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DISCUSSION

Methodological and interpretational problems in the dating of 6–7th centuries AD on the Great Hungarian Plain

Comments to *Sándor Gulyás, Csilla Balogh, Antónia Marcsik and Pál Sümegi: Simple calibration versus Bayesian modeling of archeostatigraphically controlled ¹⁴C ages in an early Avar age cemetery from SE Hungary: results, advantages, pitfalls*

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ABSZTRAKT

A Makó-Mikócsa-halom kora avar kori temető keltezéséről írt tanulmányukban Gulyás et al. 2018 alapvetően tévesen alkalmazzák a radiokarbon dátumok Bayes-féle modellezését. Vitacikkünkben a módszertani tévedések mellett az általuk használt terminológiai hibákat is tárgyaljuk.

KULCSSZAVAK

Bayes-féle modellezés, radiokarbon keltezés, avar kor

ABSTRACT

In their study on the dating of the Early Avar Age cemetery of the Makó-Mikócsa-halom, Gulyás et al. 2018 fundamentally misapplied the Bayesian modeling of radiocarbon dates. In our discussion paper, in addition to methodological errors, we also discuss the terminological mistakes they made.

KEYWORDS

Bayesian modeling, radiocarbon dating, Avar Age

INTRODUCTION

The development of the radiocarbon dating in recent years and the interpretation of the measurements by Bayesian modeling have brought further revolutionary changes[1] and extended the boundaries of the period where the radiocarbon dating can be successfully applied. Combining typology with radiocarbon measurements in order to make the Avar Age chronology more precise has a considerable antecedent.[2] We agree with the authors[3] that the Early Middle Age, especially the Avar Age, is a period where we can expect further significant research results from the use of this dating method. The reason behind this is the development of

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[1]Bayliss 2009.
[2]Stadler 2005.
[3]Gulyás et al. 2018.

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radiocarbon dating method and its interpretation with Bayesian modeling, and the varied material culture of the Avar Age. Combining the two approaches is a responsible task which requires extensive proficiency in both fields. However, we cannot leave without saying that Gulyás et al. 2018 is an excellent example of how *not* to use Bayesian modeling of radiocarbon measurements.

METHODOLOGY

The principle of Bayesian modeling of radiocarbon measurements, as described previously by many scholars, is to incorporate other available data, e.g. stratigraphic or genetic information into the calibration of radiocarbon measurements.[4] In Bayesian modeling, it is crucial that the prior information incorporated into the model truly should reflect our archaeological observations. The correctness of the Bayesian model can be interpreted in the light of whether it reflects the correlations and associations that the archaeologist observed on site. Two Bayesian models constructed based on identical measurements but structured fundamentally contradictorily, can each be statistically consistent. The main question is which one reflects our archaeological observation. An example of this is shown below.

One of the keys to the combination of calibrated radiocarbon dating and typochronological dating may be the observed archaeological, primarily vertical stratigraphy, as can be clearly seen.[5] „There is an opportunity for fine tuning a series of radiocarbon dates *with known stratigraphy* [emphasis added] using the method of Bayesian analysis.",[6] and then continue, "However, *if we have a-priori information on the stratigraphic position of the samples and their association* [emphasis added], this knowledge can help us to adjust imprecision generated by the calibration curve using Bayesian statistics relying on the so-called Bayes theorem".[7] The principle of Bayesian modeling seems to be understood by the authors themselves, which is staggering in comparison with what can be read later in the Gulyás et al. 2018 article.

In their study of the Early Avar period cemetery excavated at the Makó-Mikócsa Hill [Makó-Mikócsa-halom] site, dating to the 6th to 7th centuries based on archaeological typology, they try to prove the validity of the use of the Bayesian modeling even in those periods "where relative and absolute chronology, built on artifact typology and archeostratigraphy, *is capable* [emphasis added] of attaining a resolution of 25–30 yr.".[8] At this point, we are already facing an important methodological issue. The advantage of calibrated radiocarbon dating is exactly that it can provide a method which is independent of typological dating and its interpretation, with which archaeological dating can be controlled.

