Quantifying Ventifact Erosion Rates in California Using OSL Depth Profile Analysis

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Introduction

Ventifacts, which are rock formations abraded by wind-driven sand in arid regions, illustrate how wind erosion shapes Earth's surface and can quantify long-term aeolian erosion rate. However, few studies have reported measurements of the underlying erosion rates responsible for forming ventifacts. This study aims to provide luminescence rock surface erosion rate estimates for ten ventifacts at two locations in southern California, Silver Lake and Garnet Hill.

Sunlight penetration into rocks has an absorption mean free path of mm, meaning luminescence-depth profiles are expected to be ~2 orders of magnitude more sensitive to the effect of erosion compared to cosmogenic radionuclide measurements, which have an absorption mean free path of ~50 cm (Sohbati et al., 2018).

OSL signals in quartz and feldspar crystals accumulate in response to ionizing background radiation naturally present in all rocks, and diminish in response to sunlight exposure. When a bedrock surface is initially exposed to sunlight, luminescence signals in the uppermost few cm begin to reset at exponentially slower rates as depth increases. If the rock surface erodes, the equilibrium depth will move closer to the surface (Sohbati et al., 2018).

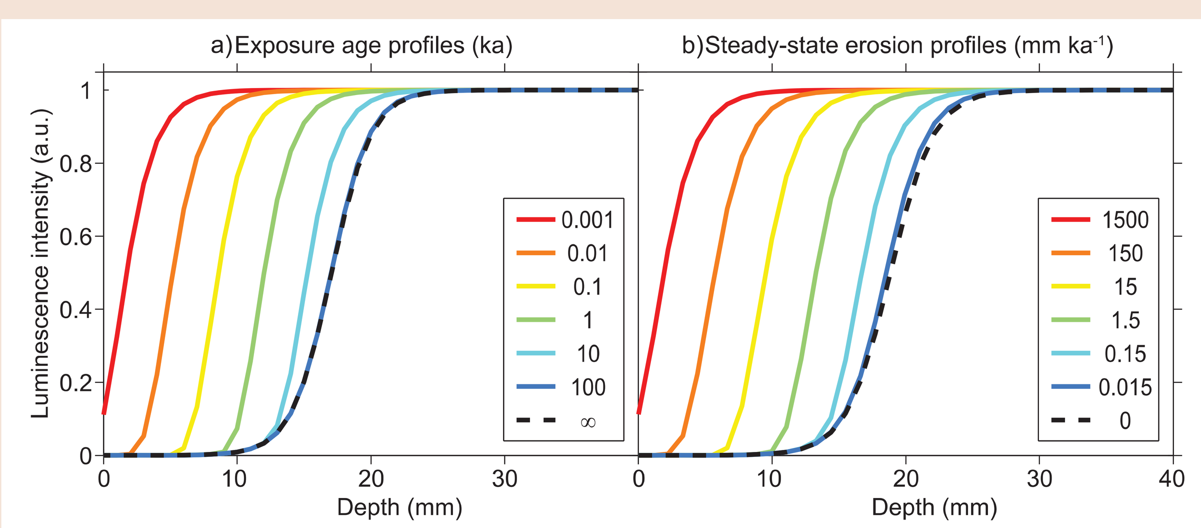

Figure 1: Model luminescence-depth profile for (a) an exposed and (b) an eroding rock surface (Sohbati et al 2018).

