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Comment on cp-2021-111

Leonid Polyak (Referee)

Referee comment on "Heavy mineral assemblages of the De Long Trough and southern Lomonosov Ridge glacial deposits: implications for the East Siberian Ice Sheet extent" by Raisa Alatarvas et al., *Clim. Past Discuss.*, <https://doi.org/10.5194/cp-2021-111-RC2>, 2021

Major comments

The paper reports a provenance study of the Late Quaternary sediments from the East Siberian margin and adjacent part of the Lomonosov Ridge (LR) based on heavy minerals. This method is time consuming, and thus used more rarely than the XRD or isotope provenance approaches. As such, it can potentially contribute insight into the depositional history at the Arctic margins, especially in the context of poorly understood Siberian glaciations.

The data include 17 sediment-core samples from the East Siberian Sea (ESS) shelf, slope (De Long Trough (DLT)), and the adjacent part of the Lomonosov Ridge (LR). Half of the samples represent glacial deposits (diamictos) from the DLT and LR. Unfortunately, a relatively uneven sample distribution limits potential provenance inferences from this data set. In particular a lack of samples from the LR core above the MIS6 diamicton doesn't allow for a comparison with interglacial/deglacial environments and with the ESS cores, which represent different geographic, depositional, and possibly stratigraphic settings. Also, the ESS shelf record is poorly represented by just two samples from the last deglaciation.

In addition to the new data, the paper provides a compilation of potential source rocks, which is useful both for this and future provenance studies in the region. It would be more logical, however, to present this information in the Study Area section rather than in the Discussion.

Results of the mineralogical study are reported with considerable detail and appear to be robust (I'm not a specialist to evaluate them more thoroughly). However, the takeaway from these data is somewhat disappointing. The discussion is not well structured and can

be difficult to follow, especially without a graphic summary. The point of section 5.2 is unclear as it does not really add much insight into glacial-interglacial transition, the more so "transitions" (I see only one). The discussion to follow (section 5.3) is even more confusing as the interpretation of the new data is mixed with inferences from or attributed to prior studies, lumped together in one paragraph. At the same time, depositional environments and processes are not adequately explained. The text has repeated questionable statements like "During glaciations sediments at the East Siberian shelf and slope were fed by grounded ice ... from the eastern hinterland region" (p. 13, lines 12-13) and "It is suggested that there was an extensive ice sheet in the northeastern Siberia particularly during MIS 6 ... and further supported by this study" (p. 13, lines 37-39). These statements are not based on the actually reported data, but primarily on not very accurate references to prior publications. The modeling experiments (Colleoni et al., 2016; Wekerle et al., 2016) indeed inferred an ice sheet in northeastern Siberia, but its existence has not been verified by geological data - neither from land, nor from the shelf. On the contrary, the cited work on the New Siberian Islands (Nikolskiy et al., 2017) indicates ice sheet advance only from the northern ESS shelf, not from the mainland.

Authors infer that sediments were initially delivered to the shelf by rivers and then transported to the slope and adjacent basins by various processes, including glacial during glacial periods. The story is probably more complex as sediment input from coastal erosion enhanced by permafrost degradation may be comparable to rivers, but overall the two-step deposition is consistent with our knowledge of modern processes at the Arctic margins. However, in this situation, identifying the ice-sheet provenance from the data under study is problematic as sediment delivered by ice directly from the mainland may not be easily distinguishable from sediment redeposited from the shelf. This task is even more complicated by multiple mechanisms of glacial sedimentation, such as subglacial till, proglacial debris flows, icebergs, etc. As these processes are not identified or even discussed in the paper, I don't see how the authors can reconstruct the ice origin.

