Aggregation and disintegration of clay soil particles under carbon dioxide and a chemolithotrophic community

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The aim of the work presented was to establish the influence of an active chemolithotrophic community on contacts between clay particles under conditions simulating the water-saturated subsurface and deep layers of a clay soil. Carbonate clay was sampled from Quaternary deluvium on Permian variegated clays from a depth of 1.5-2.0 m on the watershed of the Volga and Sviyaga rivers. An experiment was carried out with the soil particles' size distribution detected at two levels of carbon dioxide and a chemolithotrophic biofilm stimulator and two exposures - 2 and 6 months. The soil was stuffed into experimental vessels after grinding and sieving through a 0.25 mm cell. The vessels had sealed water circulation. For uniform distribution, the soil was treated with the stimulator trough porous ceramic disks - carriers exposed for 14 days in the cultural liquid based on a washout from cave calcite speleothems and a modified R2 medium. The organic matter content introduced into soils in this way was 0.3 and 1.9 mg/g of soil at exposures of 2 and 6 months, respectively, on the zero day of the experiment. The soil particles' and microaggregates' size distributions were estimated on a Beckman Coulter laser particle size analyzer. Surface interactions between particles were characterized using the author's wetting contact angle procedure for soil specimens. The soil organic matter transformation was assayed by the Tyurin method (TsINAO's modification). The carbonate cement content in the soil was estimated by the method of V.E. Sokolovich. After 2 months of experiment in the option under the only hydration influence (control) the fraction of 2-50 μm began to dominate due to the destruction of microaggregates >50 μm. Chemolithotrophs stimulated in the normal atmosphere led to increasing aggregation of particles into microaggregates >50 μm and median size of microaggregates (17 μm versus 13 μm), relative to the initial option. Chemolithotrophs stimulated under a high CO_2 content caused the disintegration of even mechanically strong particles. After 6 months of experiment the median size of microaggregates increased in all experimental options: the largest increase - up to 33 μm - was observed when chemolithotrophs were stimulated under a high CO_2 content. The volume fraction of microaggregates >100 μm in the options under a high CO2 content exceeded one in the initial option (12–16% versus 7%), herewith these microaggregates were less resistant to ultrasound, i.e. they possessed a higher degree of crystallinity than microaggregates at the normal content of CO2. According this, the degree of crystallinity decreased in the control and in the stimulated chemolithotrophs under a high CO2 content options can be concluded. On the contrary, that increased in the stimulated chemolithotrophs in the normal atmosphere and in the high CO2 content control options. The high crystallinity could correspond to the calcite form of carbonates, and an amorphous phase – to organomineral one. The particles' aggregation was accompanied by their hydrophobization, with raising wetting contact angle to 91° in the stimulated chemolithotrophs under a normal atmosphere option after 6 months. The biofilms that developed in the studied soil followed the internal nonlinear dynamics of organic matter accumulation, surface hydrophobicity formation and cement crystallization, as well as contributed to the particles' aggregation inside a period of 2-6 months.

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