The Korean Journal of Quaternary Research
Vol. 17, No. 2, pp. 71~74 (2003)

Permafrost Condition in Mongolia

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ABSTRACT

Permafrost study in Mongolia officially began in the end of 1950 years. At the first time our senior researchers concentrated on the regional characteristics of permafrost distribution and on the engineering geocryological problems. At present time we concentrate on permafrost mapping using the GIS, on permafrost monitoring based on the temperature measurement in boreholes, on permafrost phenomena monitoring in same permafrost regions and on engineering geocryological problems.

Keywords : permafrost, geocryology, mapping, GIS, phenomena, active layer, thermokarst

Introduction

Two thirds of population of Mongolia lives in permafrost distribution areas and with the increasing activity in these areas for infrastructure networks, knowledge about the distribution patterns of permafrost helps reducing installation costs and improves safety for people living in such areas. Permafrost map is shown on Fig 1.

Also monitoring sites are shown on Fig 1. The black line on figure 1 is indicated the road, which is in construction activity.

Permafrost in Mongolia

1. Permafrost characteristics

According to maps and publications on permafrost distribution in Mongolia(Gravis et al. 1974) permafrost, shown in figure 1, is characterized as follows: permafrost zones occupy almost two thirds of Mongolian territory, predominantly in the Khentei, Hovsgol, Khangai and Altai mountains and surrounding areas. The territory is characterized by mountain and arid-land permafrost, sporadic to continuous in its extent. Most of the permafrost is at temperatures close to 00C and thermally unstable. In the continuous and discontinuous permafrost areas, taliks are found on steep south-facing slopes, under large river channels and deep lake bottoms, and along tectonic fractures with hydrothermal activity.

In sporadic and isolated permafrost areas, frozen ground is found only on north-facing slopes and in fine-grained and moist deposits. The lower limit of continuous permafrost on south-facing slopes ranges from 1400 to 2000m in the Hovsgol and Khentei mountains, and from 2200 to 3200m in the Altai and Khangai mountains. The lowest limit of sporadic permafrost is found between 600 and 700m a.s.l. Average thickness and mean annual

Table 1. Mean annual permafrost temperatures per decades

Changes in the active-layer thickness at CALM borehole sites in Mongolia

No	Sites	Bore hole	Method	Thickness of active layers [cm]										Rate of changes [cm/year]
				1969	1976	1987	1996	1997	1998	1999	2000	2001	2002	
1	Baganuur	M1	TT/T	-	335	-	345	350	355	345	350	340	355	0.6
2	Nalaikh	M2A	TT/T	-	-	-	-	340	350	340	345	335	345	0.1
3	Burenkhan	M4A	T	-	-	360	-	-	-	-	375	385	380	0.8
4	Sharga	M8	T	270	-	-	-	-	-	-	-	-	285	0.4
5	Terkh	M6A	T	195	-	-	-	-	-	205	210	207	215	0.6
6	Chuluut	M7A	T	125	-	-	-	-	-	136	140	137	142	0.5

TT-thaw tube and T-temperature measurements.

Changes in mean annual ground temperatures at GTN -P borehole sites in Mongolia

No	Sites	Bore hole	Depth, [m]	Mean annual ground temperature, [°C]										A rate of changes [°C/year]
				1969	1976	1987	1996	1997	1998	1999	2000	2001	2002	
1	Baganuur	M1	15- 11	-	-0.25	-	-0.13	-0.12	-0.13	-0.14	-0.13	-0.14	-0.14	0.006
2	Nalaikh	M2A	80- 50	-	-	-	-	-0.58	-0.6	-0.57	-0.55	-0.55	-0.51	0.010
3	Burenkhan	M4A	50- 25	-	-	-0.85	-0.74	-0.69	-0.66	-0.60	-0.61	-0.50	-0.51	0.014
4	Sharga	M8	68- 11	-2.35	-	-	-	-		-	-	-	-1.53	0.024
5	Terkh	M6A	90- 15	-2.05		-1.85	-	-	-	-	-	-	-1.55	0.015
6	Chuluut	M7A	36-15	-0.72	-	-	-	-	-	-	-	-	-0.47	0.011

temperature of continuous permafrost is 50-100m and -1 to -2℃ in valleys and depressions, and 100 - 250m and -1 to -3℃ on mountains, respectively. Permafrost in Mongolia is characterized mainly by low and moderate ice content in unconsolidated sediments. Ice-rich permafrost is characteristic of lacustrine and alluvial sediments in valleys and depressions. Thickness of active layers is 1-3m in fine-grained soils and 4-6m in coarse material.

2. Permafrost dynamics

Data from various mountain regions of Mongolia obtained by temperature measurements during the last six years as compared to measurements observed 13 to 34 years ago show similar trends and changes in active-layers thickness: The average annual thickness of active layers increased by 0.1-0.6 cm in Khentei and Khangai mountains and by 0.4-0.8 cm in Khovsgol mountain regions (Table 1).

According to data during the last 10-34 years the mean annual permafrost temperatures per decades increased by 0.05-0.15℃ in the Khentei and Khangai mountains and by 0.15-0.25℃ in the Khovsgol mountain regions (Table 1).

In some study locations, local degradation of permafrost is increased and/or caused by human activities. During the past 50 years, mean annual ground temperatures in the territory of Ulaanbaatar city have increased by 1 to 3℃ and islands of permafrost with thickness of 5 to 30 m have completely thawed.