Gulyás et al. 2018 aimed to create a more accurate chronology by combining the two methods, which is a challenge as "This is a serious problem in cross-validation of archaeotypochronologies with an available resolution of 20–40 yr.".[9] Typochronological systems often contain several preconditions that are only assumptions, but Gulyás et al. 2018 treated them as facts. The main question is how reliable a 25–30 years dating based on typology is? Can we prove this doubtlessly or does this accuracy remain only an unattainable goal, an intention? Can we be sure that we are not talking about 20 or, let's say, 35 years? There is probably no archaeologist specialized in this period who would dare to make such a confident statement. Instead, we have to be content with saying that we *can estimate* a resolution of 25–30 yr.

There is a developed methodology in the literature of Bayesian modeling for the combination of typological, typochronological, and radiocarbon dating, however, the authors did not use it.[10] Although A. Bayliss and her co-authors[11] discussed similar problems in an exhaustive monograph on Anglo-Saxon burials to those they raised, which have not been utilized by the authors. By studying these, the authors would have avoided making fundamental methodological errors that could only serve as a counterexample to Bayesian modeling.

Byzantine coins placed in burials in some phases of the Avar period may help to date the assemblages but dating with coins is not unproblematic.[12] In many cases, it has been proven that the date of minting coins can only be used as a *terminus post quem* date in the dating of assemblages.[13] Gulyás et al. 2018, Tab. 1 and in the text, themselves are applied in this way, so it remained a question for us why it was not incorporated into the Bayesian model in this way.

In our studies,[14] we followed the method of comparing the results of archaeological, typological dating and Bayesian modeling. The reason for this was exactly to be able to compare two independent dating methods and to avoid tautological reasoning. After all, we just wanted to see if the typological dating was correct, whether we could support it with another, independent dating method. This is not to say that we did not incorporate archaeological information into Bayesian modeling. The principle of the Bayesian modeling is to incorporate the stratigraphic observations of the archaeological excavation, but no uncertain conclusions – e.g. typochronological dating.[15] Cemeteries of the Avar Age usually contain a high number of burials organized into rows where superposition between inhumations is extremely rare. There was no superposition in the Pitvaros cemetery either,

[4] Bronk Ramsey 2009; Buck–Meson 2015; Hamilton–Krus 2018; Mittnik et al. 2019.
[5] Gulyás et al. 2018.
[6] Gulyás et al. 2018, 1336.
[7] Gulyás et al. 2018, 1337.
[8] Gulyás et al. 2018, 1335.
[9] Gulyás et al. 2018, 1336.
[10] E.g. Whittle et al. 2011.
[11] Bayliss et al. 2013.
[12] Somogyi 2014.
[13] Somogyi 2017.
[14] Siklósi–Lőrinczy 2015; Siklósi–Lőrinczy 2017.
[15] Martin 2008; Zábojník 2008.

so we do not have a definite archaeological observation on the order in which the graves were buried.

It is no coincidence that typochronological conclusions were not incorporated into the model. By having it incorporated, we would have done only a circular argument where we would have forced our Bayesian model into the time interval we would like to see as a result. This is not independent evidence, but self-proof of the data, tautology, *petitio principii*. And Gulyás et al. 2018 do just that in their article.

Bayesian modeling in the case of Makó-Mikócsa-halom cemetery

In what follows, OxCal v4.4.1. software and the IntCal20 calibration curve were used preparing the models in Gulyás et al. 2018, as well as models we consider appropriate.[16] The interpretation of nutritional isotope data is not covered in detail here.

Gulyás et al. 2018, 1340–1342 claim Model 1 "Bayesian modeling controlled by relative chronology of the samples *derived from archeostratigraphy* [emphasis added]". In the given model, the graves were arranged in a *Sequence* based on the results of uncalibrated radiocarbon measurements. Considering the meaning of the OxCal *Sequence* command, this means that they are confident that the burial sequence given in the model is a sequence supported by stratigraphy. However, no archaeological evidence has been presented for this, and given the system of Avar cemeteries, we have strong doubts that information is available on such a definite and specific order of graves. This would mean that the burial considered to be older in the model would be superimposed by the younger burial, and each of the burials dated by radiocarbon could be arranged in a continuous vertical stratigraphic order. There is no example of such a burial custom and such a definite archaeological stratigraphy in any Avar cemetery known so far.

In our opinion, the correct version of this model in line with the archaeological information would have been if the authors placed the radiocarbon data in one *Phase* within the *Sequence*, which is an "unordered group of events",[17] i.e. we do not know the order of events within the *Phase (Fig. 1).* This is what exists in the case of Avar cemeteries. These two models are also excellent examples of whether either model is possible based on available radiocarbon measurements, however, the first contradicts archaeological observations, while the second reflects to the uncertainty that the exact order of adjacent graves is not known.

