Minor comments from editor

The first digit of line numbers >100 have been cut off in the PDF. So Comments >line 100 are page + 2nd 2 digits of the line number

L7: Add space in zip code (AB24 3UF)

L15: minimal. Response to editor comments states this has been changed to 'some'. Change has not been made.

L20: 'Evaluate past glaciation on Mars' is vague. Say something like 'to better understand the potential contribution of glaciation to landscape evolution in Deuteronilus Mensae, Mars'.

L21: Here and throughout: avoid the term 'icy geomorphic' as this is ambiguous. Implies the feature itself is icy, but this isn't always the case – some are inferred as having formed by ice that is no longer there. Better 'geomorphic evidence for past glacial occupation of these cirque-like alcoves'

L24-25: These don't really work as alternatives to one-another as currently written - one is posed as a mechanism, and one as a requirement.

Additionally…

If tying to obliquity, then the high-insolation scenario is a different obliquity state to the low-insolation/high-accumulation state. Or it arises from a climate regime that has not yet been well constrained. Can you make this clearer?

L26: 'both glacier-like forms' – 'both the estimated ages of glacier-like forms'

L30: Add 'and the timing of the formation of cirque-like alcoves' to this statement

L42: these aren't 'ice flow regimes' they are thermal regimes.

L43: Could add Gallagher et al. 2021 – they found grooves

L64: space after lag

L65: estimates ranging from > thickness estimates ranging from

L73: As stated in a previous review, the caption first needs to introduce the general purpose of the figure. E.g. 'Examples of viscous flow features and alcoves mapped in this study'. Ensure all figure captions have such a statement at the start.

L75: aprons plural x 2

L81-82: Given the new addition of Figure 7 , and the sample sizes discussed, this isn't correct as 'all alcoves mapped in this study'. It is an example of alcoves mapped in a sub-region of the study area.

L88: These processes don't result in basal slip. Basal slop drives (some of) these processes (quarrying and abrasion, not frost weathering).

L88-89: Delete the detail about meltwater through the bergschrund and randkluft. Too much detail, and inaccurate – meltwater can reach the bed from elsewhere too, e.g. crevasses.

L95: Since we've changed planet, re-state glacier-like forms *on Mars*.

L98: Avoid the term putative. This means generally accepted, which isn't always true particularly for recent papers. Instead use hypothesised, or equivalent.

P4,L00: Should this just be 'alcoves' here? Referring in general to alcoves, not your cirque like ones specifically.

P4,L02: If above change implemented, this can then become 'dedicated to identifying cirque-like alcoves'.

P4,L02: Here and elsewhere in the manuscript this should be regional population scale. Population without qualification implies global.

Figure 2: contour labels need to be larger in ii, and caption to state where panels are oblique views e.g. at least bii, and possibly also cii, as this distorts the shape significantly. It is also not made clear that aii and bii are the same cirque.

P8,L27: not clear what is meant by candidates here. One of the regions on Mars where available data is most highly consistent with…

P8,L30: avoid fretted - this is jargon and not particularly important. the key thing is that the terrain hosts valleys, plateaus and mesas.

Also, I don't think you need to say 'of disputed origin'. It just adds unnecessary confusion. What is important is that it is just the antecedent topography for glaciation.

P8, L31-32: Wouldn't this be better in the intro before you talk about the climate of the last 3Gyr? This also allows you to define Amazonian once only.

P8,L34: Mention glaciers specifically here.

P8,L38: sections on > sections towards

P8, L39: 'including'. These are the only features labelled. Delete

P9,L9: For this extent of study area, this projection will induce distortions towards the longitudinal extremes. The reviewer requested an explanation of the magnitude of these distortions, but this has not been provided in the revisions. For future reference (assuming the calculated uncertainties in sinusoidal are tolerable), a lambert projection, as in Fig 3 would have reduced these distortions.

P9, L65-71: This works well – thanks for sticking with us!

P10,L77: the stated equation doesn't match the words. Need to add 'taking the cube root of the product of'

P10, L94: delete 'to fit a table format'

P11, Altitudinal range row, column 4: delete minus – already say subtract

P11, Elevation row, column 4: Mean elevation of what? All pixels within the polygon?

