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Comment on gchron-2021-19

Anonymous Referee #1

Referee comment on "Paleomagnetic secular variation for a 21,000-year sediment sequence from Cascade Lake, north-central Brooks Range, Arctic Alaska" by Douglas P. Steen et al., *Geochronology Discuss.*, <https://doi.org/10.5194/gchron-2021-19-RC1>, 2021

Review report for;

gchron-2021-19 "Paleomagnetic secular variation for a 21,000-year sediment sequence from Cascade Lake, north-central Brooks Range, Arctic Alaska" by Steen et al.

Summary

This article presents a new data set of paleomagnetic secular variation from lake sediment cores from Cascade Lake, an interesting place of Arctic region. The authors have obtained paleomagnetic data by progressive alternating-field demagnetizations of u-channel samples, and discussed magnetic carriers and grain sizes with non-thermal rock-magnetic experiments. The secular variation (SV) features of inclination from Cascade Lake relatively well correlate with those from Burial Lake, 200 km to the west, and partly with those from the global SV models (CALS10b.1b, pm9k.1b). The two data sets (Cascade Lake and Burial Lake) may contribute to construct a regional type SV curve by stacking, which is useful for local magnetochronology. However, the Cascade Lake paleomagnetic record has no reliable age model with the measured radiocarbon dates, possibly affected by old carbon. Therefore, the authors transferred the age model with ^{14}C dates less affected by old carbon of Burial Lake to the Cascade Lake record (PSV-1 age model) by wiggle matching of SV features between Cascade Lake and Burial Lake. The correlation of SV features between different sites/basins is more or less flexible, so that the correlation needs supports of reliable age constraints. In this paper, four tephra ages published in the companion paper by Davies et al. may play an important role for it.

One of the main conclusions of this paper is that the PSV-1 age model shows evidence for the old carbon effect on the Cascade Lake ^{14}C dates above a composite depth of 160 cm. However, the evidence is weak because the correlation is flexible, and the possibility of downward-shifted recording of paleomagnetic field by authigenic iron-sulfide ferrimagnets is remained. The authors developed a discussion assuming that the main magnetic carrier is magnetite. Hence, I cannot recommend accepting this paper in the present form for publication in *Geochronology*. But the SV data of Cascade Lake may be useful as supporting evidence for the companion paper by Davies et al., although additional magnetic experiments, e.g. progressive thermal demagnetizations of NRMs,

thermomagnetic analyses (Js-T), and/or FORC experiments, are necessary to estimate magnetic carriers/particle sizes.

Individual comments

(1) P. 4, lines 125-126

The authors calibrated the ^{14}C dates of this study using the IntCal 13 calibration curve (Reimer et al., 2013). Is the curve consistently used in the calibrations for other SV records in and around Alaska, and the global SV models (Figs. 9 and 11)? We have the IntCal20 calibration curve, now (Reimer et al., 2020).

(2) P. 6 to 7, "4.2 S-ratios and $k_{\text{ARM}}/k_{\text{IF}}$ "

The authors interpret as the increasing up-core trends of the S-ratio and $k_{\text{ARM}}/k_{\text{IF}}$ reflect the progressive addition of a separate fine-grained ferromagnetic component to the magnetic assemblage dominated by high-coercivity particles in the lower part. This interpretation would be correct. However, we should note that a similar up-core increasing trend lies in the organic material content (OM), while up-core decreasing trends are present in the magnetic susceptibility (k_{IF}) and IRM (Fig. 2). These trends must be discussed, together with the trends in the proxies of soft-component (S-ratio) and magnetic grain size ($k_{\text{ARM}}/k_{\text{IF}}$), which can be associated with the gradually increased anoxic environments that cause dissolution of fine magnetites, and formation of super-fine authigenic ferrimagnets, e.g., greigites.

(3) P.7, "4.3 Hysteresis, magnetic grain size and mineralogy"

The sediments contain a high coercivity mineral of hematite (or goethite), in addition to a low coercivity ferrimagnet (magnetite?). Further, the possibility of containing iron-sulfide ferrimagnets is still remained. Thus, the authors need to reconsider the interpretation of the domain states with the Day diagram, which is originally for titanomagnetite (Fig. 3B). FORC diagram may be suitable for a mixture of magnetic minerals to estimate domain state (Roberts et al., 2017, JGR, 123, 2618–2644).

