Glacial Geomorphology of the Pensacola Mountains, Weddell Sea Sector, Antarctica

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Abstract

We mapped glacial geologic features in the Thomas, Schmidt, and Williams Hills in the western Pensacola Mountains (Figure 1). The three nunatak ranges are adjacent to Foundation Ice Stream (FIS), which drains ice from the East and West Antarctic Ice Sheets (EAIS and WAIS), into the Filchner-Ronne Ice Shelf. Glacial deposits in the Pensacola Mountains record changes in the thickness of FIS and provide insight into ice sheet history. Glacial striations oriented transverse to topography on nunatak summits indicate (a) the presence of warm-based ice (b) that ice was thick enough to flow unconstrained over topography, and (c) suggest increased contribution from the EAIS. Preserved deposits with varying weathering extents indicate multiple periods of advance of cold-based ice. Preliminary numerical modeling of ice surfaces in the Thomas Hills suggest elevation changes could be attributed to local variations in ablation in addition to surface elevation changes in FIS.

Results

GEOMORPHIC FEATURES ON EXPOSED NUNATAKS

Schmidt and Williams Hills (Figures 2,3, and 4):

- Depositional landforms are sparse with occasional highly weathered erratics found over 100 m above the modern ice surface and relatively unweathered erratics deposited beside them below 100 m.
- Thin bedrock ridges lead to steep frost heaved slopes. Downhill from frost-heaved slopes elevation gradients lessen as patterned ground appears. Patterned ground is more developed at higher elevations, ice margins show little to no development of patterned ground.

Thomas Hills (Figure 5):

- A highly-weathered till is present at all elevations; this deposit (a) contains lots of clay, (b) has a highly-oxidized surface layer, and (c) includes highly-weathered surface boulders. This till is sparsely covered at a range of elevations by erratics with different degrees of weathering.
- At low elevations, greater depositional volume is observed in preserved moraines and relatively unweathered till that indicate multiple ice surfaces 20 - 100 m higher than today; these features likely post-date the last glacial maximum.

MULTIPLE SETS OF STRIATIONS

Schmidt Hills: At an elevation of 290 m above the present day ice surface, a set of striations were found on Mount Nervo, transverse to the hills. No Name Nunatak has two sets of striations in a crosscutting relationship. One set was oriented at 300°, the other crosscutting at 240°. The last set was found on the northern flank of Point 700, oriented at 230° (Figure 2).

Williams Hills: One set of striations, oriented at 280-290, is located on Teeny Rock, °; the other set, oriented at 305-310°, is located on Pillow Knob, (Figure 3).

Thomas Hills: Striations oriented 320-360 ° are found at all elevations in the Thomas Hills. Striations oriented at 280-270 ° are found at elevations less than 200 m above the present ice surface, and truncate the 320-360 ° striations. (Figure 5).

TALLEST PEAKS HAVE SCOURED SURFACES

Glacial scour on Mount Hobbs, Williams Hills suggests maximum ice thickness was at least 562 m greater than today and striations atop Martin Peak, Thomas Hills suggest ice there was at least 675 m thicker (Figure 2,3, and 5).

