

1 **Comment on "Ice content and interannual water storage changes of an active rock**
2 **glacier in the dry Andes of Argentina" by Halla et al. (2021).**

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9 **Abstract.** Recently published work on water preservation in Chile assume that 'permafrost'
10 (cryogenic) rock glaciers are dominant. Melt pond development shows that rock glaciers are
11 glacier-derived ('glacigenic') rather than of permafrost origin.

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13 Halla et al. (2021) make a useful contribution to estimating the water content of rock glaciers at 'Dos
14 Lenguas' in Chile [-30.2465,-69.7867] using decimal Latitude Longitude. However, their interpretation
15 (Figure 10) relies on the assumption that it is a 'talus rock glacier', a body of creeping permafrost
16 unrelated to any glacier. Although commonly held, this origin is not supported by rheology (Whalley
17 and Azizi, 1994). Further, the Dos Lenguas (DL) site shows no rock glacier formation in or from the
18 extensive local talus. The glacier ice core ('glacigenic') model better explains formation and flow
19 (Whalley and Azizi, 2003). Gruben rock glacier, taken to be a 'typical' permafrost-derived rock glacier,
20 is actually of Little Ice Age origin and is glacier-ice cored (Whalley, 2020). At DL, a small glacier
21 formed in a south-facing hollow then covered by insulating weathered rock debris. To the west (6.5
22 km) of DL there are several rock glaciers where glacier ice could collect and be buried. The largest of
23 these (Figure 1) lies below a glacier and debris-covered glacier. Over the last 15+ years glacier melting
24 has produced substantial surface pools. Some 16 km from DL, the Tapado-Las Talas glacier-rock
25 glacier complex [-30.153,-69.916] has similar features. Monnier et al. (2014) show a debris-covered
26 glacier with melt (thermokarst) pools merging with a rock glacier, itself over-riding a moraine sequence.
27 Schaffer et al. (2019) considered this a complete rock glacier sequence below the Tapado glacier with
28 the debris-covered section being 'glacigenic' (their Figure 3). The Tapado glacier [-30.1510,-69.9246]
29 is now separated from a debris-covered glacier [-30.1548,-69.9212] below which is a glacigenic rock
30 glacier component [-30.1567,-69.9128]. The neighbouring Las Tolas rock glacier [-30.1541,-69.9114],
31 was viewed as 'cryogenic' (permafrost-periglacial) by Schaffer et al. (2019). There is no visible glacier
32 component in the cirque above the rock glacier, although Google Earth images (2017) show copious
33 snow collection and crevasse features (noted by Schaffer et al. 2019) on the steepest section. As with
34 the rock glaciers west of DL, the simplest explanation for all these features is glacigenic, i.e. glacier
35 derived. The seismic traces used by Monnier et al. (2014) and evidence from Schaffer et al. (2019) to
36 differentiate between glacigenic and cryogenic components are probably due to the complex
37 relationships of glacier ice-snow and debris supply.

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39 In summary, the geophysical data supplied by Milana and Güell (2008) and Halla et al. (2021) are useful
40 in the development of models to estimate water storage potential. However, their interpretation of rock
41 glaciers as 'permafrost' ('cryogenic' or 'cryo-conditioned') features in mountain environments neglects
42 the evidence in the literature of them being glacier ice-cored features as shown by the development of
43 surface meltwater ponds on several rock glaciers in the dry Andes.



Figure 1. A glacigenic rock glacier centred on the prominent surface melt pool at [-30.2414,-69.8541] shows ablation of massive, glacier-derived, ice under a debris cover. These melt pools can be traced from the uppermost part of the rock glacier through to near the snout and are persistent over several years of Google Earth imagery. A permafrost (talus-derived) feature would show 'isovolumetric' melting of ice in pore spaces and, thus have rather different water storage capability from a glacier core.

64 © Google Earth/CNES/Airbus

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