Assessing the potential of a rock/debris-covered glacier in the Uinta Mountains, Utah, as a possible analog to Martian debris-covered glaciers.

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1) Introduction:

Rock/debris-covered glaciers in the climatically periglacial Uinta Mountains, Utah, [1] present many morphological similarities to debris-covered glaciers on Mars, including lobate forms and flow-parallel ridges and depressions (fig 2). They therefore represent a candidate for analog studies [2], despite their much smaller size, and the prominence of melting as opposed to sublimation in ice ablation. Here we study the potential of one of these features, dubbed Luigi, as an analog to Martian debris-covered glaciers.

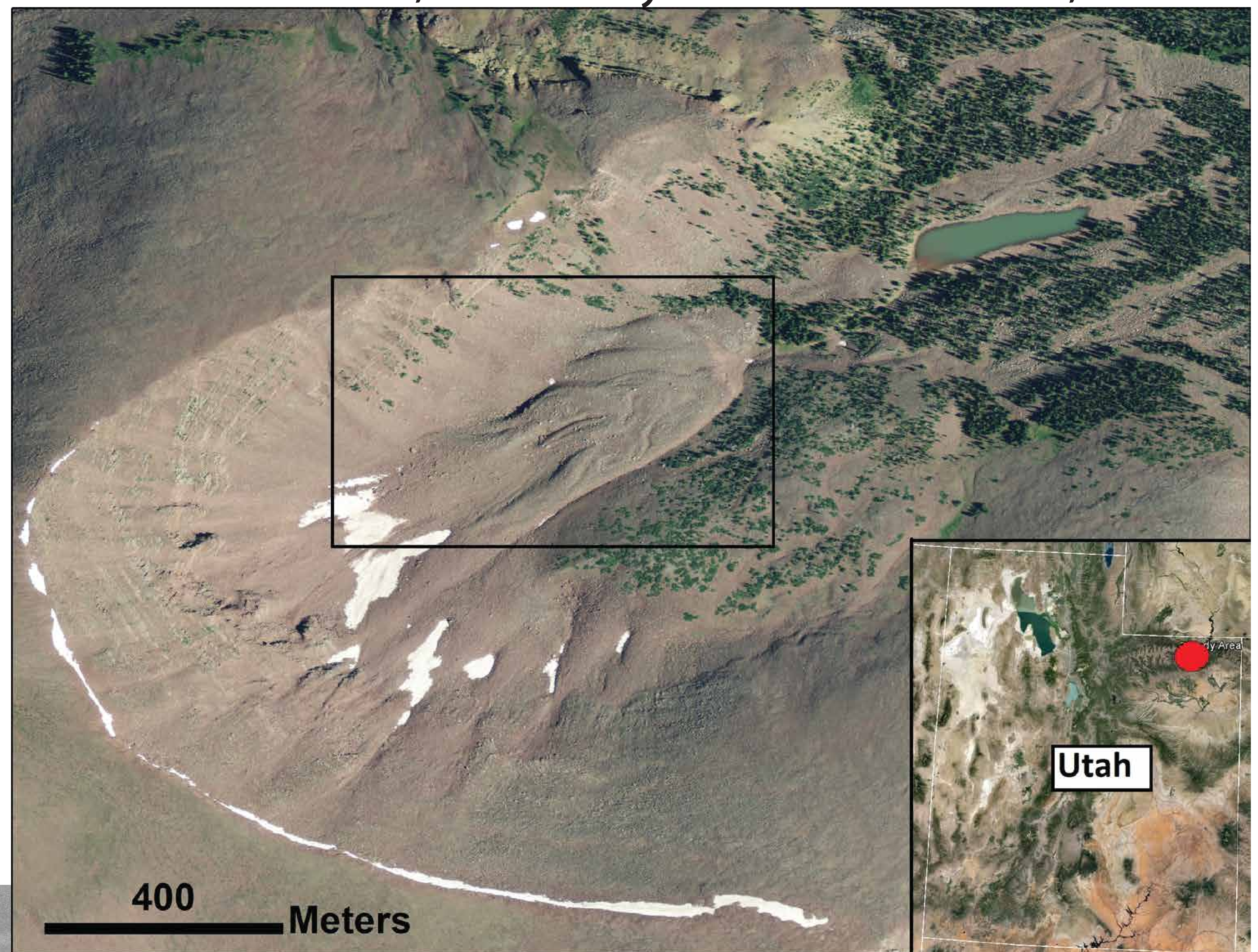

Figure 1 (Site): *NAIP photography of the rock glacier, dubbed Luigi, used in this study. (Inset) location map of study area in Uinta Mountains, Utah.*

