Relationship between ground ice of near-surface permafrost and vegetation/microtopography at taiga-tundra boundary in Northeastern Siberia

*Shinya Takano[1], Go Iwahana[2,3], Roman Petrov[4,5], Shunsuke Tei[3], Maochang Liang[6], Ryo Shingubara[1,3], Tomoki Morozumi[1], Trofim C Maximov[4,5], Atsuko Sugimoto[1,3]

1. Graduate School of Environmental Science, Hokkaido Univ., Sapporo, Japan, 2. International Arctic Research Center, Univ. of Alaska Fairbanks, Fairbanks, USA, 3. Arcitc Research Center, Hokkaido Univ., Sapporo, Japan, 4. Institute for Biological Problems of Cryolithozone SB RAS, Yakutsk, Russia, 5. Institute of Natural Sciences, North-Eastern Federal Univ., Yakutsk, Russia, 6. School of Horticulture and Garden, Yangtze Univ., China

Permafrost plays an important role in Arctic terrestrial ecosystem, and ground ice in the permafrost can contribute to vegetation and microtopography in the area. In fact, polygon mires, which are the typical microtopographic landscape of the polar tundra (Boch, 1974), are formed by the growth of massive ground ices such as ice-wedge (Chernov and Matveyeva, 1997), and a clear zonation of vegetation has been observed corresponding to the polygonal pattern in microtopography (Minke et al., 2009). Therefore, ground ice is greatly related to vegetation and microtopography in Arctic tundra region. On the other hand, changes in vegetation caused by global warming and permafrost degradation have occurred in taiga-tundra boundary (e.g. Jorgenson et al., 2001; Kravtsova and Loshkareva, 2013; Frost and Epstein, 2014), but relationship between ground ice and vegetation/microtopography in this region has not been investigated much yet.
In order to clarify this relationship, we surveyed near-surface permafrost up to 1 m depth in Indigirka lowland near Chokurdakh (70.62 N, 147.90 E), Northeastern Siberia, in July 2011 and July 2012. Landscape of the observational area consists of various types of wetlands (named “wet area” in this study) and hummocks which include micro ridge growing larches and shrubs (named “tree mound”). We obtained frozen soil cores at 22 points across tree mounds and wet areas in four observational sites (B, K, A and V) with different stand density of larch, and then cut the sampled cores with intervals of less than 10 cm. We also measured thaw depth and relative height at the sampling points and calculated gravimetric water content (GWC) of the cut soil cores. Additionally water isotopic ratios of the permafrost ice were analyzed to estimate ice formation processes.
There was a significant difference between the average GWC of the frozen cores obtained at tree mounds and wet areas (approximately 80% higher at tree mounds), and massive ices (ice-rich layers) were found in frozen layers at tree mounds. Although there was no significant difference among the average isotopic values of the ice obtained at different vegetation and landscapes, vertical profiles of the GWC and the isotopic values showed four characteristic patterns depending on the ice existence (i.e. vegetation types), sources and formation processes. These profiles indicate that massive ices can tend to be formed underground at tree mound (e.g. ice segregation at transition zone, ice-wedge growth) and contribute to vegetation and microtopography. If permafrost thaws down to 1 m depth in the future, the depression depth by the loss of the ground ice at tree mounds will be 9.3 ±2.9 cm deeper than that at wet areas. This means that the current relative height between tree mound and wet area of 32.7 cm can be reduced to approximately 23.4 cm, which can sufficiently affect the vegetation.

Keywords: permafrost, ground ice, stable isotopes of water, relative height, gravimetric water content

