Geophysical Research Abstracts
Vol. 16, EGU2014-13515, 2014
EGU General Assembly 2014

Composition of COH fluids at 1 GPa: an experimental study on speciation and solubility

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COH fluids play a fundamental role in many geological processes, controlling the location of melting in subduction zones and promoting mass transfer from the subducting litosphere to the overlying mantle wedge. The properties of COH fluids are strictly dependent on the composition of the fluid in subduction systems, i.e., the speciation of the volatile components of the fluid itself and the presence of solutes deriving from the dissolution of rock-forming minerals. In the scientific literature, the speciation of COH fluids has been generally determined through thermodynamic calculations using equations of state of simple H_2O-non-polar gas systems (e.g., H_2O-CO_2-CH_4), equations that do not consider the complexity related to dissolution processes, which are substantially unexplored in COH fluids and limited so far to aqueous fluids (Newton & Manning, 2002). The aim of this work is to investigate experimentally the speciation and the dissolution of mantle minerals in carbon-saturated COH fluids at buffered fO_2 conditions. Our experimental approach relies on two different techniques: 1) analysis by means of quadrupole mass spectrometer (QMS) of the fluids from pierced run capsules to retrieve speciation of volatile components and 2) analysis of frozen COH fluid with laser-ablation inductively coupled plasma-mass spectrometry (LA-ICP-MS) to measure the amount of solutes.

Experiments were conducted at pressure of 1 GPa and temperatures from 800 to 900°C using a rocking piston cylinder apparatus. Mantle minerals in equilibrium with COH fluid are represented by synthetic forsterite. fO_2 conditions were controlled using the double capsule technique and NNO buffer (ΔFMQ=-0.61 at 800°C; ΔFMQ =-0.98 at 900°C).

For the speciation experiments, oxalic acid dihydrate and graphite have been used to generate carbon-saturated COH fluid. The speciation was determined by analyzing the quenched COH fluid, retrieved by piercing the capsule in a gas-tight vessel at T=80°C and convoying evolved gases to a QMS through a heated line to avoid the condensation of water. This type of analyzer ensures superior performances in terms of selectivity of molecules to be detected, high acquisition rates and extended linear response range. The influence of dissolved solutes on fluid speciation has been evaluated by comparing experiments in the pure COH system and in the COH+forsterite system.

To determine the solubility of forsterite in COH fluids we performed a second set of experiments at the same P, T and fO_2 conditions above. Fluids trapped in a diamond layer were analysed by the cryogenic LA-ICP-MS technique described by Aerts et al. (2010). With this method the aqueous part of the COH fluid is frozen prior the opening and maintained frozen during the analysis to avoid any precipitation of solutes.

The results will highlight the importance of fluids for the mass transport in subduction zones. Comparison between experimental data and thermodynamic calculation will also be shown.

References:

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