Peer Community In Archaeology

Tektites as chronological markers: after careful geoarchaeological validation only!

Alain Queffelec and *Shanti Pappu* based on peer reviews by *Mike Morley*, *Sheila Mishra*, *Toshihiro Tada* and 1 anonymous reviewer

Ben Marwick, Son Thanh Pham, Rachel Brewer, Li-Ying Wang (2022) Tektite geoarchaeology in mainland Southeast Asia. Missing preprint_server, ver. Missing article_version, peer-reviewed and recommended by Peer Community in Archaeology.
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Tektites, a naturally occurring glass produced by major cosmic impacts and ejected at long distances, are known from five impacts worldwide [1]. The presence of this impact-generated glass, which can be dated in the same way as a volcanic rock, has been used to date archaeological sites in several regions of the world. This paper by Marwick and colleagues [2] reviews and adds new data on the use and misuse of this specific material as a chronological marker in Australia, East and Southeast Asia, where an impact dated to 0.78 Ma created and widely distributed tektites. This material, found in archaeological excavations in China, Laos, Thaïland, Australia, Borneo, and Vietnam, has been used to date layers containing lithic artifacts, sometimes creating a strong debate about the antiquity of the occupation and lithic production in certain regions.

The review of existing data shows that geomorphological data and stratigraphic integrity can be questioned at many sites that have yielded tektites. The new data provided by this paper for five archaeological sites located in Vietnam confirm that many deposits containing tektites are indeed lag deposits and that these artifacts, thus in secondary position, cannot be considered to date the layer. This study also emphasizes the general lack of other dating methods that would allow comparison with the tektite age. In the Vietnamese archaeological sites presented here, discrepancies between methods, and the presence of historical artifacts, confirm that the layers do not share similar age with the cosmic impact that created the tektites.

Based on this review and these new results, and following previous propositions [3], Marwick and colleagues conclude that, if tektites can be used as chronological markers, one has to prove that they are in situ. They propose that geomorphological assessment of the archaeological layer as primary deposit must first be attained, in addition to several parameters of the tektites themselves (shape, size distribution, chemical composition).

Large error can be made by using only tektites to date an archaeological layer, and this material should not be used solely due to risks of high overestimation of the age of the archaeological production.

[1] Rochette, P., Beck, P., Bizzarro, M., Braucher, R., Cornec, J., Debaille, V., Devouard, B., Gattacceca, J., Jourdan, F., Moustard, F., Moynier, F., Nomade, S., Reynard, B. (2021). Impact glasses from Belize represent tektites from the Pleistocene Pantasma impact crater in Nicaragua. Communications Earth & Environment, 2(1), 1–8, https://doi.org/10.1038/s43247-021-00155-1

[2] Marwick, B., Son, P. T., Brewer, R., Wang, L.-Y. (2022). Tektite geoarchaeology in mainland Southeast Asia. SocArXiv, 93fpa, ver. 6 peer-reviewed and recommended by PCI Archaeology, https://doi.org/10.31235/osf.io/93fpa.

[3] Tada, T., Tada, R., Chansom, P., Songtham, W., Carling, P. A., Tajika, E. (2020). In Situ Occurrence of Muong Nong-Type Australasian Tektite Fragments from the Quaternary Deposits near Huai Om, Northeastern Thailand. Progress in Earth and Planetary Science 7(1), 1–15, https://doi.org/10.1186/s40645-020-00378-4

Reviews

Evaluation round #1

DOI or URL of the preprint: **https://doi.org/10.31235/osf.io/93fpa**

Authors' reply, 05 January 2022

Thanks very much to Alain Queffelec and Shanti Pappu for coordinating the review of our submission. We are pleased that the reviewers recognise the importance of our paper, and we are grateful for their thoughtful suggestions to improve the manuscript. Here we respond to the reviews and summarise how we changed our manuscript.

Sheila Mishra: "One would expect a difference in the technology between the artefacts from Late Pleistocene to Holocene context and the Early middle Pleistocene age claimed for the Acheulian like technology. I would like to see this reported. Some model for deposition of the sediments and post depositional processes is needed."

» We have clarified that our model of deposition is based on a lagging process. We have not added additional discussion of the stone artefact technology because this is out of scope for this paper.

Toshihiro Tada: "it is not clear that this manuscript contains only reviews of literature or contains some results of the author's field surveys at the archaeological sites in addition to the literature reviews."

