Overall impression

The paper presents a valuable dataset and should be considered for publication. The manuscript needs some medium reworking to become suitable for publication. In my detailed comments (especially the longer ones) there are some issues with regard to content, which I would like the authors to spend some more thoughts on. Furthermore, I have the feeling that the significance of the paper could be clearly increased if the authors establish a link to the really central question: What is role of deglaciation? I miss this painfully in the paper. Currently the paper presents an interesting dataset from a deglaciered headwall. That's nice and as there are not excessively many comparable datasets it is sufficient for a publication in TC. However, to stick out and become a really important paper the authors have to interpret their results with respect to glaciation. Are the observed processes particularly related to a deglaciered rock wall or can I observe the same in the upper parts of the rock wall which was never covered by glacier ice? What is difference to rock wall kinematics below the glacier line or in the Bergschrund? Is the erosion faster above or below the Bergschrund? In particular the last question is considered by too many authors as obvious but the answer is not obvious at all (see last and third last detailed comment).

I think the paper should at least try to discuss these questions to bring them into the scientific focus. Hereby, I would like to encourage the authors to be more critical against apparently established knowledge what sometimes actually misses sound scientific basis.

I am looking forward to read the new version of the manuscript and hope for a successful publication in TC.

All the best,

Robert Kenner

Detailed comments:

Abstract:

I miss some information about permafrost presence or absence. This is an important factor that should be mentioned in the Abstract. Searching "permafrost" in the rest of the document gave no clear answer on this question neither.

Introduction:

P1 l29: This is an interesting (and correct) description but do you have some explanations or references why these headwalls are often oversteepened? I think there is a term for it called schrundlines. See e.g. sanders et al 2012 (cited by you). These schrundlines have obviously developed during glaciation and not after glaciation or during deglaciation. Any thoughts on that?

P2 l6ff: I would distinguish these processes more carefully. Debuttressing is probably not a driving factor at headwalls but is more related to lateral (valley) slopes of tongue shaped glaciers. Oversteepening occurs at headwalls as well as on lateral slopes but the type of glacial erosion is very different between both locations. (Perhaps rather a type of plucking behind the bergschrund!? See again sanders et al.) If you want to focus on headwalls, I think it is important to go more into detail here.

Furthermore, I feel it is a pity that all rock slope failures taking place in the vicinity of a glacier are lumped together by most of the studies in this field. Oversteepening is obviously a result of glacier erosion and not of glacier retreat. Rock slope instabilities caused by oversteepening are thus just secondarily or not related to glacier retreat. This is probably different for rock slope failures whose kinematic was not related to oversteepening or which were previously covered by glacier ice in large parts (especially the discontinuities) as it is the case at your study site.

Just recently we observed a rock fall at Flüela Wisshorn in Switzerland where more than 250’000 m3 collapsed in an old glacier cirque (you can google some pictures of it). This cubature was never covered by glacier ice, not even during the last cold period. However, the cubature was kinematically free, as the release plane (dip slope) cropped out below the cubature already before the event. This was because the lower end of the cubature was built by a terrain step which was part of a distinct schrundline. In such a case it makes absolutely no sense for me to talk about a slope failure related to glacier retreat. This instability originates most likely from glacial erosion during the last glacial maximum and collapsed now, several decades after the LIA glaciation and several thousands of years after its initiation. I claim it would have collapsed as well if the LIA glacier below the cubature would still have been present.

Maybe you can consider those differences somewhere in the introduction and perhaps also in the discussion

P3 l13: This sounds more than abstract or conclusions. I would not let the cat out of the bag here

Study area

P3 l21: the….headwall reaches a height of 100 m above the current…

Data Acquisition

P4 l16: Why just in 3 depth if the borehole is 30 m deep? Why not deeper and why not closer to the surface (to track freezing fronts)?

Data Analysis

P5l5: “(i) fracture deformation by ice segregation is of minor importance” Can you give an explanation for this? CTT are a weak indicator for the temperature profiles in greater depth aren’t they?

4 Results

P5 l22 Mention presence of permafrost

P5 l21 active layer depth = linear interpolation between thermistors??

Figure 3 and text: What is the zero curtain period you are talking about? How is it defined? I do not get it.

