ICE-CORED MORAINES MAY PRESERVE CLIMATE HISTORY IN THEIR STRATIGRAPHY: A MARS ANALOG STUDY AT GALENA CREEK ROCK GLACIER

E. I. Petersen[1], J. W. Holt[1], J. S. Levy[1], and C. S. Stuurman[1] [1]Institute for Geophysics, University of Texas at Austin, Austin TX (eric_petersen@utexas.edu),[2]Jackson School of Geosciences, University of Texas at Austin

Introduction: Galena Creek Rock Glacier (GCRG), Wyoming, has been shown in previous studies to be a debris-covered glacier [1-3] and is thus a target of interest as an analog to ice-rich viscous flow features on Mars [4].

A number of studies of debris-covered glaciers on Earth [5] and Mars [6] have sought to understand the relationships between surface morphology, internal structure, and ice accumulation history with the goal of gleaning climate information from morphologic observations.

We advance this goal by reporting on geophysical observations of the internal structure of GCRG. This work reveals a stratigraphy of debris-bounded ice units which may record climate history, and has a surface expression of flow-transverse ridges.

Study Site: GCRG flows out of a north-facing cirque in the Absaroka Mountains, Wyoming and is composed of a number of overlapping lobes of different ages. The youngest lobe, which comprises the upper 2/3 of GCRG and is at least 2000 years old [7], is known to be composed of relatively pure glacial ice underneath a surface debris layer 1-1.5m thick [2]. The debris layer is composed of cobbles and boulders weathered from andesitic headwall bedrock.

A previous geomorphic study identified lateral ice-cored moraines extending from the accumulation zone to mid-glacier as markers of episodic ice accumulation [3].

Methods: Airborne photogrammetry undertaken in November 2016 to produce a high resolution orthophoto and digital terrain model. The DTM is used to correct GPR data for topography and, when repeat datasets become available, will be used for high-resolution surface velocity mapping.

Ground-penetrating radar (GPR) data was collected in 12 reflection surveys and 1 common-midpoint survey across the surface of GCRG. Seven of the reflection surveys and the common-midpoint survey were conducted in the high cirque of the glacier, near snowfields that may comprise the current extent of the accumulation zone.

Additional observations were made of a thermokarst feature discovered during August 2015 field work that revealed the stratigraphy and composition of the upper several meters of GCRG.

Results: Observations of the thermokarst exposure (see Fig. 2) revealed a roughly 50 cm thick englacial debris band intersecting the surface at an up-glacier dip of roughly 30° in association with a subtle surface ridge.

GPR imaged a number of candidates for debris bands in reflectors that similarly intersect the surface at up-

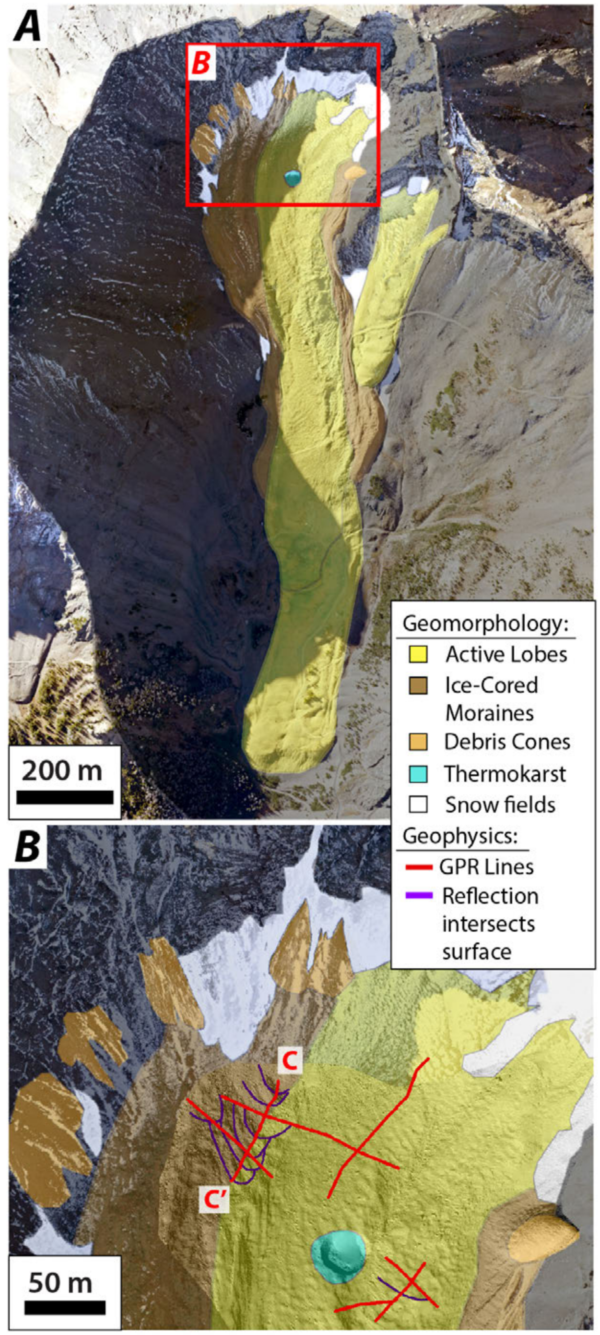

Figure 1: *(A) Geomorphic Map of GCRG reworked from [3] and overlain on aerial photography. (B) Detail of GCRG cirque region. The surface intersection of subsurface reflections in GPR are mapped and interpolated, showing that stratigraphic units are concentrated at the border of the active lobe and ice-cored moraines.*