Acknowledgements

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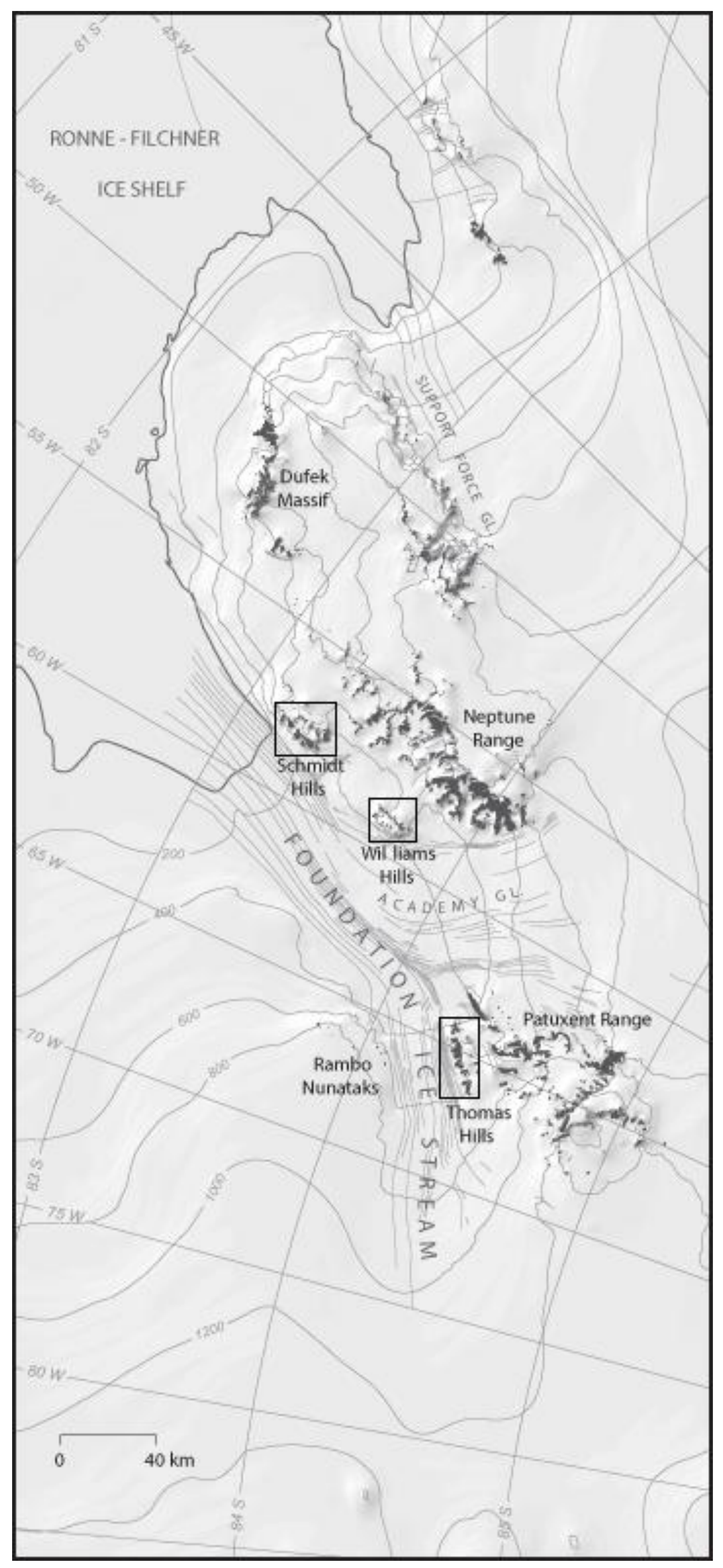

Figure 1. Regional map showing field areas in the Pensacola Mountains and Foundation Ice Stream