» We have clarified in several places in the text about which parts of the paper are review and which are presentation of new information.

Toshihiro Tada: "the objective observation results described in Fiske et al. (1999) and the interpretation by Fiske et al. (1999) are written in a mixture."

» We have edited our presentation of this paper to clarify and separate their results from their interpretation.

Toshihiro Tada: "maintain the neutrality and objectivity of the literature review, it is better to mention literature suggesting that the tektites found in the "laterite" layer in SE Asia are in situ, as well as literature suggesting that the tektites are reworked."

» We have edited the literature review in many places to clarify how the literature interpret previous tektite finds

Toshihiro Tada: "Figures 3, 4, 5, and 6, hard to discern whether these objects are really tektites or not from the photographs alone... add evidence to demonstrate that these objects are tektites such as geochemical

data or radiometric date of the glass or water content. If it is difficult to obtain these data, high-resolution photographs or enlarged photographs are very welcome."

» We have re-taken the photo of the tektite in Figure 4. It has not been possible for us to re-take photos for the other figures because of restrictions in accessing the samples. Similarly, chemical analyses of the samples are not possible at this time, unfortunately. Our hope is that the publication of this paper will motivate an interest in further analyses of these samples, and our requests for access will be more successful.

Toshihiro Tada: "The scales in the photograph of the artefact in Figure 4 are too small. The excavation site photograph in Figure 4 needs a scale. The drawing of glazed ceramics in Figure 6 needs a scale."

» We have made these changes to the Figures, which have improved them greatly, thank you.

Toshihiro Tada: "There are many problems with the reference list."

» We have removed the items that were not cited, and added the missing references. Thanks for this careful checking.

Anonymous: "I would recommend more information on the details of the tektites (dimensions/preservation), perhaps as tables to enable comparison with those found elsewhere in terms of morphology, size ranges, etc."

» It is currently not possible for us to obtain this information. Our hope is that the publication of this paper will motivate an interest in further analyses of these samples, and our requests for access will be more successful.

Anonymous: "I would like to see expanded data on the sites discussed, as also in higher resolution maps. Perhaps inset maps of the areas under discussion in Vietnam would be helpful if presented along with the geomorphological or sedimentary contexts, e.g. if the sites are plotted on soil maps or geology/geomorphology maps.

» We have updated Figure 1 to include a higher resolution map of Vietnam showing the location of sites discussed in the text in more detail. We have not included soil/geology maps because we do not discuss these in the text.

Anonymous: "On page number 10, in the introduction paragraph for "Tektites from archaeological sites in Northern Vietnam", the author has mentioned five archaeological sites but only four are listed. The Dong Choi site is missing from the list."

» We have updated the text to include mention of all five sites.

Anonymous: "Fiske, P., Putthapiban, P., Wasson, J. (1996). Excavation and analysis of layered tektites from Northeast Thailand: Results of 1994 field expedition. Meteoritic and Planetary Sciences, 31, 36-41. Here please check the journal name. It should be Meteoritics."

» We have updated the reference list to correct the journal name. We found that M&PS was known as Meteoritics before Jan 1996, so we have updated the references to be consistent with the journal name at the time of publication. This Fiske et al 1996 was in the Jan 1996 issue, so was one of the first to be published when the journal name was changed to M&PS

Anonymous: "In the article you have referred to Son 2014 and 2017. But both references are not mentioned in the reference list."

» We have updated the text reference list to fix these incorrect references.

Anonymous: "Figure-1: The site name Go Da and Roc Tung are not mentioned on the map."

» We have updated Figure 1 to show the locations of these sites.

Anonymous: "In the Figure-2 description author has described the sediment layers (1 to 5) is according to colour variation. Is it possible here to describe the layers as per the sediment composition? For example, whether it is a sandy layer or clayey or silty in nature? Also in the same figure, though scale details are written in the figure description, the scale and the numbers for the layers are not clearly visible. For the same figure please give the types of the artefacts."

» We have updated the Figure 2 caption to include sediment texture details. We were not able to modify the layer numbers. We have not added further details about the stone artefacts because these are not the primary focus on the paper.

Anonymous: “Figure-4: Could you please provide a section diagram with the scale bar? Also please mention the types of artefacts that are shown in the image.”