Permafrost Mapping

Joint Mongolian and Soviet geocryological expedition in 1967-1971 played a considerable role in studing regularities of permafrost distribution in Mongolia. As a result of the expedition compiled permafrost map

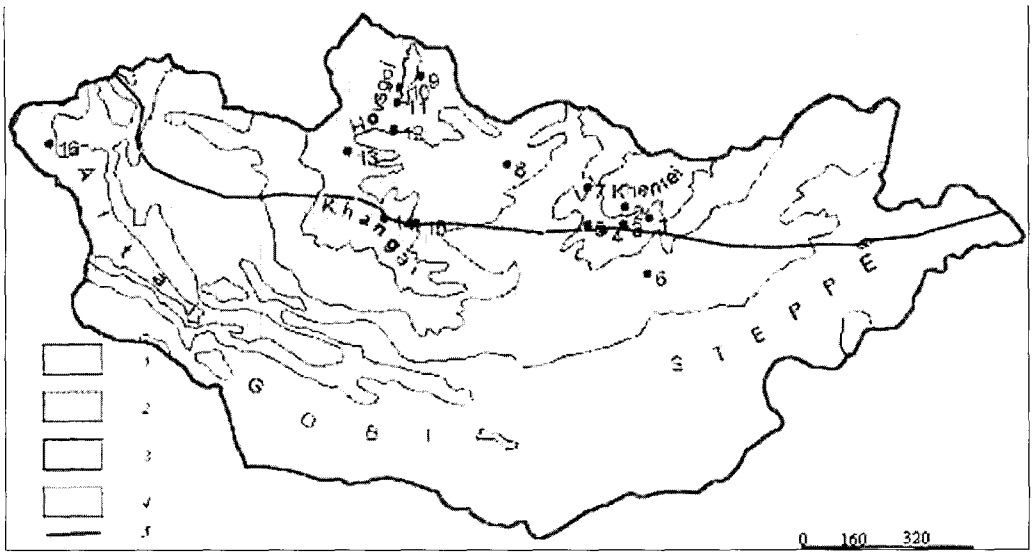

Fig. 1. Schematic map of permafrost distribution and location of monitoring sites in Mongolia.

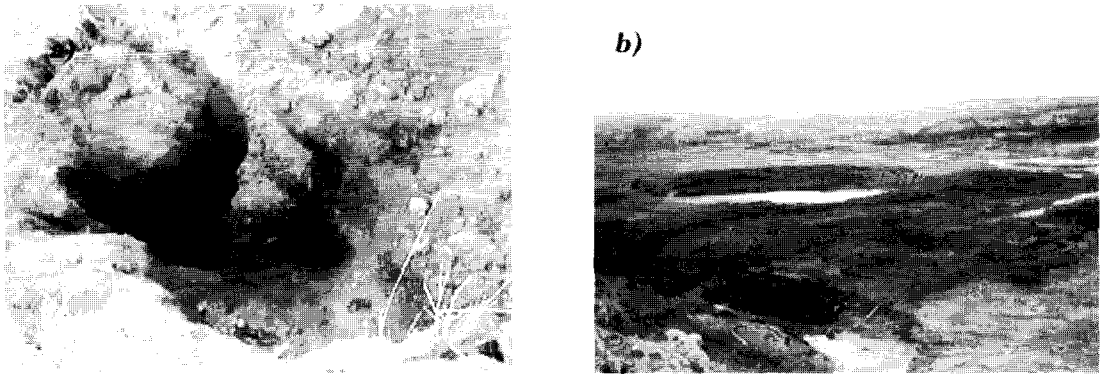

Fig. 2. Thermokarst evolution stages in Darkhad depression of Hovsgol mountain region.
a) first period of thermakarst process, b) thermakarst process in its middle stage of activity

of Mongolia at a scale of 1:1 500 000(Gravis, et. al).

Researchers compiled permafrost and seasonal frozen and thawing ground's maps of Mongolia and different regions of Mongolia at the different scales(Tumurbaatar and Sharkhuu). They used the traditional methods of mapping. Main criteria of permafrost mapping in Mongolia are mean annual ground temperature and its changes depending on geographical and geological condition of regions. Using the GIS software Arcview 3.2 in this year we have been complied permafrost map along the road, which is in construction activity.

Cryogenic Phenomena

During the last four years dynamics of cryogenic processes have been studied at the various regions of the Mongolia. Active thermokarsts are direct indicators of recent and present permafrost degratation under the influence of climate warming and human activities.

Fig 2 shows thermokarst processes in different stages of activity in darkhad depression of Khovsgol mountain region.

There exist numerous pingos and thermokarst lomes

of different sizes and evolutional stages in the depression bottom. Observation results show that different evolutional stages of thermokarst processes are direct indicators of climate warming in last and present periods and climate warming began in early time in this region.

1. Continuous and discontinuous (50-100%); 2. Isolated (1-50%); 3. Sporadic (0-1%) permafrost areas. 4. No permafrost or seasonal frost area. 5. road. Numbers on the map: 1. Baganuur (a, b), 2. Terelj (a, b, c, d), 3. Nalaikh (a, b, c, d), 4. Bogd Khan (d), 5. Argalant (a, b, c, d), 6. Gurbanturuu (a, d), 7. Baruun Kharaa (d), 8. Erdenet (c), 9. Dalbay (a, b, c, d), 10. Ardag (a, b), 11. Hatgal (a, b), 12. Burenkhan (a, b), 13. Sharga (a, b), 14. Terkh (a, b, d), 15. Chuluut (a, b, d) and 16. Tsengel (a) monitoring sites. Letters in brackets: a. CALM; b. GTN-P; c. SFTM and d. CPPM measurements.

Conclusion

This paper presents a summary of existing permafrost study as well as permafrost condition in Mongolia. Permafrost in Mongolia is degrading at various, but considerable rates depending on the local natural conditions. Permafrost, especially sporadic and isolated, is very sensitive to climate change and human activies. In future we need to complete the complex observation of natural conditions in same selected areas. For this complex observation we invite the scientists of this field to co-operation.

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