

# Thermal Regimes of Periglacial Talus Landforms; Complex Micro-Climatic Processes in the Sierra Nevada, California

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Fig 1. Periglacial talus field



Fig 2. American pika and pika haypile in typical talus setting

## BACKGROUND

Talus fields are hillslope landforms comprising coarse fragmented rock. Many talus fields have periglacial origins, forming in situ during cold arid periods as bedrock is exposed and freeze-thaw processes erode substrates. Interaction with ground ice creates distinctive landform structures of even-sized, sorted clasts having open matrices and abrupt margins (Fig 1). Studies in the Arctic and Alps are beginning to elucidate autonomous internal thermal regimes of talus that appear decoupled from adjacent free-air circulation. Taluses are known to depress permafrost elevations as much as 1000m and retain underlying ice despite high air temperatures over the talus. These landforms are little studied for their importance as hydrologic reserves. Taluses are inhabited by thermally sensitive American pika (*Ochotona princeps*), a non-hibernating lagomorph species dependent on talus for habitat. Pika collect forage in haypiles where they spend considerable time in summer and winter (Fig 2). Understanding thermal regimes of talus is key to assessing the status of pika under future global warming scenarios.

## OBJECTIVES

- Investigate seasonal thermal regimes of periglacial-derived talus fields in the eastern Sierra Nevada
- Investigate thermal conditions at pika haypile talus sites

## METHODS

### 1) Intensive Talus Study

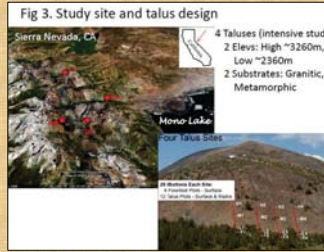
The study area is in the eastern Sierra Nevada (ESN), Mono County, CA (Fig 3). Four talus sites were selected on S-facing slopes, two each at low and high elevations. At each elevation, one talus is dark metamorphic substrate; the other is light granitic substrate.

At each talus, 28 thermochrons (Maxim iButtons) were deployed in early summer 2009, distributed along four transects upslope. Pairs of iButtons were located on the talus surface and 1m below the surface (rock matrix) at low-, mid-, and high elevation plots along each transect. An iButton was also placed on the forefield ground adjacent to each transect (Fig 3).

iButtons were programmed to record temperatures hourly through summer 2009. We retrieved data in Sept 2009 and re-programmed iButtons to record 4-hr intervals through winter 2009-2010. We retrieved winter data from the two low elevation sites in late May 2010.

### 2) Haypile Study

Pairs of iButtons were deployed in late summer 2009 at pika haypiles on 26 taluses from diverse elevations, aspects, and substrates in the ESN. One iButton was placed at the haypile (talus surface) and another 1m below in the talus matrix. These were programmed for 4-hr intervals; iButtons were retrieved from 10 sites in late May 2010.

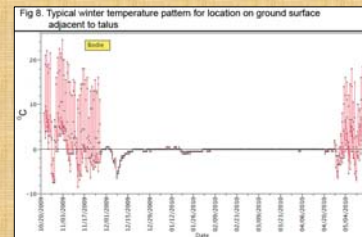
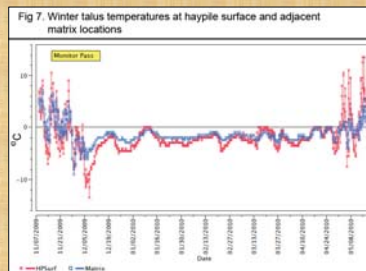
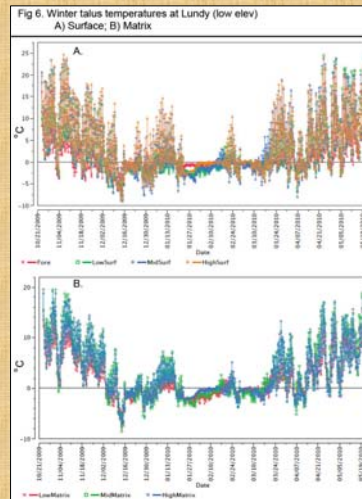
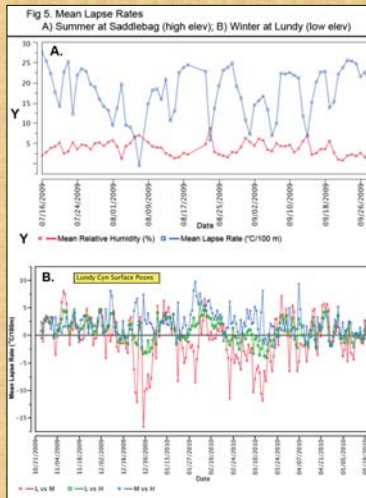
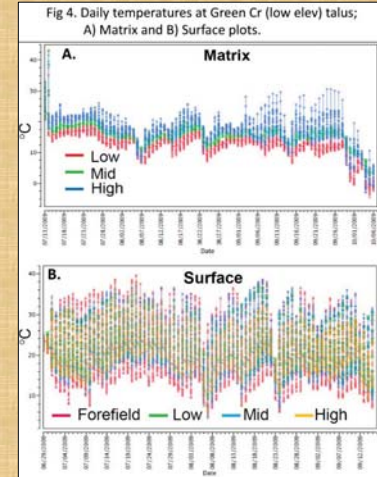