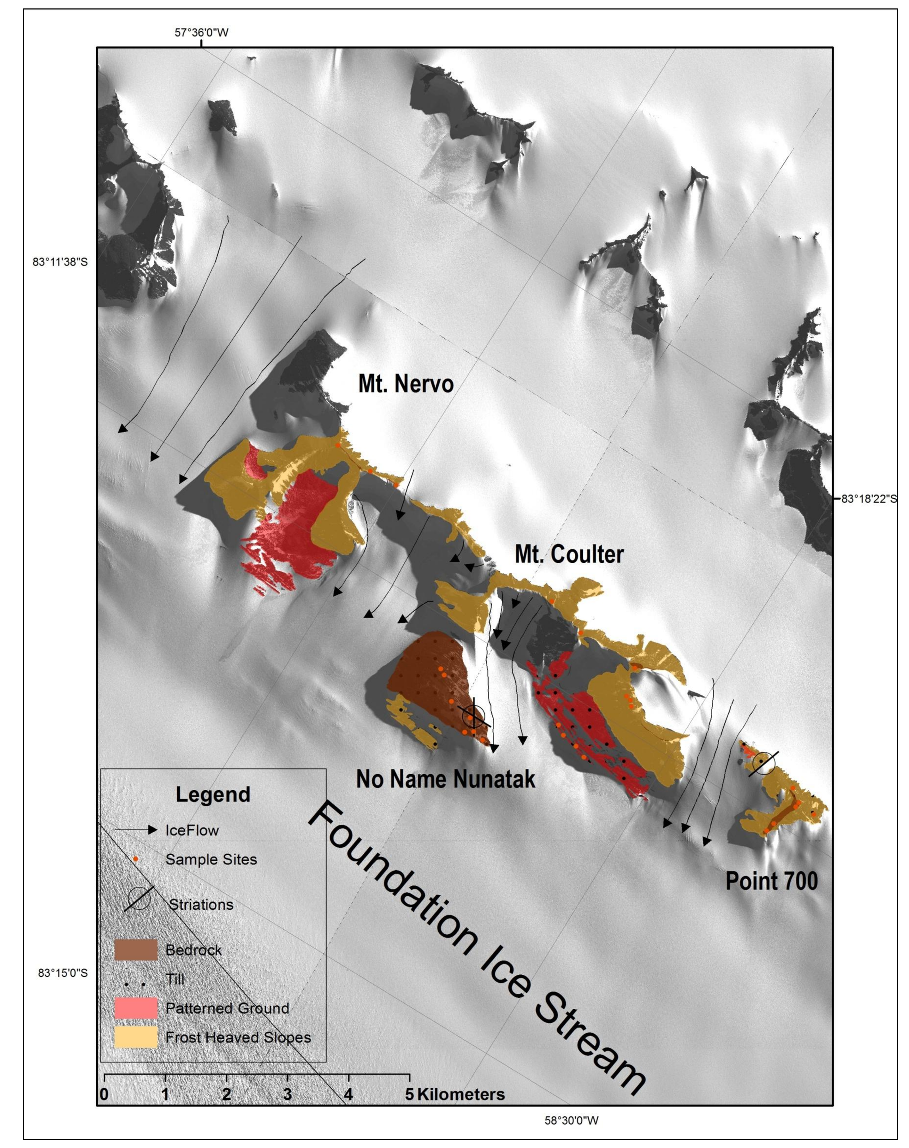

Figure 2. Glacial geologic map of the **Schmidt Hills**.

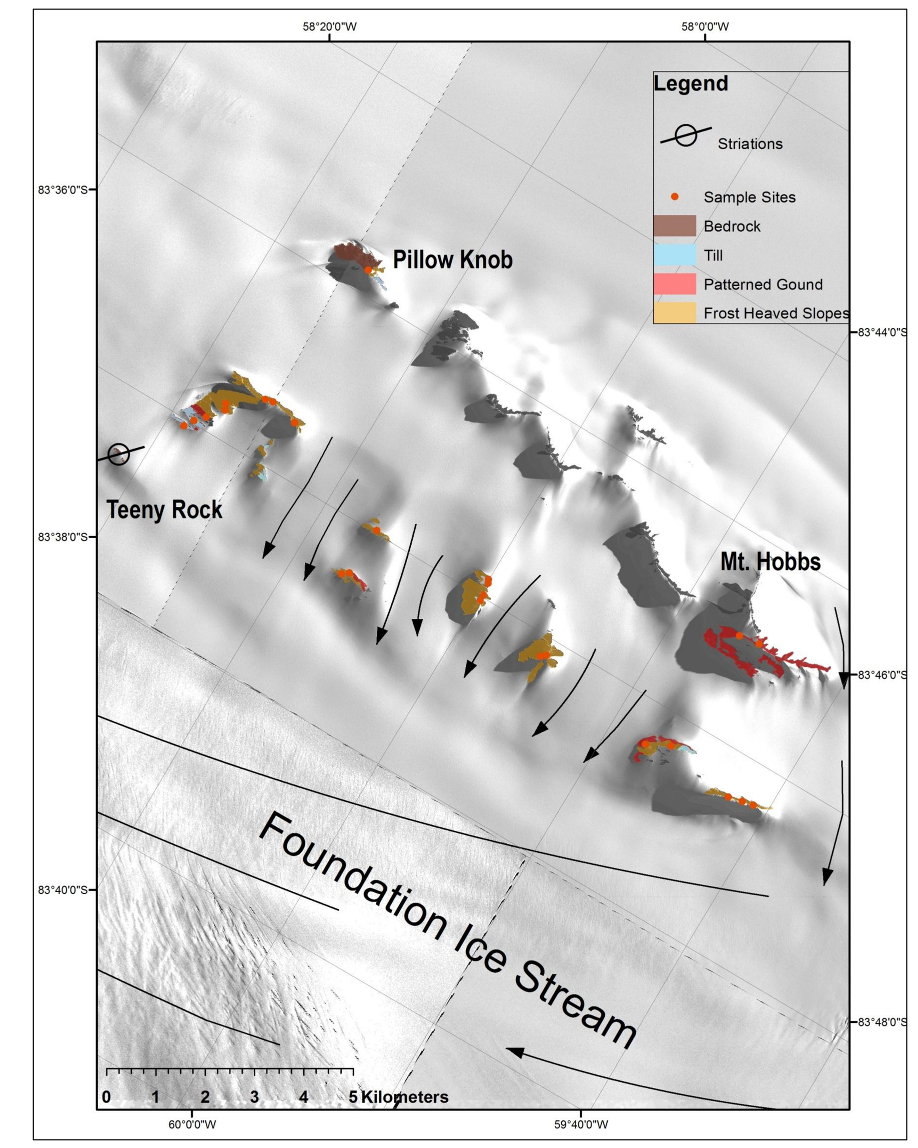

Figure 3. Glacial geologic map of the **Williams Hills**.