P11, Aspect row, column 2: delete north (or degrees relative to north, but that isn't typically stated).

Figure 4: Contour labels need to be larger

Also Figure 4: the revisions to panel B have introduced an error - the H line should end at the end of the L line. currently the H line measures outside the alcove boundary.

P13, L08: alcove > alcoves

P13,L09: This isn't 'alignment', it is projection.

P13, L10: is 100m this the typical magnitude of misalignment? Are there any which exceed this?

P15,L26: The lip in this profile appears to correspond to where the transect intersects mantling materials, so I suspect it is not a true lip but the mantling deposit.

P15, L35: see earlier comment re icy geomorphic features. Better would be 'geomorphic features related to ice' - this could then include features *containing* ice and features formed by ice.

P15, L38: Better would be 'mantling deposit' – remember the mantle is a thing!

P16, linear terrain row, column 5: accelerating flow is inherently extensional. Not clear therefore what is meant by compressed accelerating flow.

P16, mantle row, column 3: This isn't the main descriptor of mantling deposits. There should be a preceding statement which is a primary description, then this can supplement it.

P16, mound and tail row, column 3: core of ice? not really possible to tell this at this scale. More likely to be sedimentary. Definitely not a core of ice if equivalent to drumlins.

P16, mound and tail row, column 4: I'd rephrase this as 'Drumlins, but with some morphometric differences'

P18, L53: alcoves *which* no

P18, L53: ‘and raised moraine like ridge’ this comes after 'no longer appear to', yet I can see arcuate features beyond the alcoves. Should this say that they *have* raised moraine-like ridges at their termini? If not, mention the arcuate features but state that they don't have significant relief - this is evidence that they once did contain glacial ice.

Figure 7: This is a really useful figure - thanks for adding. However, it needlessly repeats elements of Figure 3, and comes too late. Replace Figure 3 with this. You could also then use this figure to point to the locations of the examples shown in other figures.

P22, L83: Is it mean size? Or just size? Individual points are plotted. Please clarify and make clear in text.

P22, Table 4, column 4: Define somewhere how alcove volume was calculated. this isn't in the acme2 output table.

Fig 11: Could simplify this by only showing iii column – it repeats I and ii but is more useful because they are scaled.

P23,L11. ‘Average area’. Axis label says volume not area

P23, L16: I would argue that a feature such as a moraine or streamlined bedform does not necessarily mean that there is still ice (be that active or relict). It just means there was once ice there.

P24, Table 5. Change imagery to images. This is a metric of occurrence (yes/no) per image, not according to the area of image in which it occurs. Imagery could be interpreted as the latter. You could make it even clearer by ‘Percent of HiRISE images containing feature’ (same with CTX column).

P24,L28: presence *or past presence* of ice, or processes of ice loss.

P26,L53: by being called cirque-like, they are inherently *candidate* cirques. Rephrase to 'whether cirque-like alcoves are *indeed* cirques

P27, L63: ‘more episodes + lasted a longer amount of time’: these are listed as part of the same hypothesis, but should be separated. Then at the end, you can say it could have been a combination of these factors.

P27, L64 ‘erosion rates on Mars were much more rapid’. I don't think anyone is realistically suggesting this. It is ok to explain which are the least likely explanations. So I recommend counteracting this hypothesis before the future modelling statement.

P27,L69: winds don't have a lee side, slopes do. So more likely to grow on the lee side of slopes crossed by westerly winds?

P27, L72: ‘northern winter’: under higher obliquity?

P27,L72-73: a bit repetitive given cirque bias is already stated. Simply state here that the observed bias is similar to glacier-like forms.

P27, L74: get rid of northerly, confusing when direction is opposite sense to a northerly wind. Just say poleward facing

P27,L77: what pattern? this reads as if they have an easterly bias (the main topic of the preceding paragraph). But I think you mean to compare to cirques on Earth.

