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Characteristics of permafrost at local and regional scales: the Altai and Khentii Mountains, Mongolia

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Abstract

Keywords: the Altai and Khentii mountains; permafrost monitoring; Mongolia

In Mongolia, permafrost predominantly occurs in the Altai, Khuvsgul, Khangai, and Khentii Mountains and their surrounding areas where the southern boundary of the Siberian permafrost is roughly located. During the last several years numerous permafrost monitoring sites were established along these Mountains in order to measure the thermal properties of permafrost. The main objective of this article is to present basic characteristics of permafrost in local and regional scales in the case of the Altai and Khentii Mountains. Based on datasets from these boreholes we here present synoptically summarized results for the Altai and Khentii Mountains.

Altai Mountains: The Altai Mountains are located in western Mongolia (Figure 1) and is comprised of the tallest mountains in the country. Currently there are 21 boreholes within the Altai and at varying depths (1-15 m). Of these 21 BH's, 3 have been re-drilled near older boreholes where soil temperature measurements were collected 30-33 years ago. The southernmost borehole (BH 20) is located in a valley at 2415 m above the sea level (asl) where mean annual ground temperature (MAGT) at 8 m was -0.1ɵC and active layer thickness (ALT) was more than 8 m for the last 5 years. However, the temperature at 8 m depth has increased by about 0.1ɵC during last 30 years. This insignificant change in temperature is likely not intense enough to initiate a phase change. BH 22 is in close proximity to BH 20 however it is located on a gentle north-facing slope at 2025 m asl. At BH 20, the MAGT at depths of 1 m and 3 m was about 5.7ɵC and 3ɵC, respectively, likely indicating that permafrost is absent. Similar results were found at BH 18 where MAGT was 6.7 ɵC at 1m depth. BH 72 at 2421 m asl and BH 73 at 2208 m asl are located on north-facing slopes in the Khantaishir Mountains which lies between the Altai and Khangai Mountains. The distance between the sites is about 5 km and with similar slope inclinations and vegetation cover. At these sites, permafrost is present in BH 72 with more than 6 m ALT while permafrost is absent in BH 73, indicating that the elevation gradient is important for locally existing permafrost. BH 37 at 1714 m asl is located in a valley in the middle of the Altai Mountains, where MAGT at 10 m depth was -0.2ɵC and ALT reached 3.5 m. Although elevations vary between BH 20 and BH 37, the differences in MAGT at both sites were small. These differences can be explained by latitudinal differences between the sites.

In the northern Altai, permafrost is present in 13 out of 15 boreholes. The two boreholes with no permafrost are located on south facing slopes. BH 29 experiences only thin permafrost between 8 m and 15 m where MAGT was -0.01ɵC at 10 m. Interestingly BH 29 is located at the foot of a north-facing slope at 1995 m asl and similar vegetation cover compared with other sites. However, the MAGT decreases with increasing elevation along the north-facing slope.

For instance, MAGTs at a depth of 10 m were -0.2ɵC at BH 30 (2240 m asl), -2.2ɵC at BH 31 (2358 m asl) and -3.3ɵC at BH 32 (2500 m asl). The most northern boreholes in the Altai Mountains are BH 26 on the gently south-facing slopes and BH 27 on the gently north-facing slope and are separated by about 4 km. Yet, both boreholes are at similar elevation (2120 m asl) and have similar vegetation cover and soil textures. However, ALTs were 3.3 m at BH 26 and 3.9 m at BH 27, and MAGTs at 10 m were -0.76ɵC and -0.40ɵC, respectively. This indicates that topography has a strong effect on permafrost temperature at local scales. At BH 26, the MAGT at depth of 10m has increased by 0.4ɵC during the last 30 years.

Khentii Mountains: The Khentii Mountains are approximately located in the transition zones between the Siberian boreal forests to wide steppe. This transition zone corresponds roughly to a change from Siberian continuous permafrost zone to the seasonally frozen ground zone. In the Khentii Mountains, nine boreholes are situated at different topographies, vegetation covers and elevations (Figure 1). Automatic soil weather stations, including sensors of ground temperatures and moisture, were installed at BH 100 on a south-facing slope covered by steppe and BH 101 on a north-facing slope covered by forest, on permafrost. Both sites have almost the same elevation and slope inclinations of 11–12°), but are approximately 1.58 km apart. During the summer, the ground surface temperature was warmer at BH 100 than BH 101, due to the large amount of downward shortwave radiation received on the dry south-facing slope. But in the winter ground surface temperatures were warmer at BH101 due to more snow insulation effect. However, the MAGT was warmer at the BH100. Overall, the forests at the edges of boreal forests are an important factor in contributing to cooler ground temperatures and the existence of permafrost in this region, which occurs only beneath forested north-facing slopes (Ishikawa et al., 2012; Dashtseren et al., 2014). The same MAGTs (-0.5ɵC) were observed at the sites BH 59 and BH 60, where elevations were 1450 m and 1496 m, respectively.

