

Interactive comment on “Paleointensities on 8 ka obsidian from Mayor Island, New Zealand” by A. Ferk et al.

A. Ferk et al.

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Dear Dr. Bowles,

Thank you for suggesting our paper for publication in Solid Earth after minor clarifications and corrections. Please find enclosed the response to your comments .

On behalf of all authors, Annika Ferk

General Comments/Summary This manuscript presents geomagnetic paleointensity results from an ~8 ka obsidian in New Zealand. As there are currently few paleointensity results from the southern hemisphere, this work represents an important contribution towards a better-constrained geomagnetic field model. The experimental methods were very thorough, as the authors attempted to correct for both anisotropy and cooling

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rate effects, both of which are rarely done. However, sample alteration precluded applying these corrections in most cases. Identification of the remanence-carrying magnetic mineralogy was also hampered due to the high paramagnetic to ferromagnetic ratio. The manuscript should be published with minor clarifications and corrections.

Specific Comments 1) The authors were frustrated in their attempts to determine anisotropy and cooling rate corrections for most specimens due to sample alteration. Yet in the introduction they state that by choosing these particular samples they would be able to correct for these biasing effects. A slightly longer discussion on the uncertainty arising from the inability to apply these corrections seems in order. Previous work by two of the authors (Leonhardt et al., 2006, EPSL, 243, 282-292) suggests that cooling rate corrections are 13-20% in obsidian, though Bowles et al. (2005, Geochem. Geophys. Geosys., 6, Q07002) find no systematic bias in submarine glass. Although it may be preferable to determine sample-specific cooling-rate dependencies of magnetization, could not an estimate be determined simply by assuming published values for SD material or by using the relationship determined for the one successful sample? The samples seem fairly uniform in terms of their magnetic properties, and one might expect cooling rate dependencies to also be similar. - We have slightly changed the introduction to state more clearly that applying ATRM and CR corrections was hindered due to alterations. Further we have included approximations of the cooling rate corrected paleointensity in the discussion.

As Muxworthy points out in his comment, magnetostatic interactions would affect the cooling-rate dependence, but I would be surprised if there were considerable magnetostatic interactions in the glass. Have there been any TEM studies of similar obsidians that imaged the magnetic minerals? - See answer to Muxworthy's comment. Unfortunately, to our knowledge there are no such TEM studies.

2) A considerable amount of text is devoted to the cooling rate experiments and results (Section 3: Relaxation geospeedometry), which are already published in Gottsmann and Dingwell (2002). Especially considering that only one of the cooling rate results

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is even used in the present study, I would recommend paring Section 3 down considerably. The results could be summarized in a single paragraph. Likewise, 5 out of 11 figures are merely reproduced from Gottsmann and Dingwell (2002). While Figure 2 is useful in orienting the reader, I think the remaining 4 figures (Figures 3-6) could be eliminated and the reader referred to the original source. - We have shortened the whole section considerably. There is now only a short introduction to the general concept of relaxation geospeedometry and a summary of the results left. We have also eliminated the former figures 3-6.

3) Although the authors state that the paleointensity data are of “good quality” (and results in Fig. 10 appear quite good), it would be nice to have more information on the quality selection criteria used. What are the “default criteria” used in data interpretation? It should also be relatively easy to include in Table 2 the actual quality statistics referred to in the text (e.g., list f, g, DRAT, etc.). - It was wrong to say that we were using the default criteria. Instead we decided from sample to sample whether it's data is reliable. The sentence about the default criteria is left out now and instead the quality parameters are included in the table.

Also, the authors should define or give a reference for the criteria “d(TR)” (pg. 689, line 26). I am uncertain as to what this is. - d(TR) is just the relative difference between a thermal demagnetization before and after the pTRM acquisition of the respective temperature step. This parameter was introduced by Leonhardt et al., 2004. We have now included both the explanation and the reference in the manuscript.

4) How are the uncertainties at the specimen level determined in Table 2 (for uncorrected paleointensities)? Are these used at all? They appear to be disregarded when calculating site averages and standard deviations. - The uncertainties are calculated via: $\text{error}(\text{paleofield}) = \text{paleofield} * \text{error}(\text{slope})$. It is true: the errors aren't used for the site averages. We chose to use arithmetic means and standard deviations for the different sites. The mean for the whole 8ka flow (using both sites) is then a weighted mean with $1/(\text{arithmetic standard deviation})$ as weighting factor. These explanations

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can be found in the last paragraph of section 5.1. However, even if the errors are not used for weighting they are used for determination of errors for HATRM and HATRM,CR as minimum-maximum errors and via full error propagation, respectively. This can be found both in the text and in the caption of table 2.

5) Page 688, Lines 8-11. The interpretation of the difference between the FC and ZFC (or LTSIRM) warming curves as arising from an antiferromagnet is non-unique. It looks very similar to the difference you see in nano-magnetite or -titanomagnetite, where at low temperatures magnetocrystalline anisotropy increases dramatically. - Thanks to the referee for this comment. We have included this additional explanation in the manuscript.

6) The writing is unclear or awkward in many places, often due to improper English language usage or grammar. I have tried to highlight the most problematic sections below. - We have addressed all the technical corrections mentioned below and also read through the manuscript again. However, we do not think that besides those comments below there is anything else that needs to be changed to improve readability.

Technical Corrections Page 680

Line 24 It may be more appropriate to cite one or some of the original work or discussion on cooling rate differences (e.g., Coe, 1967; Halgedahl et al., 1980; Dodson and McClelland-Brown, 1980; Fox and Aitken, 1980. . .) - References to Fox and Aitken, 1980 and Papusoi, 1972 are now included.

