (2013), concluding that chemical diagenesis resulted in minimum ages. Moreover, excluding both the date function for Ethelruda and the constraining boundaries, the start of the dated IUP is 44.9–43.6 ka cal B.P., both with and without the 1940s samples. This provides a minimum age estimate for the underlying undated IUP deposits containing Ethelruda at their base. In conclusion, differences in the Bayesian models used do not appear to explain the divergence between our dates and those reported by Douka et al. (2013). Our data provide reliable estimates for modern humans and the IUP at Ksâr ‘Akil and support our initial conclusions for an early chronology for modern humans in the Levant. This is in line with other Levantine datasets and is compatible with the Levantine corridor hypothesis.

4.3 Ways to move forward

At this point, it is important to also realise that a chronology based on Bayesian modelling is just that: a model. It gives a representation of the most parsimonious chronological interpretation and should be treated as a hypothesis not the ultimate truth. Attempts should be made, as we have done, to develop multimethod approaches using independent data sets to

evaluate the probability that a model (Bayesian or otherwise) is correct rather than relying solely on approaches inherent to the modelling, e.g., outlier analyses or agreement indices.

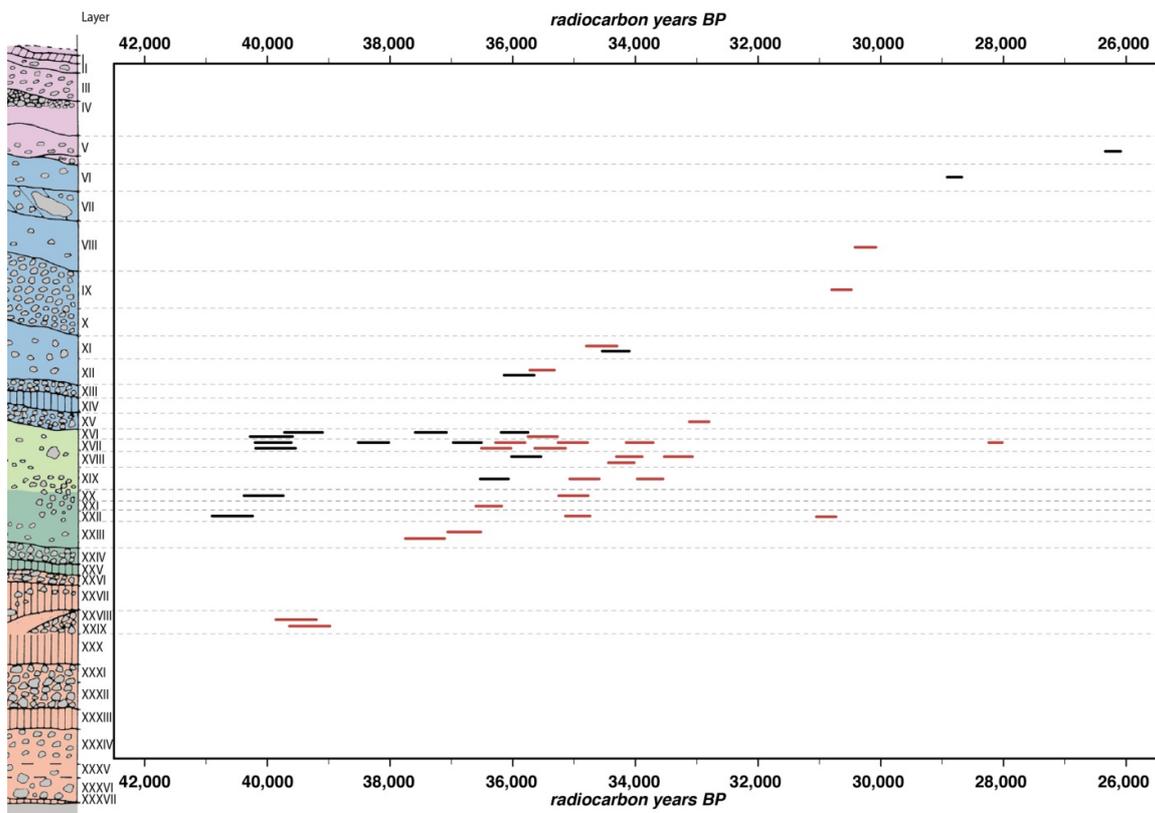


Figure 4.2: Radiocarbon determinations by Douka et al. 2013 (red) and Bosch et al. 2015a (black) for Ksâr 'Akil sorted by layer. Results show a one-sigma range (uncal BP).