The inference on different sources for glacial sediments in cores from the DLT and LR is more convincing and informative. However, it raises questions too. Most important, the SW provenance of the MIS6 diamicton in the LR core is inconsistent with the direction of the eroding ice flow indicated by the seafloor bedforms (Jakobsson et al., 2016). One possibility is that the erosional event is not reflected in the sedimentary record (hiatus), while the diamicton was deposited from icebergs. In any case, this issue needs to be discussed. Further, it is not clear whether the diamicton recovered in the DLT is correlative to the MIS6 diamicton on the LR. Chances are the DLT diamicton is younger, and thus represents the provenance of a different glaciation.

References are limited. Only studies of heavy minerals are used for discussing the ESS sediments, while papers dealing with other mineralogical aspects could provide a more comprehensive context (e.g., Washner et al., 1999; Viscosi-Shirley et al., 2003; Nwaodua et al., 2014; Ye et al., 2020). Relevant studies of the distribution and composition of glacial deposits at or adjacent to the ESS margin are also missing (e.g., Schreck et al., 2018; Joe et al., 2020; Ye et al., 2020). A broader Arctic Ocean context can be derived from recent provenance papers (e.g., Dong et al., 2020; Xiao et al., 2021).

Some additional comments

Abstract

- This study concentrates on defining the mineralogical signature and dynamics of the ESIS (p. 1, lines 16-17).

This statement is misleading. The study deals with mineralogical signature of sediments from the ESS margin. Whether it reflects the ESIS provenance is a matter of interpretation, even more so for the ice-sheet dynamics.

Introduction

- "... previous studies have suggested the existence of ice sheets over parts of the East Siberian continental shelf during the larger Pleistocene glaciations following the mid-Pleistocene transition (Colleoni et al., 2016; Niessen et al., 2013), the Saalian (Marine Isotope Stage 6) (Jakobsson et al., 2016)" (p. 2, lines 2-4).

This statement is inaccurate and confusing. Are we talking about multiple glaciations or just the MIS6? And where does the MPT come from? While there is evidence for a very large impact of the MIS6 glaciation on the Arctic, we do not know whether it featured the largest ice sheet on the East Siberian margin. Niessen et al. (2013) demonstrated glacial seafloor features in this region but have not constrained their age. Later studies suggested a very extensive glacial footprint in at least some parts of the East Siberian and Chukchi margin for MIS4 (Schreck et al., 2018; Joe et al., 2020; Kim et al., 2021).

Materials and Methods

- What is the point for a detailed description of seismostratigraphy? These data are not used in the paper.

Discussion

- What are "our mineral assemblages" (p. 13, line 19)? Please be specific.

- What is "the eastern sector of the East Siberian Ice Sheet" (p. 13, line 27)? So far, the extent and configuration of this, largely hypothetical ice sheet is very poorly understood. What can be inferred from the data is that the mineralogical signature indicates delivery from the eastern part of the ESS.

Conclusions

- "This suggests that due to dynamics of the ice flow and deposition the glacial ice not only grew out from the East Siberian shelf but also from the New Siberian Islands and westerly sources" (p. 14, lines 10-11).

How could the ice sheet grow from the new Siberian Islands, if it was advancing on the islands from the north (Nikolskiy et al., 2013)? And what are the "westerly sources"?

Terminology

- I don't think the "Central plateau" is a good term for the study area as the entire East Siberian shelf is pretty flat. This term has been used indeed by Naugler et al., 1974, but it

doesn't make much geomorphic or geological sense. More generic terms like "inner shelf" or just "shelf" would be more appropriate.

Recommendations

Overall, I believe the MS requires a considerable revision. Ideally would be to investigate a few more samples to fill the gaps in the sedimentary record under study, notably from post-MIS6 sediments in the LR core and from the Holocene on the ESS shelf. However, I understand the practical constraints. The text, especially the Discussion, needs to be better articulated, with a clear delineation of inferences from the data reported and a more comprehensive and to the point use of information from prior studies. A summary figure would be very helpful for following and comprehending the interpretation. The conclusions, abstract, and the title need to be coherent with the data-based interpretation. An accurate title would be something like "Heavy mineral provenance of glacial deposits at the East Siberian margin, Arctic Ocean".