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Earth System Science Data Discussions



# *Interactive comment on* "Supraglacial dust and debris: geochemical compositions from glaciers in Svalbard, southern Norway, Nepal and New Zealand" *by* K. A. Casey

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This paper presents supraglacial snow and ice chemistry data from four glaciers in different Alpine settings. The dataset is valuable for a number of reasons and worthy of publication in ESSD. For instance, for me as a glacial hydrochemist there is a need for supraglacial snow and ice chemistry data to interpret the chemical signal in glacial bulk meltwater. The documentation, presentation and focus could be improved at places, and I have a few suggestions that might be helpful to the author. Overall, I enjoyed reading the paper and found the dataset interesting.

Specific comments:

1. Page 109, lines 6-13: This part of the Introduction is a bit unclear. I suggest that you rewrite and expand this section to give the reader a more thorough introduction to the topic. First, it should be emphasized that the focus here is the glacier surface, not the 'glacier geochemical composition' in all ice facies (e.g., basal debris-rich ice is likely to have a different composition than supraglacial ice). It will also be appropriate to give a short overview of supraglacial snow-ice dynamics, such as the firnification process, preferential ion leaching from the snowpack and formation of superimposed ice. Then, an explanation of supraglacial dust and debris entrainment processes would be informative. In particular, it would be relevant to mention mass movement processes such as avalanches and rock-falls and glacial processes such as medial moraine appearance, marginal debris transport along shear planes (thrusting) and the potential role of ice crystallography in trapping wind-blown dust particles (see references in Goodsell et al., 2002, page 288). I guess this organization will make it easier for the reader to follow the discussions of geochemistry in the Background section and of dust and debris provenance in the remaining part of the paper.

2. Page 113, lines 10-24: More documentation on sample collection is needed. Were the snow samples collected at surface or at intervals in a snow pit profile? Was it fresh snow or an old surface? What about ice lenses? Were the ice samples collected at the glacier surface or was the top layer removed before sample collection? Were the ice samples snow-derived or formed by refrozen meltwater (superimposed ice; basal ice)? Did the samples contain visible cryoconite?

3. Page 115, lines 10-16: A significant limitation of this dataset is the lack of Cl measurements in determining the importance of sea-salt derived solutes. In Svalbard the snow chemistry composition in five pits on nearby Longyearbreen showed that sea-salt deposition was the most important process, but dust deposition was detected due to relatively high Ca and SO4 concentrations (Yde et al., 2008). At Grønfjordbreen the basal ice contains a high Cl concentration, supporting the hypothesis of a significant input of sea-salt deposits (Yde et al., 2012). Both at Longyearbreen and Grønfjordbreen



ESSDD
5, C8–C11, 2012





the SO4 concentrations in glacier meltwater are very high compared to global standards, indicating that S is derived from a reactive source, which most likely is the local S-rich coal (Yde et al., 2008, 2012). Also, at both Grønfjordbreen and Aldegondabreen cryogenic calcite precipitates are formed in the proglacial and subglacial environments (Yde et al., 2012), and it could be interesting to examine whether a similar process occurs in the supraglacial environment.

Minor comments:

4. P. 108, l. 19-20: This reference to data access should also be given in the main text (e.g., at the beginning of section 4).

5. P. 109, l. 11-13: The influence of anthropogenic processes is often related to elements such as C and N.

6. P. 111, l. 17: Grønfjordbreen and Aldegondabreen are valley glaciers, not cirque glaciers.

7. P. 111, l. 24: Insert a sentence on the local geology (see references in Yde et al., 2012).

8. P. 112, l. 6: Insert a sentence on the local geology (see Matthews et al., 1979).

9. P. 115, l. 8-14: Explain in more detail how these seasonal patterns are demonstrated. Could you make a figure that visualizes seasonal changes in composition?

10. P. 116, l. 6-7: Why do Al and Ti suggest sublimation and leaching?

11. P. 118, l. 15: Why was Ti chosen as the reference element?

12. P. 121, l. 1-16: This part on total elemental abundance is significantly hampered by the lack of determinations of important elements such as C, N and Cl. I suggest that section 5.5 is deleted.

13. P. 121, l. 17-P. 122, l. 8: The section on air trajectories is superfluous and does not



ESSDD
5, C8–C11, 2012





lead anywhere. I recommend that section 5.6 and Fig. 6 are deleted.

14. P. 124, l. 17-20: Delete these two superfluous sentences.

15. Table 1. This table should only show the physical characteristics. Therefore, delete all notes on influences in column 2.

16. Figure 2. Delete the superfluous pictures.

References (sorry for the self-citations here but I think they are most appropriate):

Goodsell, B., Hambrey, M.J. and Glasser, N.F. 2002. Formation of band ogives and associated structures at Bas Glacier d'Arolla, Valais, Switzerland. Journal of Glaciology, 48(161), 287-300.

Matthews, J.A, Cornish, R. and Shakesby, R.A. 1979. Saw-tooth moraines in front of Bødalsbreen, southern Norway. Journal of Glaciology, 22(88).

Yde, J.C., Riger-Kusk, M., Christiansen, H.H., Knudsen, N.T. and Humlum, O. 2008. Hydrochemical characteristics of bulk meltwater from an entire ablation season, Longyearbreen, Svalbard. Journal of Glaciology, 54(185), 259-272.

Yde, J.C., Hodson, A.J., Solovjanova, I., Steffensen, J.P., Nørnberg, P., Heinemeier, J. and Olsen, J. 2012. Chemical and isotopic characteristics of a glacier-derived naled in front of Austre Grønfjordbreen, Svalbard. Polar Research, 31, 17628, doi:10.3402/polar.v31i0.17628.

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