Soil Morphology and Toposequence Complexity in the Alaskan Arctic Foothills

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Background and Objectives: Despite studies across large parent material and climate gradients, (i.e. Ping et al., 2008, Walker et al., 2008), quantitative data across soil toposequences in the continuous permafrost zone remain limited. Recent modeling studies have shown high uncertainties in lower hillslope SOC stocks in the continuous permafrost zone. For the state of Alaska, the uncertainty in SOC mass in these regions is greater than 200% of current statewide SOC estimates (Shelef et al., 2017). Hence, there is a need for expanded focus on the spatial pattern of soil morphology and soil classification along hillslopes, and major opportunities to bridge the gap from hillslope to landscape scales. As part of an ongoing study to assess carbon stocks in the continuous permafrost zone, our objective was to better constrain soil morphology and classification along hillslopes in the continuous permafrost zone.

Methods: We investigated soils along toposequences on paired hillslopes along the Dalton highway near Happy Valley and Sagwon (***Figure 1A, 1B, and 1C***). Both of these hillslopes lie outside of Late Wisconsinan glacial limits, but inside of Pleistocene glacial limits (Sagwon - Anaktuvik River advance, Happy Valley - Sagavanirktok River advance). Each of these sites are characterized by Moist Acidic Tundra vegetation and have a loess mantle of less than 1m in thickness over re-worked glacial till. At seven locations along each hillslope, soil pits, permafrost cores, or some combination of both were examined to a minimum depth of 2m. Soil morphology was described and U.S. great group classification was determined.