In their second model, "the likelihood of absolute age ranges estimated by archeotypochronology and the recorded radiocarbon dates were combined to better *constrain* ^{14}C ages to the *expected* [emphasis added] age interval of the cemetery".[18] That is, in this model, the radiocarbon measurements were admittedly placed in such a way that they were forced into a time interval corresponding to the archaeological expectation: the typochronological dating. If we incorporate into the model that a calibrated time interval must fall within a given time frame at the very beginning of the process, the result will be tautological. This is especially true in cases such as the cemetery in Makó presented by Gulyás et al. 2018 where the archaeological typological dating includes many assumptions and uncertainties. Besides, the constraint conditions built into the Model 2, they preclude the calibrated radiocarbon data from being up to one year older or younger than the specified range. The application of Bayesian modeling of radiocarbon measurements in the archeology of the Avar period may bring progress in testing, supporting, or refuting typological dating. However, Model 2 in Gulyás et al. 2018 is by no means suitable for this.

According to this Model 2, "The opening of the cemetery must have started between 559–578 AD (68.2%) or 545–593 AD (95.4%). The cemetery was abandoned between 641–660 AD (68.2%) or 616–656 AD (95.4%). The estimated span of cemetery use by Model 2 [67–97 yr (68.2%), 43–121 yr (95.4%)] correspond to 3 generations as proposed by archeochronology".[19]

The radiocarbon data of the Makó cemetery, which is known from a purely preliminary report, are challenging to interpret. Based on the published, available information, the following model is considered appropriate, taking the Byzantine coins found in the burials into account *(Fig. 2).* We incorporated the start date of the minting of the two Byzantine coins into the model as *terminus post quem* data to constrain only the dating of the two burials in which the solidi were found. After all, in the case of the other burials in the cemetery, we do not have information about the chronological relationship with these coins. The dating of these burials can well be narrowed down by coins. The cemetery's start boundary can be estimated to *535 (68.2%) 568 AD* and *516 (95.4%) 587 AD*, respectively. The end of the cemetery can be estimated to *647 (68.2%) 676 AD* and *615 (95.4%) 689 AD*, and its span of use can be estimated at *79 (68.2%) 114* and *41 (95.4%) 127 years.* For the beginning of the Avar age, 568 AD is considered a generally accepted date based on historical sources,[20] although its assessment has been more nuanced in recent years.[21] Secondly, we modeled the cemetery by considering 568 AD as the start boundary *(Fig. 3).* The end of the cemetery can be estimated to *645 (68.2%) 674 AD* and *616 (95.4%) 686 AD,* and its span of use can be estimated at *72 (68.2%) 93* and *45 (95.4%) 99 years.*

As the grave assemblages of the cemetery dated by radiocarbon measurements have not been published in detail, it is currently not possible to determine the time of the examined burials in more detail.

[16] Bronk Ramsey 2009; Reimer et al. 2020.
[17] Bronk Ramsey 2009, 343–345.
[18] Gulyás et al. 2018, 1344.
[19] Gulyás et al. 2018, 1344.
[20] Pohl 2018.
[21] Koncz 2015.