» We have updated the caption to Figure 4 to indicate the depth of the excavation. The section drawing is overlaid over the photograph of the section. We have not added further details about the stone artefacts because these are not the primary focus on the paper.

Anonymous: “Figure-5: As shown in Figure-3, could you please show the in situ locations of these six tektites?”

» Unfortunately these details are not available to us. Our hope is that our paper will draw attention to the need for more detailed field methods in future excavations in the region.

Decision by Alain Queffelec and Shanti Pappu, posted 29 September 2021

This manuscript is sound but merits some revisions.

Dear Ben Marwick et al.,

I am pleased to inform you that your manuscript has been evaluated by four reviewers.

As you can see below, the comments are very positive but some reviewers have raised several points to improve the clarity of your manuscript, as well as details that would make your work easier to read. In particular, Toshihiro Tada suggests changes in the text and raise some minor comments, especially about the list of references that is not in agreement with the citations in the text. Another reviewer asks improving the quality of some of the figures and maps, and providing more detail in the description of the sites your team studied on their own.

I therefore ask you to address these comments and suggestions before submitting a new version of the manuscript.

All the best

Reviewed by Sheila Mishra, 12 September 2021

Review of Tektite geoarchaeology in mainland Southeast Asia Marwick,Son and Brewer

Sheila Mishra

This paper presents enough examples of tektites in young contexts to indicate that, as they argue, the presence of tektites on their own are of little value in age estimation.

It brings home the fact that infact the presence of tektites only certainly shows an age younger than their age (<700ka). The widespread co-occurence of younger artefacts and dates with tektites shows that infact their occurrence in younger contexts is very common.

I read the paper by Xie et al 2021 which is one of the sites mentioned in the paper. Xie et al clearly say that almost all the finds reported earlier from the Bose basin are from the upper 1-1.5 m which surely makes their re-working probable. Young dates are reported for the sediments. The actual context of the sites is somewhat perplexing as neither the concept of terraces or of laterites is very clear. I was confused by their statement of “basal gravels from the top of T 4”.

The point of commenting on this other paper is that it seems to me that the actual processes of both depositional and post-depositional processes of the sediments in which the tektites co-occur are not really understood by the excavators or other archaeologists working on the problems. I was able to visit some of the sites when a conference as arranged in 2001 after the publication of the paper in Science. I was struck then by the extremely low frequency of artefacts. The sediments where not in any way “laterite” as we know it in India but the post depositional alteration of the sediments was intense and not really in conformity with a Holocene

age. In my experience in the Indian context there are no such things as terraces and the enormous amount of sediments makes it difficult to understand them in relation to successive terrace surfaces. Geologists are not much help in understanding these processes as they are not well studied. It is also an obviously technically affected region, and so processes might by quite dynamic. The sites are quite far away from the main river channel and would be affected by local runoff and erosional as well as depositional processes.

Just as the younger objects (and dates) show the younger age of the artefacts, the tektites do show that some stone objects dating to around 700 ka are present in the landscape.

This paper is clearly written and provides some new examples of the younger context of tektites and is fairly convincing in calling into question the assumed age of the Bose Acheulian. On the other hand it is possible that both the artefacts and tektites come from some horizon below the horizons established as disturbed or younger than the age of the tektites.

One would expect a difference in the technology between the artefacts from Late Pleistocene to Holocene context and the Early middle Pleistocene age claimed for the Acheulian like technology. I would like to see this reported. Some model for deposition of the sediments and post depositional processes is needed.

Xie, G., Chen, X., Li, D., Yu, M., Hu, Z., Lu, H., Huang, Q., Lin, Q., 2021. Stratigraphy and chronology of the palaeolithic industry in Bose Basin, South China: Excavation of Gaolingpo. Archaeological Research in Asia 26, 100284

Reviewed by Toshihiro Tada, 17 September 2021

Download the review

Reviewed by anonymous reviewer 1, 28 September 2021

Review of the paper "Tektite geoarchaeology in mainland Southeast Asia" by Ben Marwick et al.