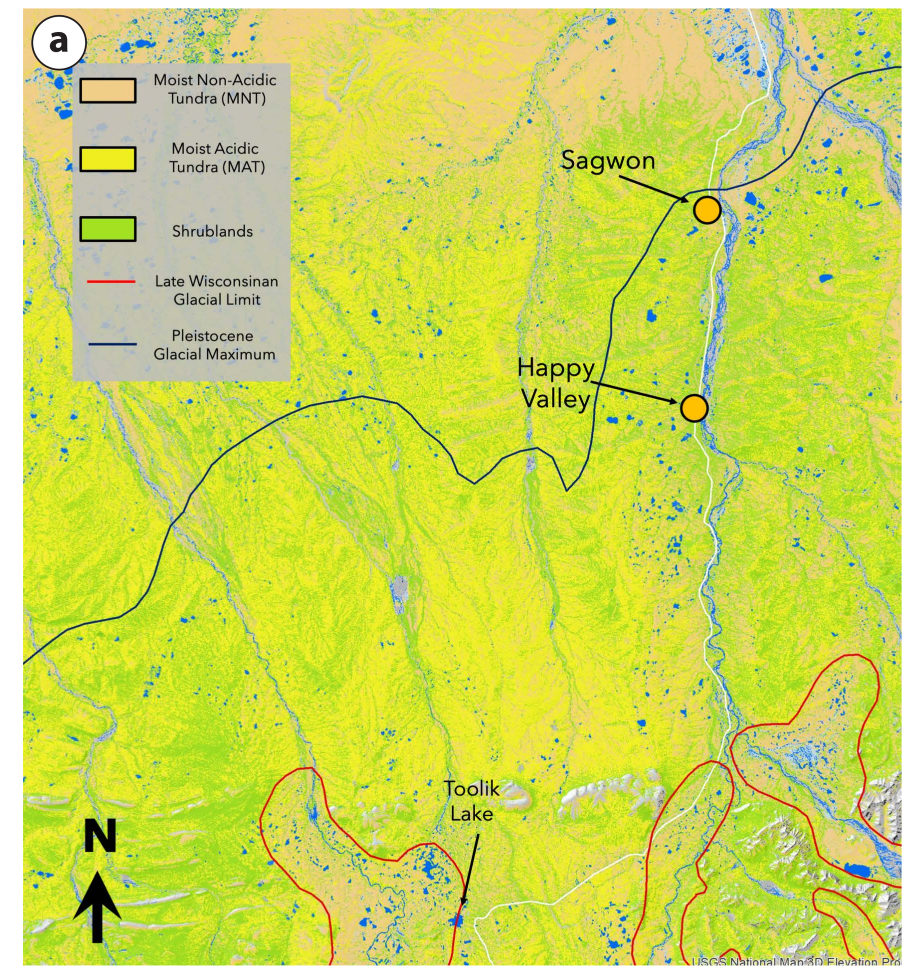
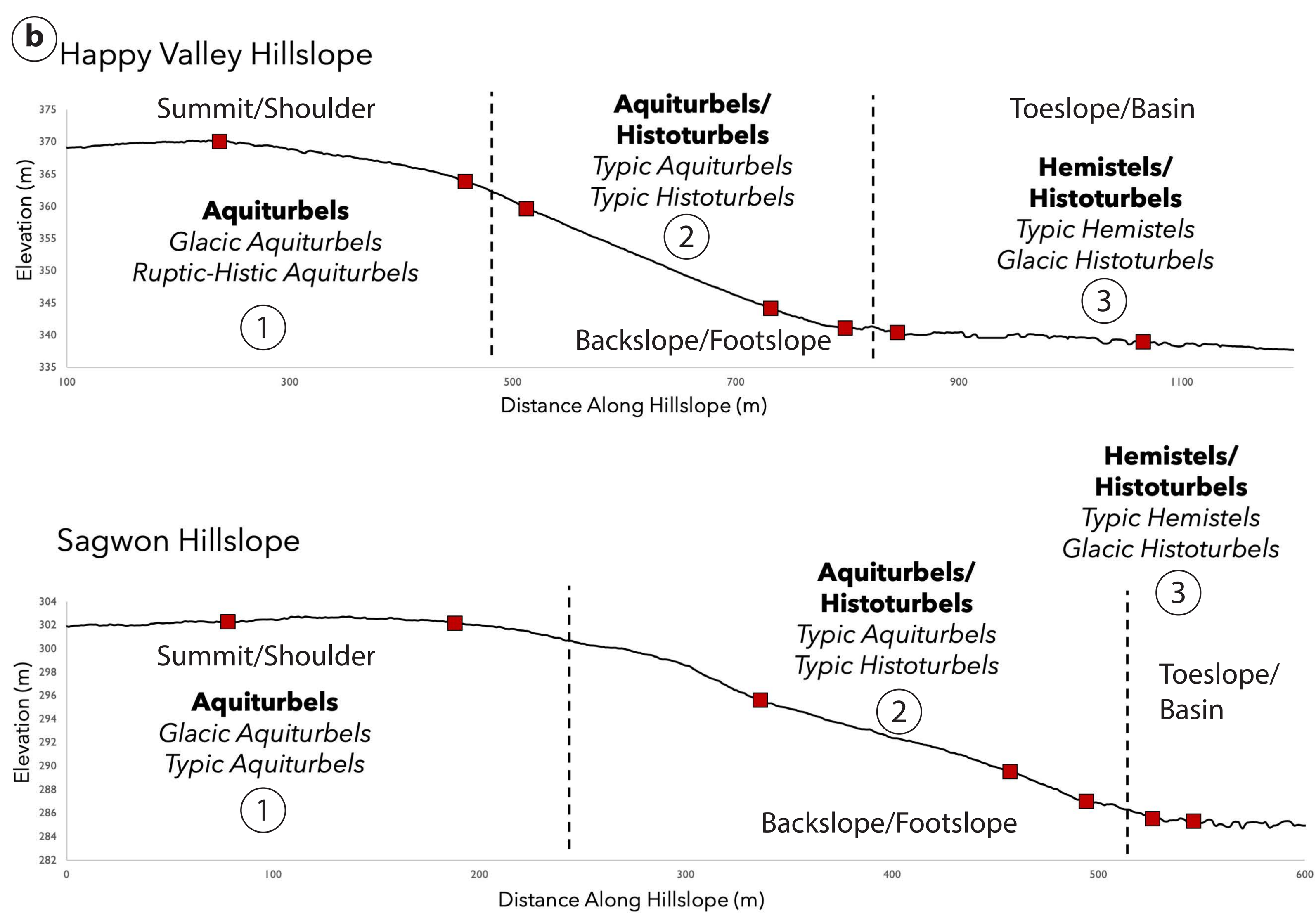