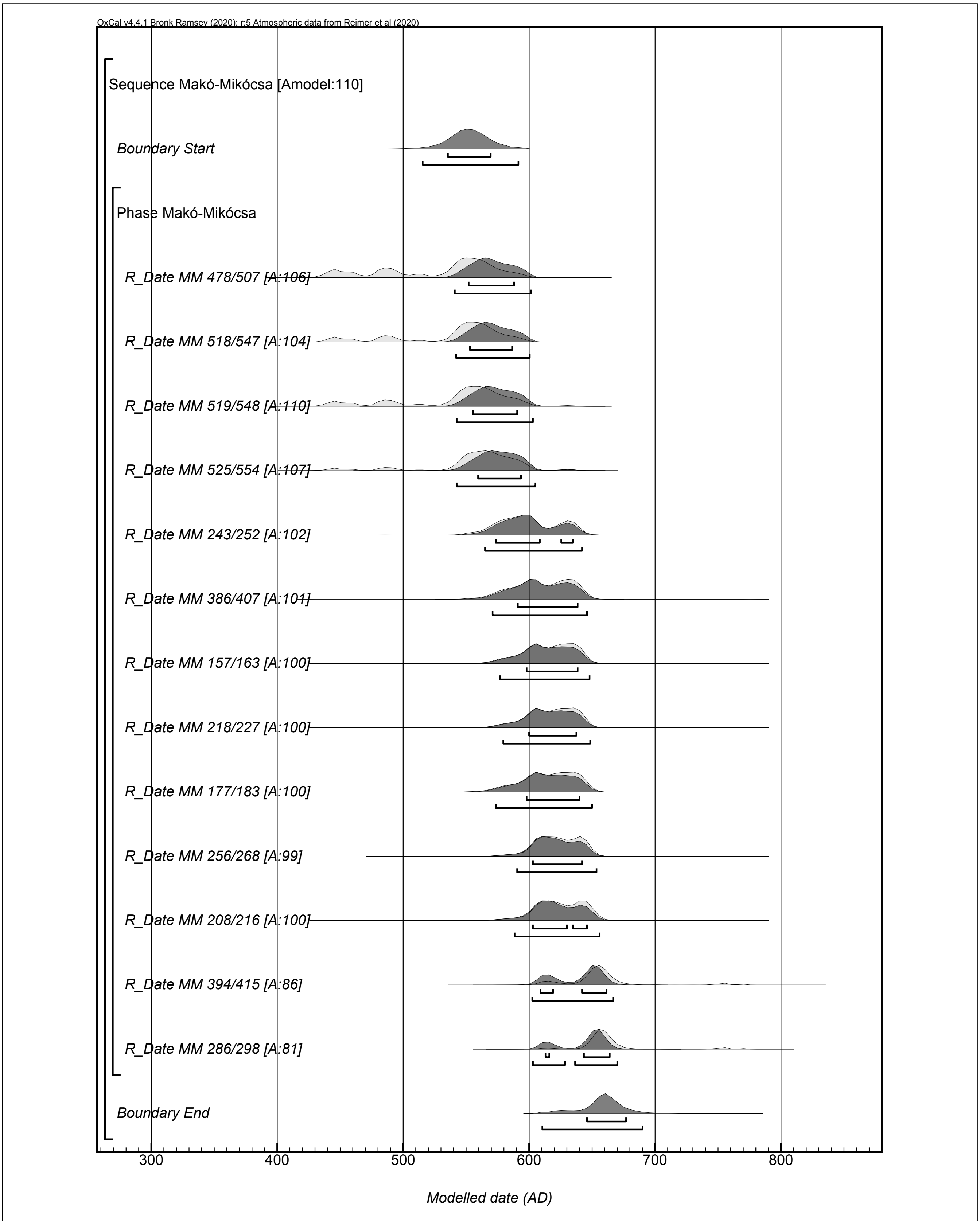

Fig. 1. Probability distribution of radiocarbon dates from Makó-Mikócsa-halom cemetery taking stratigraphic information into consideration. The square brackets on the left-hand side and OxCal keywords define the model

1. kép. A Makó-Mikócsa-halom lelőhelyen feltárt temető radiokarbon méréseinek valószínűségi eloszlása a stratigráfiai információk figyelembevételével. A bal oldali szögletes zárójelek és az OxCal kulcsszavak egyértelműen meghatározzák a modellt

