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Comment on tc-2021-88

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Community comment on "Comment on "Ice content and interannual water storage changes of an active rock glacier in the dry Andes of Argentina" by Halla et al. (2021)" by W. Brian Whalley, The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-88-CC1, 2021

Geophysical data on rock glacier permafrost

The reviews relating to the "Comment" by W.B. Whalley rightly state that geophysical data must be considered in order to reliably define subsurface material properties and ice conditions. Such geophysical information exists at both sites, Gruben (Gärtner-Roer et al., 2021) as well as Dos Lenguas (Halla et al., 2021). It does not indicate the presence of major buried surface ice bodies.

Already the earliest D.C.resistivity soundings carried out for hydropower development in the Swiss Alps (Fisch et al. 1978; Haeberli 1985) documented perennially frozen talus/debris with characteristic resistivities in the medium-to-high kΩm range inside viscous flow features usually called rock glaciers. Since then, numerous soundings have been carried out in many parts of the world (cf., for instance, Barsch and King, 1989). The technique is standard and used for various applications in research on mountain permafrost (cf., for instance, Hilbich et al., 2011; Mathys et al., 2021). Resistivity values possibly indicating buried surface ice (low MΩm range for ice patches, high MΩm range for glacier ice from temperate snow-ice metamorphosis; cf. Haeberli and Vonder Mühll, 2006) have rather rarely been reported and exclusively in combination with frozen ground (cf., for instance, Hilbich et al., 2021). This so far collected geophysical evidence not only agrees with results from the application of various other geophysical (especially seismic and electromagnetic) methods, but also with information from an increasing number of core drillings, borehole observations, laboratory creep tests, numerical model calculations and subsurface temperature measurements (Haeberli et al. 2006, Cicoira et al. 2020). The entirely speculative belief that (temperate?) glaciers alone – independently of deep subsurface freezing – can form rock glaciers remains in full contradiction with the results from adequate field measurements related to subsurface material properties, thermal aspects and ice conditions.

Surface ice in various forms – mostly ice patches or small glaciers – can, of course, be in

contact with creeping perennially frozen materials (cf., for instance, Gärtner-Roer et al., 2021; Kunz and Kneisel, 2020). Buried remains of such surface ice embedded within permafrost can enable the development of thermokarst lakes or "melt pools". A well-documented example is the former thermokarst lake at Gruben. This lake had grown in the former contact zone of the polythermal LIA Gruben glacier with the thick, perennially frozen and continuously creeping/advancing debris of a much older flow feature ("periglacial part" of the complex Gruben rock glacier; Gärtner-Roer et al., 2021). It had to be artificially emptied because of increasing flood hazards (Kääb and Haeberli, 2001).

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