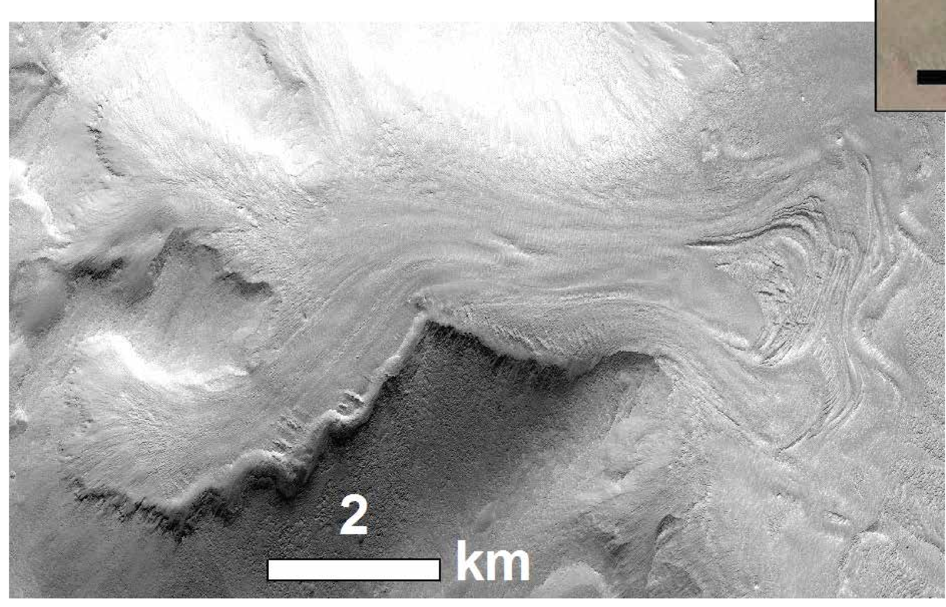

Figure 0: *HiRISE imagery of a debris-covered glacier on Mars.*

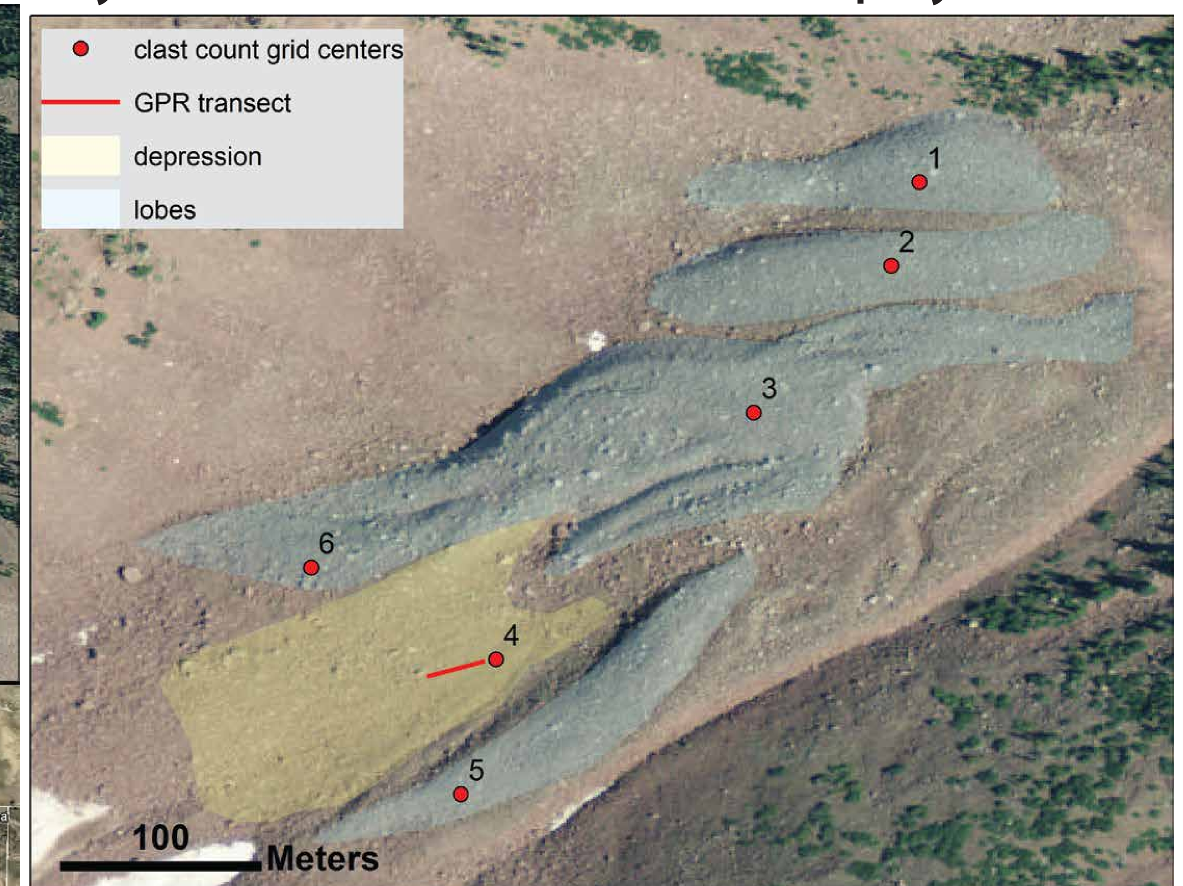

Figure 2: *Geomorphic map of Luigi showing lobe/ridge morphology and the extent of a large central depression in the feature's upper body.*

2) Methods:

- LiDAR scans of Luigi and the surrounding headwall were taken from base points along the south and north side of Luigi, as well as below the toe. Scans were stitched together to produce a high resolution DEM for geomorphic analysis.
- Clast size-distributions were measured in grids on individual lobes and ridges, as well as in the large depression.
- GPR reflection and CMP surveys were acquired at 50MHz frequency over a 24m transect in the large depression.

Table 1: *Clast size distribution summary for each grid.*

Grid	long axis mean (cm)	short axis mean (cm)	long st dev (cm)	short st dev (cm)
1-1	38.3	14.8	29.0	11.8
2-1	49.2	18.8	28.4	12.5
3-1	31.4	11.4	24.3	9.3
4-1 loose	3.3	1.1	2.4	1.1
4-1 embedded	13.8	6.8	5.7	2.8
5-1	27.9	10.1	24.5	8.2
6-1	24.5	9.6	22.9	10.0