The article presents a piece of updated information on tektites in archaeological contexts as chronological markers and suggests that they are reliable only when supported by other dating methods. In this context, the paper is important and provides another perspective that would have implications for the chronology of some of the Palaeolithic assemblages from East Asia. The review with insights and updates on the tektite geochronology would suggest a rethink on debates related to the earliest Palaeolithic sites in SE and E Asia. While the focus is on sites in Vietnam (An Khe sites), it has implications that span theories of hominin dispersals across Asia. The crux of the argument lies in the disparity of age estimates from stratigraphic contexts using other dating methods versus the proposed age of the tektites. For this, a comprehensive discussion on the same has been provided and contributes to the bulk of the paper. Important here are discussions on the occurrence of the tektites at various sites across Australasia in redeposited or reworked contexts and that this redeposition is not a single event.

The crucial site in this context is that in the Bose basin, where discoveries of dated Acheulian-like bifaces were situated at around 800 ka based on tektite presence. This had significant implications for studies of the Acheulian across Asia, rethinking debates on hominin dispersals and demolishing in many ways the infamous 'Movius line'. The challenge to using tektites for sites in this region has a history with several other authors also debating the in situ nature of tektites and thus the age of the Bose basin sites. Here, too, the authors imply that the Bose sites are far younger in age and that the tektites were redeposited in these fluvial sediments. This is in line with previous debates on this issue as having been referred to here as well. Arguments proposed to support the older age of the tektites are also summarised in this paper, although these arguments are criticised in this paper. The authors suggest that tektites were introduced to the site by hominins making Acheulian-like bifaces, based on Late Pleistocene artefacts on tektites and ethnographic analogies. This point may however be expanded on.

The focus of the paper is on sites in N. Vietnam, where the tektites occur in sites dating to the Holocene. While this is no doubt fascinating, I would recommend more information on the details of the tektites (dimensions/preservation), perhaps as tables to enable comparison with those found elsewhere in terms of morphology, size ranges, etc. This would be of use for readers unfamiliar with the data from Vietnam. Further information on An Khe sites would also be useful, as this is where the crux of the matter lies, i.e. bifaces dated using tektites. Here, based on published literature, the authors challenge interpretations that the bifaces are as old as the tektites and suggest reworking based on similarities in stratigraphic contexts with other sites in Vietnam and elsewhere. In this context, reports on sites in Thailand that challenge interpretations of tektite reworking are important and are cited here. The authors draw on these arguments (based on tektite morphology, etc.) to suggest that similar methods if used at Go da and Roc Tung would support interpretations of an early age.

While I recommend publication, I would like to see expanded data on the sites discussed, as also in higher resolution maps. Perhaps inset maps of the areas under discussion in Vietnam would be helpful if presented along with the geomorphological or sedimentary contexts, e.g. if the sites are plotted on soil maps or geology/geomorphology maps.

Some additional points:

On page number 10, in the introduction paragraph for "Tektites from archaeological sites in Northern Vietnam", the author has mentioned five archaeological sites but only four are listed. The Dong Choi site is missing from the list.

Fiske, P., Putthapiban, P., Wasson, J. (1996). Excavation and analysis of layered tektites from Northeast Thailand: Results of 1994 field expedition. Meteoritic and Planetary Sciences, 31, 36-41. Here please check the journal name. It should be Meteoritics.

In the article you have referred to Son 2014 and 2017. But both references are not mentioned in the reference list.

Figure-1: The site name Go Da and Roc Tung are not mentioned on the map.

In the Figure-2 description author has described the sediment layers (1 to 5) is according to colour variation. Is it possible here to describe the layers as per the sediment composition? For example, whether it is a sandy layer or clayey or silty in nature? Also in the same figure, though scale details are written in the figure description, the scale and the numbers for the layers are not clearly visible. For the same figure please give the types of the artefacts.

Figure-4: Could you please provide a section diagram with the scale bar? Also please mention the types of artefacts that are shown in the image.

Figure-5: As shown in Figure-3, could you please show the in situ locations of these six tektites?

Download the review

Reviewed by **Mike Morley**, 06 September 2021

The preprint presents a review and critique of tektites and their utlitiy as chronostratigraphic markers at archaeological sites. In my opinion this short paper is timely and the premise is sound – that dated tektites can rarely be used as the sole method of establishing the age of a site unless the precise context of the dated material is known. Given that tektites might easily be entrained in younger deposits where they represent a lag deposit, Marwick et al argue that they can only be used alongside other dating techniques, and claims made thus far on the antiquity of sites in China and Vietnam need to very carefully evaluated with these issues in mind. It is my opinion that this paper represenmts a useful addition to the scientific literature concerning the dating of archaeological sites.