(4) P.8, "4.4 Characteristic remanent magnetization"

The ChRM determined with a small MAD value is a strong point of this study. However, the orthogonal projections of demagnetization data seem to show that the magnetization vector does not decay toward the origin. Doesn't this result indicate the presence of a higher coercivity component except hematite/goethite? A PDRM component by detrital hematite/goethite particles should have a component with a similar direction with that of detrital magnetite particles.

(5) P.10, "4.5 Normalized remanence (relative paleointensity)"

The main magnetic carriers of Cascade Lake sediments comprise a high-coercivity mineral

(probably hematite) and a low-coercivity mineral (possibly magnetite/greigite). I consider the $\text{NRM}_{20-70\text{mT}}/\text{ARM}_{20-70\text{mT}}$ and $\text{NRM}_{20-70\text{mT}}/\text{IRM}_{20-70\text{mT}}$ are better RPI proxies, because they are less affected by high-coercivity components. Unfortunately, no curves of normalizers $\text{ARM}_{20-70\text{mT}}$ and $\text{IRM}_{20-70\text{mT}}$ are shown in Fig. 7, so that we cannot evaluate the correlation between the RPI and normalizers ("R" is not helpful). The k_{LF} , $\text{ARM}_{45\text{mT}}$, and $\text{IRM}_{45\text{mT}}$ in Fig. 7 include both mineral components, and in addition the contributions of high-coercivity particles increased in the $\text{ARM}_{45\text{mT}}$ and $\text{IRM}_{45\text{mT}}$, compared with those before AFD.

(6) P. 13, "5.1 Magnetic assemblage"

The authors indicate that the fine grained and low-coercivity ferromagnetic component is carried by (titano)magnetite. As mentioned in (2), greigite is also a candidate. Authigenic greigite particles are fine, with coercivity ranges similar to magnetite. Therefore, it is difficult to separate the components of magnetite and greigite by AF demagnetization. To reject the possibility of the presence of greigite, the authors should show evidence with thermal experiments, e.g. progressive thermal demagnetizations of NRMs, thermomagnetic analysis (Js-T), and so on.

(7) P. 13, line 330

I do not agree the reason of the linear depth-age relation over the past 17 ka for the Burial Lake 14C age model's being more realistic than the Cascade Lake 14C age model.

(8) P. 15, Figure 9

The correlation of inclination features between Cascade Lake and Burial Lake seems to be generally good (Fig. 9). But I do not agree with the correlation with the global SV models. Many tie-points between I3 and I8 are flexible. For example, the oldest part of the pfm9k.1b Inc-GAD may not reach the inclination feature I7 of the Burial Lake inc-GAD, and the I6-I8 of the pfm9k.1b may correlate in phase to around I4 of the Burial Lake. The correlations in Fig. 9 are not robust, and thus the authors must be careful with using the tie-point ages for age models and others.

(9) P. 16, "5.3 Age model discrepancy"

For the age model discrepancy, the authors discussed two possible causes; the old carbon of aquatic organic materials and the lock-in depth of PDRM. If the authors do not show evidence for the absence of authigenic greigite, readers would concern the effect of it. Large downward shifts of paleomagnetic signals in the record carried by greigites are likely (e.g., Robert et al. (2005) GRL).

The authors mention that four tephra ages published in the companion paper by Davies et al. provide strong evidence for the discrepancy. If they clearly show the discrepancy without help of PSV data, the authors can construct a new age model with selected measured ^{14}C dates and the tephra ages for the Cascade Lake SV curve. In this case, they should not mention the old carbon effect in the conclusion. In place, they would have a merit of making a type SV curve in Alaska by stacking the Cascade Lake and Burial Lake SV data, both of which have independent age models.

(10) P. 17, lines 414-415

The authors mention that high-amplitude inclination shifts at this time are contemporaneous with low relative paleointensity estimates (Fig. 11). However, the relative paleointensity curve plotted in Fig. 11 is after 15.3 ka, which does not show paleointensity values around 17 ka. Readers may want to see the global VADM values plotted until about 20 ka.

(11) P. 17, lines 434-435

“Magnetic grain-size estimation (Fig. 3 and 4) suggests fine PSD magnetites”

As mentioned in (3), we cannot estimate grain sizes (domain states) with a Day plot of magnetic mineral assemblages of low-coercivity ferrimagnets and hematites, which are suggested by the relatively small S-ratio values ranging from 0.5 to 0.88 throughout the sequence.