Page 681

Line 5 “crystals” Be more explicit, e.g., “single silicate crystals with magnetite inclusions” - Agreed: “Crystals” was too general. We have changed the text accordingly.

Line 7 What is the source for the data in Fig. 1? - Data from Korte and Constable, 2005 and Genevey et al., 2008. These citations are now included both in the figure caption and in the text.

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Line 8 “The data set behind of for example the global field model...” Change to: “For example, the data set behind the global field model...” - Done.

Page 682

Lines 11-13 Unclear. Perhaps: “The deposit has been interpreted as a fountain-fed flow that deformed after emplacement...” ?? - Right, this was unclear. It has been changed accordingly.

Line 29 Replace “i.e.” with “e.g.” - Done.

Page 683

Line 9 Change “in” to “an”. Close bracket needed after Al₂O₃. - Addressed.

Page 685

Line 15 “For some samples also the dependences of hysteresis and backfield on temperature were measured...” Change to “For some samples, the temperature dependences of hysteresis and backfield were also measured...” - Done.

Line 18 “different low temperature experiments” Describe those experiments here. - Lines 10-19 from page 687 were moved here.

Line 23 “according data was” Change to “data were”. Remove the word “according” - Done

Page 686

Line 4 Change “shows” to “show” - Done.

Line 7-8 Sentence beginning “Plotting of Mrs/Ms...” is awkward. Perhaps something like: “These two samples plot in (near?) the SD region of a standard Day plot (Mrs/Ms vs. Bcr/Bc), assuming a magnetite mineralogy.” - Done.

Line 9 (and 25) Describing a hysteresis loop as “thin” seems strange. Perhaps say that it is “dominated by paramagnetic behavior”. - Done.

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Page 687

Line 6 Insert comma after “loops” - Done.

Line 12 Change “of” to “off” - Done.

Line 13, 15, 18, 19 Change “implied” or “applied” to “imparted”. In general, fields are “applied”, while remanences are “imparted”. - All changed.

Line 18 Add “in zero field” after “cooling” - Done.

Lines 10-19 Move up to beginning of section where you are describing methods. - Done.

Page 688

Line 18 Change “inch” to “1-in”. Also on Page 689, Line 12, change “8 inch cores” to “eight 1-in cores”. That way it is clear that the cores are not 8 inches long. - Changed in both cases.

Line 24 Add reference for pTRM checks (Coe, 1967, J. Geomag. Geoelec., 19, 157-179). - Added.

Page 689

Line 6 Remove the word “were” - Done.

Line 17 Add comma after “In total” - Done.

Line 22 Remove “higher” - Done.

Line 23 Sentence beginning “However, for the temperature intervals...” is awkward. Perhaps something like “However, for the temperature intervals used for paleointensity determination, the DRAT parameter (Selkin and Tauxe, 2000), which measures deviations in pTRM checks, is typically ≤ 5.1 , suggesting the data are reliable. - Changed.

Page 690

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Line 9 Change “magnetic” to “magnetically” - Done.

Line 18 Change colon to period. - Done.

Lines 18-22 Sentence beginning “After determining. . .” is long and awkward. Perhaps something like: “After determining the ATRM tensor, a paleointensity scaling factor, f_{ATRM} , is calculated based on the directions of the ancient field and the laboratory field.” - Changed.

Page 691

Line 7 Remove the words “also for them” - Removed.

Lines 8-10 Perhaps instead: “Vector subtraction of the TRM remaining at 390°C from each step in the anisotropy experiment should yield a reasonable measure of the ATRM tensor.” - Changed.

Line 21 Change “with-in” to “within” - Done.

Line 27 Remove “already” - Done.

Page 693 Lines 1, 2 “rock magnetic” is two words - Addressed.

Line 4 What are the “thermal repeat steps”? - Thermal demagnetization is repeated after imparting the pTRM. This is the so called tail check. We have tried to clarify this in the text.

Line 22-23 “. . .alteration connected to $T_b < T_g$. . .” Change to “. . .alteration at $T_b < T_g$. . .” Also, the claim that this alteration can be ruled out may be a bit of an overstatement , given that 16 of 24 samples altered during the ATRM experiments at $T < T_g$. - This was wrong in the manuscript and we are thankful that Julie made us look at this sentence again: We are talking about alteration connected to $T_g < T_b$ and not $T_b < T_g$ as originally in the manuscript. And in the case with $T_g < T_b$ the alteration is actually “connected to” and not just “at” $T_g < T_b$ as Julie suggested in her comment. We have tried to clarify this in the manuscript. Further, this kind of alteration due to $T_g < T_b$ can really be ruled

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out even if there is alteration at $T < T_g$.

Page 695

Line 2 Insert comma after “It is” - Done.

Line 6 “Rock magnetic” is two words - Done.

Line 9 “Mathematica” should be capitalized. - Done.

Figure 1 Where are these data from? Reference? - Data from Korte and Constable, 2005 and Genevey et al., 2008. These citations are now included both in the figure caption and in the text.

Figure 2 The inset map is very hard to see. Is it possible to make it a little bit larger? - Unfortunately, J. Gottsmann does not have separate files for the inset and the geological map. Therefore, the only possibility is to make the whole figure larger. We have done this in the revised version.

Figure 3 Scale? - Vertical thickness of obsidian is 90 cm. This has been added to the figure caption.

Figure 6 “Encircled is data. . .” Change to “Encircled (spelled correctly) data are from a single 5-m long flow ridge sampled in detail.” - Changed.

Interactive comment on Solid Earth Discuss., 3, 679, 2011.

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