Authors' Response to Referee Comments

In black are referee comments
In red are author responses

Although probably covered by the blanks (re-extracts) done after each step heat temperature step. I just worry about the 3He/4He ratios of the lower T step heating steps possibly having a higher R because the 3He is successfully diffusing out of the matrix faster than 4He because of the difference in mass. Perhaps a little more discussion could be added on why this worry is likely unfounded? A little on diffusion rates of 3He and 4he with varying T. And/or consider publishing the re-extract data so readers can see that there was zero (or very low) 3He and 4He on the re-extract at 800C? This is important because the 800C step is the only one that really contributes 3Hec (as stated) by this step heat method.
To clarify, there were not re-extracts after each step heat temperature step. Three hot blanks were run on an empty furnace at the beginning of the experiment at each temperature step. Two re-extracts were run at the end of the experiment to ensure total release of He. I will add a citation and sentence to alleviate concerns about He diffusion.

This is not a huge point, but I'm not sure that the two-step method is always done as the authors suggested, namely that the step after crushing always involved completely powdered olivine/pyx sample. Often researchers just use the crushed leftovers (or sometimes uncrushed phenocrysts) and it works fine as there isn't much mantle gas, the crushing step opened most of the host inclusions and/or the exposure duration and site PR were high enough to overcome some left over mantle gas and get a high % 3Hec. Some labs will try using in vacuo crushed sample material first and then power if needed as the powdering step brings with it a host of problems as the author's state.
I added clarified that the second step does not always involve powdering.

Line by line comments:
18 – should give the temp step ranges of the three ranges used rather than just 700-1400C
I added in the temperature step ranges.

20 – 'youngest'…. how? Morphologically, relative age relationships?
I added in stratigraphically to describe what youngest means in the paper.

24 – I'd remove the 'for decades' to avoid confusion
I removed this part of the sentence for clarity.

35-37 – I'd list mantle He first and the other sources after that as mantle is the most important for young volcanics
I rearranged the sentence so that mantle He is listed first.

55-65 – I'd just mention that this newer variant of the isochron method was introduced in Blard 2021 and has different axes that the 'traditional' isochron method of Cerling and Craig, 1994; Blard and Pik , 2008; etc.
I clarified the change in axes.

66 – again, ‘youngest’ , how do you know they’re the youngest?
I added in stratigraphically.

69 – not sure what ‘following work on peridotites’ means – has this step heat correction already been done and published before? Or is this saying that the peridotites analyzed here have already been studied which aided in developing this new method? Either way, perhaps rewrite this.
This sentence was rewritten for clarity.

75 – 14C ages are typically given as either 14C yr BP (if uncalibrated) or cal yr BP (if calibrated). The reference that is cited should tell which.
I added in yr.

88 – I’m not exactly sure what ‘primary depositional features’ are on a lava flow? Maybe primary lava flow morphology, or something like ropy texture suggests that it is a flow top with minimal weathering.
This sentence was changed for clarification.

101-105 – so the olivine samples were a mix of phenocryst and xenocryst olivine, as well as possible olivine from ultra-mafic xenoliths? Are they all seeing the same mantle gas environment? All the ways you calculate the 3Hem they look the same at least.
The olivine analyzed contains two types of olivine, the phenocrysts and xenocrysts. It is likely that the mantle gas trapped inside the olivine from the xenocrysts and phenocrysts ha

113 – multiple problems with exponents and units in this line
This is fixed now.

120 – is this a resistance furnace?
Yes, this is clarified now in text.

125 – second time with these exponents and units, maybe not a mistake but intentional. Describing a concentration as 10^-3 Matoms is a little confusing, similarly 10^3 M atoms is as well.
This is fixed now.

145 – so again with the exponent and M – why not just say 10^12 instead of 10^6 M…
^{4}He concentrations are in atom/g now.

170 – the crush results in this table are not Matoms/g but rather Matoms. No leeway on this, you don’t know how much mass was crushed.
We disagree. We know how much mass was placed into the crusher and how much was retrieved. These facts allow us to have a fairly accurate value for the mass and a crush concentration. This is a standard way to report ^{4}He concentration for crushes.
=
172-174 – this assumption is likely untrue and I’m not sure its ‘curious’ to test it in this way (which I’m ok with – testing it in this way that is…), but rather interesting, valuable, or illustrative?

Wording has been changed.

183 – the Thirumalai 2011 paper cited in the figure caption is not in the ref list.
This has been fixed.

185 – might be worth it here to remind readers that these step heat samples were powdered.
I will add a note about this in the figure caption. I think the methods section makes it clear that they are powdered.

205 – maybe before mantle in the end of the line put 'persistent', so its 'persistent mantle Helium'
I added in persistent.

237 – the 3 on 3He isn't superscripted
This has been fixed.

264 – not sure which PR calculator you're using, is it the FORMER Cronus Earth calculator, the Balco one…sometimes called the UW calculator, but not sure what it's routinely called now, I'd just put the web address for clarity.
Link added.

271 – for the average of the two ages, how is the uncertainty determined? If you average the ages the standard deviation might be better for the uncertainty (about 0.2). If you averaged the 3Hec and determine an age then seems ok to use the internal uncertainty associated with the exposure age calculator (more like 1.1 that is used). Should just say.
I have updated the manuscript to use standard deviation for uncertainty on the average age.

288—maybe remind readers of the association of TS peridotite to these samples? And you set up and used TS as shorthand for Twin Sisters earlier, maybe either use it consistently after that or just don't worry about shorthand for a location you only mention a few times.
The connection is that both samples have a source of mantle He that cannot be removed by powdering.

Figures
Fig 1 – I find some of the colors hard to match back to the legend, they are clearly labelled though.
We will leave this figure as is.

Fig 2 – maybe should put equation of that line inside the figure space rather than in the caption, and include statistical tests on that regression: r2, p, MSWD etc. Should also note that the line is extrapolated beyond the two data clusters.
We will leave this figure as is. I have noted that the line is extrapolated beyond the two data clusters.

Fig 3 – this figure is key to the whole paper and is interesting. I would shorten the lines, to maybe like +/- 50 deg C around the T that you measured 3He and 4He at. As is, it looks like you are declaring that there is some sort of degassing domain change at 900 C and 1200 C but I don't think you're really trying to say that?

This figure has been updated! The cause of the issue was a formatting error in Sigma Plot.