MORPHOLOGY OF SOILS IN ALASKA, USA

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Summary: Three field tours were undertaken across Alaska from 2005-2007 in an effort to better document the diversity of soils and associated features contained therein. Input and interactions between the USDA-NRCS, soil science academicians, and consulting soil scientists were vital to describing the soils observed. Specifically, ice lenses and veins in soils were observed in situ in permafrost throughout mid to northern Alaska. Excavation pits and cores taken along the Dalton Highway from Fairbanks to Deadhorse, AK were prime examples of permafrost, wet soils, etc. On the Arctic North Shore, polygon soil formation was documented in association with large ice wedges. Melting of the exposed permafrost was noted along the shoreline. Detailed soils mapping was performed in the Salcha-Big Delta agricultural region with a wide variety of soil classifications observed.

INTRODUCTION

Soils of Alaska demonstrate tremendous variability across the state. Thick permafrost on the North Slope toward the Arctic Ocean predominates, while soils farther south form from volcanic ash, loess, and alluvial processes [1]. Parent materials in the interior of Alaska are predominantly loess, alluvium and glacial outwash. The main source of loess in the Salcha-Big Delta region is the Tanana River. The Salcha-Big Delta (128,047 ha) is predominantly an agricultural area and is a priority area for soil delineation/update. It includes Entisols, Inceptisols, Gelisols, Mollisols and Histosols and is scheduled to be completed next year.

With respect to the morphology of frozen soils, special terminology is used. Mineral or organic soils near the surface which freeze and thaw seasonally in response to climatic variation are termed the active layer (Figure 1). Soil which remains permanently frozen (at or below 0°C) throughout the year is termed permafrost [2]. An area of unfrozen soil surrounded by permafrost is known as a talik. Fairbanks, AK is a transitional area with respect to permafrost in soils. To the south, permafrost is discontinuous, isolated or non-
Figure 2. Extent of permafrost in Alaska [3].

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existential (Figure 2). To the north, it gradually becomes thicker toward the Arctic North Shore (Figure 2). Permafrost is vitally important to structural stability. Buildings constructed in areas of permafrost are often elevated above the ground so that cold air can contact the soil and keep the permafrost frozen. If structures were built directly on ground containing permafrost, the soil would gradually warm, the permafrost would melt, and peers for the structure would become unstable. Thus, allowing the soil to stay cold ensures that it will remain stable. The morphology of ice associated with permafrost is quite variable. Ice wedges, lenses and vein ice are common in permafrost. Ice patterns range from large flows to finely disseminated ice. Areas with >30% ice in any given horizon are formally notated as Wf horizons (frozen water).

The United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS) has developed a mandate that initial soils mapping of the United States be completed by 2010 (Mike Risinger, personal communication). Yet, much of Alaska remains unmapped due short sampling season (only a few months), limited personnel, and remote terrain. While Alaska may not meet the 2010 deadline for comprehensive, detailed soil delineation, the current plan is to use vegetation, photo-tones and research currently being done by other scientists across the state to compile a completed initial map by the deadline (Mark Clark, personal communication). In 2005 and 2006, field tours were assembled by Dr. Chien Lu Ping (University of Alaska – Palmer) and the USDA-NRCS with three key goals: 1) to show visiting soil scientists the diversity and morphological uniqueness of soils across the state, 2) prepare sites for the World Congress of Soil Science cryosol field tour, and 3) collect samples and data that would aid in understanding the dynamic nature of soils across the arctic.

MATERIALS AND METHODS

Three separate sampling excursions are included as part of this paper. In 2005, a wide variety of sampling sites were selected generally along the Dalton Highway which runs from Fairbanks, AK 668 km north to Deadhorse, AK. In 2006, other sites were accessed via helicopter and sampled along the Arctic Ocean coastline tundra from Deadhorse, AK to Kaktovik, AK. In 2007, sites in the Greater Delta area were accessed by all terrain vehicles and boat. Pits for pedon description at each site were hand dug. When present, mats of organic matter were first cut and carefully set aside. Next, a plastic tarp was placed adjacent to the excavation site. Excavated soil was carefully placed on the tarp, so as not to leave any mineral soil on the surface adjacent to the
A pedon of the Goldstream soil series was excavated for sampling just north of Fairbanks, AK. The Goldstream series is classified as a coarse-silty, mixed, superactive, subgelic Typic Histoturbel [4]. The profile horizonation, as sampled, is presented in Figure 3. The mineral soil profile is covered by thick organic layers in various stages of decomposition as evidenced by the Oi, Oe and Oa horizons. Mineral soil textures are silt loams. The active layer exists from 40 cm to 75 cm. The soil is very poorly drained and below 75 cm, permafrost is found with a bluish tint, indicative of reduced Fe$^{2+}$.