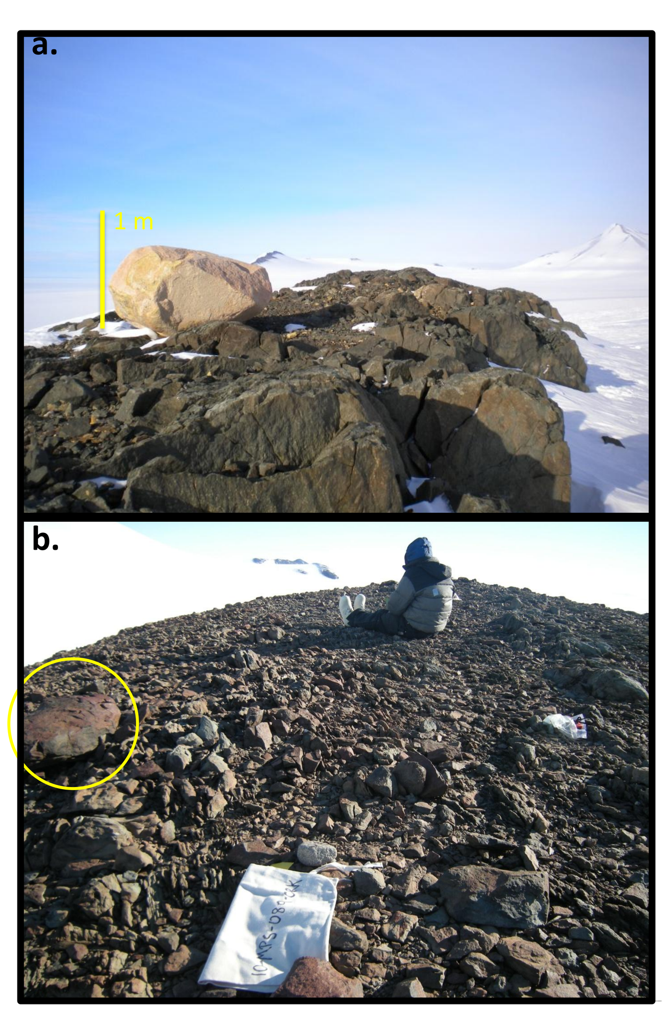

Figure 4. a) an unweathered erratic, exposed just above the ice level, and b) a weathered erratic with a flaking rind, representing long periods of exposure in periglacial regimes.

