Evaluating Fluid-Host post entrapment interaction in UHP fluid inclusions

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Fluid inclusions (FI) are the only direct way to sample fluids, including the C-bearing ones relevant to investigate the Deep Carbon Cycle [1], circulating during active subduction of continental crust at sub-arc depth. The main difficulty of the FI study lays in the identification of the most preserved inclusions, e.g. those lacking chemical post-trapping re-equilibration with the host mineral. In the ultra-high pressure (UHP) Brossasco-Isasca Unit of the Dora-Maira Massif, there are impure marbles lenses that experienced peak metamorphic conditions at ~4.3 GPa and ~730°C [2] and multiple events of prograde-to-early-retrograde UHP dissolution-precipitation of dolomite [3].

Detailed petrographic investigation of the chemically simple impure marble allows to distinguish five main FI generations within zoned Di. The generation trapped at UHP conditions consists of primary tri-phase (S+L+V) multisolid aqueous FI. Micro-Raman analysis allowed to recognize four subtypes (Ia, Ib, Ic, Id), depending on the fluid content and the included mineral assemblage: Ia) Mg-Cc+H_2O_L+H_2O_V+N_2; Ib) H_2O_L+Mg-Cc+Tlc+ H_2O_V+N_2; Ic) Mg-Cc/Cc+Atg+Ctl+Tlc±Tr±Dol+H_2O_L+H_2O_V+N_2; Id) Mg-Cc/Cc+Atg+Ctl+Tlc+Dol±Tr. SEM-EDS qualitative analyses on opened FI also revealed the presence of chlorides (NaCl, KCl) and Fe-sulphides.

Thermodynamic modelling in the system CMS-H_2O-CO_2 allowed the identification of possible post-entrapment reactions between the host Di and the solute rich aqueous fluid. This allowed to recognize that Ib-Id FI subtypes represent stages of progressive FI chemical re-equilibration with the host, whereas Ia FI subtype contain incidentally trapped carbonates. These data indicate the presence, at UHP conditions, of a COHN electrolytic fluid (i.e., not a COHN molecular fluid) containing dissolved Ca+Mg+Si, and minor Fe+Na+K+Cl+S. Image analyses and Micro-Raman maps allowed to estimate the fluid bulk composition from the most preserved FI (subtype Ia).

[1] Kelemen & Manning, (2015) P Natl Acad Sci USA, 112(30), E3997-E4006.

[2] Castelli et al. (2007): J Metamorph Geol., 25(6), 587-603.

[3] Ferrando et al. (2017): Am. Mineral., 102(1), 42-60