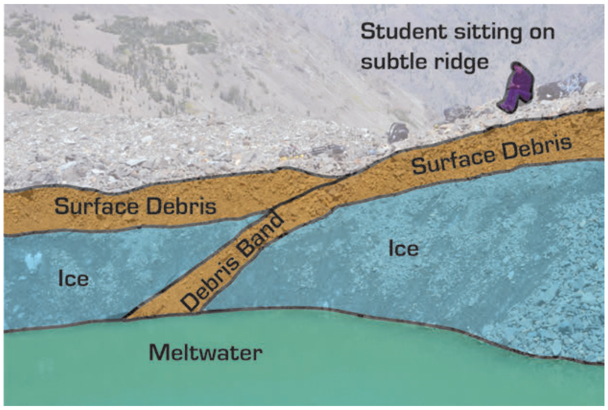

Figure 2: *Image of thermokarst exposure of GCRG's near-subsurface, found in association with a meltwater pond. Under a dry surface debris layer 1.5 m thick is relatively pure glacial ice, superficially soiled with debris that has fallen over its ablating surface. A roughly 50-cm-thick englacial debris band is found intersecting the surface near a subtle ridge at an up-glacier dip of roughly 30°.*

glacier dips of 25-35°. Nearly all of these reflectors were imaged near the border of or within ice-cored moraines mapped by [3] (Fig 3).

GPR reflectors form a complex, localized nested-spoons architecture in the ice-cored moraine on the east side of GCRG's cirque (see mapped intersection of reflectors with surface in Fig 1). This architecture ends near the mapped border of the moraines; the centerline of GCRG lacks any strong reflectors as candidates for englacial debris bands.

The common mid-point survey acquired over the ice-cored moraine produced subsurface radar velocities of 0.15-0.17 m/ns, most consistent with a composition of relatively pure ice.

Discussion and Conclusion: We interpret the reflectors imaged in GPR under the mapped ice-cored moraines as englacial debris bands with thicknesses <1 m and the units between them as pure ice bodies. The nested spoons stratigraphy may record (1) alternating periods of net ice and net debris accumulation or (2) episodes of debris-facilitated ice accumulation. Because the ice-cored moraine has accumulated and flowed at a much slower rate than the centerline of GCRG [2], this stratigraphy is likely to preserve a climate history older than the 2000 year age of the young lobe.

The moraine stratigraphy is additionally associated with flow-transverse surface ridges similar in appearance to those observed on Martian glacial-like forms [8]. Ongoing work by [9] seeks to identify the morphologic differences between glacial ridges associated with internal structure vs. those initiated by buckle-folding of debris.

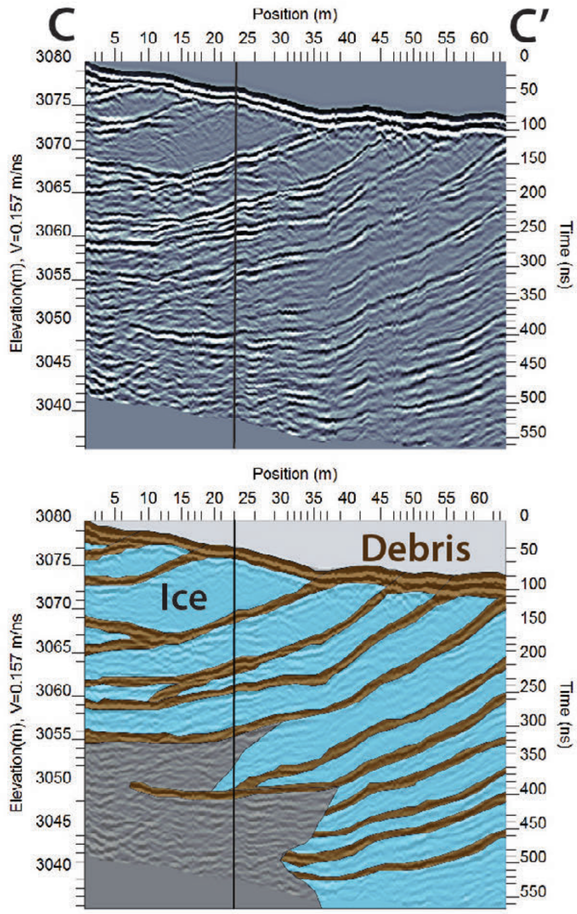

Figure 3: *Reflection radargram at 100MHz acquired near the mapped border of active rock glacier and ice-cored moraines [3]. Up-glacier reflectors intersect the surface near subtle ridges at up-glacier dips of 25-30°. By analogy with the thermokarst observations they are interpreted as englacial debris bands bounding ice units.*

This work illustrates that future study of ridges on Martian glaciers will lead to the identification of sites that will yield a wealth of glaciological and climate information to future missions and instruments.

References: [1] Potter (1972), GSA Bulletin 83(10), 3025-3058, [2] Potter Jr., et al. (1998), Geog. Annaler: Series A, Phys. Geog. 80(3-4), 251-265, [3] Ackert, Jr. (1998), Geog. Annaler: Series A, Phys. Geog. 80(3-4), 267-276, [4] Souness and Hubbard (2012), Progress in Phys. Geog. 36(2), 238-261, [5] MacKay et al. (2014), JGR: Earth Surface 119(11), 2505-2540, [6] Grindrod and Fawcett (2011), GRL 38(19), [7] Clark et al. (1996), EOS Trans. AGU 77(23), 217-222, [8] Hubbard et al. (2014), The Cryosphere 8(6), 2047-2061, [9] Stuurman et al. (2017), LPSC #2740.