Geophysical Research Abstracts
Vol. 19, EGU2017-1054, 2017
EGU General Assembly 2017

Redistribution of radioactive mine wastes by slushflows and other processes in small mountain river basin in Russian Subarctics

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The Khibiny Mountains located in central part of the Kola Peninsula (Northern European Russia) are characterized by harsh climatic conditions and frequent occurrence of hazardous or even catastrophic processes. Most widespread of those are snow avalanches taking place every year and slushflows with average recurrence interval of about 10 years. The latter represent specific type of hyperconcentrated gravitational flow of oversaturated mixture of snow and water (20 to 70%) with relatively low sediment concentration (up to 10-15%). Most often slushflows form during spring snowmelt in small mountainous basins (in most cases up to 3-6 km^2) with thick snowpacks or snow dams caused by avalanches in stream channels. Typically observed volumes vary in a range of 20000-40000 m^3, while rare catastrophic events can reach 200000-500000 m^3. Kinetic energy of frontal wave that can be up to several meters high and concentrates most of the largest debris is most likely lower than that of typical debris flow of similar size, mainly because of much lower slushflow density (900-1200 kg m^{-3}). Nevertheless, rare occasional measurements of front wave velocity gave dramatic values of 20-25 m s^{-1} maximum. Such characteristics combined with unpredictable rapid formation make slushflows definitely hazardous processes that can cause serious damage to industrial and residential infrastructure as well as injuries or causalities to people. For example, the Khibiny Mountains have at least 200 locations where formation of slushflows was detected at least ones over the last 50 years. Widespread constructions and communications associated with intensive exploration of mineral resources as well as growing interest to the area as touristic attraction for skiing and other wintertime activities make the Khibiny Mountains an area of serious geomorphic hazards associated with slushflows. In this particular study, we considered the Hackman basin where heavy debris flows occur at least ones per several decades. One of the unique features of that basin is that there was radioactive ore mine active in late 1930s on one of the steep valley sides. The mine was active only for several years as the production of radioactive minerals appeared to be much lower than expected. However, mine wastes are still remaining there as scree slopes on right valley side in its middle reach under several mine entrances. Colluvial material on these screes is highly enriched by several natural radionuclides including members of the ^{232}Th decay chain. We have made an attempt to use this feature for fingerprinting sediment redistribution along the valley by slushflows and fluvial processes. Results of gamma-spectrometric analysis of finer sediment fractions from different geomorphic settings within the Hackman basin have shown that there is a systematic non-uniform spatial distribution of ^{232}Th decay chain natural radionuclides closely related to its geological background and geomorphological structure. It proves that natural lithogenic radionuclide content in clastic sediments can be used for fingerprinting of slushflows debris sources and sinks and, possibly for distinguishing between in situ slushflow deposits and those partly reworked by later fluvial activities.