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Interactive comment on "Investigating cold based summit glaciers through direct access to basal ice: A case study constraining the maximum age of Chli Titlis glacier, Switzerland" *by* Pascal Bohleber et al.

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General comments

I agree with the first referee that this paper presents a series of interesting findings from a summit glacier in Switzerland that suggest that a cold-based thermal regime has been persistent at this site resulting in the preservation of the basal ice for c. 5,000 years. The paper is therefore clearly appropriate for publication within The Cyrosphere although I think there are areas that would benefit from further work.

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Discussion paper

Areas for improvement

âĂć Agree firstly with the comments of the first referee - particularly the need to include a map of the study site that indicates the location and setting of the glacier and the tunnel. âĂć The paper focuses on the examination of basal ice at the site but is unclear whether the use of the term “basal” is used simply to refer to its position at the base of the glacier or in its glaciological sense (ice which is produced at and interacts with the bed; e.g. Knight, 1997). Either way, I would recommend that the authors consult some of the relevant literature to inform their description and interpretation of the ice examined in this study. âĂć On a related note, I would like to see a more detailed description of the ice facies observed within the tunnel within section 3 to support the more detailed ice petrography reported in section 3.4 (see for example Hubbard & Sharp, 1995). âĂć The impact of the work would be enhanced if greater emphasis was given to the broader context of the work and its key findings within both sections 1 and 5. What is the wider palaeoclimatological and palaeoglaciological significance of the preservation of ice 5,000 years at this altitude? âĂć Section 4.5 in particular would benefit from a clearer structure to help emphasise and explain the key points.

Minor comments P1 - Abstract - Highlight the primary research question this research is aiming to address. Feel this will help to establish its wider context and significance. P1 - L8/9 - Explain what is meant my “standard glaciological tools”. P1 - L9 - Clarify what is meant by the use of the term “sophisticated”. P1 - Section 1 - Explain more explicitly why cold-based thermal conditions are of such importance - i.e. warm-based conditions and basal melting lead to the loss of the oldest ice - impossible therefore to date onset of most recent phase of glaciation. P1 - L19/20 - Provide the approximate altitudinal ranges for “uppermost summit ranges” and “lower altitudes”. P2 - L4 - Basal temperatures persistently below the pressure melting point? P2 - L5 - Clarify what is meant by “glacier buried tree parts” - re-word. P2 - L8/9 - Give greater emphasis to this key broader aim of the research (e.g. could be presented at the start of the final paragraph in this section) and provide a little more explanation on how the paper will help

to realise this aim. P3 - L6 - “as well at around...” P3 - L8 - What attribute provides the layering? Variations in bubble content, sediment concentration? As mentioned earlier, providing a more detailed description of the characteristics of the basal ice here and within section 4 would be helpful. P3 - L25 - Reword from “third spot” to “third profile”. P3 - L28/29 - Use of the term “clear” here needs further clarification. Again - highlights need to include a section (maybe initially in section 2) that provides a more detailed description of the basal ice facies observed and clarification of the significance of the use of the term “basal”. P4 - Figure 1 - Include scale in Figure 1A. P4 - L4 - “20cm vertical intervals” P5 - Section 3.2 - Where the stable isotope measurements taken from all the ice blocks? (Fig 2 suggests not) P5 - L3 - “The outermost 10 cm of each block exposed to the tunnel was removed” P5 - Section 3.3 - Which blocks were used for the radiocarbon dating? P6 - Section 3.4 - Include a description of the macroscopic characteristics of the ice facies investigated here - ideally refer to an ice facies classification scheme. Explain why the clear ice facies was specifically targeted for analysis. P6 - Section 4.1 - It’s worth emphasising here that the measured temperatures are significantly lower than those previously recorded by Haeberli. P7 - L7 - Equilibriation? P7 - Section 4.2 - Explain the significance of a replication of the basal isotope anomaly. Does this indicate that the basal ice formed from precipitation during colder climatic conditions? P8 - Figure 2 - Illustrate which samples have been obtained from the clear ice (cf. Figure 1D/E). P8 - Again, a brief description of the ice facies and their key characteristics (e.g. debris content and bubble content) would help provide a context for the microstructural characteristics. P9 - Figure 3 - Where have have these results been obtained from? “Selected results” rather than “exemplary results”. P9 - Section 4.4 - Does progressive downwasting and thinning of the ice provide a potential explanation for the fall in temperature? P9 - L6 - Suggest rewording to - “...from basal temperature measurements revealing temperatures well below the pressure melting point” P10 - L6 - “karst” rather than “carst” P10 - L19/20 - Emphasise why a cold-based thermal regime is required to preserve old basal ice. P10 L19-22 - What is the source of this organic material and how has it been incorporated into the basal ice? P10 - L26-28 - What is the layer-

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ing composed of? Variations in bubble content and ice crystal size? Suggestion here would be that this could be foliated ice in which case it could be illustrative of shear deformation. P10 - L29 - What is meant by the use of the term “dark”. Bubble free? P12 - L6-7 - Earlier text suggested limited deformation whilst this suggests the potential for deformation - watch for possible contradictions here. Would typically expect significant shear strains in the basal ice layers of non-temperate glaciers frozen to hard rock beds. P12 - L24-25 - Key finding - Give greater emphasis within the section. P13 - L5 - Suggest re-wording to: “Tmperature measurements demonstrate basal temperatures that are well below the pressure melting point...” P13 - L9 - “...five ice blocks suggests a chronological order...” P13 - L14-15 - This final sentence is the key finding. Give greater emphasis (new paragraph?) and elaborate briefly on the potential palaeoclimatological and palaeoglaciological implications.

References Hubbard, B. & Sharp, M., 1995. Basal ice facies and their formation in the Western Alps. Arctic & Alpine Research, 27(4), 301-310. Knight, P.G., 1997. The basal ice layer of glaciers and ice sheets. Quaternary Science Reviews, 16(9), 975-993.

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