**Tbl 1. Summer mean talus temperatures °C (high & low elev taluses)**

	Surface	SD	Matrix	SD
Low Meta	22.4	5.3	20.5	2.5
Low Granitic	18.2	3.4	15.2	1.2
High Meta	16.1	4.2	13.9	2.2
High Granitic	14.9	4.0	12.7	1.4

**Tbl 2. Winter mean talus temperatures °C (low taluses only)**

	Surface	SD	Matrix	SD
Meta	2.7	0.6	2.6	0.7
Granitic	0.2	0.8	-0.1	0.8



## RESULTS

### 1) Intensive Talus Study

#### Summer

Matrix temperatures were significantly colder than talus surface temperatures (Tbl 1).

Matrix daily temperature fluctuations were significantly greater than at surface locations (Fig 4).

Temperatures were coldest at locations low in the talus slope (surface and matrix); strong positive lapse rates developed, to 30°C/100m. Lapse rates were negative or zero on days of high humidity (Fig 5a).

Surface temperatures were significantly warmer on dark metamorphic substrates than on light granitic substrates at both elevations; substrate was not a significant factor in matrix temperature differences.

Maximum talus surface temperatures commonly exceeded 40°C (low elev) and 32°C (high elev); maximum temperatures of talus basal matrices were 25°C (low elev) and 18°C (high elev).

#### Winter (low elevation sites only)

Winter matrix temperatures were consistently but non-significantly colder than talus surface temperatures (Tbl 2).

Daily talus temperature fluctuations of surface and matrix locations at one site suggest either frequent snow-free conditions or air movement through snow (Fig 6). The other site indicated snow coverage with flat-line temperatures near 0°C much of winter.

Lapse rates in winter were much different than rates in summer. Complex patterns of positive and negative rates developed, with different patterns at the surface versus matrix and differences over the course of winter (Fig 5b).

Talus temperatures (surface and matrix) during mid-winter ranged between 0°C and -5.0°C; minimum temperatures occurred in late fall (likely prior to snow coverage?) and reached -19°C.

### 2) Haypile Study

#### Winter

Unlike patterns in the main talus study, talus surface temperatures at haypiles were significantly colder than matrix locations below haypiles (Fig 7). Minimum surface temperatures were colder than -10°C multiple times during winter.

Matrix daily temperatures fluctuated significantly less than adjacent surface haypile temperatures and rarely were colder than -2°C (Fig 7).

Daily fluctuations and winter temperatures lower than -2°C of matrix and surface suggest that either cold air circulates from the outside atmosphere through snow, ventilates within the open matrix, or that the sites remain snow-free through winter. This pattern contrasts with flat-line 0°C records for locations off-talus where iButtons were placed on the ground surface (Fig 8).

## CONCLUSIONS

- Talus thermal regimes are complex, appear to be distinct from off-talus climatic conditions, and are influenced by internal dynamics of rock-matrix structure and talus ventilation.
- Talus matrices provide cool summer refugia for pika despite surface temperatures higher than lethal maxima. Haypile sites are thermally atypical for talus, and appear to be located where adjacent matrices are warm in winter.
- Previous work that indicated persistence of water flow through taluses combined with current results on thermal regimes suggest that taluses are important hydrologic reservoirs.

## REFERENCES

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