Field Sites

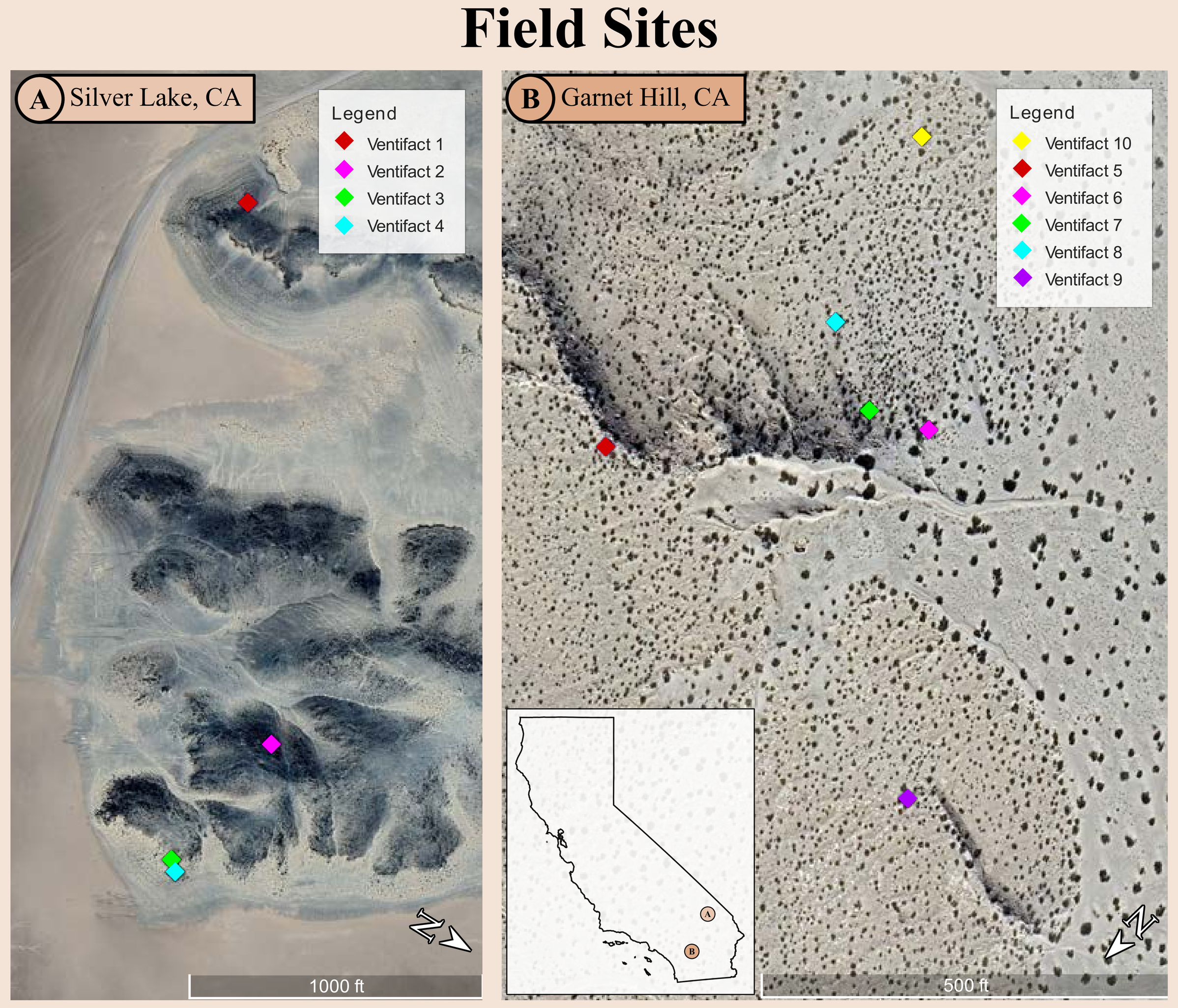

Figure 2: (a) Silver Lake and (b) Garnet Hill field sites in southern CA.