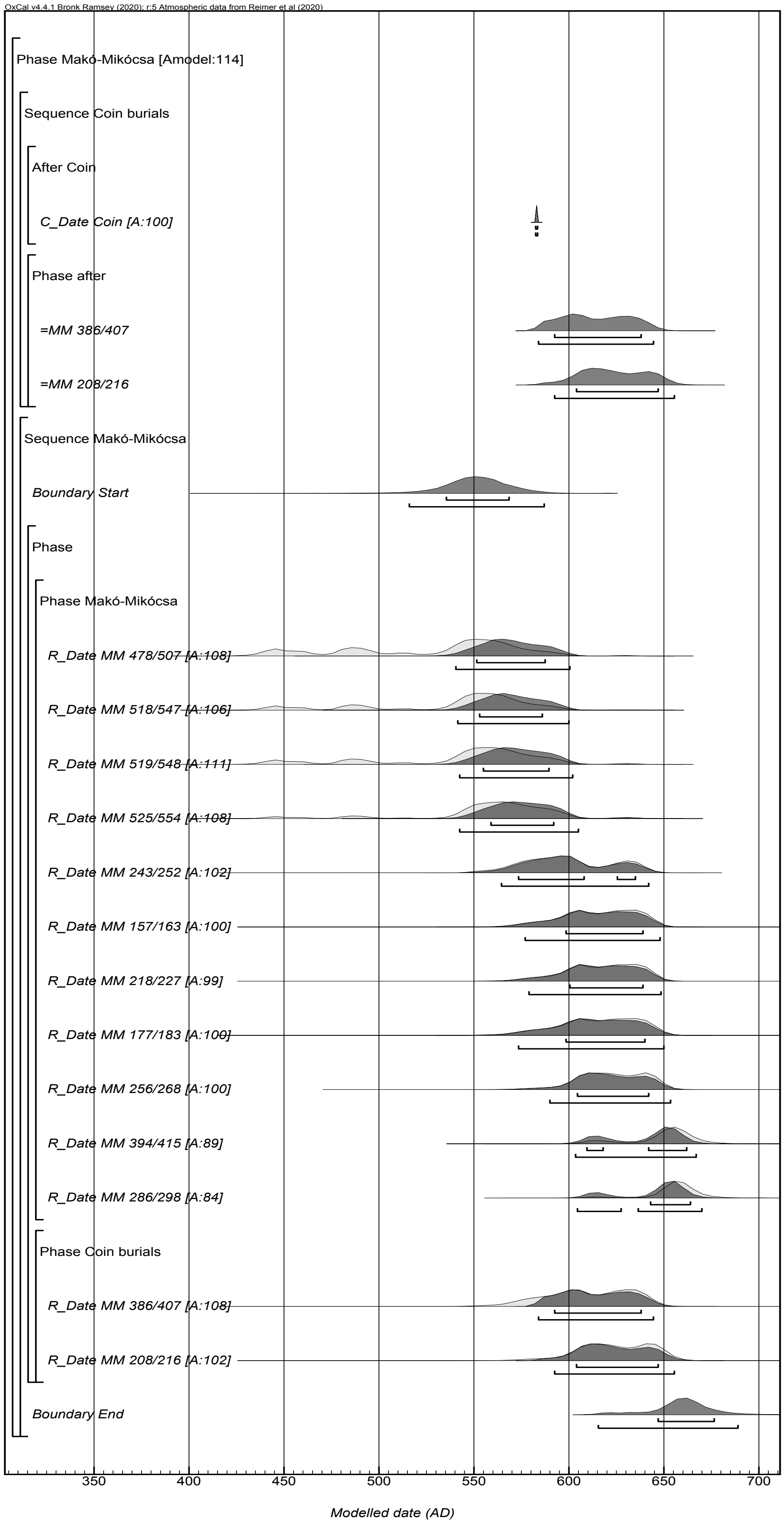

Fig. 2. Probability distribution of radiocarbon dates from Makó-Mikócsa-halom cemetery taking the coins from Graves MM 208/216 and MM 386/407 into consideration. The square brackets on the left-hand side and OxCal keywords define the model

2. kép. A Makó-Mikócsa-halom lelőhelyen feltárt temető radiokarbon méréseinek valószínűségi eloszlása az MM 208/216 és MM 386/407 sírban lévő érmék verési idejének figyelembevételével. A bal oldali szögletes zárójelek és az OxCal kulcsszavak egyértelműen meghatározzák a modellt