P27,L77 'found glacier-like forms to have a poleward bias' – at global scales

P27,L78-79: grammar here is messy. Cut the sentence after 'glacier-like forms face southwards'. Then: in contrast, cirque-like alcoves in Deuteronilus.

P27,L78: Grammatically, 'this' is referring to the cirques, but you mean to refer to the GLF trend. Revisit the grammar of this entire paragraph - it could be a lot tighter.

P27, L81-82: Move 'for both…' statement before the statement where you talk about the largest cirque-like acloves by volume.

P27,L83-84: again, this is not written very clearly. Revisit this entire paragraph and tighten it up.

P27,L86: should the equator-facing statement be covered by the citations too?

P27, L87-87:. Statement starting 'as a result'. This sentence lacks a citation. I would also qualify southward-facing with (equator-facing), as you do in the conclusions - that is clearer

P28,L90: 'remains unclear'… …and alternative mechnisms which do not require liquid water have been demonstrated as possible mechansims for gully formation on Mars (citation).

P28, L91-92: 'water ice precipitation'…otherwise known as snow 😉

P28, L96: 'would allow for increased insolation' need to explain under what climate/obliquity regime, since the earlier passage says that equator-facing slopes received less insolation. Separate these hypotheses out (there are currently contradictary statements in the same paragraph), and make clear when things are alternatives.

P28, L97-98: we explored this potential association in Section 5.1.2 – this is 5.1.2, delete.

P28, L98-99, sentence beginning 'on the other hand'. move this up amongst the explanation of DM GLF distributions at the start of this paragraph. You say the largest ones face southward, but it is an important point that most are pole-facing.

Figure 14: Captions need to have an introductory statement about what the figure shows overall.

P29, L21: It would make more sense for the GLF comparisons in the aspect section to move here.

P30,L56: space in may lack

P30, L56-57: Not sure what you mean by elongation out of the alcove

Section 5.2.2: I still agree with the reviewer that this section is too speculative. I suggest deleting, to focus on the actual results of the data collection.

P31,L75-76: I don't understand the need to invoke this alternative interpretation. Seems very unlikely.

P34,L42: millions of years > million years.

P35, L76-78: this should explain how the temperature at Beacon valley differs from the current mean annual temperature on Mars. The mention of the Butcher et al. velocities right at the end of this section - which are under Mars' current mean annual temperature comes too late, and contradicts the preceding statement that mars glacier surface velocities are unknown.

P36, L96-97: but this should be qualified by the fact that this is based on surface velocities for terrestrial glaciers, which (as the butcher et al study shows) may not be realistic for the typical temperatures at Mars' mid latitudes. Can note that the temperature history is not well understood and could have been warmer at times, but the temperature assumption in the calculations needs to be addressed.

P37, L27: This should move up to qualify the statement that surface velocities of glaciers are unknown. You should also note that this was for a thin VFF (<100m thick), *but* on a steep slope (these two effects will somewhat counter eachother, but perhaps thicker ice flowed faster, though perhaps also a thin vff is an ok analogue for a cirque glacier).

P38, L48: 'Kilometer-scale glaciation' odd phrasing. I don't think you really need to suggest you've extended the knowledge of glacial extent. The identification of cirque-like alcoves is enough - e.g., extended knowledge about the landscape imprints of formerly more extensive glaciation in Dueteronius Mensae in the past, and potential landscape evolution processes.

P38,L54: Make the first conclusion: 435 alcoves in Deuteronilus Mensae are morphometrically consistent with origins as glacially-eroded cirques.

P38,L57-58: does this explicitly explain the latitudinal gradient *within* the mid latitudes (as opposed to favourable ice accumulation in the mid-lats relative to the poles?)

P39, L80 ‘glacial conditions’. arguably using terrestrial velocities is not 'using Mars glacial conditions'.

P39,L83-84: Qualify this with 'however, these estimates are highly dependent upon the past flow velocity chosen, which is poorly constrained for past climate regimes on Mars.

Data availability statement: Previous versions of the manuscript stated that the alcove data would be released. Now it reads that it will be available by email. Following ESurf policy, if data will not be released, a robust justification must be given in the statement. I recommend releasing the data as previously stated.