The ground thermal state in the southern boundary of the Siberian permafrost is changing. For example, permafrost has disappeared at both BH 57 and BH 56 over the last 30 years. In the BH 57, the soil temperature at 10 m was -0.1ɵC in1984, however, it was 1.3ɵC in 2014. The BH 61 is in a swampy bottom of a small depression, where MAGTs were -0.2ɵC and -0.1ɵC at the depths of 4.5 m of 9.5 m in 1978. Whereas, the MAGTs were -0.1ɵC at 4 m, 0.3ɵC at 6 m and 0.9ɵC at 10 m in 2011, respectively.

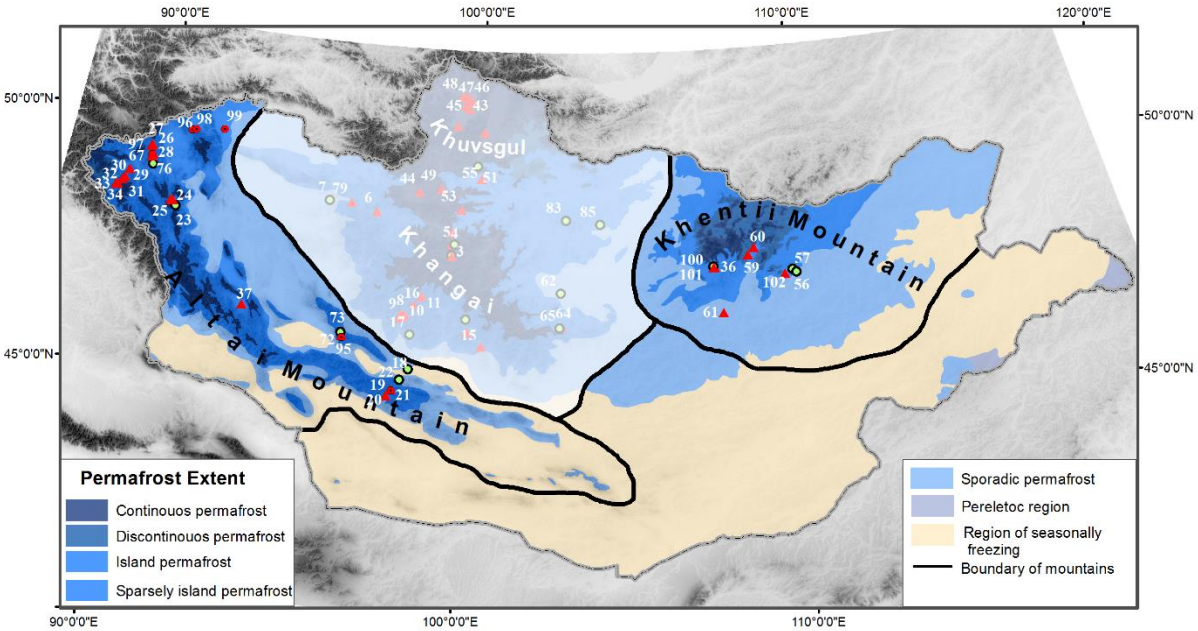

Figure 1. Permafrost distribution in Mongolia based on Gravis *et al*. (1971), locations of sites and numbers (BH); the monitoring sites with continuous temperature measurements in permafrost (red triangles) and without permafrost (green circles), and the ground surface temperature monitoring sites (red circles).

References

Dashtheren A, Ishikawa M, Iijima Ya, Jambaljav Ya. 2014. Temperature Regimes of the Active Layer and Seasonally Frozen Ground under a Forest-Steppe Mosaic, Mongolia. Permafrost and Periglacial Processes **25** (4):295-306.

Gravis GF, Jamsran C, Zabolotnik SI, Sukhodrovsky VL, Sharkhuu N, Lisun A., Lonjid H, Luvsandagva D, Tumurbaatar T. 1971. Geocryology map of Mongolia (1:1 500 000)"

Ishikawa M, Sharkhuu N, Jambaljav Y, Davaa D, Yoshikawa K, Ohata T. 2012. Thermal state of Mongolian permafrost. In Proceedings of the Tenth International Conference on Permafrost,Vol. **1**. 25–29 June, Salekhard, Yamal-Nenets Autonomous District, Russia, Hinkel KM (eds.). The Northern Publisher: Salekhard, Russia; 173–178.