Ventifact 4 Results

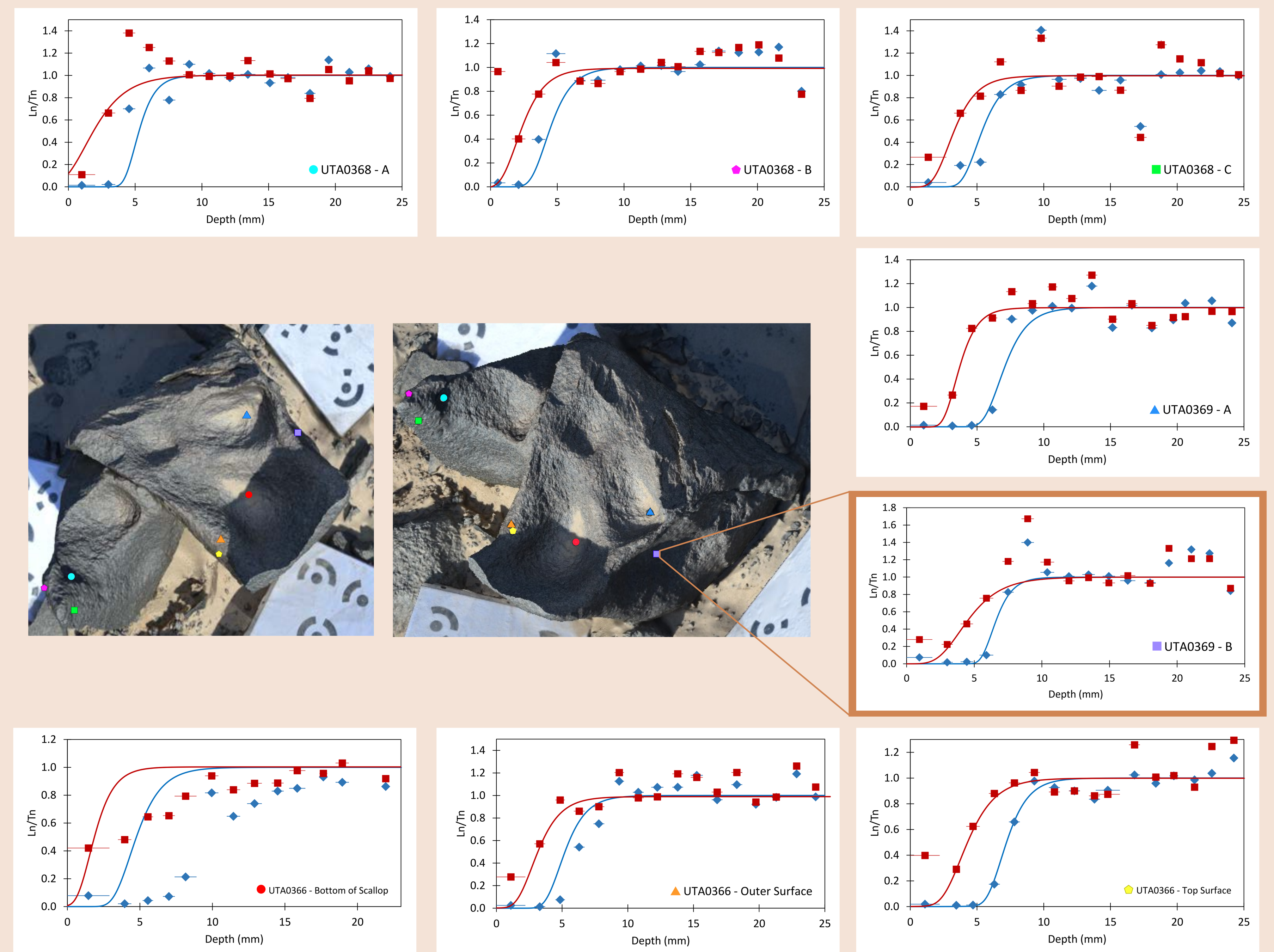

Figure 3: IR_{50} (blue diamonds) and $pIRIR_{225}$ (red squares) luminescence depth profiles from 4 rock core samples taken from ventifact 4 at Silver Lake site.

