We kindly thank Referee 2 for their time considering and reviewing our submitted manuscript. Below we provide a response to each of the two comments from Referee 2.

Ultimately, sharp contacts and pristine glass shards do not provide robust evidence that an ash layer is primary. Moreover, since the tephra layers identified here are compositionally identical and in sediments younger than the Vedde ash, other lines of evidences are essential to categorically prove these are not redeposited Vedde ash. Therefore I find the conclusions of the paper here are unsupported. Numerous other high-resolution lake records have shown that it is extremely difficult to discriminate reworked ash from older (primary) events, and that ash can be redeposited, producing discrete visible and cryptic layers with perfect pristine glass shards (even over tens of thousands of years after the original eruption). Rigorous morphological, geochemical and sedimentological work has not been demonstrated, and may not be able to rule out the possibility of redeposition.

We thank the reviewer for raising this point and allowing us to clarify our rationale.

The claim put forward by Reviewer 2 that: „…, sharp contacts and pristine glass shards do not provide robust evidence that an ash layer is primary" is misguided and, as presented, unsupported by any evidence or observations. This claim is also somewhat surprising, because both observations and measurements have demonstrated that grain morphology/grain shape is perhaps one of the best tools available to differentiate between primary and reworked deposits (e.g., Wilcox and Naeser, 1992; Leahy, 1997; Guðmundsdóttir et al 2011; Lowe, 2011; Óladóttir et al 2011; Dugmore et al., 2020; <u>see also quotes extracted from these publications below</u>). Additional aspects that help to define primary tephra layers are 1) homogenous geochemical compositions, 2) minimal incorporation of exotic material (e.g., lithic fragments, biological microfossils, etc.), 3) lack of sedimentary structures such as turbidites that would indicate redeposition, and 4) spatial distribution of the layer across different landscapes and deposits (Lacasse et al., 1998; Boygle, 1999, Shane et al., 2006; Gudmundsdóttir et al., 2011; Lowe, 2011; Dugmore et al., 2020):

Quote from Guðmundsdóttir et al 2011

"Morphological measurements and microprobe analyses were used to discriminate between primary and reworked tephra. <u>The morphological measurements reveal fresh glass grains at the intervals where the nine tephra layers have been located, demonstrating the usefulness of this method to evaluate whether a tephra layer is primary or reworked</u>. It appears that a ruggedness value of less than 0.4 is indicative for primary tephra in this environment. Microprobe analyses are unsurpassed as a tool to correlate tephra to source volcanic system and to distinguish between a primary tephra layer, which manifests itself by a dominant glass composition, and reworked tephra consisting of grains with several different glass compositions."

Quote from Óladóttir et al 2011

„When defining primary tephra both field observations and chemical composition are important. Three field observations have proved useful in distinguishing between primary tephra and reworked material: (1) Colour and contacts. Primary tephra has distinct colour as it is not contaminated by soil and unrelated tephra grains. Sharp contacts indicate primary undisturbed tephra. Laterally continuous bedding can also be diagnostic. (2) Grain size and shape. During wind erosion grains become abraded and sorted, leading to decreasing grain size and increased sorting in reworked material compared with primary tephra. (3) Thickness. Thick tephra can cover vegetation completely, increasing the possibilities of tephra reworking. A homogeneous chemical composition confirms the primary character of tephra whereas heterogeneous results may indicate (1) contamination from surrounding units, (2) contemporaneous eruptions at two or more volcanic systems or (3) reworked material."

Quote from Lowe (2011) – tephrochronology review paper

"Various other laboratory analyses can also provide clues that tephra reworking has occurred. For example, partial rounding of grains in a tephra layer and the loss of glassy coatings from fresh crystals both point towards a reworking event (e.g., Wilcox and Naeser, 1992; Leahy, 1997). If the major element concentrations of glass shards in a tephra are normally homogeneous (i.e., analyses of individual shards show only small deviations from one shard to the next), then multiple populations of such shards indicate that post-depositional mixing has probably occurred, or that two or more tephras were deposited effectively simultaneously from closely-spaced eruptions."

With these criteria for defining primary tephra layers in mind, we respectfully disagree with the reviewer that our evidence for primary deposits is unsupported. All tephra layers described in our study have sharp contacts, pristine shard morphometry, tight geochemical populations, do not contain any substantial exotic material, and feature large grain sizes that cannot be mobilized by wind and are not normally graded as a redeposited turbidite would be. The tephra layers also have potential correlations in both a south Iceland lake and the marine realm north of Iceland (see main manuscript). Moreover, Torfdalsvatn's lake catchment is low relief, which makes remobilization of soil and sediment challenging. Finally, the stratigraphical replication of Björck et al.'s 1992 record with our team's newer 2012 core further supports the presence of multiple primary tephra deposits, a principle previously highlighted specifically for Icelandic lake sediments (Boygle, 1999).

While the reviewer is correct that ash can be reworked as layers or as cryptotephra (Boylge, 1999; Wutke et al., 2015), our collective lines of evidence, all of which are supported by the literature, strongly suggest the tephra layers we evaluated are primary deposits. We recognize that some of the arguments supporting this conclusion may not have been clearly articulated in the submitted manuscript. Therefore, we will revise the manuscript to include a Discussion section dedicated to clearly outlining our reasoning for identifying the tephra layers as primary deposits. We hope that this will allay any concerns of redeposition by the reviewer.

The authors also need to show the integrity of the lake sediments, showing the tephrostratigraphy over a longer period of sedimentation and show the compositions of glass shards incorporated within the sediments over different timescales. I would suggest presenting the complete tephrostratigraphy of the lake sediments and including the work in this manuscript alongside a discussion of interpreting taphonomic issues like these that are commonly faced by the tephrochronological community working with sedimentary records.

We thank the reviewer for raising this point and allowing us to clarify our rationale. While the comment is unfortunately somewhat unclear to us, a discussion of tephra shards from non-primary tephra layers (i.e., background tephra) seems irrelevant to this study. Tephra preservation is certainly an open research direction in the field, however, our aim here is to report on primary ash deposits that may serve as regional age control points. As we have detailed above, our collective evidence strong supports that the tephra layers in this study are primary airfall deposits. We will keep the reviewer's suggestion to explore taphonomic processes of tephra in the background sediment in mind as a potential avenue for future research, but we would like to stress that this information is not relevant for the conclusions drawn in our current study.

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