Extended abstract No. /121

GENERAL REVIEW OF THE PEAT LANDSCAPE GEOCHEMISTRY IN EUROPEAN RUSSIA (ER) AND DISTRIBUTION OF Ge, U and ^{137}Cs IN PEAT SOILS.

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SUMMARY

The Landscape Geochemistry Conception aims to study the distribution of chemical elements, basic regularities of their migration in all components of European Russia (ER) and affected by natural and anthropogenic factors, at local, regional and global levels for any period. These parameters are determined by the type of peat geochemical landscape (PGL) as follows:
- PGL of low annual temperature and plain relief;
- PGL of increased hydrodynamic activity;
- PGL of highly-mineralized water supply. Correlation between the hydrochemical background level of an element and its accumulation in peat is found to be the general regularity; for example distribution of Ge, U, and ^{137}Cs.

KEY WORDS: environment, landscape geochemistry, peat, peat soils, trace elements.

INTRODUCTION.

Most scientists believe that the biochemical nature of the peat, i.e. the relationship between properties of a peat bog and the composition of a peat forming plants is the basis for systematizing the mires. The alternative idea is that the chemical composition of the organic mineral matter of similar peat types varies greatly; therefore the botanical classification of peats fails to characterize properties of the peat soils and mires. In this paper, we try to demonstrate that both concepts can be applied to a particular geochemical situation. This is especially true for the distribution of trace elements in peat soils and mires.

MATERIALS AND METHODS

The research of peat soils and mires of ER has been conducted in three periods, between 1971 and 1988 and between 1992 and 1994, and in 1999-2007. Full profiles of about 2500 pits dug in peat soils were characterized. Samples were collected from the topsoil. The bulk contents of Cu, Zn, Co, Mo, Mn were determined by colorimetric methods and those of Ti, V, Cr, Ni, Ga, Zr, Pb, Ag, Y, Yb, Be, Sc, Sn, Sr, Ba and La with GSP spectrophotometer; contents of mobile Cu, Co, Zn, Mo, and Mn using specific sets of extractions. Chemical analysis of peat and organic soils used in Russia do not significantly differ from internationally accepted routine methods (Sapek, A. and Sapek, B., 1988). Ge was determined in alkaline extract, U - in NaOH extract. ^{137}Cs was determined using several extraction methods: distillated water, 1 N CH_3COONH_4 solution and 6 N HCl solution.

RESULTS

The Landscape Geochemistry conception as the integrated approach to the problems of the environment is the main paradigm of scientific research of peat and peat soils for agricultural purposes, of ecological problems and in search of mineral deposits, etc.
It aims to study the distribution of chemical elements and compounds, their diffusions and basic regularities of their migration in all components of the environment as affected by natural and anthropogenic factors, at local, regional and global levels for any period. The pH-Eh parameters, the type of geochemical bars was studied. Geochemical coefficients and formulae as relative parameters of natural and anthropogenic processes were widely used. For comparative analysis, the geochemical coefficient was calculated - Clarke concentration - as a ratio between the content of an element in a sample, and its mean content in the world soils. Within the ER, the studied peatlands occupy the area of the greatest geotectonic structure - Russian platform, and are to be considered as a classical example of Humid peat formation.
Regularities of the trace elements concentration and distribution are determined by the type of PGL as follows:

- PGL-1 with low average annual temperatures, high moisture content and the plain relief (mainly glacial-fluvioglacial). 60% of the total area of peat soils in ER, are situated within this province.
- PGL-2 with increased hydrodynamic activity and greater mineralization of the bog-and-ground water with wide range of pH-Eh values. This is a zone of an intensive authigenic minerals formation and wide development of peat soils in high-in-ash.
- PGL-3, being Azonal, with unusual conditions of peat soils occurrence (with surrounding solid rock shores, coastal peat soils, high-mountain, etc.). Water-and-mineral supply of the peat soils is ensured by the highly-mineralized confined water of the solid rocks. A concentration of elements often exceeds the “threshold” values.