Ventifact 7 Results

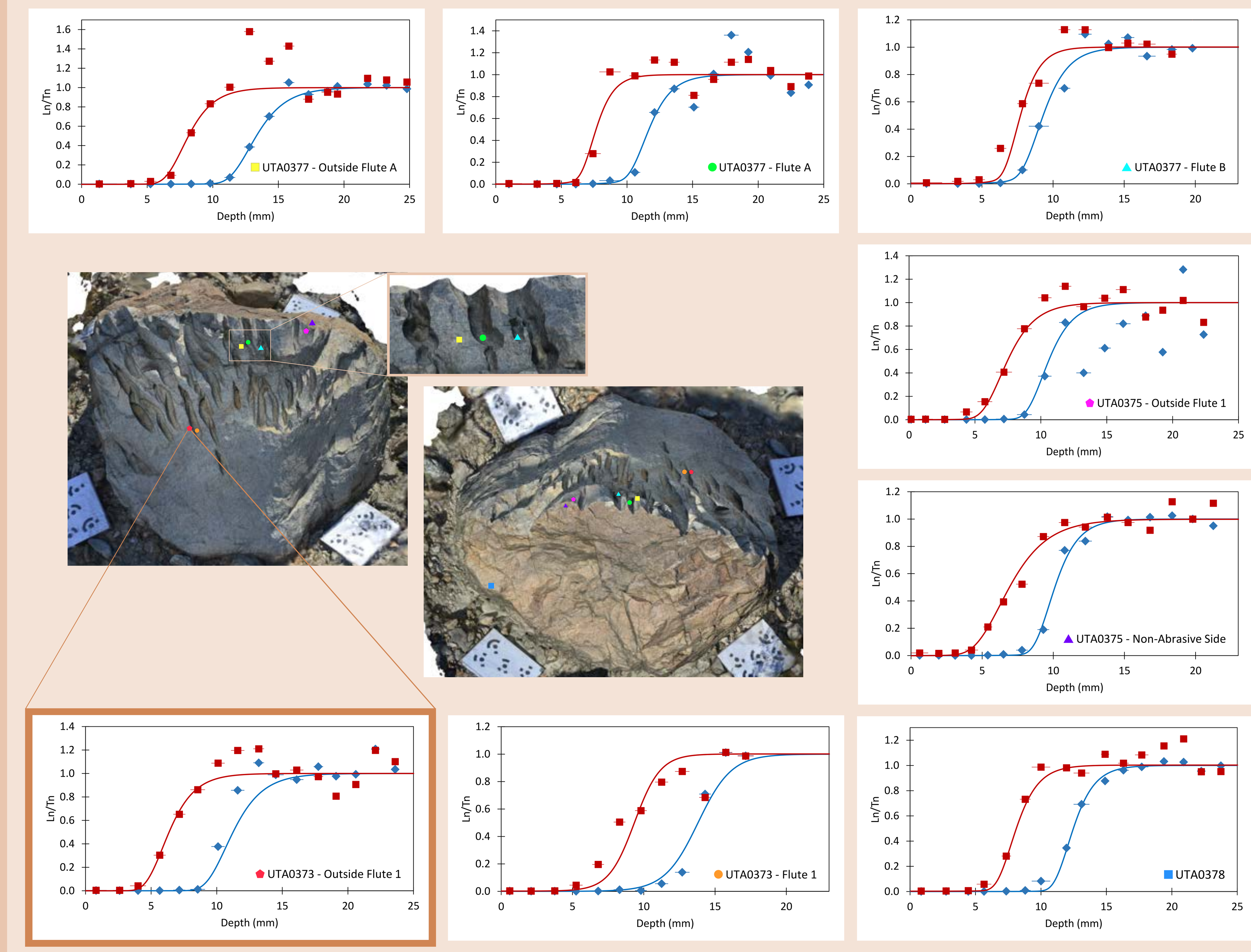

Figure 4: IR_{50} (blue diamonds) and $pIRIR_{225}$ (red squares) luminescence depth profiles from 4 rock core samples taken from ventifact 7 at Garnet Hill site.

Observations

There is no strong contrast in erosion rates: within flute and outside flute; within scallop and outside scallop; or abrading and non-abrading surfaces. Ventifacts are likely not active within the averaging timescale of luminescence signal, probably decades to millennia.

