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Suprapermafrost taliks in the Shestakovka River watershed, continuous permafrost environment, investigated by GPR and ERT techniques

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Continuous permafrost is usually considered as impermeable frozen ground. It is often assumed that surface flow and flow in the shallow active layer (AL) are main sources of river runoff in permafrost basins. Although existence of taliks is acknowledged, their distribution, genesis, evolution and role in surface-subsurface water interactions remain unresolved issues. The research objective is to estimate taliks distribution, depth and geometry in the Shestakovka River research watershed, Eastern Siberia, using electrical resistivity tomography (ERT) and ground-penetrating radar (GPR) geophysical techniques.

The Shestakovka River watershed with area 170 km2 is located in 20 km to south-west of Yakutsk within the erosion-denudational slope of the ancient accumulative plain with absolute elevation of 150-280 m. The permafrost thickness is 200-400 m. The upper 40 m of the section are represented by quartz-feldspar sands with rare inclusions of silty sandy loam and loam. The climate is cold and dry with mean annual air temperature -9.5°C, precipitation 240 mm/year. Dominant landscapes are pine (47% of the watershed area) and larch (38%) forest. AL thickness in the pine forest could reach 3-4 m. Water-saturated suprapermafrost taliks were occasionally found on the gentle slopes covered by pine forests. Larch forests are characterized by cold permafrost with AL thickness up to 1 m.

To estimate the talik abundance fourteen profiles 300 m long each were selected on the gentle slopes covered by pine forests. GPR measurements in May 2017 showed that there are water-saturated suprapermafrost taliks at eight profiles out of fourteen. Typically taliks were discovered in the depth interval from 2.5 to 10 m. If assume that selected profiles are representative for pine forest landscape of the watershed we conclude that 28% of the watershed area could be occupied by taliks. The high fraction of taliks containing suprapermafrost groundwater suggests possible importance of groundwater pathways for the river runoff generation even for the small watershed in continuous permafrost zone.

Six profiles (five with taliks and one without) were selected for more time-consuming ERT measurements and repeated investigations in September 2017 when AL thickness reaches maximum. Joint interpretation of GPR and ERT results, taliks depth, geometry and relations of talik distributions to topography and landscape features will be discussed in the paper.

Understanding of groundwater storages and its seasonal dynamics could advance concepts of runoff generation that underlay hydrological, hydrogeological and permafrost modelling strategies and future projections.

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