In the PLG-1 the composition and properties of peat soils and mires of NW part of ER of glacial and fluvio-glacial relief depend on the botanical composition, degree of decomposition and ash content of peat. These organic soils are characterized by low fertility. They developed only as a result of peat accumulation, and were unaffected by other geological and geochemical processes. They are low in P, Cu, Mo, and Co, so that their contents are by 2 to 10 times below the optimum of peat soils and agricultural crops. The concentrations of these essential elements sometimes are so low that it may cause the endemic diseases of humans and farm animals.

Organic soils and mires of PGL-2 are penetrated by flow-through surface and ground waters. These lowland peat soils with high ash content are characterized by high content of the dissolved salts. Their redox potential changes greatly, so pre-determine the formation of authigenious minerals. The profile of these soils may contain various bands of sand, silt, lay, lime, etc. Properties of these peat soils do not depend on the botanical composition of peat, and the degree of its decomposition, even when the ash content is less than 18%. They have quite satisfactory agrochemical properties: low pH, high absorbing capacity, large to moderately large nutrient content.

Calcareous peat soils develop in areas with eroded topography, in deeply cut river valleys.

Authigenous minerals of iron ore occur in peat soils mainly as vivianite, ochre and siderite. Mineralized peat layers enriched with iron always develop in places characterized by the most intensive dynamics of bog and ground waters. The oxidized iron accumulates in surface layer as goethite and hydro-goethite and typically occurs as iron ore at the depth of 0.6 to 1.2 m. Vivianite is typical for peat soils and overlies sands enriched with P within the area of denudation. Iron phosphates are found in native mires as small spots of white vivianite.

PLG-3 of Vyatka-Kama lowland that occupies the eastern part of the Russian Platform, overly large geotectonic structures. They are composed of Lower Triassic, Jurassic, and Lower Cretaceous deposits represented by clays with sandy beds and siltstones.

In these organic soils and mires, maximum CC (3 to 15 and more) are noted for U, Ge, Ni, Cr, Yb, Y and Cu. Sulphate salinization of drained peat soils develops when soil and ground (mainly confined) waters are enriched with sulphates. The soil salinity changes from weak (2 to 3% sulphur, and 0.75 to 1.5% of the sum of dissolved salts in water extract) to strong (4 to 5% and 2.5%, respectively). The basic process of the trace elements accumulation takes place in grass-turfy horizon due to humic acid formed.

All over the ER such elements as Cu, Ge, Pb, Mo, Yb, Zn, Co, Mn, Sr, and Ni are relatively concentrated in lowland peat soils whilst V, Cr, Ba, Ti, Zr, Ga, Be, Y, Sn, Sc and La are not accumulated there. Correlation between the hydrogeochemical background level of an element and its accumulation in peat is found to be general regularity. This thesis is illustrated in the paper by the distribution of the inorganic trace elements Ge, U and ^{137}Cs.

The placing of peat deposits with either contents of Ge is extremely clear controlled by basic rock relief. The favorable denudation areas are the rocks, developed due to intensive weathering during the stage of the earth's crust formation (T_1 - J_3), or tectonic intensive areas. Peat deposits are the secondary halo of Ge dispersion, where it migrates from under-laid basic rocks. The super-chalk concentrations of Ge in peat soils and mires of ER are identified in Vyatka-Kama, Meshchiora and Trans-Volga lowlands, especially of zones of close contact with enclosing rocks; CC then reaches 14. The places of bog with high content of Ge are characterized by maximum ground water streams: Ge concentration in water is 10^{-6} - 10^{-5}g.l^{-1}. Ge migrates in a free way what causes its dissimilation through the whole peat deposit. Certain correlation between Ge content in water and that of the peat is noted.

The upper limit of Ge concentration in a peat with low ash is 19.4 mg.kg^{-1}, for peat rocks in contact zone with underlain bedrocks this value is 30 mg. kg^{-1} d.m. Very often Ge concentrated areas are located within the border of high solid rock bank. Due to Manskaya and Drozdova (1964) the process of Ge accumulation in peat can be treated as sorption. Coefficient of Ge sorption is about 100. Under the initial content of Ge 0.3-2.3 mg.kg^{-1}, 20% of Ge turns into water extract and 80% - into alkaline extract, thus the peat deposits of the ER are not concentrators of Ge (Kreshtapova, 1993). The unique Ge concentrations as 26-68 mg.kg^{-1} are formed in case of entering of the thermal waters from fissure zones of tectonic breaches connected with volcanic activities to a peat deposit in Kamchatka (Kostin et al., 1973).

