Reconstructing past glacier extent throughout Lunana, Bhutan

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Introduction

- Himalayan glaciers are rapidly retreating with climate change (1) – major implications for downstream communities.
- A gap exists in understanding Bhutan's glacial history - crucial for understanding contemporary ice loss and Glacier Lake Outburst Flood (GLOF) risk (1).
- Previous work suggests glacier advance and retreat were asynchronous across the Lunana basin, Bhutan Himalayas (2).

Moraines

- Formed through deposition of sediment at glacier terminus or sides (3).
- Provide evidence of past glacier positions (4).
- Dated using relative and absolute age techniques (5).

Study aim:

To quantify the long-term evolution of glaciers in the Lunana region of Bhutan, from the Last Glacial Maximum to present day.

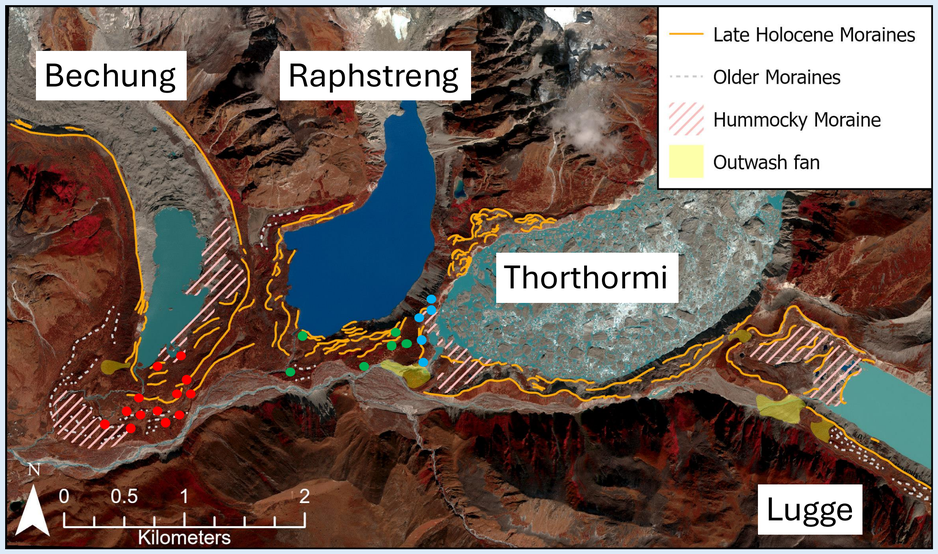

Figure 1: Map of glaciers in the Lunana Basin, Bhutan, annotated with preliminary mapping of moraines and site locations in the field for Bechung, Raphstreng, and Thorthormi glaciers.

Methodology

1. Conduct preliminary mapping of moraines from high resolution satellite imagery before fieldwork.
2. Gather relative dates of moraines in the field using Lichenometric (20 boulders per moraine) and Schmidt hammer dating (25 samples on 10 boulders per moraine).
3. Collect samples in the field for Optically Stimulated Luminescence (OSL) dating to provide absolute ages.

Issues in the field

- Due to the inaccessibility of moraines, data collection was limited.
- Lichens were either dead or yet to colonize boulders.
- Could not collect OSL samples due to issues with sampling methods and lost equipment.
- Illness limited data collection – remote fieldwork with time constraints.

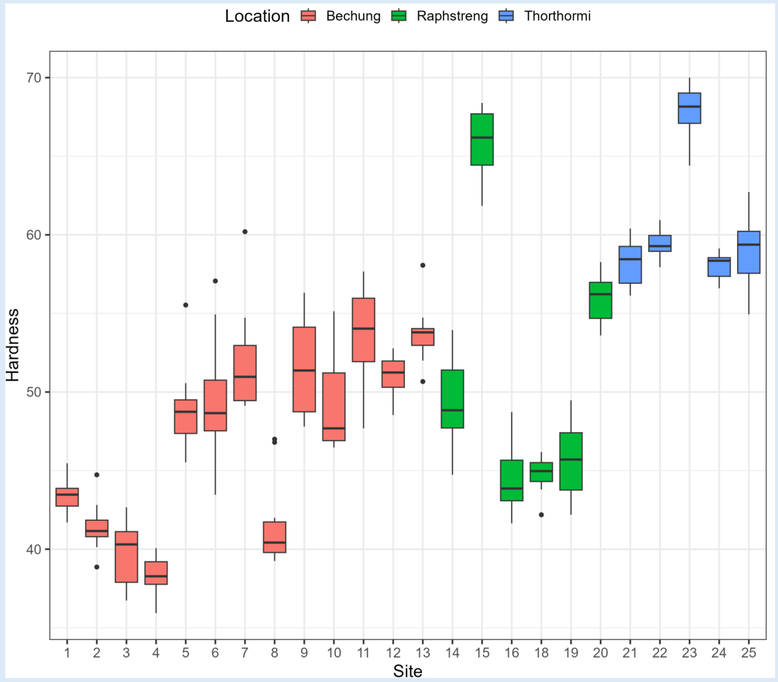

Figure 2: Boxplot of average rock hardness at 25 sites (site 17 not included) across the moraine complexes of Bechung, Raphstreng, and Thorthormi, locations displayed in figure 1.

Location	P-value (p<0.05)
Bechung - Raphstreng	0.0003
Bechung - Thorthormi	0.0000
Raphstreng - Thorthormi	0.0000

Table 1: Statistical analysis of rock hardness at the three glaciers, using a Tukey's test in Rstudio. Significant values highlighted in green.

Results

- Rock hardness is significantly different on moraines of the three glaciers, p-values<0.05 (Table 1).
- Softest boulders were found on Bechung moraines, approx. 36-60.
- Hardest boulders were found on Thorthormi moraines, approx. 55-70.
- Boulders are softer on moraines further away from the glaciers, evident at Bechung and Raphstreng (Sites 1-4, 8, 14, 16-19).

References

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Discussion

- Older moraines often have softer boulders, like at Bechung, due to increased weathering with prolonged exposure since glacier retreat (6).
- Different stages of glacier retreat and standstill evident for Bechung and Raphstreng indicated by decreasing rock hardness values on large moraines with increased distance from glaciers.
- Clear differences in rock hardness of moraines for each of the three glaciers; proving asynchronous retreat theory (2).
- Rock hardness values indicates that Bechung retreat occurred much longer ago than Raphstreng and Thorthormi, with Thorthormi displaying hardest rocks suggesting that retreat occurred more recently.

Next steps

I. Attempt to roughly date moraine complex using a rock hardness age curve specific to Bhutan granite (if one exists).
II. Create a geomorphological map of the Lunana basin.

Figure 3: Pictures taken in the field of Raphstreng glacier and its glacier lake (left) and of Bechung forefields with Lunana valley in the background (right). Credit: Niamh Hope.

Conclusions

- Climate change has caused significant glacier retreat across the Lunana basin.
- Lunana glaciers are responding to climate warming at different rates.
- Understanding Lunana glacier dynamics in the past is crucial for predicting future change and assessing GLOF risk with the expansion of glacier lakes with retreat.

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