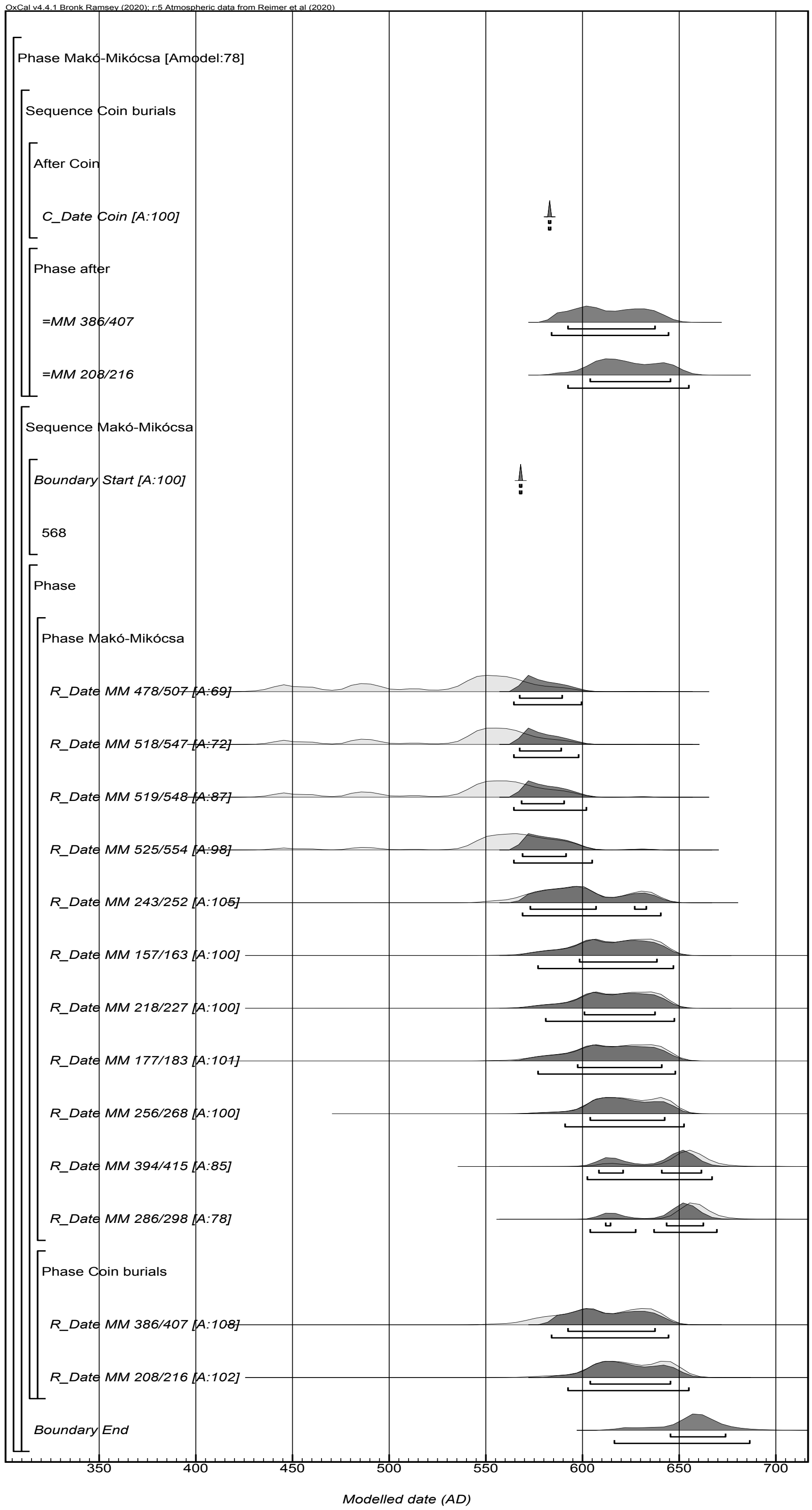

Fig. 3. Probability distribution of radiocarbon dates from Makó-Mikócsa-halom cemetery taking the coins from Graves MM 208/216 and MM 386/407, and the historical date (568 AD) for the beginning of the Avar period in the Carpathian basin into consideration. The square brackets on the left-hand side and OxCal keywords define the model

3. kép. A Makó-Mikócsa-halom lelőhelyen feltárt temető radiokarbon méréseinek valószínűségi eloszlása az MM 208/216 és MM 386/407 sírban lévő érmék verési idejének, valamint a Kárpát-medencei avar kor kezdetére vonatkozó történeti dátum (568) figyelembevételével. A bal oldali szögletes zárójelek és az OxCal kulcsszavak egyértelműen meghatározzák a modellt

TERMINOLOGY AND ACADEMIC WRITING

There is no cemetery map of Makó-Mikócsa-halom in either the current or the previous publication,[22] so it is complicated to reconstruct the stratigraphic relationship between the burials. From the brief summaries published so far,[23] it appears that the cemetery system does not differ from that experienced in other Early Avar cemeteries. So far, only short reports have been published on the archaeological material of the site,[24] from which we cannot get detailed information about the grave goods dated with radiocarbon measurements. Gulyás et al. 2018, 1339–1340, Tab. 1 report "inferred archeotypochronological ages" of graves dated by radiocarbon measurements, but it is not clear on what basis they were dated back to the period given in Tab. 1, as the grave goods remain unpublished, unknown to the reader. No description or visual documentation has been provided, so the given typochronological date is unverifiable. This is also important because in the case of typochronology, the classification of particular objects into types can be disputed; therefore, it would be especially important to jointly evaluate the finds and their controllability. Although this traceability, verifiability is the basis of scientific evaluation. Further complicating the checking of the data is that the numbering of the supplement material and the reference to the supplement material in the main text do not match.

