The Cryosphere Discuss.,
doi:10.5194/tc-2016-155-RC1, 2016

Interactive comment on "Surface formation, preservation, and history of low-porosity crusts at the WAIS Divide site, West Antarctica" *by* John M. Fegyveresi et al.

M. Schneebeli (Referee)

schneebeli@slf.ch

Received and published: 29 July 2016

The paper by Fegyveresi et al presents glaciological and meteorological observations concerning the formation of a thin crust at the snow surface around the WAIS drill site. The existence of this glazed crust has been described for several decades, but detailed information about the formation is lacking. This paper contributes to the understanding of the formation of these specific layers.

The methodology to investigate the formation of these layers is rather old-fashioned, and is not taking into account developments in snow characterization. The paper is in most aspects descriptive, with little quantitative information especially about the microstructure of the snow.

The paper describes in much detail the observations, but little quantitative data analysis and no modelling at all. The authors formulate extensively a general hypothesis on the formation of these layers, but do not substantiate their claims. The recent developments in snow metamorphism are not considered, and essential aspects in the interpretation are missing, especially concerning the radiation balance and the thermal conditions of the snowpack in the topmost layers of the snowpack.

I suggest the following revisions: - The short and longwave radiation balance should be calculated and used in the interpretation of the formation of the crusts. - Ideally, the weather data should to model the thermal conditions of the snowpack in the top 30 cm, this should not be a major difficulty (there are several snowpack models easily available, as Crocus and SNOWPACK). - A statistical analysis of the processes is needed, it does not become clear in the paper if the same weather conditions occur without formation of a glazed surface. - The hypotheses concerning the formation should be reformulated and quantified based on the results above

Based on the old-fashioned methods, several questions will probable remain open concerning the microstructural properties of the snow. It is a pity that now snow samples were cast using Diethyl-phthalte, this technique was already used in 1957 in Antarctica.

A general comment is also that the authors seem not to be aware of the difference between the terms "diagenesis" and "metamorphism". Diagenesis describes the densification by internal compaction or by a foreign sintering material. Metamorphism describes the recrystallization of minerals. Diagenetic processes in snow and firn occur in Antarctica below the isothermal zone (i.e. a few meters depth). Above, the dominant process is metamorphism.

Specific remarks: l 38 According to instruments, these are radiation sensors, not insulation sensors

l 40 There is no detailed data later in the manuscript about the crack spacing, so delete in abstract l 42 If this theory is correct, then a very strong convective vapor transport would be necessary, and calculations (see e.g. Ebner et al, Calonne et al.)

l 48 Was this layering also found in the snowpit?

l 54 Are there any measurements done on the spatial extent of these layers (e.g. in the snowpit)?

l 110 The radiation instruments are described here in detail, but the data not used, why? These data are essential for the interpretation of crust formation. Especially snow surface temperature can determined precisely from the pyrgeometers.

l 165 I miss in this description the following information, resolved with mm-vertical resolution: density and specific surface area, ideally also coordination number. This information is available by a number of techniques, even with simple thick-sectioning of cast samples. Fig. 9 is just a photo with no quantitative information.

l 170 Is there any statistics on size? This is very descriptive.

l 201 How are the PRD-strings influenced by solar heating? The 10 cm depths is clearly not sufficient to prevent solar heating.

l 204 A 3 K over 40 cm results only in a temperature gradient of 7.5 K m-1, far too small to create a relevant mass flux (see e.g. Pinzer et al, 2012).

l 211 I would expect detailed drawings of the layer, how many snowpits measured, detailed statistics (spacing, size, ...)

l 217 How should I interpret "most commonly"? Any statistics here?

l 221 I think you have either to reduce the approximate sign (and the about 2 m snow pit, or with the over a depth of 2.000 m?). What was the number of pits?

l 240 "should be quite accurate", what do mean in numbers by this?

l 249 The upper 30 cm are definitively not firn but snow, see the great discussion in

Anderson, D. L., and C. S. Benson (1963), The densification and diagenesis of snow, in Ice and Snow: Properties, Processes and Applications, edited by W. D. Kingery, pp. 391–411, MIT Press.

l 257 -274 The following descriptions are not a discussion, but a narrative of the observations

l 275-282 I agree that surface hoar is an atmospheric deposition on the ground, but this paragraph disagrees with your hypothesis of vapor creeping out of cracks.

l 283 Measured density data for crusts (for any snow layers) is not presented in this manuscript

l 301 I could not find any calculated temperature gradients in the result section

Suggestions on recent papers on snow metamorphism

Calonne, N., F. Flin, C. Geindreau, B. Lesaffre, and S. Rolland du Roscoat (2014), Study of a temperature gradient metamorphism of snow from 3-D images: time evolution of microstructures, physical properties and their associated anisotropy, The Cryosphere, 8, 2255–2274, doi:10.5194/tc-8-2255-2014.

Ebner, P. P., C. Andreoli, M. Schneebeli, and A. Steinfeld (2015), Tomography-based characterization of ice-air interface dynamics of temperature gradient snow metamorphism under advective conditions, Journal of Geophysical Research: Earth Surface, 120(12), 2437–2451, doi:10.1002/2015JF003648.

Pinzer, B. R., M. Schneebeli, and T. U. Kaempfer (2012), Vapor flux and recrystallization during dry snow metamorphism under a steady temperature gradient as observed by time-lapse micro-tomography, The Cryosphere, 6(5), 1141–1155, doi:10.5194/tc-6-1141-2012.

Interactive comment on The Cryosphere Discuss., doi:10.5194/tc-2016-155, 2016.