The more important issue at hand, namely the substantial differences in radiocarbon determinations between the two published chronologies (Table 4.1; Fig. 4.2), remains unresolved. Our drastically different radiocarbon determinations, especially in the lower part of the sequence where our ages are up to 4000 radiocarbon years older, show that different pre-treatment and dating methods may hugely alter the results. Moreover, shell dates have been proven problematic in other studies. For example, at Üçağızlı I (Turkey) radiocarbon dates on shell are generally much younger than dates on charcoal (Kuhn et al. 2009; see also Mangerud 1972; Hogg and Higham 1998; Douka et al. 2010). In their reply, Douka et al. (2015) state that they deem our radiocarbon ages to be accurate; obviously, they think theirs are too, so why then do our chronologies diverge more and more the further back in time we go? After careful consideration of all steps of both our analyses, we concluded that differences between the two chronologies most likely have their origins in the pre-treatment methods and sample selection strategies (Table 4.2; see also Chapter 3 and Bosch et al. 2015a, Supplementary Information

section 2). Specifically, we have reason to believe that the so-called CarDS method (Douka et al. 2010; Russo et al. 2010), which uses a heavy liquid to divide the to-be-dated aragonite from potentially intrusive (recrystallized) calcite in an effort to purify diagenetically compromised samples, might not be adequate to extract all contaminants (e.g., Busschers et al. 2014).

Furthermore, shells that are used as ornaments are usually collected from active beaches or fossilized beaches and have been exposed to marine taphonomic processes that damaged the shells and left them subject to diagenetic alterations. At present, we do not fully understand what is causing the divide in age estimations; therefore, at least for now, it might be best to avoid dating visibly taphonomically altered shells. The ways forward to resolve issues with dating shell, are (1) to further tease apart details in the pre-treatment methods and sampling strategies to better understand what is causing the different age estimates and ultimately overcome our methodological issues; (2) to determine what it is we want to date (i.e., the target event) and which selection strategy or dated event provides the closed approximation of the target event (Dean 1978); and 3) to develop methods to detect diagenetically compromised samples, for example, using amino acid racemization (e.g., Demarchi et al. 2013) and identifying carbonate substitution pathways under various post-depositional conditions (e.g., Busschers et al. 2014). It would also be valuable to explore the effects of burning on archaeological shells (e.g., Milano et al. 2016), as this process can potentially damage samples.

Table 4.1: Radiocarbon determinations for Ksâr 'Akil used by Douka et al. (2013) and Bosch et al. (2015a). Radiocarbon determinations are provided per layer and with laboratory reference number. * U-series dates from van der Plicht et al. (1989), ~ dates on the same shell, † dates from Mellars and Tixier (1989), ‡ dates from Vogel and Waterbolk (1963), § date from Wright (1962), ** dates by Douka et al. (2010).

