The Cryosphere Discussions

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Comment on tc-2021-190

Anonymous Referee #1

Referee comment on "Microstructure, Micro-inclusions and Mineralogy along the EGRIP ice core – Part 2: Implications for paleo-mineralogy" by Nicolas Stoll et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-190-RC1, 2021

It was my pleasure to review “Microstructure, Micro-inclusions and Mineralogy along the EGRIP ice core - Part 2: Implications for paleo-mineralogy”. This paper presents a novel dataset of impurities in a Greenland ice core. The data is interesting, and the methods properly presented. However, the introduction and discussion could be considerably improved.

The introduction brings in a great deal of previous research but doesn’t make clear points about the knowledge gap that the paper is addressing. Nor does it state any hypotheses or provide much theoretical framework on which hypotheses could be made. The importance of impurities is brought up and the word important is used repeatedly. But nowhere is the link made between this particular research effort and its applications to ice mechanics, etc. Neither is the later discussions of chemistry and mineralogy at all prefigured in the introduction.

Without any research questions initially laid out, the discussion wallows in vague competing hypotheses without definitively defending any point of view. A great deal of the text is dedicated to hypothetical future research, methodological shortcomings, and irrelevant statements about the general state of the science. The text lacks depth of analysis in chemistry or mineralogy. Particularly, the authors need to defend a theory of how the minerals they analysed formed. The questions of whether the sulfate and nitrate minerals are atmospherically formed or formed in ice and snow is not even properly raised, much less resolved. The composition of dissolved ions should be known from the continuous flow analysis, but it isn’t included. The text also needs to say more about the rare minerals. How confident are the authors that they really found jacobsite, pyromorphite, kröhnkite, etc.? These are not common minerals, so this could be misidentification of the spectral patterns. If the authors are confident, then some sort of discussion is needed about whether these are detrital (i.e. you got lucky and found a rare mineral in dust) or authigenic, representing some sort of chemical pathway found specially in the ice core.

In short this is a study in search of a research question. If the authors think they have answered a scientific question, they need to state the question and state the answer. If they don’t think they’ve learned anything from their work, they should fold this data into part one.

I have some more line by line comments below:

Line 3: "Poorly understood" is a catch-all phrase. Can you be more specific about the gap in knowledge you are trying to address?

Line 3: Should "Continuous Flow Analysis" be capitalised?

Line 19: This sentence needs to be revised – the double usage of "chemical compounds" is awkward and confusing.

Line 20: "Also"? Is this different from their "atmospheric, marine, terrestrial or biological origin"?

Line 22: Peroxide needs a citation.

Line 22: This sentence is fairly tautological.

Line 26: Ferrosilite, wollastonite, and troilite are not decteted components of the dust!

Line 27: Are salts a subject of this study or not? In the previous sentence, you said it was mainly mineral dust.

Line 29: The text about the ice lattice needs to be moved upward to where you previously discuss the ice lattice.

Line 31: Separate the tephra and the sulfate into different sentences.

Line 34: You already said this.

Line 37: What is CFA? (acronym used without definition)

Line 43: What do you mean by mechanical properties?

Line 44: Is this another area or a consequence of the control of impurities on mechanical properties?

Line 53: Say something more. Important for what?

Lines 68-72: Maybe rewrite this to be less negative about previous work.

Line 80: What companion study? Where is the citation?

Line 91: Unique is a dangerous word to use.

Lines 144-152: This should probably have some citations.

Lines 165-176: I would move this paragraph upwards. Some of the prior details about which peaks were distinguishable etc. could be moved to results.

Line 195: Can these impurity maps be made available in a supplemental file?

Line 203: Why not include all 26 species? It's not like 26 lines is too long for a table.

Figure 4: The color scheme for this figure is strange. I would cluster the minerals by type rather than alphabetically. The color coding needs to relate to how you discuss minerals later in the text. I.e. all minerals that you presume to source from dust need to be

clumped together and similarly colored. Sulfates and nitrates and black carbon should each be their own unique colors that cannot be confused with other minerals. Similar minerals should be next to each other with similar colors. I.e. rutile and anatase, "mica" and prehnite, etc.

Also, why is graph a normalised to 100% but graph b presents absolute values.

Also, might it be possible to have time on the top axis to counter depth on the bottom axis? And, I think two decimal points for depth is excessive.

Table 2: Please clarify why some species are identified by mineral name and others aren't. Is it unclear which magnesium sulfate mineral is present, for instance?

Line 209 (and elsewhere): Terms like carbonate and sulfate can be confusing when applied in the fashion. It's probably better to say "the carbonate mineral …". Though in this case, everyone should know that dolomite is a carbonate mineral, as you've included the chemical formula.

Line 210 (and elsewhere): The "might be" has me a little worried. Maybe in table 2 you can add a column for alternate possibilities for the species where identification is in doubt. Or maybe create a supplemental file that lays out the alternative possibilities.

Line 267: In what sense is this data accompanying?

Line 321: This is confusing to me. How is going from sulfates and dust to dust and sulfates (i.e. gypsum) a meaningful shift?

Line 325: What does it mean to expose mineral diversity in detail?

Line 326: You already said this in the previous paragraph.

Line 330: This makes no sense in terms of charge balance and stoichiometry. Sulfate can't just blow in without any kind of attached cation. It could be deposited as acidic aerosols of sulfuric acid (i.e. either H_2SO_4 or SO_3) and then gain its cations from other sources. Or it is deposited as a sulfate-bearing compound (gypsum, etc.). You need to explain the full chemical sequence of events that you are proposing. If it was acidic and then exchanged with chloride salts and precipitated, you would be left with a highly acidic chloride rich brine (i.e. HCl), probably in the grain boundaries of the ice crystals. If you really think that there is HCl in ice cores, by all means defend that point.

Line 334: Is data scarce? This paper certainly made it less scarce.

Line 345: A closer investigation? Were they investigated at all?

Section 4.2.2: This might benefit by some sort of figure where you plot your data against that of Sakurai et al.

Line 349: Awkward writing.

359: Didn't you intentionally select dust rich sections? Did Sakurai et al. do the same? If not, there's your explanation.

374: I think you actually have a good number of observations. I don't think this section needs to be as self-critical.

Line 380: What about XRD? That's usually quite a reliable way to do mineralogy.

Line 385: I don’t understand the methodological explanation.

Line 388: Iizuka et al. say that the sulfatisation is proportional the dust flux, which makes sense because it gives the atmospheric sulfuric acid something to react with.

Line 394: Why would dry deposited sulfates have such diverse mineralogy? Where are the sulfates coming from? The question isn’t really explained or addressed.

Line 398: There’s quite a lot of reference to future work here. I would rather have you focus on what you can infer from this work.

Line 404: What do Fe minerals have to do with anything? I don’t follow the logic of this paragraph. I.e. are you claiming that Fe is a sign of authigenic mineral formation? If so, which minerals, which reaction pathways?

Line 418: Typography

Line 431: What is the point of this whole paragraph if you only conclude that this unlikely to be relevant and untested?

Line 435: What do you mean it is unlikely? Either it is observed, or it isn’t. This constant reference to non-existent studies is really grating.

Section 4.5: This entire section is pointless. There are no research questions addressed here.