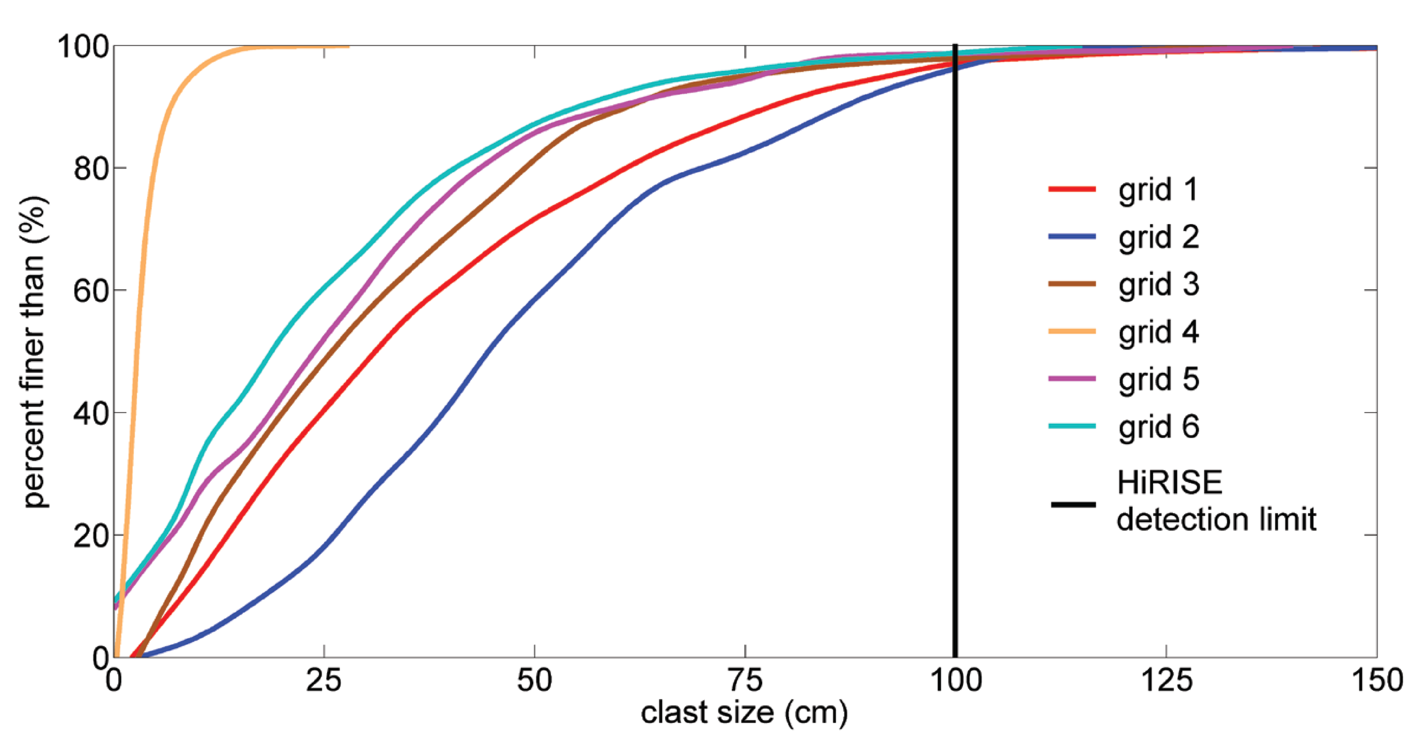

Figure 3: *Cumulative percent curves for the clast sizes measured in each grid. HiRISE detection defined as the length of 4 pixels.*

3) Clast Size Distribution Results:

- Clast size distributions revealed that over 90% of the boulders measured in each grid would remain unresolved in HiRISE imagery.
- This could lead to the assumption of a smoother surface than actually exists, and could challenge the current understanding of the atmosphere-buried ice interactions of LDAs, which assume LDAs to be covered with a layer of fine sediment, not boulders [1].