Figure 3: The rock temperatures show distinct zero curtains in Autumn but not in spring. This is interesting and important. Is this somewhere discussed? There must be a lot of water somewhere in the rock that caused the long autumn zero curtain by freezing...? But why is there no ZC in spring? Where has the ice gone!? Or has the water percolated away in autumn without freezing??

P5 l22 Anomalies during zero curtain period? You are talking about ZC at which depth? Increase of 1K during zero curtain at 3m depth means +1°C what is not possible as active layer depth was 3m in 2016!?

Along with shorter zero curtain period… Where? When? Unclear!

Section is hard to follow, try to formulate more precise.

P6 l16 The the

P6 l16 Probably because of ice layers at the base of the snow cover which often prevent water infiltration during snow melt. See Phillips *et al.* (2016)

P6 l33 deformation parallel to the surface means CDh, i.e. horizontal deformation, right? Better use a consistent terminology.

4.2 Crack Deformation Data here and in the entire paper: it is confusing if you are talking about CD/CV increase or decrease. Increase or decrease means the cracks deforms faster or slower but what you actually want to describe is positive or negative deformation i.e. opening or closing of the cleft. Right? Please adapt the wording here.

4.2 Crack Deformation Data In general this paragraph is very descriptive and basically repeats what can be seen in figure 5. You can shorten it a bit and focus on/summarize the core results (there is deformation simultaneously to rain/snowmelt or without rain /snowmelt, temperature correlates with this and that…) This is easier to follow and the reader gets it faster.

Figure 6: Again, what is zero curtain here? Is it zero curtain at the surface or CTT??? But then snow cover and zero curtain period would occur simultaneously. There is a zero curtain during the snow melt and you couldn't separate these two periods as you did it in the figure … Completely unclear to me….

Discussion

P9 l5 ff Any thought why there is no spring zero curtain in the GT in 3 m depth? (but an autumn zero curtain?)

P9 l11/12 again see Phillips et al 2016

P9 l24: Within the surface? At the surface or within the ground/rock mass!

P9 l26: refer to autumn zero curtains in 2 and 3m depth which are a proof for significant amounts of water in the rock mass!!

P11 l15: I am quite skeptical about the relevance of debuttressing in headwalls of glaciers. This is an often heard hypothesis which established more by repeating it again and again than by sound research on it. You cited Keuschning et al but in this paper debuttressing is once more mentioned as important factor without giving any sound justification. The efficiency of debuttressing was shown for lateral slopes of valley glaciers but not for headwalls. Here we see erosion processes like plucking in the bergschrund causing oversteepening. This is a sign for glacial forces that rather act in the same direction as the critical rock slope deformation and not against the rock slope deformation. Rock masses obviously detached from the headwall as they were still covered by glacier ice, otherwise there would not appear an oversteep rock wall under the melting glacier. Rock masses still detach during deglaciation and after glaciation. Perhaps they detach more often than, as the atmospherically forced processes which you have measured in your nice dataset are more efficient than. But perhaps this is wrong and we are completely of the track! Perhaps the rock falls in freshly deglaciert areas are just an adaption process following oversteepening!? This is the big question that we should try to answer!

P12 l14 See also Kenner *et al.* (2011) how observed the same at the summit wall of Gemsstock

P12 l16 I think it is absolutely right that you emphasize shallow instabilities. But are you sure that erosion increased after deglaciation compared to the period during which it was ice covered? How do you know? Erosion during glacier coverage was obviously strong as well, as I said before: otherwise there would not appear an oversteep rock wall under the melting glacier. The only difference is that you can see the rock slides now and before they were invisible because they took place below the glacier line. I do not say that the one thing or the other is right or wrong but I consider it as an open question on which your paper could not give a satisfying answer so far.

Kenner R, Phillips M, Danioth C, Denier C, Zgraggen A. 2011. Investigation of rock and ice loss in a recently deglaciated mountain rock wall using terrestrial laser scanning: Gemsstock, Swiss Alps. *Cold Regions Science and Technology* 67: 157-164. doi: 10.1016/j.coldregions.2011.04.006

Phillips M, Haberkorn A, Draebing D, Krautblatter M, Rhyner H, Kenner R. 2016. Seasonally intermittent water flow through deep fractures in an Alpine Rock Ridge: Gemsstock, Central Swiss Alps. *Cold Regions Science and Technology* 125: 117-127. doi: S10.1016/j.coldregions.2016.02.010