Gulyás et al. 2018 study contains several grammatically problematic sentences that make it difficult to understand. Right from the beginning of their study, they use a term, "archeotypostratigraphy",[25] which is not known or used in the archeological literature. It is not clear what exactly is meant by this, as the term "archeotypochronology" is used several times in the text to distinguish it.

"The *first application* [emphasis added] of a combination of archeotypochronology and Bayesian modeled ^{14}C dates for Late Avar Age assemblages is from a cemetery of *Szegvár-Oromdűlő* [emphasis added] in SE Hungary (Siklóssy [sic!] and Lőrinczy 2015).".[26] This single sentence contains several fundamental errors. In addition to the fact that our name was incorrectly described, it was not even apparent to them[27] that the title of our cited study already states that we reported Bayesian modeling of the Pitvaros-Víztározó site and not the Szegvár-Oromdűlő site, as they mention it.[28] In fact, our study on Bayesian modeling of the Tiszavasvári-Kashalom-dűlő and Hajdúnánás-Fürj-halom-járás sites was the first to report Avar Age burials dated by Bayesian modeled radiocarbon measurements from present-day Hungary. This would be much more relevant for the dating of the Makó cemetery, as these are Early Avar Age burials dated with Byzantine coins, which, in contrast to the Pitvaros site, may be partly contemporary with the Makó cemetery.[29]

The authors' lack of experience in Bayesian modeling and the lack of basic understanding are reflected in their argumentation for the absence of the OxCal code, claiming that "as no OxCal code is available for this publication we have no information on how the model was built".[30] In contrast, it can be verified that we reported the model, from which all the parameters built into the model can be read accurately.[31] Based on this, anyone familiar with the use of OxCal software and Bayesian modeling can accurately recreate the model we published. No one needs to "*assume* [emphasis added] the construction of a simple Bayesian model in OxCal"[32] as we have accurately described and published all the necessary data.[33] In our study, we published the map of the cemetery, the assemblages of all burials dated with radiocarbon data and all the underlying data,[34] based on all these, statements can be accurately reconstructed and verified.

Their statement for the event 774–775 AD lacks the principles of scientific publication. "Authors of this paper *incorrectly blamed* [emphasis added] a major supernova explosion dated at 774/775 AD, to alter radioactive carbon present at the time and thus to contribute to the modification of conventional ^{14}C ages (Siklóssy [sic!] and Lőrinczy 2015).".[35] In this sentence, a solid judgment is formulated, which, according to the rules of the scientific literature, would have been indispensable to be supported by evidence, arguments, and references. With this statement, they attribute to us[36] the interpretation of the event, although in our cited study we referred to the results of previous writings by other authors as a possible explanation for the rapid increase in ^{14}C.[37] The basis of scientific research is that this can be debated if the researchers line up arguments and evidence to substantiate their claim. In their absence, this finding is rather unprofessional and not accepted in academic writing. Nowadays, the 774–775 AD event is widely "considered to have been caused by an extreme solar proton event (Mekhaldi et al. 2015; Miyake et al. 2015)".[38]

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[22] Balogh 2017; Gulyás et al. 2018.
[23] Balogh 2017; Gulyás et al. 2018.
[24] Balogh 2017; Balogh 2018.
[25] Gulyás et al. 2018, 1335.
[26] Gulyás et al. 2018, 1337.
[27] Gulyás et al. 2018.
[28] Siklósi–Lőrinczy 2015; Siklósi–Lőrinczy 2017.
[29] Siklósi 2014.
[30] Gulyás et al. 2018, 1337.
[31] Siklósi–Lőrinczy 2015, Fig. 6; Siklósi–Lőrinczy 2017, Fig. 7.
[32] Gulyás et al. 2018, 1337.
[33] Siklósi–Lőrinczy 2015, 708; Siklósi–Lőrinczy 2017, 483.
[34] Siklósi–Lőrinczy 2015, 710–712, 719–736; Siklósi–Lőrinczy 2017, 484–492, 494, 499–504.
[35] Gulyás et al. 2018, 1337.
[36] Siklósi–Lőrinczy 2015.
[37] Melott–Thomas 2012; Miyake et al. 2012; Hambaryan–Neuhäuser 2013.
[38] Reimer et al. 2020, 19.