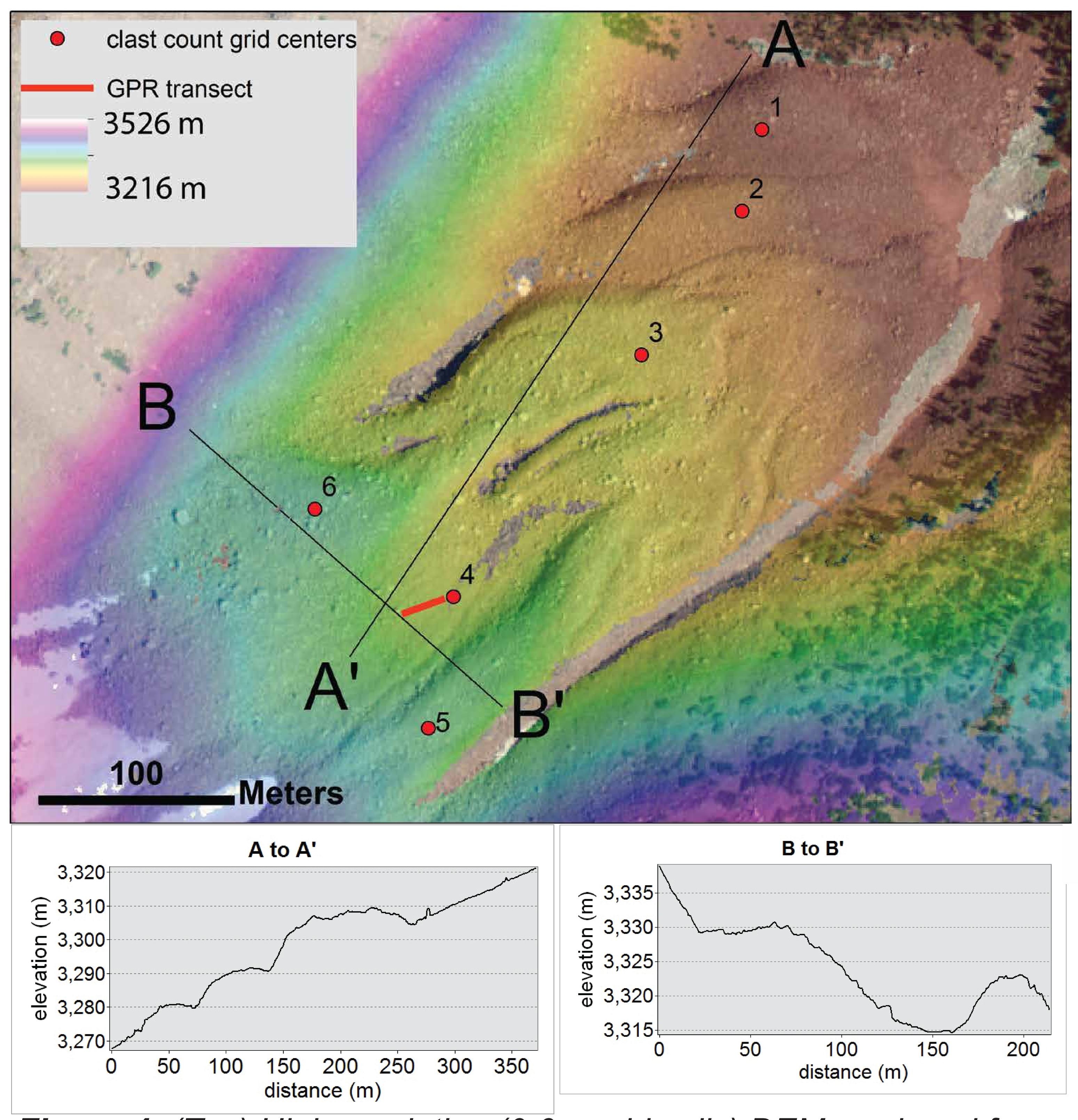

Figure 4: *(Top) High resolution (0.6m grid cells) DEM produced from LiDAR scans overlaid on NAIP imagery. (Bottom) Topographic profiles from A to A' over the lobes and B to B' over the depression (locations indicated above).*

4) LiDAR Results:

- LiDAR scans revealed a topography very similar to that observed on Martian debris-covered glaciers, with distinctive convex-up topography on each lobe.
- The smooth depression shows up very clearly in LiDAR scans.

