Geophysical Research Abstracts
Vol. 17, EGU2015-959-2, 2015
EGU General Assembly 2015

Lithology, porosity and morphology influence on temperate low- and mid-altitudes cold screes susceptible to host permafrost

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The ventilated cold screes from the temperate regions develop high negative thermal anomalies (ground versus air annual temperature) in their lower parts due to cold air aspiration in wintertime, which support the formation of cold reservoirs and sometimes of the perennial frozen ground. Ground and air temperature monitoring, geophysical soundings, debris texture and porosity measurements and dendrogeomorphological analyses were applied at Detunata sites in Apuseni Mts (Western Romanian Carpathians) to investigate a low-altitude cold scree (ca. 1080 m) accommodated in basalt debris. The large negative anomalies (6 – 6.8 °C), the high resistivity values (up to 65 kΩm) recorded in late spring and mid-autumn and the dwarf forest occurrence (whose growth rates are ca. 3 times smaller than the common forest) support the permafrost presence. The new results were integrated into an inter-site evaluation based on the internationally reported cold screes which reveals the priority of lithology in controlling their thermal behavior and implicitly the cold reservoir formation or even permafrost into low- and mid-altitude cold screes. As long as the mean slope of debris exceeds a critical threshold (25°), the exceptional high porosity is the driving factor for an extensive and intensified chimney circulation responsible for the overcooling of the winter aspiration zone normally placed on the slope bottoms and on the negative features (depressions, furrows) in case of rock glacier – talus slope morphology. Lithology assessment highlights that most of the cold screes (ca. 2/3) are composed by only two rock types: basalts and limestones. The poor thermal-conductive basalts which built the most porous screes show the highest negative offsets (6 – 9 °C), which recommend them as the optimum rock type for the low-altitude permafrost sites (< 1200 m) and stands for more than $\frac{3}{4}$ of the cold screes. Limestone is a preferred accommodation for the mid-altitude permafrost sites (1200 – 1800 m) in the cases of steep debris with blocky lower sectors that also develop large thermal anomalies, up to 4 – 5 °C. Scree orientation proves unimportant for the low-altitude permafrost due to the extraordinary large thermal anomalies (> 6 °C) that fade the exposure impact (most of the reported cases are western and southern exposed debris), but for the mid-altitude permafrost sites the slope exposure really count, as ca. 80% of them develop on the shadowed northern aspects.