In forested areas from Fairbanks north toward the Brooks Mountain Range, organic matter tends to accumulate in depressional, low-lying areas. In some instances, these organic deposits are permanently frozen and can be excavated for description using a gas powered auger. In other areas, seasonally thawed organic deposits essentially “float” over permafrost or non-frozen mineral deposits. A unique thermodynamic microenvironment is created by these features resembling a toposequence on a small scale. At the lowest point, water exists at the surface and supports sedge vegetation with no permafrost underneath. Increasing in elevation by <0.5 meter, a muskeg is formed (similar to a terrace in alluvial systems) (Figure 4). The muskeg is somewhat drier and has fewer sedges, being a transitional-type feature. At another 0.5 m above the muskeg, the peat island is formed (Figure 4). Here the organic materials form soils which are classified as hemistels.
Farther to the north near the Brooks Mountain Range, lies the Chandalar Shelf, a system of old lake basins and terraces with extensive hummocks across the landscape (Figure 5). Extreme variability in the landscape is seen as the hummocks undulate at the surface. Depth to the permafrost varies annually, depending on snowfall received and climate. When early snowfall is received, it can act as an insulator against much colder temperatures (-40°C) that follow later in the year. The permafrost in this profile shows sheeting of ice across the mineral soil (Figure 6). The unnamed soil at this site is classified as a fine-loamy, mixed, superactive, gelic, Typic Aquiturbel and was found in somewhat poorly drained lacustrine parent materials at an elevation of approximately 977 m [4]. It should be noted that the very low annual temperature and cryoturbation of these soils allow for the incorporation and long term storage of considerable amounts of organic carbon [5, 6]. This effectively serves as a carbon sink, so long as the material remains frozen.

North of the Brooks Mountain Range lies the Arctic North Slope, a vast expanse of arctic tundra underlain by thick permafrost that was sampled and described in 2006. Here, polygon soil pattern landscapes are common, with large ice wedges in troughs between polygons (Figure 7). As water drains into these troughs, it refreezes as temperatures drop. The ice expands and pushes the remaining soil upward causing a rim (Figure 8). The constant thawing/freezing and associated shrinking/swelling give rise to extensive cryoturbation in these soils. As such, fragments of well preserved O horizons are readily found at considerable depths, having been incorporated via cryoturbation. Along the Arctic Ocean coast, exposed permafrost melts in the summer months, allowing overburden soils to slump off into the ocean (Figure 9). Aerial views of the landscape provide clear views of the polygon patterns formed (Figure 10).

Field description in 2007 occurred from June to September and focused on the Salcha-Big Delta agricultural region south of Fairbanks, AK. Teams of two or three persons sampled transects chosen from photo-tones on aerial photographs. Initial map unit delineation lines were drawn on the aerial photographs using wax pencils under a stereograph. Slope and landscape position were also considered. Following ground truthing, map unit line delineations were changed as needed to reflect real-world attributes observed during sampling. Soil pits were excavated to a minimum depth of 183 cm with sharpshooter shovels and bucket augers where possible. At least 25 cm of permafrost was excavated to denote any changes present.
A commonly observed soil near the Salcha River is a sandy-skeletal, Typic Cryofluvent [4] (Figure 11). A prevalent feature in permafrost of the area is ice lenses, where ice has been segregated repeatedly into bands throughout the soil. Thinner bands exist in finer textures such as silt loam, while larger ice masses are more common in coarse textures such as loamy sand.

Permafrost in this region is also dropping deeper in soil profiles or disappearing altogether. Much of this is from the removal of vegetation, which serves as an insulator to the permafrost. This loss of vegetation can be human induced in the form of cutting down trees and creating burn rows, or from natural causes such as wildfires. It is noteworthy that natural resource managers in Alaska correctly let wildfires burn as a natural part of the ecosystem whereas in the lower 48 US states, fires are extinguished quickly, protecting property and homes, but disrupting natural ecosystems which have always included fires [7].
CONCLUSIONS

Field expeditions in Alaska in 2005-2007 have clearly shown the diversity of soils in the state; from interior Alaska’s loess and outwash plains, to the polygon soil formation of the North Slope, to hummocks carpeting the landscape near the Brooks Mountain Range. A wide variety of soils, permafrost, and features such as peat islands, muskegs, cryoturbation, etc. are observed along the Dalton Highway from Fairbanks, AK north to Deadhorse, AK. Soils in the Salcha-Big Delta area have gone through a large amount of change since they were originally mapped. Much of what was then mapped as permafrost is now a thin mantle of loess over sands and gravels. Because of our shifting climate and land use patterns, soils in Alaska will continue to change yet maintain a unique and important niche in soil classification.

REFERENCES