The distinctive property of Vyatka-Kama lowland is the formation of peat deposits with high content of U. The formation of U-bearing peat bogs is under the conditions of ascending neotectonic movements, rising of considerable unchanged basic rocks masses over the basis of erosion and appearance of stratum pressure waters. The basic rocks - Permian particoloured aleurites - are the source of U in peats. U-bearing plots with the U content of 0.001-0.01% (and up to 0.2% in peat ash) occupy not more than 2-6% of the peat deposit total area. Ore formation is located directly near the basic slope. The thickness of the U enriched strata is 0.05-1.0 m, with its minimum in the upper layers. Waters are mainly hydrocarbonate-calcium or sulphate-hydrocarbonate calcium. The total mineralization of waters is 300-700 $mg.l^{-1}$.

U-bearing peat bogs are characterized by low content of phosphorus (less than 0.1% d.m.), increased sulfur content (1.5-4% d.m.) and high iron content (more than 4%). We observed the separate crystalines of authigenic pyrite nodule, dispersed in a peat, in the upper boundary of a capillary border on the depth of 40 cm (after draining of U peat bog). The mechanisms of the U fixation in peat deposits under natural conditions includes the process of U sorption by peat as well as the process of oxidizing-and-reduction with influence on the sorption. The role of the carbonate U form is sharply decreased in low-acid-medium and the main significance is obtained by cation uranile forms that are easily sorptioned on the suspended particles and colloids, including the organic ones.

The numerous measures of Eh-potential in ore peats gave the values from - 50 up to -100 mv, to be compared to values on -200-250 mv in some peat bogs. The lowest values of Eh up to -297 mv are found in extremely decomposed salty peats under pH of 6.7.

After Chernobyl Nuclear Power Plant accident on April 26, 1986, worldwide concern has grown to evaluate the dose of ^{137}Cs radiation and its long-term effects on human health. In peat soils of Bryansk oblast, ^{137}Cs from the Chernobyl accident fallout varies from 2-3 to 100-250 KBq/kg dry organic soil. Peat-bog ecosystem accumulate this element. In peat soils, ^{137}Cs is mainly retained in the insoluble form (68-85% of total ^{137}Cs content). In nine years (from 1990 to 1999), the ^{137}Cs content in the topsoil (0-14 cm) has dropped by only 1%. Deep peat layers do not contain ^{137}Cs. Thus the migration of this element in peat soil is absent. Mires with a high organic matter contents serve as sinks and natural filters for chemical elements. Human activity may abruptly change the chemical conditions of the mire and, thus, cause the release of accumulated elements, including toxic ones, into the surrounding environment (Kreshtapova and Chekin, 2008).

It could be concluded that:

a) the profile of bog soils represents the system of microgeochemical barriers, which determine the behavior of ^{137}Cs in transitional bogs;

b) The behaviur of ^{137}Cs in peat dust and peaty horizons of bog soils differs, being determined by specific features of soil genesis and of watershed areas;

c) bog soils transform ^{137}Cs into hardly movable compounds, transforming transitional bogs into critical ecosystems.

DISCUSSION

Geologists and geochemics who investigated the peat deposits as geological object are well-known: Fortesque, 1980; Salmi, 1963; Shotgk et al., 1992; Swain, 1970, and Von Post, 1924 and others. They described the salt-affected mires which are characterized by the cations accumulated such as Na, Ca, Mg, Fe, Mn, Ba, Cu, Ge, U, Sr as well as the anions - Cl, SO_4, S, CO_2 and phosphates. In this paper and previously (Kreshtapova, 1993) we tried to show properties of the peat soils and mires in situ which are integrated in the conception of Peat Landscape geochemistry. This conception is true of former geological epoch (Makedonov et al., 1973) and especially for ancient crusts of weathering. It is shown now that importance of carbonaceous deposits in formation of Pre-Cambrian period was yet considerable (Melegic and Basalajev, 1988).

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