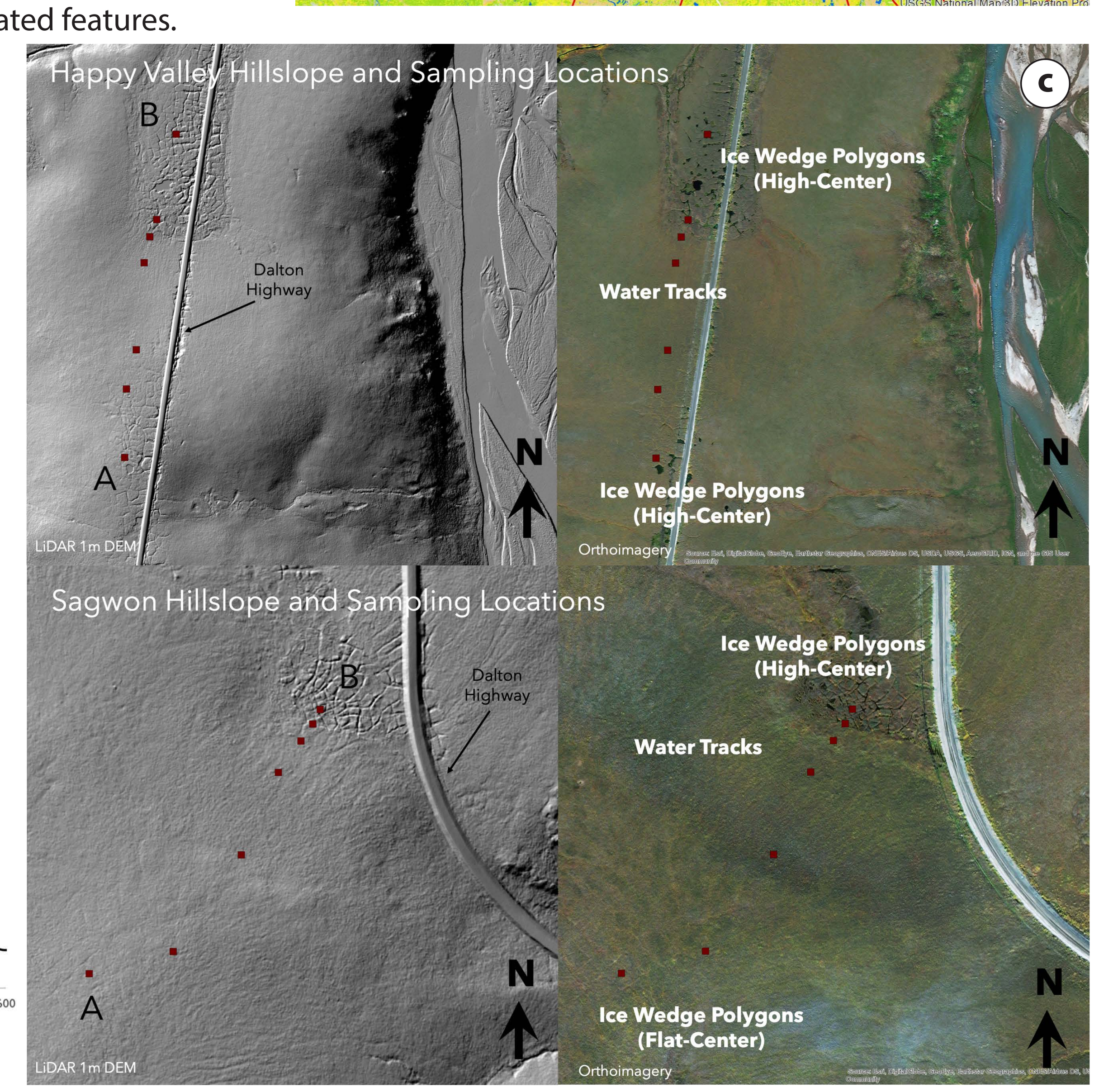


