Catalytic activity of some crustal rocks: Experiments on the vapor conversion of methane

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Fluids accelerate reaction rates between minerals, growth of mineral grains, melting processes, deformations and re-crystallization in mineral aggregates. The opposite influence, i.e. catalytic effects of rocks and minerals on the reactions between fluid components, is a poorly studied topic of geochemistry related to the fluid-rock interactions. Nevertheless, crustal rocks with compositions based mostly on SiO_2 and Al_2O_3, modified by the catalytic active "metal" components, are good analogue of the catalytic systems used in the industrial technologies, while components of the fluid fluxes (H_2O, CO_2, CO, CH_4, H_2, N_2, SO_2, NH_3), can be considered as a raw material for a catalytic generation of a wide spectrum of the products. We report results of experimental study on the methane conversion by vapor on three rocks: (1) massive antigorite-lizardite serpentinite (Bogorodskoe deposit, Urals), (2) antigorite-lizardite asbestos (Bazhenovskoe deposit, Urals) and (3) oceanic ophitic gabbro (Logachev Field, Mid-Atlantic Ridge). Samples were crushed to the fractions 0.5-0.71 mm before experiments. The experiments were performed using a flow-type quartz glass catalytic reactor at ambient pressure and 500-850ºC. The volume ratio H_2O/CH_4 in the reaction zone was 8-10/1, filtration rate through the rock 1 cm-thick layer was 0.5-0.6 cm/s, the time of the contact of the H_2O-CH_4 mixture with samples was 1.5-2 s. All the samples are catalytically active. However, serpentinite shows the highest catalytic effectiveness. The conversion of CH_4 to H_2 on this rock increases with temperature and reaches 14 % at 825^{O}C. The conversion to CO and CO_2 at 825^{O}C is 3 % for both components. The reaction products include ethanol and methanol, which do not form on standard catalysts. Presence of other oxygen-bearing hydrocarbons in the run products cannot be excluded. Catalytic activity of asbestos and gabbro is 2-3 times lower than that of the serpentinite. Nevertheless, the experiments inspire testing of the catalytical properties of other crustal rocks as potential alternatives for the artificial catalytic materials to develop the catalytic geochemistry.