Replies to reviewers:

Reviewer #2

Rev2: The authors present a new perspective of possible post-depositional processes that affect mineral dust records, particularly below 1000 m depth in the 1620 m long TALDICE ice core. The datasets are of high quality and obtained using Coulter counter and spectroscopic measurements such as Synchrotron radiation, X-ray fluorescence and XANES. Crucial properties of dust such as the concentration, grain-size, their elemental composition with a focus on Fe-mineralogy are discussed in depth. The study shows englacial formation of specific minerals in deep ice affecting the original scenario of dust deposition and conclude highlighting potential impacts while interpreting dust records on deep ice cores. While the originality, scientific quality and significance of the work is excellent, the manuscript falls short on language with several grammatical errors which needs language editing. I recommend this manuscript, after necessary language editing, for publication in the journal's special issue: Oldest ice: finding and interpreting climate proxies in ice older than 700000 years.

Reply: thank you very much for this positive comment and for your suggestions which will improve the quality of our manuscript

Rev2: I do not mention any corrections regarding language as the manuscript needs thorough language editing. Following are some specific comments.

Reply: in the new version of the manuscript an accurate revision of language and grammar will be carried out.

Rev2: Line 35: The authors mention the role of depth and pressure in the post-depositional processes that has not been previously addressed - however this aspect of depth and pressure altering dust records aren't discussed in the results and discussion. I suggest to modify or delete this sentence.

Reply: agreed

Rev2: Line 38: replace ine with ice.

Reply: corrected

Rev2: Section 2: Though co-ordinates are provided, I suggest a location map especially with surrounding dust sources would be useful for many.

Reply: we have updated Fig.1 adding a small and simple map to show the position of Talos Dome in Antarctica. We didn't add information about local dust sources, this topic is extensively discussed in some of the references cited in the text (Delmonte et al., 2010; Baccolo et al., 2018).

Rev2: Sample Preparation: I have some queries on technical aspects of sample preparation. You mention that the preparation took place in the ISO6 clean room - were the ice sections decontaminated under the laminar flow bench or in the clean room? At what temperature did this process take place? Also, considering the 2 cm thin ice sections used in this analysis, how thin was the ice after 3 baths decontamination? do you decontaminate the ice sections using ice cold ultra-pure water bath to avoid melting the sections that are already 2 cm thin?

Reply: the preparation took place inside the clean room (ISO6), in particular the decontamination was carried out on a table available in the room, but not directly under the bench. Once decontaminated, samples were placed under the laminal flow of the ISO5 bench. The procedure took place at ambient air temperature, which inside the room is set constant at 18°. About the ultra-pure water baths: each bath takes about 20 seconds. From our experience this is a good compromise which allows to have a sufficiently large sample with a sufficient removal of the outer ice layers. At the end of the three baths the ice strips looses about half of their mass and thickness goes from 2 cm to a little bit more than 1 cm. During the procedure ice is always handled with pre-cleaned plastic forceps.

Rev2: I understand that you analysed 191 coulter counter samples and 54 filtered samples for spectroscopy. If not, you might have to clarify it in the sample preparation section.

Reply: yes, the reviewer is right

Rev2: line 78: remove extra ”in”.

Reply: done

Rev2: Line 93: According to this paragraph, there are 55 samples, while you mention 54 in Lines 78 and 87. Your dataset in the supplement seems to have 54 samples.

Reply: thanks for highlighting this mistake. The samples are actually 54, we made a mistake saying that we prepared 3 sample from MIS4, they are actually 2.

Rev2: Line 144: CLPP (coarse local particle percentage).

Reply: corrected.

Rev2: Lines 197–201: This paper focuses on many possible reactions of Fe-minerals happening in deep ice. The authors do mention about carbonate dissolution in deepest samples backed with well-known ice core studies. However, there is also a possibility that such post-deposition processes alter dust chemistry immediately after the snow deposition as shown from the surface snow cores by Mahalinganathan and Thamban (2016) that has not been observed in the holocene / interglacials of deep ice cores. Do you think the carbon dissolution and Fe-mineral reactions which are apparent in deep sections of TALDICE may be happening constantly from the time after snow deposition (instead of happening at a deeper section, (unless it is depth-pressure based), but are missed due to lesser spatial study?

Reply: thanks, I didn’t know that paper, it was an interesting reading. We are quite sure that dust deposited in Antarctica, especially if transported from extra-Antarctic sources, has already undergone to reactions and changes during the atmospheric transport. A partial dissolution of carbonates during transport is likely, in particular during glacials. However, the processes that we are describing in the Talos Dome ice core has very clear trends which involve the ice below a certain threshold. From our evidence it is evident that the precipitation of jarosite is not favored in the first 1000 m of the core. At the same time, we note that Fe-oxidation (Fig. 1c) starts at about 500 m deep, as also the depletion of Ca and Mg in mineral particles (see

Fig. S4). This means that Fe reaction and the precipitation of secondary minerals are possible only below a threshold. It remains to be understood if the threshold is related to pressure, temperature, time, ice re-crystallization or probably to a combination of these processes.

Rev2: Figure 1: ngdustg−1 ice of dust concentration in figure. The caption misses mentioning MIS 7.5 and 9.5 for red bands.

Reply: corrected.

Rev2: Figure 3: Reference is not linked.

Reply: we have now added the missing reference

Rev2: Figure 6: Choose contrasting colors for panels c, d and e.

Reply: we have updated the figure accordingly

Rev2: Table 2: SD for MIS-6 column is missing

Reply: this is because only one sample corresponds to this climatic stage and we couldn't determine SD

Thank you very much for your careful reading and for your constructive suggestions

Best regards,

Giovanni Baccolo and the coauthors