Rock Hardness and Depth of Bleaching

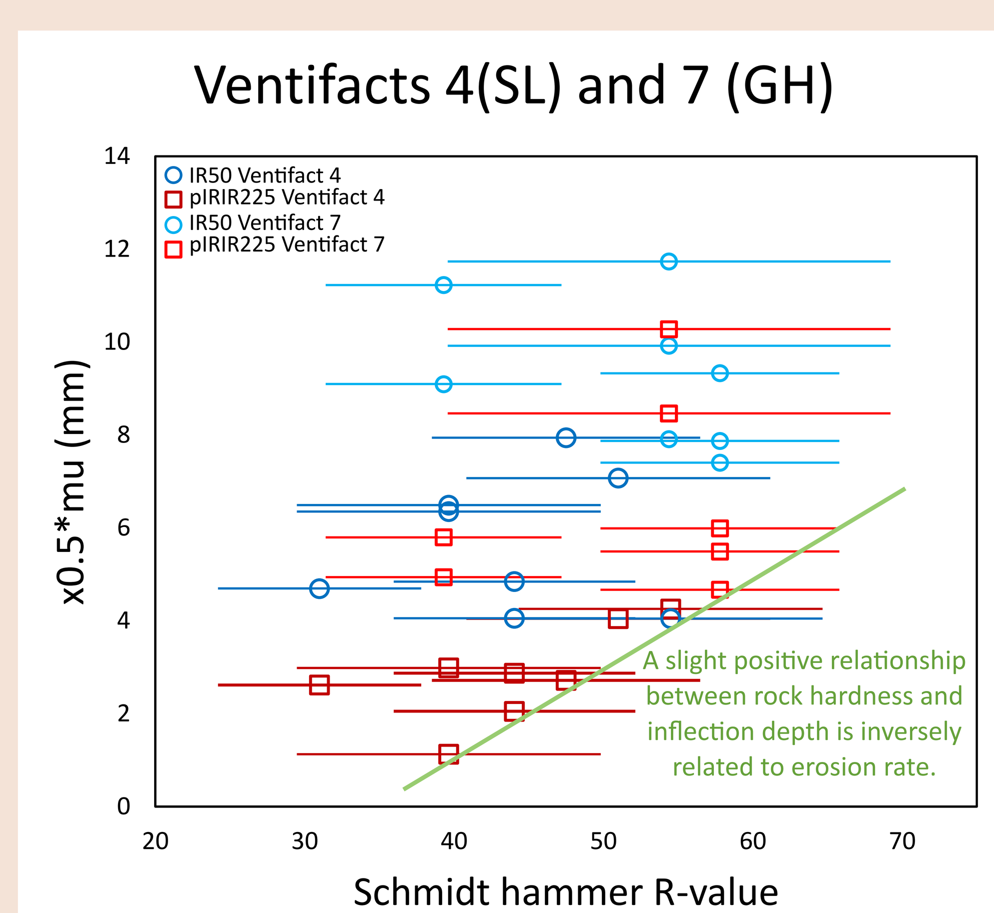

Figure 5: Possble trend between rock hardness and normalized inflection depth for ventifacts 4 (SL) and 7 (GH).

Figure 6: Normalized inflection depth profiles of IR50 and post-IRIR225 for ventifacts 4 (SL) and 7 (GH) categorized by feature type.

Future Work

1. Obtain ten IRSL and post-IR IRSL depth profiles from wafered rock cores, along with ten IRPL depth profiles from surface-perpendicular rock slabs, to estimate mm-scale erosion rates for each of the ten sampled ventifacts.
2. Create a sub-mm-resolution 3D model using structure-from-motion techniques.
3. Conduct a detailed survey of ventifact characteristics (hardness, dimensions).
4. Perform in-situ cosmogenic ^{14}C, ^{10}Be, and ^{26}Al measurements to estimate exposure duration and decimeter-scale erosion rates.
5. Develop a manual erosion rate experiment.

References and Acknowledgements

Sohbati, R., Liu, J., Jain, M., Murray, A.S., Egholm, D.L., Paris, R.B., & Guralnik, B. (2018). Centennial- to millennial-scale hard rock erosin rates deduced from luminescence-depth profiles. *Earth and Planetary Science Letters*.

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