Methane-rich fluids in the upper mantle: Their speciation, subduction and involvement in redox melting reactions

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In this study we use a new experimental approach for the synthesis and direct observation of reduced magmatic COH-fluids at conditions relevant for the upper mantle. The main goal is to investigate the change of the fluid speciation as a function of oxygen fugacity (fO_2) and to provide further information about the involvement of reduced carbon-bearing fluids in mineral or melting reactions. It is known, that reduced methane-rich fluids are 'incompatible' compared to more oxidized fluids, i.e. water and CO_2, which can be incorporated in wt% concentrations in OH-bearing minerals and carbonates. Therefore, CH_4-fluids are likely to survive deep subduction without being consumed by the surrounding rock. Fluids are highly mobile and by passing through more oxidized environements, 'redox melting' reaction can be initiated. The knowledge of such processes is particularly important for understanding the formation of deep magmatic hot spots, deep melting or the early formation of volcanoes and volcanic roots.

Experiments of this study were carried out at pressures ranging from 3 to 5 GPa, temperatures up to 1300 °C at fO_2 conditions near the IW. Numerous fluid inclusions were trapped in olivine crystals and investigated using Raman spectroscopy. Obtained spectra reveal that at studied fO_2s fluids consist mainly of CH_4 along with small amounts of high hydrocarbons like C_2H_6. Water has not been detected, but H_2 was found to be incorporated in olivine, suggesting that a certain amount of H_2 is present in the fluid as well. Our results are inconsistent with published fluid speciation models, which predict significant H_2O contents at these fO_2 conditions. We demonstrate that fluids with significant contents of CH_4 are likely to be stable under the conditions recorded by some mantle samples.