

The Cryosphere Discuss., author comment AC3
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Reply on CC1

W Brian Whalley

Author 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-AC3>, 2021

Thank you for your comments Wilfried.

- Please note that I said, 'The geophysical data supplied by Milana and Güell (2008) and Halla et al. (2020) will be useful in the interpretation of these factors in glacier/rock glacier formation ...' In other words, evaluating the nature of the 'mixture model' that should be applied to the rheology (6, supra) will be helpful in establishing the geophysical properties and variability in rock glaciers. I am well aware of the range of geophysical results available from rock glaciers and why they can be so variable (acknowledged by Referee 2) and noted this in my original comment. This is also part of the review of the mixture models provided by Whalley and Azizi (1994) and I do not propose to discuss this variability here as my point was, and is, to look at visible forms and how they might inform us as to the origin of rock glaciers. The rheology gives the landform and its details, not the variable geophysical signature.
- I am also aware of Gruben glacier/rock glacier and its ice-dammed lakes and the so-called 'periglacial part'. But readers should note that an interpretation of that rock glacier landsystem suggests that the rock glacier *does* have a glacier ice core (Whalley, 2020). It is no different from the observations of glacier ice cores in rock glaciers that have been recorded over the years from many parts of the world, for example; Kesseli (1941), Potter et al. (1998) and more recently Whalley (2021b). No amount of geophysical pleading can refute these observations. It is for time, as more meltwater pools are exposed, and readers to evaluate. A rough calculation (see 8, supra) shows that such meltwater pools are from the decay of massive glacier ice – which is what was the case at Gruben (Whalley, 2020).
- It is certainly true that boreholes and exposures do show the complex nature of ice and debris in rock glaciers, see for example Janke et al. (2015) and Jones et al. (2019), especially near rock glacier snouts. Because of the increasing surface debris loads down-valley, ice exposures tend to be hidden by debris. However, some snout collapses can be seen in GE, such as at Glockturmferner (Austria) [46.89846,10.65058], compared with earlier views (Kerschner, 1983). Lliboutry described a section in the one of the four 'glaciers **enterrés**' below the west face of Cerro Negro (Andes of Santiago). The exact location is unknown but is in the vicinity of [-33.1484,-70.2367] (Lliboutry, 1961, Fig. 1). The section (Lliboutry, 1961 Fig. 4) and (Lliboutry, 1965 Fig.17.21) shows complex relationships between ice; young, old bubbly and bubble free ice together with silt and pebbled bands. This is more complex than the section shown by Trombotto-

Liaudat and Bottegal (2020). Figure 8 of Janke et al. (2015) shows section of a meltwater pool showing banding, similar to Gruben rock glacier's drained lakes (Whalley, 2020). There is clearly much to be gained about the structures of glaciers as they become exposed at the snouts of rock glaciers. This will help in matching geophysical attributes to structural glaciology and debris content.

- Although there have been descriptions of rock glaciers since the early 20th C, the paper by Wahrhaftig and Cox (1959) has become particularly important in discussion about these features (Stine, 2013). Indeed, it has become the 'Urtext' for those believing the 'permafrost' origin of rock glaciers promoted by Wahrhaftig and Cox. The book by Barsch (1996) provides the stated dogma of the permafrost viewpoint. This text is followed by Barsch (1987) who denigrates many observations of glacier ice cores. Subsequently, sins of omission have followed by disregarding any other possibilities than the permafrost dogma, e.g. Swift et al. (2021). Please see Whalley (2021a) where some of these wrongs are addressed.
- Professor Haeberli, as a true believer in the Urtext and permafrost dogma, has always maintained that rock glaciers cannot have glacier ice cores (i.e. be glacial). For him, this means that not only do glacier ice cores not exist but that any continuum or equifinality does not occur (pace Referee 2). Yet there are many reports of glacier ice in rock glaciers, as well as the well-established work of Potter at Galena Creek that cannot be denied (although I leave it to readers to adjudicate). Quoting many references that support a permafrost viewpoint amounts to 'affirming the consequent' (modus tollens). In terms of swans and rock glaciers, all swans are not white and at least some rock glacier swans are black and contain glacier ice cores. Thus, supposition and following a particular point of view is insufficient to replace valid contra-observations. In a Popperian sense therefore we might have to wait for contra-indications of permafrost, or affirmation of the appearance of glacier ice by meltwater ponds.
- I have mentioned the work of the late Professor Louis Lliboutry in reporting '**glacier enterré**' and in particular the complexities of snout stratigraphy. He also said (Lliboutry, 1990); 'I do not wish to enter into a public controversy with W. Haeberli about the origin of rock glaciers; he has always been deaf to my arguments. Nevertheless, the readers of his passionate assertions (Haeberli, 1989) must be aware that he intentionally omits to quote my detailed observations in the dry Andes (Lliboutry, 1955, 1965, 1986).' Further, 'Nevertheless, for the advancement of science, the essential point is not "must rock glaciers be left to scientists claiming to be permafrost specialists" but "what can we learn from the existence of rock glaciers in a given area"? I maintain that the geographical study of rock glaciers as an extreme case of glacier fluctuations, as an indicator of favourable mass balances in the past, or of past surges, would be much more rewarding than to consider them as a mere case of standard permafrost, or of creeping regolith.' (Lliboutry, 1990).