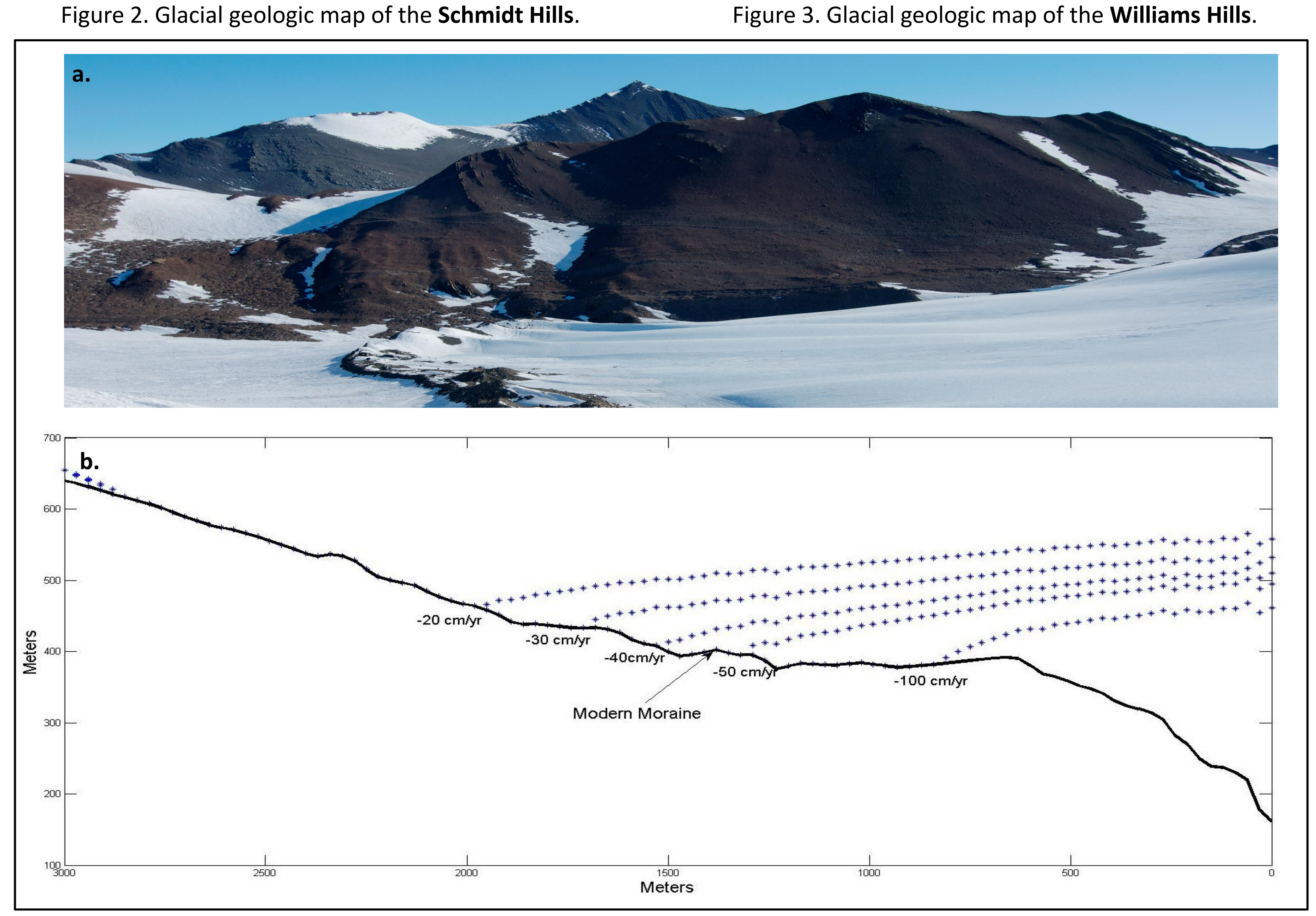

Figure 6. a) Thomas Hills moraine sequence, and b) ice-surface profiles calculated with different ablation rates.

Numerical Modeling

We used a glacier flowline model to determine whether lowering of blue ice lobes documented by Thomas Hills moraine sequences can be driven by changes in ablation rates, or requires changes in FIS. The model uses the finite difference method, divides the glacier profile into nodes at 5-meter intervals, and records the average ice thickness at each node given values for both prescribed and fundamental input parameters. Prescribed input parameters include the bed topography and the length of time represented by the model run. Bed topography was measured from 1-2 km ice-penetrating radar profiles of ice lobes using a 100 mHz antenna. The flowline ablation model defines the glacier toe condition as the point beyond which there is no ice flux. Mass contribution from FIS is simulated by an accumulation rate applied to the first node of the model domain. An ablation rate is then applied to the rest of the model domain, simulating wind ablation in the Thomas Hills. Using Glen's flow law and the shallow ice approximation, the model calculates surface slope, ice thickness, velocity, and volume flux over the glacier profile. Figure 6 shows calculated ice surfaces resulting from different ablation rates.

