

Geochronology Discuss., author comment AC2  
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## Reply on RC2

Richard N. Holdaway et al.

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Author comment on "Evidence for old carbon contamination in 14C wiggle-match age series for the 946 CE eruption of Changbaishan volcano" by Richard N. Holdaway et al., Geochronology Discuss., <https://doi.org/10.5194/gchron-2021-13-AC2>, 2021

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### Reviewer 2

This is a really interesting article that also raises an interesting point that there is at least the potential that trees being dated by Dendro/14C wiggle matching may be influenced by geological dead 14C. As such the paper should be published. It is an important but fundamentally overlooked point. I do, however, have a number of concerns that need in my mind to be addressed.

\*\*\*We appreciate the reviewer's view that our paper deals with "an important but fundamentally overlooked point" and are pleased with their recommendation. We respond to their concerns in detail below.

My first issue is one that is also raised by the first referee, in that there are many sources of contamination that can cause problems with 14C ages, and may not be removed by standard techniques. There is clearly a problem that is unlikely to be related to volcanic CO<sub>2</sub> in the ages that are too young, as opposed to being too old. This needs to be discussed in more detail. In fact I think the paper needs to more be an examination of the problems that can be encountered with 14C ages and placed in the context of wiggle match dating of eruptions.

\*\*\*As in our response to this point as raised by Reviewer 1, we will expand our discussion of other potential sources of contamination while confirming our position that, for wiggle match series measured on trees within the influence of a volcanic edifice, geologic/magmatic carbon is an unappreciated but potentially dominant source. And one which can provide enough contaminating carbon to actually change the position of best fit on a calibration curve.

In this unusual case we know the age very specifically and that allows a discussion of these problems. Some of the problems with the dates relates to contamination by older 14C, which may be from volcanic degassing, but could be from a range of other issues. Some dates have been contaminated by young 14C and this is unlikely to be a volcanic origin. One way of looking for potential contamination sources is through delta 13C measurements. In cases where 14C and 13C of volcanic emissions have been considered on modern trees there is evidence of a shift in both isotopes. The fact that it is pretty difficult to find 13C measurements for most of the cases used in this study makes the point that there are a whole host of quality assurance issues in radiocarbon dating of

volcanic eruptions that need to be considered.

\*\*\*We agree that  $\delta^{13}\text{C}$  is a potentially useful marker of the source of any contaminating carbon. We have explored, and continue to explore, the possibility of  $\delta^{13}\text{C}$  evidence for the source(s) of contamination. As the reviewer notes, such data are rarely reported and we very much agree that there are issues of quality assurance in radiocarbon dating of eruptions.

The known age of the B-TM makes this a great paper around which to have that wider discussion. This is moreso because I do not see how, unless we know the exact age of the eruption, we can use this approach, to finding old carbon. Also even if we can find the percentage of old carbon in a sample, without additional measurements such as  $^{13}\text{C}$  we can't start to suggest the source of the old carbon with much reliability.

\*\*\*We agree and certainly hope that our paper could be a focus for a wider, constructive, discussion on the issues which undoubtedly surround the wiggle match process. We propose our method as a way of identifying the potential presence of old carbon in a wiggle match tree, by exploring the possibility of the existence of other, conceivably better, matches if zero contamination is not assumed.

I also wasn't sure why the outlier function in OxCal wasn't used instead as this has largely superseded the use of AIs in OxCal outlier detection studies. The AI is simply the area of overlap between posterior and prior. I would like to see at the very least the analyses done again with appropriate outlier detection.

\*\*\*We investigated but did not pursue the use of the "outlier" function in OxCal. We think that this is basically another way of isolating ages that don't fit with an *assumed* position of fit on the curve. A different way of applying the Procrustean approach to a wiggle match fit. As such, we do not believe that its application would be appropriate here. We used AIs because they are recognised numerical method of assessing overall fit of a wiggle match series to a calibration curve. They allow fits at different sections of the curve to be compared objectively.