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Genesis, properties and ecosystem role of carbonate lacustrine sediments in northern taiga ecosystems on terraces of lakes with sulfate waters

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The research was carried out in northern taiga (boreal forests) of the Arkhangelsk region of Russia, in the basin of Pinega river, in the area where gypsum rocks of lower Perm outcrop.

Lake waters, influenced by gypsum karst springs (or by direct dissolution of gypsum rocks), are characterized with increased calcium-sulfate mineralization, ranging from 900 to 1700 mg\l. It has been found that intensive sulfate reduction in water saturated sediments is accompanied by deposition of $CaCO_3$ in the lowest layer. The process can be described by the following equations (R. Lal et al (eds.), 2003):

$$2CH_3CHOHCOO^- \text{ (aq)} + SO_4^{2-} \text{ (aq)} \rightarrow 2CH_3COO^- \text{(aq)} + 2HCO_3^- + H_2S\text{(gas)}$$

$$H_2S\text{(s)} + Fe^{2+}\text{(aq)} \rightarrow FeS\text{(s)} + 2H^+\text{(aq)}$$

The sulfate-reducting bacteria use the compost as an organic substrate and remove sulfate from solution either by converting it to H_2S, which is lost to the atmosphere, or by forming insoluble iron sulfides. Bicarbonate is formed as a by-product of sulfate-reduction. The third step in calcification involves the chemical precipitation of $CaCO_3^{\cdot}$

$$Ca^{2+} + 2HCO_3^- \quad \leftrightarrow CaCO_3 + CO_2\text{(gas)} + H_2O\text{(liquid)}.$$

The sediment accumulated in this way is composed mainly of calcium carbonate (with oxides-admixtures in the order of 13-17%). The low level of MgO and high concentration of SO_3 (4,08-5,29%) and Sr (up to 1233 mg/kg) are assign of genetic link between of loose lacustrine carbonate sediments and gypsum rocks.

The thickness of this type of carbonates on terraces of big lakes (lake Pershkovskoye on the territory of Pinega state reserve) reaches 30 sm.

The higher level terraces (on less thick carbonate sediments) saw the formation of Calcaric Regosols (dark humus eutrophic soils), and the lower ones – Histi-calcaric Regosols.

pH of mineral horizons in soils on loose limy deposits is in alkaline range. pH of organic horizons is also less acid than in soils of landscapes on silicate glacial deposits and those on outcrops of carbonate-free gypsum. The content of carbon of humus happen to be as high as 9,14 % - that is much higher than in soils of landscapes on glacial deposits. Ash content in the litter horizon of Calcaric Regosols is rather high mainly due to accumulation of calcium, and also S, Mg, Si, Zn and Sr. Histi-calcaric regosols on loose carbonate sediments are enriched with a number of “ash elements” in their peat horizons: Ca, S, Sr, Br, Cu, P, Mn, Zn, Ni.

The high ash content in plant organs has been observed in plant assemblages on loose carbonate deposits, accompanied by high accumulation of Ca, S, Sr, Zn and Br. At the same time carbonate substrate lead to deconcentration of Cl, Mn, Fe, Rb and, sometimes, Ni and Cu in plant tissues.

Carbonane chlorosis effects Histi-calcaric Regosols by suppressing forest growth, while tree assemblages of high canopy class cover Calcaric Regosols on not so thick carbonates. Simultaneously, on both that soils large amount of plant species was found in the lower tiers.