References: [1] Laabs B. and Carson E. (2005) Uinta Mountain Geology. [2] Leveille R. (2010) Planetary and Space Science 58, 631-638. [3] Holt, J., et al. (2008) Science 322, 1235-1238. [4] Mangold N. (2003) JGR 108.

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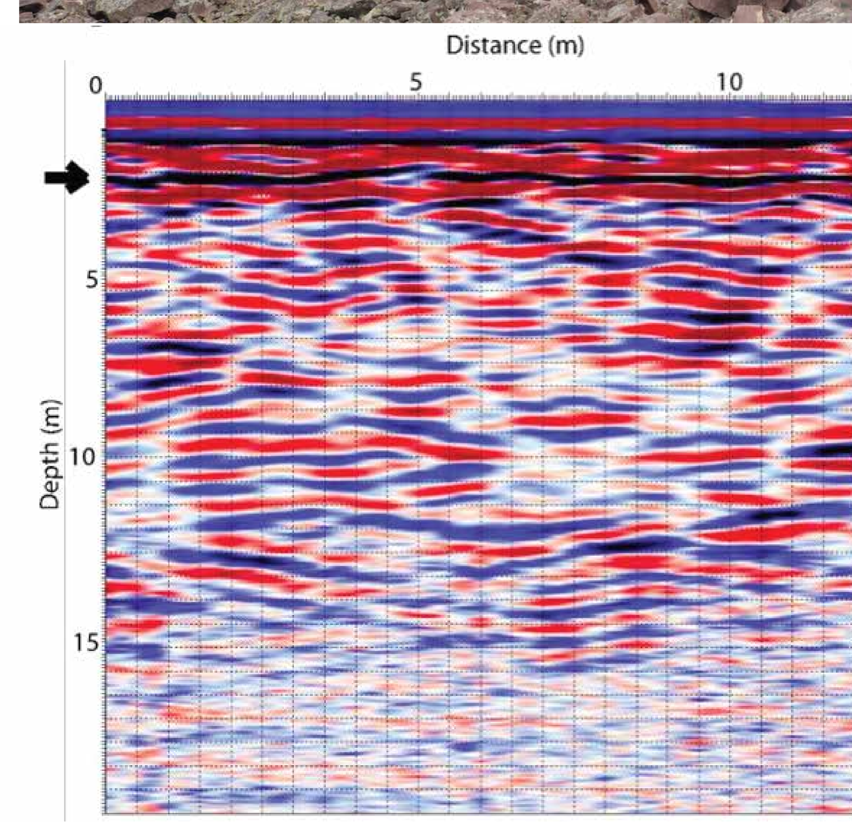

Figure 5: *(Above): photograph of GPR experiment in progress, showing the smooth depression and the boulder-dominated flow-parallel ridge in the background. (To left) radargram converted to depth using results of CMP survey. Location of continuous reflector is indicated by black arrow.*

5) GPR Results:

- A continuous reflector at ~2.5m depth is interpreted as the transition between the fine-clasted depression surface layer to a matrix of boulders entrained in ice or finer clasts
- There is a prominence of point scatterers (boulders) down to about 15m depth in the depression, below which we are unable to confirm or disconfirm the presence of water ice.
- If relatively pure water ice is present below this surface layer, then the thickness of the insulating debris layer is of similar magnitude to that observed in Martian debris-covered glaciers [3].

6) Conclusions:

- Rock and debris-covered glaciers are very difficult to work on.
- The internal ice content of this feature remains unconstrained.
- As a result, it remains unclear how well this particular feature will perform as an analog to Martian debris-covered glaciers.
- Martian debris-covered glaciers may be covered by a loose matrix of boulders, even if they appear smooth in HiRISE.