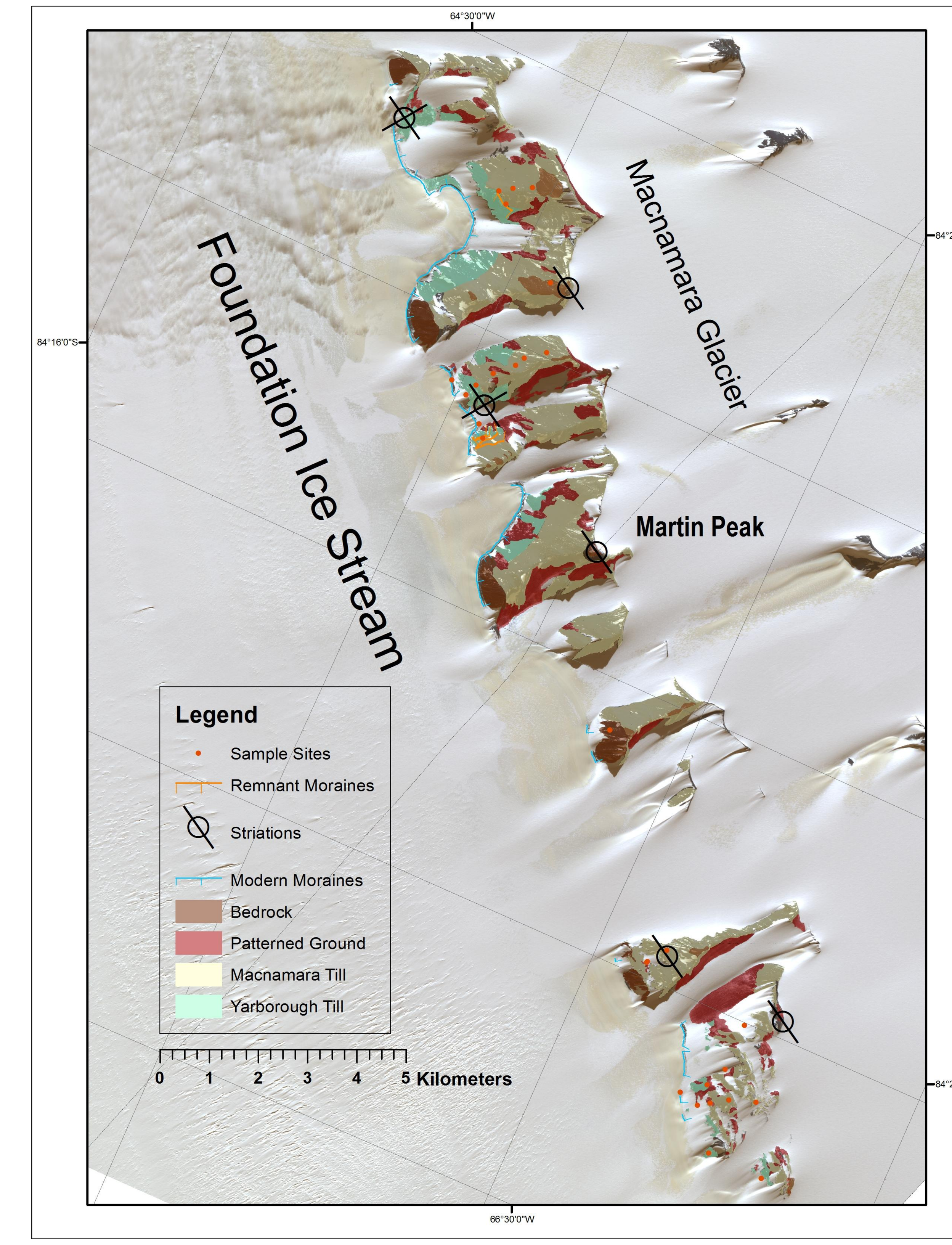

Figure 5. Glacial geologic map of the **Thomas Hills**.

Interpretations

MULTIPLE PERIODS OF GLACIATION

The presence of glacial erratics with varying weathering extents represents multiple glaciations. In the Thomas Hills, preserved moraines and relatively unweathered till indicate multiple ice surfaces 20-100 m higher than today; these features likely post-date the last glacial maximum. Highly-weathered surface boulders in the Macnamara Till (Figure 5), indicate long-past, thick ice cover.

EVIDENCE OF WARM- AND COLD- BASED ENVIRONMENTS

Highly-weathered erratics adjacent to relatively unweathered erratics suggest preservation of older erratics in a cold-based environment. Striations and the clay-rich Macnamara Till suggest a thick, warm-based glaciation overran topography at some point in the past.

ALL NUNATAKS PREVIOUSLY OVERRUN AT LEAST ONCE

Glacial erratics found on scoured peaks record the fact that ice eroded peaks during a maximum and subsequently deposited erratics.

STRIATIONS RECORD CHANGING FLOW DIRECTION

In the Schmidt Hills, crosscutting striations indicate a change from FIS-parallel flow to thicker ice surfaces with oblique flow. Striations found on Pillow Knob were at 200 m above present day ice, indicating ice cover much of both sets of hills. In the Thomas Hills, striations indicate a shift from flow overriding the topography, to the advance of blue ice lobes flowing from FIS to the base of the hills.

ROLE OF WIND-DRIVEN ABLATION IN ICE-SURFACE ELEVATION CHANGE

Preliminary numerical modeling of ice surfaces in the Thomas Hills suggest elevation changes could be attributed to local variations in ablation in addition to surface elevation changes in FIS.