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Geochemical reasons for high risk of natural and antropogenic hazards in northern taiga karst ecosystems on hard gypsum outcrops

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Ecosystems formed on hard gypsum are rare natural objects that can be observed within very small areas, where this rock outcrops. Gypsum is very poor rock in most macro- and microelements (except Ña, S, and Sr) and belongs to the range of extremely oligotrophic substrates (along with oligomictic sands and coral atolls). Therefore, ecosystem on hard gypsum is a good object for studying how plants accommodate to the nutrient deficiency and find sources of food. The geochemical cycle in this case is very specific because of an abundance of calcium and sulfur and a lack of such vital elements as phosphorus, potassium and many others. So, there are problems of determining the sources of elements and the mechanisms of their input and cycling in ecosystems on hard gypsum. Phytocenoses on hard gypsum are very peculiar and differ from those associated with other rocks (Gypsum karst of the world, 1996). So, research on these unique natural objects can help to comprehend and, hopefully, to save biological diversity of the world.

Northern taiga ecosystems on hard gypsum were studied at the area of Pinega State Reserve in the Arkhangelsk region (coordinates of key sites are . The study area is located in the southeast of the White Sea-Kuloy Plateau and characterized by an intensive development of surface gypsum karst. Landscapes on gypsum substrates are very specific and characterized by a dissected karst topography and predominance of soils formed on hard gypsum. Phytocenosiums confined to soils on hard gypsum are oligotrophic and significantly differ from generally known boreal forests. In the northern taiga, these are open woodlands characterized by the prevalence of oppressed pines and larches and the presence of rare arcto-alpine species (e.g., *Gypsophylla uralensis subsp. pinegensis*) in the lower tiers. Chemical methods of rocks, soils and plants samples investigation include pH (potentiometrically), humus (T'urin's method), nitrogen (K'eldal's method) and total content of other 20 macro- and microelements (X-ray fluorescence analysis).

The analysis of hard gypsum and the local geochemical background of Pinega region (glacial loamy deposits) showed that gypsum rock is enriched only by S, Ca, and Sr: it consists of 99% of $CaSO_4*2H_2O$ and has very low content of other minerals. The content of Br, N and Pb are close to that of moraine. But contents of all other chemical elements are insufficient for normal plant growth, e.g., such important nutrients as K and Mn are found in quantities of 1/400 and less than 1/1000 of their contents in silicate loamy soils of the study area, which confined with typical taiga phytocenosiums.

Distribution of all studied chemical elements in the profiles of soils formed on gypsum shows that there is no accumulation of any eluvium during soil formation on gypsum because of total dissolution of disintegrated gypsum material. In soils on gypsum litter is the main horizon of most of nutrients accumulation and, therefore, its role for plants nutrition became more important than in soils of landscapes on glacial deposits. Other peculiarities of soils on hard gypsum are: 1) acid or weakly acid reaction and 2) low content of organic carbon.

The geochemical specifics of soils lead to significant transformations in the composition of plant organs. All typical boreal species are characterized by increased Ca and Sr concentrations, and some of them (spruce, birch, mountain cranberry and blueberry) can concentrate also S, K, Mg, Fe, Zn, and Rb. Apparently, for all this group of elements this increased accumulation is caused by the bioavailability in form of sulfates, and for Ca, S, and Sr – by abundance of this elements in gypsum substrate. Elements found in decreased concentrations in plant organs belong to the group of insignificant components of gypsum substrate (Mn, Si, K, P, Mg, Fe, Al, Cl, Rb, Ni). However, each plant species is characterized by individual tendency for impoverishing in certain elements. At the same time the differences of elements concentrations in plant organs on gypsum outcrop and in glacial landscapes are less than in soil forming substrates. So we can see the role of organic falloff in the process of soil organic horizons homogenization, which provide more balanced nutrients supply during decay than mineral soil horizons.

At the initial stage of litter accumulation on gypsum substrate, the falloff gradually accumulates from plants that obtain nutrients from small areas of loose silicate deposits covering gypsum on slopes and bottoms of karst microlows. Thus, elements assimilated from silicate deposits (and, of cause, from the air) move into soils on hard gypsum. This is a most important link in the geochemical cycle in ecosystems, because there are only several vascular plants that are capable of occupying practically bare hard gypsum substrate. They are very important for soil formation and characterised by a peculiar chemical composition: *Festuca ovina* – oligotrophic plant with a wide ecological amplitude, and *Gypsophila uralensis Less. Subsp penegensis* - gypsophilic plant. Unlike other plants of karstified open woodlands, *Festuca ovina* doesn't concentrate Ca, Sr and S: their concentrations in the above-ground part of this plant in karst landscapes are similar to concentrations in plants of glacial moraine landscapes. Simultaneously, *Gypsophila uralensis Less. Subsp* is distinguished among all other plants as a supreme accumulator of calcium (6.38 % of dry weight), sulphur (0.38%), and copper (13 mg/kg) with the total ash content of 15.24 %.

Although gypsum karst ecosystems are rarely visited by man in the area of investigation, they are often being damaged by fires because of abundance of separately growing trees in the woodlands and very dry during rainless periods in summer lichen cover on gypsum soils. The fires destroy soil litter, which is extremely precious for the whole ecosystem on geochemically pure gypsum, and cause an intensive denudation of organic horizons and on slopes of karst landforms.

Basing on the age of the oldest trees in the ecosystems we had found out that among phytocenosiums, simultaneously damaged by fire, cenosiums on gypsum outcrops always have poorer stand quality class than on glacial deposits due to slow processes of post-pyrogenic recovery.

Each fire is a start point of new litter accumulation after burning and karst denudation. This process on gypsum outcrops is very slow due to nutrients deficiency in substrate – so that litter horizon is thin and fragmentary on karst elevations.

The described territory has many beautiful natural caves and perspective for developing of speleotourizm. Therefore the threat of antropogenic fires and trampling demands strict measures of nature protection.