Layer	Douka et al. 2013	Bosch et al.2015
V	26,500 ± 900 (MC-1191†)	26,210 ± 130 (GrA-53005)
	26,900 ± 600 (OxA-1797†)	
VI	29,300 ± 800 (OxA-1798†)	28,810 ± 130 (GrA-54848)
VII	30,250 ± 170 (OxA-19194)	
	30,250 ± 850 (OxA-1803†)	
VIII	30,640 ± 160 (OxA-20875)	
IX	30,360 ± 140 (OxA-20023)	
	31,200 ± 1300 (OxA-1804†)	
	32,400 ± 1100 (OxA-1805†)	
VII-IX	28,840 ± 380 (GrN-2195‡)	
X	32,000 ± 1500 (MC-1192†)	
	34,550 ± 250 (OxA-25585)	
XI		34,310 ± 230 (GrA-53006)
XII	35,520 ± 200 (OxA-20024)	35,880 ± 260 (GrA-57545)
XV	35,020 ± 240 (OxA-20876)	
XVI	36,040 ± 240 (OxA-22665)	35,960 ± 230 (GrA-57544)
		37,320 ± 270 (GrA-57598)
		39,890 ± 310 (GrA-57599)
		39,910 ± 370 (GrA-54847)
XVII	28,130 ± 110 (OxA-X-2342-57)	34,090 ± 220 (GrA-53001)
	33,300 ± 240 (OxA-20486)	36,730 ± 240 (GrA-57602)
	33,930 ± 220 (OxA-20487)	38,260 ± 260 (GrA-57603)
	35,390 ± 250 (OxA-22269)	39,850 ± 340 (GrA-54846)
	36,270 ± 240 (OxA-20877)	
XVIII	33,760 ± 210 (OxA-X-2338-8)	36,290 ± 240 (GrA-57542)
	34,230 ± 210 (OxA-20488)	
	34,830 ± 240 (OxA-25653)	
XIX	35510 ± 240 (OxA-22664)	39,390 ± 330 (GrA-53004)
	32,960 ± 160 (OxA-X-2361-14)	
XX	35,010 ± 240 (OxA-20879)	40,040 ± 340 (GrA-57597)
XXI	36,390 ± 210 (OxA-20025)	
XXII	30,890 ± 160 (OxA-25665)	40,550 ± 350 (GrA-53000)
	34,940 ± 200 (OxA-20880)	
XXIII	36,790 ± 270 (OxA-20489**)	
	37,430 ± 320 (OxA-20490**)	
XXV / (XXVI)	43,750 ± 1500 (GrN-2579‡)	
16 m	44,400 ± ? (Gro-2574-75§)	
XXVI B	47,000 ± 9000 (G-88174*)	
XXVIII (A)	39,310 ± 330 (OxA-20491~)	
	39,530 ± 330 (OxA-25656~)	
XXXII	51,000 ± 4000 (G-88177*)	

Table 4.2: Summary of potential factors that could influence radiocarbon determinations on the shells of Ksâr 'Akil, including the implication for our chronology and an assessment and rationale of the likelihood of its occurrence. For more detailed descriptions of the factors and rationale, please see Chapter 3 and Bosch et al. (2015a), Supplementary Information Section 2.

Factor	Implication	Assessment	Rationale
Sample selection			
Dating of beached shells I: Time elapse between the 'target-event' or human activity and 'dated event' or time of shell death	Younger	Unlikely	This does not fit the pattern seen (our dates would be younger than Douka et al.'s dates)
Dating of beached shells II: Increased liability of postmortem diagenesis due to increased incidence of damage due to taphonomic processes in active marine environments	Older	Likely	The incidence of damage due to taphonomic alterations is high in beached specimens and virtually absent in live-collected ones
Archaeological use life: Shell ornaments and tools are used for a longer amount of time than shellfish of which the shell is discarded after consumption	Younger	Unlikely	This does not fit the pattern seen (our dates would be younger than Douka et al.'s dates)
Ante-mortem: Over-compensation of reservoir effect in intertidal species	Older	Unlikely	<i>Phorcus turbinatus</i> does not grow its shell while out of the water at low tide due to stress, hence the discernable growth increments
Ante-mortem: Hard-water effect: due to precipitation of old carbon on shells by exposure to fresh water from a limestone environment	Older	Unlikely	<i>Phorcus turbinatus</i> has a limited tolerance for temperature and salinity changes and lives in the lower intertidal zone avoiding locations with fresh-water input
Ante-mortem: introduction of old carbon while foraging	Older	Unlikely	<i>Phorcus turbinatus radulae</i> are soft (Moh's scale: 2) and do not leave substantial damage on the rocks during foraging
Postmortem: Hard-water effect: due to precipitation of old carbon on shells by exposure to fresh water from a limestone environment	Older	Unlikely	Both the Groningen and Oxford sample cleaning protocols are sufficient to eliminate this source of contamination
Sample pre-treatment			
CarDS pre-treatment method does not eliminate all sources of diagenesis	Older	Likely	CarDS does not eliminate contamination in the aragonite fraction, e.g., aragonite-aragonite substitutions, which can occur in saline conditions
Radiocarbon measurement			
Groningen vs Oxford	Unknown	Unlikely	Measurement protocols at both laboratories are nearly identical

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