Figure 1 (right and below). (a) Regional setting of paired hillslopes showing generalized vegetation types (Walker, 2018) and Late Wisconsinan and Pleistocene glacial maxima (Manley and Kaufman, 2002), **(b)** Hillslope cross-sections derived from 1m LiDAR data, sampling locations (red boxes), soil classification, and generalized soil-landscape units (SLU, labelled 1, 2, and 3) **(c)** LiDAR-derived hillshade and orthoimagery with sampling locations (red boxes) and annotated features.





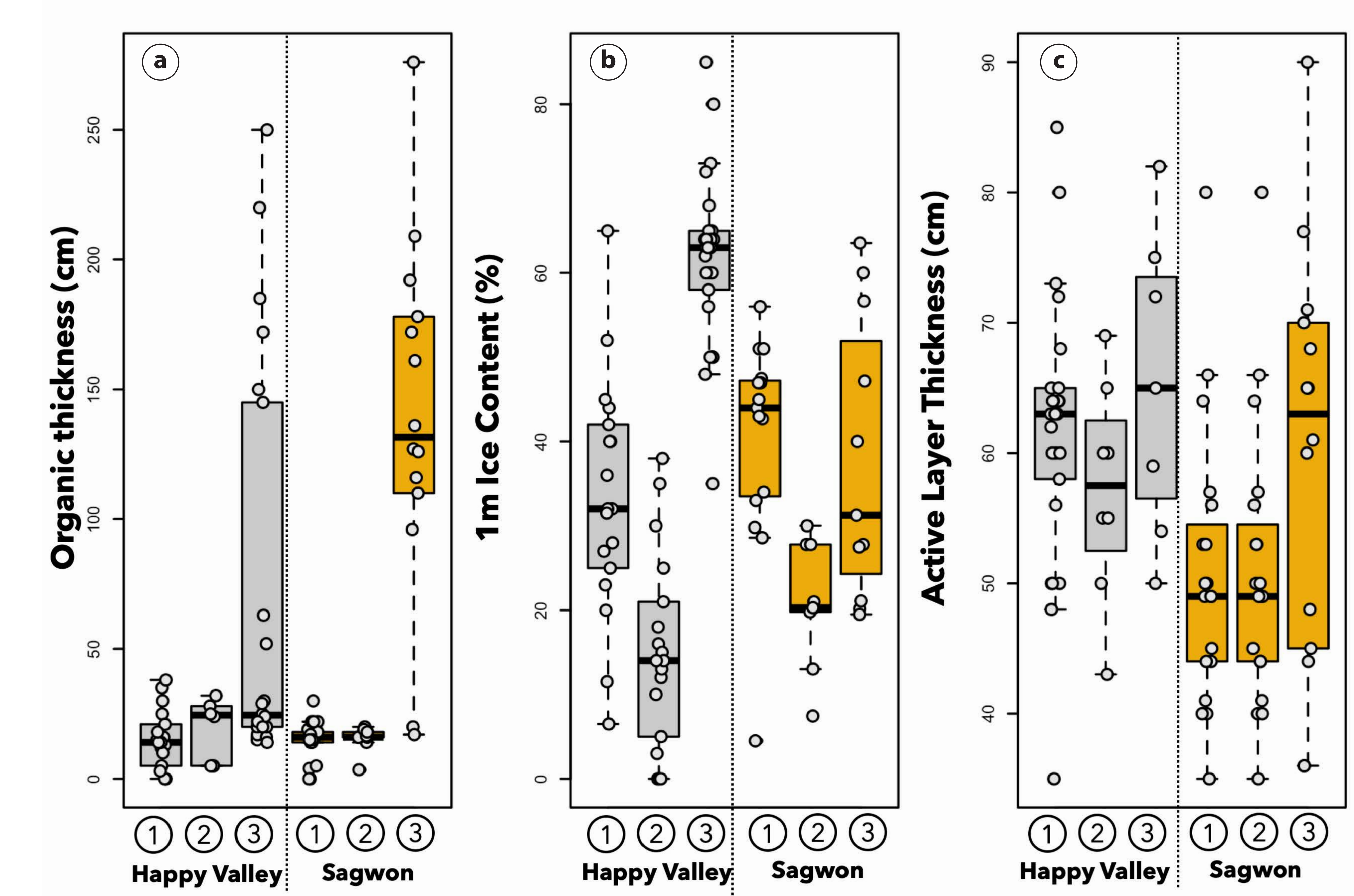


Figure 2 (above). Boxplots and stripcharts showing the variability of **(a)** Surface organic thickness (cm), **(b)** 1m volumetric ice content estimates, and **(c)** Interpreted active layer thicknesses beween soil-landscape units (SLU) along the Happy Valley (grey boxes, on left of each figure) and Sagwon (gold boxes, or right of each figure) hillslopes. SLU relate to the same numbers (1-3) in ***Figure 1***.

Results: Surface features along both hillslopes were broadly analogous, with ice wedge polygons present at summit/shoulder (SLU1) and footslope (SLU3) positions and water tracks visible on backslope and upper footslope (SLU2) positions (***Figure 1C***). The thickness of the surficial organic layer showed little variability across most of the hillslope (***Figure 2a***), but increased significantly in thickness and variability at toeslope and basin positions. Volumetric ice content estimates in the top 1m were highest at summit/shoulder (SLU1) and footslope positions (SLU3) (***Figure 2b***), corresponding with the presence of ground ice observed at those locations. Interpreted active layer thickness was not significantly different between hillslope positions, but was highly variable within SLUs due to complexity associated with patterned ground (***Figure 2c***). Representative soil morphology associated with each SLU is shown in ***Figure 3***.

References: Walker. 2018. Maps of Vegetation Types and Physiographic Features, Kuparuk River Basin, Alaska. ORNL DAAC; Manley & Kaufman, 2002, Alaska PaleoGlacier Atlas, INSTAAR. Ping et. al. 2008, JGR 113, G03S12; Walker et al., 2008, JGR 113, G03S01; Shelef et al. 2017, GRL 44, 6134-6144
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Figure 3 (below). Representative soil morphology corresponding with SLUs: **(a)** a Glacic Aquiturbel on a shoulder position (SLU1), **(b)** a Typic Aquiturbel/marginal Typic Histoturbel on a lower footslope (SLU2), **(c)** a Typic Hemistel on a toeslope (SLU3).