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The Cryosphere Discussions

Interactive comment on "A quasi-annual record of time-transgressive esker formation: implications for ice sheet reconstruction and subglacial hydrology" *by* Stephen J. Livingstone et al.

Anonymous Referee #2

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General comments:

The paper by Livingstone et al. titled "A quasi-annual record of time-transgressive esker formation: implications for ice sheet reconstruction and subglacial hydrology" is presented in high quality concerning both the text and figures. The study uses new methods (ArcticDEM) to map and analyse a large number of esker segments over a wide area in central Nunavut, Canada, to discuss esker formation and the implications for reconstructing subglacial drainage. The paper is within the scope of, and well suited for, The Cryosphere. The authors present interesting new results on the morphometric properties of the eskers and their relationship with de Geer moraines. Theses finds

have the potential to have important implications and significance for reconstructions of subglacial drainage and sediment transfer of ice sheets. However, I do have some major concerns, both concerning the originality and the quality, of the interpretations of, and suggested models of formation for, esker beads and de Geer moraines which I would like to see addressed before I can recommend this manuscript for publication. My concerns and comments are specified below.

Specific comments:

Originality of the proposed model of esker formation:

One of the main finds put forward in this manuscript is the identification of annual esker "beads". The authors do mention that esker beads being annual has been proposed in earlier studies but argue that their data "provides a more robust demonstration" (p. 15, line 304), a statement I strongly disagree with. The annual nature of such eskers beads were exemplified over 100 years ago based on many years extensive mapping and detailed sedimentological and stratigraphic work in Sweden, where such "beads" were correlated to annual ("de Geer") moraines and even individual glacial varves (see: de Geer 1897; 1905; 1910; 1940). The early works are published in Swedish (de Geer 1897; 1905) and German (de Geer 1910), but nonetheless they are well cited and by no means "hidden" in the litterature. There are also a more recent English translation of de Geer (1910) by Dullo & Hay (2002), and the works by de Geer is also summarized in English in de Geer (1940), which is actually cited in this manuscript. As a matter of fact in Sweden, and also in some Canadian work (e.g. Allard, 1974), this type of eskers (with annual "beads") are referred to as De Geer type - eskers. The results presented in this manuscript are still new, interesting and important data from a remote and not so well studied area, but it is not more robustly or convincingly demonstrated in this manuscript that these beads are annual when compared to previous studies. If you disagree, please provide an explanation of why your data provides a more robust demonstration. I recommend adding some of the key references relating to the early pioneering works on beaded esker formation, i.e. de Geer (1897; 1910), and include a

discussion how these relate to your findings. We should not let the hard and impressive work of our old heroes to fall into oblivion and take credit for “reinventing the wheel”!

Esker bead- and De Geer moraine formation model:

In this manuscript, the annual nature of the esker beads are based on their relation to, assumed, annually formed de Geer moraines (similar to de Geer, 1910). De Geer moraines are assumed to be annually formed following the original hypothesis of them being formed during winter advances/standstill of the ice margin during overall retreat (de Geer, 1889), so far, so good. However, in this manuscript the authors then argue that, based on the relation between esker beads and moraines, the moraines are formed during summer melt seasons by deformation and squeezing of saturated till to the ice margin and refer to the process described by Price (1970). Price (1970) is, however, a study of a terrestrial ice margin on Iceland, so say that this process did produce the moraines, why do we not see De geer moraines above the marine limit (line 170)? and how can one still explain that they still are formed annually? How can you explain the gap between the moraines? What is there that speaks against the moraines simply being formed during winter advances that reaches the esker bead from the previous year, by the same process you describe on line 226-228? Or, that esker beads start to form prior to the onset of summer retreat from the moraines? Ice marginal advance/retreat is not necessarily in phase with the start/end of melt season as observed at present day ice margins (e.g. Schild & Hamilton 2013).

Further comments (line number, followed by comment):

18, give calibrated ages and be consistent with the use of either “yr” or “a” (kyr/ka), here you use “yr” but further down in the manuscript you suddenly use “ka” change throughout the manuscript.

19, choose either kyr or ka

22, choose kyr or ka

41, here I miss a reference to the pioneering work by de Geer (1897). De Geer (1910) and/or de Geer (1940) would also suffice.

85 (Figure 1), use either ka or kyr in the figure.

139, how do you distinguish “till blankets”? From ArcticDEM or aerials? Geological maps? please specify.

Figures 3-4, Beautiful figures!

184-185, as also mentioned above on line 41, here I miss a reference to the work by de Geer concerning “hypothesis 1”.

Figure 5, See my comments on the proposed model for esker bead and de Geer moraine formation above.

228-229, This view of these smaller interannual moraines proposed by Möller (1962) is not a generally accepted view. Please rephrase this sentence with e.g.: “proposed” or “suggested by Möller (1962).

251-264, See my comments on the proposed model for esker bead and de Geer moraine formation above.

273-275, This sentence reads like you are the first to come to this conclusion, please add a reference to e.g. de Geer (either 1910 or 1940), who suggested and showed that this was the case.

277 & 281, use either “yr” or “a”

304, see my comments above concerning if your results are more robust.

309-310, use either “yr” or “a”

329, “Identification” is a strong word. You have not proven that the beads are annual, you can however suggest that they are based on the assumption that the de Geer moraines are annual. Please rephrase.

368 & 370, use either “yr” or “a”

Figure 9, Please add north arrow to the maps.

409-412, See my comments on the proposed model for esker bead and de Geer moraine formation above.

420, To say that the beads “records a high-resolution (annual) record” is to strong. You infer them to be annual but have yet to prove that they are. Please rephrase.

422-423, use either “yr” or “a”

433, again, how do you know the thickness (and presence) of a till blanket?

References: Allard, M. (1974). Géomorphologie des eskers abitibiens. Cahiers de Géographie Du Québec, 18(44), 271–296. https://doi.org/10.7202/021195ar

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