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A Kr. u. 6–7. század keltezésének módszertani és értelmezési problémái az Alföldön

Megjegyzések *Sándor Gulyás–Csilla Balogh–Antónia Marcsik–Pál Sümegi: Simple calibration versus Bayesian modeling of archeostatigraphically controlled ^{14}C ages in an early Avar age cemetery from SE Hungary: results, advantages, pitfalls* című tanulmányához

Siklósi Zsuzsanna – Lőrinczy Gábor

A Makó-Mikócsa-halom kora avar kori temető keltezéséről írt tanulmányukban Gulyás et al. 2018 alapvetően tévesen alkalmazzák a radiokarbon dátumok Bayes-féle modellezését. Vitacikkünkben a radiokarbon keltezés módszertani kérdéseit és a Bayes-féle modellezéssel pontosított radiokarbon adatok értelmezésének problémáit, valamint a cikkben olvasható terminológiai hibákat tárgyaljuk.

A radiokarbon keltezés módszerének utóbbi évtizedekben lezajlott fejlődése ma már lehetővé teszi azt, hogy olyan történeti korokban is sikerrel alkalmazzuk e módszert, amely keltezéséhez a radiokarbon dátumok pontossága korábban nem volt elegendő. Ez a mérési módszer fejlődésének is, de sokkal inkább a Bayes-féle modellezés radiokarbon mérésekre való alkalmazásának és az adatok interpretációjának fejlődésének köszönhető. Ahhoz, hogy a radiokarbon dátumok Bayes-féle modellezését megfelelően alkalmazzuk, nagyfokú jártasságra van szükség nemcsak e módszer területén, hanem a feltáró régészekkel együttműködve az adott korszak tipológiai rendszereit tekintve is.

A Bayes-féle modellezés lényege, hogy a radiokarbon adatok értelmezésébe bevonjuk az egyéb rendelkezésre álló információkat. Ezek többnyire stratigráfiai megfigyelések, de lehetnek genetikai adatok vagy más régészeti információk is. A modellezés eredménye annyiban lesz helyes, amennyiben az eljárásba bevont, egyéb információk is azok. Így a modellezés során beépített feltételeink változtatásával az eredményeink is változhatnak. Sőt, felépíthetünk akár két olyan modellt is, melyek statisztikailag konzisztensek, azonban nem biztos, hogy mindkettő egybevág régészeti megfigyeléseinkkel. Gulyás et al. 2018 a Makó-Mikócsa-halom lelőhelyen feltárt kora avar kori temető radiokarbon adatainak Bayes-féle modellezése jól példázza, hogy a régészeti megfigyeléseknek teljes mértékben ellentmondó modellépítés is lehet statisztikailag konzisztens.

A radiokarbon keltezés és a tipokronológia kombinálása szintén nagyfokú jártasságot és óvatosságot kíván. A tipológiai alapú keltezés eredményeinek a modellezésbe való beépítésével könnyen tautológiához juthatunk, ahogyan ezt Gulyás et al. 2018 tanulmányában is láthatjuk. Cikkünkben közöljük azokat a Bayes-féle modellezéseket, amelyek az ásatási megfigyelésekkel konzisztens módon a jelenleg rendelkezésre álló stratigráfiai információk *(1. kép)*, a sírokban lévő érmék verési idejének figyelembevételével *(2. kép)*, valamint a Kárpát-medencei avar kor kezdetére vonatkozó történeti dátum figyelembevételével *(3. kép)* keltezik a Makó-Mikócsa-halom lelőhelyen feltárt temetőt.

Végezetül érintjük azokat a terminológiai és a tudományos írás stílusát, érvelését érintő hiányosságokat, melyek gátolják a Makó-Mikócsa-halom lelőhelyen feltárt temető keltezésének jobb megértését.